

Fish Community Assessment

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RAPID BIOASSESSMENT PROTOCOL V — FISH (EPA 1989, 1999)

The following are excerpts from U.S. EPA (1989, 1999; www.epa.gov/owow/monitoring/rbp) guidance manuals. For more extensive information, the reader should refer directly to those manuals.

Rapid Bioassessment Protocol V (RBP V) is a rigorous approach similar to species-level identification with the macroinvertebrate RBP in accuracy and effort, but focuses on fish. Electrofishing, the most common technique used by agencies that monitor fish communities, and the most widely applicable approach for stream habitats, is the sampling technique recommended for use with RBP V.

The fish community biosurvey data are designed to be representative of the fish community at all station habitats, similar to the “representative qualitative sample” proposed by Hocutt (1981). The sampling station should be representative of the reach, incorporating at least one (preferably two) riffle(s), run(s), and pool(s) if these habitats are typical of the stream in question. Sampling of most species is most effective near shore and cover (macrophytes, boulders, snags, brush). Sampling procedures effective for large rivers are described in Gammon (1980), Hughes and Gammon (1987), and Ohio EPA (1987).

Typical sampling station lengths range from 100 to 200 m for small streams and 500 to 1000 m in rivers, but are best determined by pilot studies. The size of the reference station should be sufficient to produce 100 to 1000 individuals and 80% of the species expected from a 50% increase in sampling distance. Sample collection is usually done during the day, but night sampling can be more effective if the water is especially clear and there is little cover (Reynolds 1983). Use of block nets set (with as little wading as possible) at both ends of the reach increases sampling efficiency for large, mobile species sampled in small streams.

The RBP V fish community assessment requires that all fish species (not just gamefish) be collected. Small fish that require special gear for their effective collection may be excluded. Exclusion of young-of-the-year fish during collection has only a minor effect on IBI scores (Angermeier and Karr 1986), but lowers sampling costs and reduces the need for laboratory identification. Karr et al. (1986) recommended exclusion of fish less than 20 mm in length. However, this may prevent detection of species-specific effects, or early life stage effects from recent pollution incidents. This

recommendation should be considered on a regional basis and is also applicable to large fish requiring special gear for collection (e.g., sturgeon). The intent of the sample (as with the entire protocol) is to obtain a representative estimate of the species present, and their abundances, for a reasonable amount of effort. However, if threatened or endangered species are present, special attention should be given to documenting their presence and numbers.

Sampling effort among stations is standardized as much as possible. Regardless of the gear used, the collection method, site length (or area), and work hours expended must be comparable to allow comparison of fish community status among sites. Major habitat types (riffle, run, and pool) sampled at each site and the proportion of each habitat sampled should also be comparable. Generally 1 to 2 hours of actual sampling time are required, but this varies considerably with the gear used and the size and complexity of the site.

Atypical conditions, such as high flow, excessive turbidity or turbulence, heavy rain, drifting leaves, or other unusual conditions that affect sampling efficiency, are best avoided. Glare, a frequent problem, is reduced by wearing polarized glasses during sample collection.

Sample Processing

A field collection data sheet (Figure C.1) is completed for each sample. Sampling duration and area or distance sampled are recorded in order to determine level of effort. Species may be separated into adults and juveniles by size and coloration; then total numbers and weights and the incidence of external anomalies are recorded for each group. Reference specimens of each species from each site are preserved in 10% formaldehyde, the jar labeled, and the collection placed with the state ichthyological museum to confirm identifications and to constitute a biological record. This is especially important for uncommon species, for species requiring laboratory identification, and for documenting new distribution records. If retained in a live well, most fish can be identified, counted, and weighed in the field by trained personnel and returned to the stream alive. In warmwater sites, where handling mortality is highly probable, each fish is identified and counted, but for abundant species, subsampling (weigh, measure, observe for abnormalities, and return) may be considered. When subsampling is employed, the subsample is extrapolated to obtain a final value. Subsampling for weight is a simple, straightforward procedure, but failure to examine all fish to determine frequency of anomalies (which may occur in about 1% of all specimens) can bias results. The trade-off between handling mortality and data bias must be considered on a case-by-case basis. If a site is to be sampled repeatedly over several months (i.e., monitoring), the effect of sampling mortality might outweigh data bias. Holding fish in live-boxes in shaded, circulating water will substantially reduce handling mortality. More information on field methods is presented in Karr et al. (1986) and Ohio EPA (1987).

Data Analysis Techniques

Based on observations made in the assessment of habitat, water quality, physical characteristics, and the fish biosurvey, the investigator concludes whether impairment is detected. If impairment is detected, the probable cause and source are estimated and recorded on an Impairment Assessment Sheet (Figure C.2).

Data can be analyzed using the Index of Biotic Integrity (IBI) (or individual IBI metrics), the Index of Well Being (IWB) (Gammon 1980), or modified IWB (OEPA 1989; Gammon 1989), and multivariate statistical techniques to determine community similarities. Detrended correspondence analysis (DCA) is a useful multivariate analysis technique for revealing regional community patterns and patterns among multiple sites. It also demonstrates assemblages with compositions differing from others in the region or reach. See Gauch (1982) and Hill (1979) for descriptions of, and software for, DCA. Data analyses and reporting, including parts of the IBI, can be computer generated. Computerization reduces the time needed to produce a report and increases staff capability to examine

6. Rate each IBI score to one of the five integrity classes.
7. Translate total IBI score to one of the five integrity classes.
8. Interpret data in the context of the habitat assessment. Individual metric analysis may be necessary to ascertain specific trends.

Species Richness and Diversity

These metrics assess the species richness component of diversity and the health of the major taxonomic groups and habitat guilds of fishes. Two of the metrics assess community composition in terms of tolerant or intolerant species. Scoring for the first five of these metrics and their substitutes requires development of species–water body size relationships for different zoogeographic regions. Development of this relationship requires data sufficient to plot the number of species collected from regional reference sites of various stream sizes against a measure of stream size (watershed area, stream order) of those sites. A line is then drawn with slope fit by eye to include 95% of the points. Finally the area under the line is trisected into areas that are scored as 5, 3, or 1. A detailed description of these methods can be found in Fausch et al. (1984), Ohio EPA (1987), and Karr et al. (1986).

Metric 1. Total number of fish species — Substitute metrics: total number of native fish species, and salmonid age classes.

This number decreases with increased degradation; hybrids and introduced species are not included. In cold-water streams supporting few fish species, the age classes of the species found represent the suitability of the system for spawning and rearing. The number of species is strongly affected by stream size at small stream sites, but not at large river sites (Karr et al. 1986; Ohio EPA 1987). Thus, scoring depends on developing species–waterbody size relationships.

Metric 2. Number and identity of darter species — Substitute metrics: number and identity of sculpin species, benthic insectivore species, salmonid yearlings (individuals); number of sculpins (individuals); percent round-bodied suckers, sculpin and darter species.

These species are sensitive to degradation resulting from siltation and benthic oxygen depletion because they feed or reproduce in benthic habitats (Kuehne and Barbour 1983; Ohio EPA 1987). Many smaller species live within the rubble interstices, are weak swimmers, and spend their entire lives in an area of 100 to 400 m² (Hill and Grossman 1987; Matthews 1986). Darters are appropriate in most Mississippi basin streams; sculpins and yearling trout occupy the same niche in western streams. Benthic insectivores and sculpins or darters are used in small Atlantic slope streams that have few sculpins or darters, and round-bodied suckers are suitable in large midwestern rivers. Scoring requires development of species–water body size relationships.

Metric 3. Number and identity of sunfish species — Substitutes: number and identity of cyprinid species, water column species, salmonid species, headwater species, and sunfish and trout species.

These pool species decrease with increased degradation of pools and in-stream cover (Gammon et al. 1981; Angermeier 1983; Platts et al. 1983). Most of these fishes feed on drifting and surface invertebrates and are active swimmers. The sunfishes and salmonids are important sport species. The sunfish metric works for most Mississippi basin streams, but where sunfish are absent or rare, other groups are used. Cyprinid species are used in cool-water western streams; water column species occupy the same niche in northeastern streams; salmonids are suitable in cold-water streams; headwater species serve for midwestern headwater streams; and trout and sunfish species are used in southern Ontario streams. Karr et al. (1986) and Ohio EPA (1987) found the number of sunfish species to be dependent on stream size in small streams, but Ohio EPA (1987) found no relationship between stream size and sunfish species in medium to large streams, nor between stream size and headwater species in small streams. Scoring of this metric requires development of species–water body size relationships.

Metric 4. Number and identity of sucker species — Substitutes: number of adult trout species, number of minnow species, and number of suckers and catfish.

These species are sensitive to physical and chemical habitat degradation and commonly comprise most of the fish biomass in streams. All but the minnows are long-lived species and provide a multiyear integration of physicochemical conditions. Suckers are common in medium and large streams; minnows dominate small streams in the Mississippi basin; and trout occupy the same niche in cold-water streams. The richness of these species is a function of stream size in small and medium-sized streams but not in large rivers. Scoring of this metric requires development of species–water body size relationships.

Metric 5. Number and identity of intolerant species — Substitutes: number and identity of sensitive species (5), amphibian species, and presence of brook trout.

This metric distinguishes high- and moderate-quality sites using species that are intolerant of various chemical and physical perturbations. Intolerant species are typically the first to disappear following a disturbance. Species classified as intolerant or sensitive should only represent the 5 to 10% most susceptible species; otherwise this becomes a less discriminating metric. Candidate species are determined by examining regional ichthyological books for species that were once widespread but have become restricted to only the highest quality streams. Ohio EPA (1987) uses number of sensitive species (which includes highly intolerant and moderately intolerant species) for headwater sites because highly intolerant species are generally not expected in such habitats. Moyle (1976) suggested using amphibians in northern California streams because of their sensitivity to silvicultural impacts. This also may be a promising metric in Appalachian streams which may naturally support few fish species. Steedman (1988) found that the presence of brook trout had the greatest correlation with IBI score in Ontario streams. The number of sensitive and intolerant species increases with stream size in small and medium-sized streams but is unaffected by size of large rivers. Scoring this metric requires development of species–water body size relationships.

Metric 6. Proportion of individuals as green sunfish — Substitutes: proportion of individuals as common carp, white sucker, tolerant species, creek chub, and dace.

This metric is the reverse of Metric 5. It distinguishes low- from moderate-quality waters. These species show increased distribution or abundance despite the historical degradation of surface waters, and they shift from incidental to dominant in disturbed sites. Green sunfish are appropriate in small midwestern streams; creek chubs were suggested for central Appalachian streams; common carp were suitable for a cool-water Oregon river; white suckers were selected in the Northeast and Colorado where green sunfish are rare to absent; and dace (*Rhinichthys* species) were used in southern Ontario. To avoid weighting the metric on a single species, Karr et al. (1986) and Ohio EPA (1987) suggest using a small number of highly tolerant species. Scoring of this metric may require development of expectations based on water body size.

Trophic Composition Metrics

These three metrics assess the quality of the energy base and trophic dynamics of the community. Traditional process studies, such as community production and respiration, are time-consuming, and the results are equivocal; distinctly different situations can yield similar results. The trophic composition metrics offer a means to evaluate the shift toward more generalized foraging that typically occurs with increased degradation of the physicochemical habitat.

Metric 7. Proportion of individuals as omnivores — Substitutes: proportion of individuals as yearlings.

The percent of omnivores in the community increases as the physical and chemical habitat deteriorates. Omnivores are defined as species that consistently feed on substantial proportions of

plant and animal material. Ohio EPA (1987) excludes sensitive filter-feeding species such as paddlefish and lamprey ammocoetes and opportunistic feeders like channel catfish. Where omnivorous species are nonexistent, such as in trout streams, the proportion of the community composed of yearlings, which initially feed omnivorously, may be substituted.

Metric 8. Proportion of individuals as insectivorous cyprinids — Substitutes: proportion of individuals as insectivores, specialized insectivores, and insectivorous species; and number of juvenile trout.

Insectivores or invertivores are the dominant trophic guild of most North American surface waters. As the invertebrate food source decreases in abundance and diversity due to physicochemical habitat deterioration, there is a shift from insectivorous to omnivorous fish species. Generalized insectivores and opportunistic species, such as blacknose dace and creek chub, were excluded from this metric by the Ohio EPA (1987). This metric evaluates the midrange of biotic integrity.

Metric 9. Proportion of individuals as top carnivores — Substitutes: proportion of individuals as catchable salmonids, catchable wild trout, and pioneering species.

The top carnivore metric discriminates between systems with high and moderate integrity. Top carnivores are species that, as adults, feed predominantly on fish, other vertebrates, or crayfish. Occasional piscivores, such as creek chub and channel catfish, are not included. In trout streams, where true piscivores are uncommon, the percent of large salmonids is substituted for percent piscivores. These species often represent popular sport fish such as bass, pike, walleye, and trout. Pioneering species are used by Ohio EPA (1987) in headwater streams typically lacking piscivores.

Fish Abundance and Condition Metrics

The last three metrics (plus the final optional matrix) indirectly evaluate population recruitment mortality, condition, and abundance. Typically, these parameters vary continuously and are time-consuming to estimate accurately. Instead of such direct estimates, the final results of the population parameters are evaluated. Indirect estimation is less variable and much more rapidly determined.

Metric 10. Number of individuals in sample — Substitutes: density of individuals.

This metric evaluates population abundance and varies with region and stream size for small streams. It is expressed as catch per unit effort, either by area, distance, or time sampled. Generally sites with lower integrity support fewer individuals, but in some nutrient-poor regions, enrichment increases the number of individuals. Steedman (1988) addressed this situation by scoring catch per minute of sampling greater than 25 as a three, and less than 4 as a one. Unusually low numbers generally indicate toxicity, making this metric most useful at the low end of the biological integrity scale. Hughes and Gammon (1987) suggest that in larger streams, where sizes of fish may vary in orders of magnitude, total fish biomass may be an appropriate substitute or additional metric.

Metric 11. Proportion of individuals as hybrids — Substitutes: proportion of individuals as introduced species, simple lithophils, and number of simple lithophilic species.

This metric is an estimate of reproductive isolation or the suitability of the habitat for reproduction. Generally, as environmental degradation increases, the percent of hybrids and introduced species also increases, but the proportion of simple lithophils decreases. However, minnow hybrids are found in some high-quality streams; hybrids are often absent from highly impacted sites; and hybridization is rare and difficult for many to detect. Thus, Ohio EPA (1987) substitutes simple lithophils for hybrids. Simple lithophils spawn where their eggs can develop in the interstices of sand, gravel, and cobble substrates without parental care. Hughes and Gammon (1987) and Miller et al. (1988) proposed using percent introduced individuals. This metric is a direct measure of the loss of species segregation between midwestern and western fishes that existed before the introduction of midwestern species to western rivers.

Metric 12. Proportion of individuals with disease, tumors, fin damage, and skeletal anomalies — this metric depicts the health and condition of individual fish. These conditions occur infrequently or are absent from minimally impacted reference sites but occur frequently below major pollutant sources. They are excellent measures of the subacute effects of chemical pollution and the aesthetic value of game and nongame fish.

Metric 13. Total fish biomass (optional) — Hughes and Gammon (1987) suggest that in larger areas, where sizes of fish may vary in orders of magnitude, this additional metric may be appropriate.

Because the IBI is an adaptable index, the choice of metrics and scoring criteria is best developed on a regional basis through use of available publications (Karr et al. 1986; Ohio EPA 1987; Miller et al. 1988). Several steps are common to all regions. The fish species must be listed and assigned to trophic and tolerance guilds. Scoring criteria are developed through use of high-quality historical data and data from minimally impacted regional reference sites. This has been done for much of the country, but continued refinements are expected as more fish community ecology data become available. Once scoring criteria have been established, a fish sample is evaluated by listing the species and their abundances, calculating values for each metric, and comparing these values with the scoring criteria. Individual metric scores are added to calculate the total IBI score (Figure C.3).

Station No. _____

Site _____

Metrics ^a	Scoring Criteria ^b			Metric Value	Metric Source
	$\frac{5}{\%}$	$\frac{3}{\%}$	$\frac{1}{\%}$		
1. Number of Native Fish Species	>67	33-67	<33		
2. Number of Darter or Benthic Species	>67	33-67	<33		
3. Number of Sunfish or Pool Species	>67	33-67	<33		
4. Number of Sucker or Long-Lived Species	>67	33-67	<33		
5. Number of Intolerant Species	>67	33-67	<33		
6. % Green Sunfish or Tolerant Individuals	<10	10-25	>25		
7. % Omnivores	<20	20-45	>45		
8. % Insectivores or Invertivores	>45	20-45	<20		
9. % Top Carnivores	>5	1 - 5	<33		
10. Total Number of Individuals	>67	33-67	<33		
11. % Hybrids or Exotics	0	0 - 1	>1		
12. % Anomalies	<1	1 - 5	>5		

Scorer _____ IBI Score _____

Comments: _____

^a Karr's original metrics or commonly used substitutes. See text for other possibilities.

^b Karr's original scoring criteria or commonly used substitutes. These may require refinement in other ecoregions.

Figure C.3 Data summary sheet for Rapid Bioassessment Protocol V. (From EPA. *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish*. Office of Water, U.S. Environmental Protection Agency. Washington, D.C. EPA 444/4-89/001. 1989.)

Hughes and Gammon (1987) and Miller et al. (1988) suggest that scores lying at the extremes of scoring criteria can be modified by a plus or minus; a combination of three pluses or three minuses results in a two-point increase or decrease in IBI. Ohio EPA (1987) scores proportional metrics as 1 when the number of species and individuals in samples are fewer than 6 and 75, respectively, when their expectations are of higher numbers.

Table C.1 Tolerance, Trophic Guilds, and Origins of Selected Fish Species

	Trophic Level	Tolerance	Origin
Willamette Species			
Salmonidae			
Chinook salmon	piscivore	intolerant	native
Cutthroat trout	insectivore	intolerant	native
Mountain whitefish	insectivore	intolerant	native
Rainbow trout	insectivore	intolerant	native
Cyprinidae			
Chiselmouth	herbivore	intermediate	native
Common carp	omnivore	tolerant	exotic
Goldfish	omnivore	tolerant	exotic
Leopard dace	insectivore	intermediate	native
Longnose dace	insectivore	intermediate	native
Northern squawfish	piscivore	tolerant	native
Peamouth	insectivore	intermediate	native
Redside shiner	insectivore	intermediate	native
Speckled dace	insectivore	intermediate	native
Catostomidae			
Largescale sucker	omnivore	tolerant	native
Mountain sucker	herbivore	intermediate	native
Ictaluridae			
Brown bullhead	insectivore	tolerant	exotic
Yellow bullhead	insectivore	tolerant	exotic
Percopsidae			
Sand roller	insectivore	intermediate	native
Gasterosteidae			
Threespine stickleback	insectivore	intermediate	native
Centrarchidae			
Bluegill	insectivore	tolerant	exotic
Largemouth bass	piscivore	tolerant	exotic
Smallmouth bass	piscivore	intermediate	exotic
White crappie	insectivore	tolerant	exotic
Percidae			
Yellow perch	insectivore	intermediate	exotic
Cottidae			
Paiute sculpin	insectivore	intolerant	native
Prickly sculpin	insectivore	intermediate	native
Reticulate sculpin	insectivore	tolerant	native
Torrent sculpin	insectivore	intolerant	native
Midwest Species			
Petromyzontidae			
Silver lamprey	piscivore	intermediate	native
Northern brook lamprey	filterer	intolerant	native
Mountain brook lamprey	filterer	intolerant	native
Ohio lamprey	piscivore	intolerant	native
Least brook lamprey	filterer	intermediate	native
Sea lamprey	piscivore	intermediate	exotic
Polyodontidae			
Paddlefish	filterer	intolerant	native

Table C.1 Tolerance, Trophic Guilds, and Origins of Selected Fish Species (continued)

	Trophic Level	Tolerance	Origin
Acipenseridae			
Lake sturgeon	invertivore	intermediate	native
Shovelnose sturgeon	insectivore	intermediate	native
Lepisosteidae			
Alligator gar	piscivore	intermediate	native
Shortnose gar	piscivore	intermediate	native
Spotted gar	piscivore	intermediate	native
Longnose gar	piscivore	intermediate	native
Amiidae			
Bowfin	piscivore	intermediate	native
Hiodontidae			
Goldeye	insectivore	intolerant	native
Mooneye	insectivore	intolerant	native
Clupeidae			
Skipjack herring	piscivore	intermediate	native
Alewife	invertivore	intermediate	exotic
Gizzard shad	omnivore	intermediate	native
Threadfin shad	omnivore	intermediate	native
Salmonidae			
Brown trout	insectivore	intermediate	exotic
Rainbow trout	insectivore	intermediate	exotic
Brook trout	insectivore	intermediate	native
Lake trout	piscivore	intermediate	native
Coho salmon	piscivore	intermediate	exotic
Chinook salmon	piscivore	intermediate	exotic
Lake herring	piscivore	intermediate	native
Lake whitefish	piscivore	intermediate	native
Osmeridae			
Rainbow smelt	invertivore	intermediate	exotic
Umbridae			
Central mudminnow	insectivore	tolerant	native
Esocidae			
Grass pickerel	piscivore	intermediate	native
Chain pickerel	piscivore	intermediate	native
Northern pike	piscivore	intermediate	native
Muskellunge	piscivore	intermediate	native
Cyprinidae			
Common carp	omnivore	tolerant	exotic
Goldfish	omnivore	tolerant	exotic
Golden shiner	omnivore	tolerant	native
Horneyhead chub	insectivore	intolerant	native
River chub	insectivore	intolerant	native
Silver chub	insectivore	intermediate	native
Bigeye chub	insectivore	intolerant	native
Streamline chub	insectivore	intolerant	native
Gravel chub	insectivore	intermediate	native
Speckled chub	insectivore	intolerant	native
Blacknose dace	generalist	tolerant	native
Longnose dace	insectivore	intolerant	native
Creek chub	generalist	tolerant	native
Tonguetied minnow	insectivore	intolerant	native
Suckermouth minnow	insectivore	intermediate	native
Southern redbelly dace	herbivore	intermediate	native
Redside dace	insectivore	intolerant	native
Pugnose minnow	insectivore	intolerant	native
Emerald shiner	insectivore	intermediate	native
Silver shiner	insectivore	intolerant	native

Table C.1 Tolerance, Trophic Guilds, and Origins of Selected Fish Species (continued)

	Trophic Level	Tolerance	Origin
Cyprinidae			
Rosyface shiner	insectivore	intolerant	native
Redfin shiner	insectivore	intermediate	native
Rosefin shiner	insectivore	intermediate	native
Striped shiner	insectivore	intermediate	native
Common shiner	insectivore	intermediate	native
River shiner	insectivore	intermediate	native
Spottail shiner	insectivore	intermediate	native
Blackchin shiner	insectivore	intolerant	native
Bigeye shiner	insectivore	intolerant	native
Steelcolor shiner	insectivore	intermediate	native
Spotfin shiner	insectivore	intermediate	native
Bigmouth shiner	insectivore	intermediate	native
Sand shiner	insectivore	intermediate	native
Mimic shiner	insectivore	intolerant	native
Ghost shiner	insectivore	intermediate	native
Blacknose shiner	insectivore	intolerant	native
Pugnose shiner	insectivore	intolerant	native
Silverjaw minnow	insectivore	intermediate	native
Mississippi silvery minnow	herbivore	intermediate	native
Bullhead minnow	omnivore	intermediate	native
Bluntnose minnow	omnivore	tolerant	native
Fathead minnow	omnivore	tolerant	native
Central stoneroller	herbivore	intermediate	native
Popeye shiner	insectivore	intolerant	native
Grass carp	herbivore	intermediate	exotic
Red shiner	omnivore	intermediate	native
Brassy minnow	omnivore	intermediate	native
Central silvery minnow	herbivore	intolerant	native
Catostomidae			
Blue sucker	insectivore	intolerant	native
Bigmouth buffalo	insectivore	intermediate	native
Black buffalo	insectivore	intermediate	native
Smallmouth buffalo	insectivore	intermediate	native
Quillback	omnivore	intermediate	native
River carpsucker	omnivore	intermediate	native
Highfin carpsucker	omnivore	intermediate	native
Silver redhorse	insectivore	intermediate	native
Black redhorse	insectivore	intolerant	native
Golden redhorse	insectivore	intermediate	native
Shorthead redhorse	insectivore	intermediate	native
Greater redhorse	insectivore	intolerant	native
River redhorse	insectivore	intolerant	native
Harelip sucker	invertivore	intolerant	native
Northern hog sucker	insectivore	intolerant	native
White sucker	omnivore	tolerant	native
Longnose sucker	insectivore	intermediate	native
Spotted sucker	insectivore	intermediate	native
Lake chubsucker	insectivore	intermediate	native
Creek chubsucker	insectivore	intermediate	native
Ictaluridae			
Blue catfish	piscivore	intermediate	native
Channel catfish	generalist	intermediate	native
White catfish	insectivore	intermediate	native
Yellow bullhead	insectivore	intolerant	native
Brown bullhead	insectivore	intolerant	native
Black bullhead	insectivore	tolerant	native

Table C.1 Tolerance, Trophic Guilds, and Origins of Selected Fish Species (continued)

	Trophic Level	Tolerance	Origin
Ictaluridae			
Flathead catfish	piscivore	intermediate	native
Stonecat	insectivore	intolerant	native
Mountain madtom	insectivore	intolerant	native
Slender madtom	insectivore	intolerant	native
Freckled madtom	insectivore	intermediate	native
Northern madtom	insectivore	intolerant	native
Scioto madtom	insectivore	intolerant	native
Brindled madtom	insectivore	intolerant	native
Tadpole madtom	insectivore	intermediate	native
Anguillidae			
American eel	piscivore	intolerant	native
Cyprinodontidae			
Western banded killifish	insectivore	intolerant	native
Eastern banded killifish	insectivore	tolerant	native
Blackstripe topminnow	insectivore	intermediate	native
Poeciliidae			
Mosquitofish	insectivore	intermediate	exotic
Gadidae			
Burbot	piscivore	intermediate	native
Percopsidae			
Trout-perch	insectivore	intermediate	native
Aphredoderidae			
Pirate perch	insectivore	intermediate	native
Atherinidae			
Brook silverside	insectivore	intermediate	native
Percichthyidae			
White bass	insectivore	intermediate	native
Striped bass	insectivore	intermediate	exotic
White perch	insectivore	intermediate	exotic
Yellow bass	insectivore	intermediate	native
Centrarchidae			
White crappie	invertivore	intermediate	native
Black crappie	invertivore	intermediate	native
Rock bass	piscivore	intermediate	native
Smallmouth bass	piscivore	intermediate	native
Spotted bass	piscivore	intermediate	native
Largemouth bass	piscivore	intermediate	native
Warmouth	invertivore	intermediate	native
Green sunfish	invertivore	tolerant	native
Bluegill	insectivore	intermediate	native
Orangespotted sunfish	insectivore	intermediate	native
Longear sunfish	insectivore	intolerant	native
Redear sunfish	insectivore	intermediate	native
Pumpkinseed	insectivore	intermediate	native
Percidae			
Sauger	piscivore	intermediate	native
Walleye	piscivore	intermediate	native
Yellow perch	piscivore	intermediate	native
Dusky darter	insectivore	intermediate	native
Blackside darter	insectivore	intermediate	native
Longhead darter	insectivore	intolerant	native
Slenderhead darter	insectivore	intolerant	native
River darter	insectivore	intermediate	native
Channel darter	insectivore	intolerant	native
Gilt darter	insectivore	intolerant	native
Logperch	insectivore	intermediate	native

Table C.1 Tolerance, Trophic Guilds, and Origins of Selected Fish Species (continued)

	Trophic Level	Tolerance	Origin
Percidae			
Crystal darter	insectivore	intolerant	native
Eastern sand darter	insectivore	intolerant	native
Western sand darter	insectivore	intolerant	native
Johnny darter	insectivore	intermediate	native
Greenside darter	insectivore	intermediate	native
Banded darter	insectivore	intolerant	native
Variagate darter	insectivore	intolerant	native
Spotted darter	insectivore	intolerant	native
Bluebreast darter	insectivore	intolerant	native
Tippecanoe darter	insectivore	intolerant	native
Iowa darter	insectivore	intermediate	native
Rainbow darter	insectivore	intermediate	native
Orangethroat darter	insectivore	intermediate	native
Fantail darter	insectivore	intermediate	native
Least darter	insectivore	intermediate	native
Slough darter	insectivore	intermediate	native
Sciaenidae			
Freshwater drum	invertivore	intermediate	native
Cottidae			
Spoonhead sculpin	insectivore	intermediate	native
Mottled sculpin	insectivore	intermediate	native
Slimy sculpin	insectivore	intermediate	native
Deepwater sculpin	insectivore	intermediate	native
Gasterosteidae			
Brook stickleback	insectivore	intermediate	native

From EPA. *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish*. Office of Water, U.S. Environmental Protection Agency. Washington, D.C. EPA 444/4-89/001. 1989.

Table C.2 National List of Intolerant Fish Species^a

Common Name	Latin Name
Cisco	<i>Coregonus artedii</i> .
Arctic cisco	<i>Coregonus autumnalis</i> .
Lake whitefish	<i>Coregonus clupeaformis</i> .
Bloater	<i>Coregonus hoyi</i> .
Kiyi	<i>Coregonus kiyi</i> .
Bering cisco	<i>Coregonus laurettae</i> .
Broad whitefish	<i>Coregonus nasus</i> .
Humpback whitefish	<i>Coregonus pidschian</i> .
Hortnose cisco	<i>Coregonus reighardi</i> .
Least cisco	<i>Coregonus sardinella</i> .
Shortjaw cisco	<i>Coregonus zenithicus</i> .
Pink salmon	<i>Oncorhynchus gorbuscha</i> .
Chum salmon	<i>Oncorhynchus keta</i> .
Coho salmon	<i>Oncorhynchus kisutch</i> .
Sockeye salmon	<i>Oncorhynchus nerka</i> .
Chinook salmon	<i>Oncorhynchus tshawytscha</i> .
Pygmy whitefish	<i>Prosopium coulteri</i> .
Round whitefish	<i>Prosopium cylindraceum</i> .
Mountain whitefish	<i>Prosopium williamsoni</i> .
Golden trout	<i>Salmo aguabonita</i> .
Arizona trout	<i>Salmo apache</i> .
Cutthroat trout	<i>Salmo clarki</i> .

Table C.2 National List of Intolerant Fish Species^a (continued)

Common Name	Latin Name
Rainbow trout	<i>Salmo gairdneri/O. mykiss</i> .
Atlantic salmon	<i>Salmo salar</i> .
Brown trout	<i>Salmo trutta</i> .
Arctic char	<i>Salvelinus alpinus</i> .
Bull trout	<i>Salvelinus confluentus</i> .
Brook trout	<i>Salvelinus fontinalis</i> .
Dolly varden	<i>Salvelinus malma</i> .
Lake trout	<i>Salvelinus namaycush</i> .
Inconnu	<i>Stenodus leucichthys</i> .
Arctic grayling	<i>Thymallus arcticus</i> .
Largescale stoneroller	<i>Campostoma oligolepis</i> .
Redside dace	<i>Clinostomus elongatus</i> .
Cutlips minnow	<i>Exoglossum maxillingua</i> .
Bigeye chub	<i>Hybopsis amblops</i> .
River chub	<i>Nocomis micropogon</i> .
Pallid shiner	<i>Notropis amnis</i> .
Pugnose shiner	<i>Notropis anogenus</i> .
Rosefin shiner	<i>Notropis ardens</i> .
Bigeye shiner	<i>Notropis boops</i> .
Pugnose minnow	<i>Notropis emiliae</i> .
Whitetail shiner	<i>Notropis galacturus</i> .
Blackchin shiner	<i>Notropis heterodon</i> .
Blacknose shiner	<i>Notropis heterolepis</i> .
Spottail shiner	<i>Notropis hudsonius</i> .
Sailfin shiner	<i>Notropis hypselopterus</i> .
Tennessee shiner	<i>Notropis leuciodus</i> .
Yellowfin shiner	<i>Notropis lutipinnis</i> .
Ozark minnow	<i>Notropis nubilus</i> .
Ozark shiner	<i>Notropis ozarcanus</i> .
Silver shiner	<i>Notropis photogenis</i> .
Duskystripe shiner	<i>Notropis pilsbryi</i> .
Rosyface shiner	<i>Notropis rubellus</i> .
Safron shiner	<i>Notropis rubricroceus</i> .
Flagfin shiner	<i>Notropis signipinnis</i> .
Telescope shiner	<i>Notropis telescopus</i> .
Topeka shiner	<i>Notropis topeka</i> .
Mimic shiner	<i>Notropis volucellus</i> .
Steelcolor shiner	<i>Notropis whipplei</i> .
Coosa shiner	<i>Notropis zaenocephalus</i> .
Bleeding shiner	<i>Notropis zonatus</i> .
Bandfin shiner	<i>Notropis zonistius</i> .
Blackside dace	<i>Phoxinus cumberlandensis</i> .
Northern redbelly dace	<i>Phoxinus eos</i> .
Southern redbelly dace	<i>Phoxinus erythrogaster</i> .
Blacknose dace	<i>Rhinichthys atratulus</i> .
Pearl dace	<i>Semotilus margarita</i> .
Alabama hog sucker	<i>Hypentelium etowanum</i> .
Northern hog sucker	<i>Hypentelium nigricans</i> .
Roanoke hog sucker	<i>Hypentelium roanokense</i> .
Spotted sucker	<i>Minytrema melanops</i> .
Silver redhorse	<i>Moxostoma anisurum</i> .
River redhorse	<i>Moxostoma carinatum</i> .
Black jumprock	<i>Moxostoma cervinum</i> .
Gray redhorse	<i>Moxostoma congestum</i> .
Black redhorse	<i>Moxostoma duquesnei</i> .
Rustyside sucker	<i>Moxostoma hamiltoni</i> .
Greater jumprock	<i>Moxostoma lachneri</i> .
Blacktail redhorse	<i>Moxostoma poecilurum</i> .

Table C.2 National List of Intolerant Fish Species^a (continued)

Common Name	Latin Name
Torrent sucker	<i>Moxostoma rhothoecum</i> .
Striped jumprock	<i>Moxostoma rupiscartes</i> .
Greater redhorse	<i>Moxostoma valenciennesi</i> .
Ozark madtom	<i>Noturus albater</i> .
Elegant madtom	<i>Noturus elegans</i> .
Mountain madtom	<i>Noturus eleutherus</i> .
Slender madtom	<i>Noturus exilis</i> .
Stonecat	<i>Noturus flavus</i> .
Black madtom	<i>Noturus funebris</i> .
Least madtom	<i>Noturus hildebrandi</i> .
Margined madtom	<i>Noturus insignis</i> .
Speckled madtom	<i>Noturus leptacanthus</i> .
Brindled madtom	<i>Noturus miurus</i> .
Frecklebelly madtom	<i>Noturus minitus</i> .
Brown madtom	<i>Noturus phaeus</i> .
Roanoke bass	<i>Ambloplites cavifrons</i> .
Ozark rockbass	<i>Ambloplites constellatus</i> .
Rock bass	<i>Ambloplites rupestris</i> .
Longear sunfish	<i>Lepomis megalotis</i> .
Darters ^a	<i>Ammocrypta</i> sp.
Darters ^a	<i>Etheostoma</i> sp.
Darters ^a	<i>Percina</i> sp.
Sculpins ^a	<i>Cottus</i> sp.
O'opu alamo (goby)	<i>Lentipes concolor</i> .
O'opu nopili (goby)	<i>Sicydium stimpsoni</i> .
O'opu nakea (goby)	<i>Awaous stamineus</i> .
Johnny darter	<i>Etheostoma nigrum</i> .
Bluntnose darter	<i>E. chlorosomum</i> .
Slough darter	<i>E. gracile</i> .
Cypress darter	<i>E. proeliare</i> .
Orangethroat darter	<i>E. spectabile</i> .
Swamp darter	<i>E. fusiforme</i> .
River darter	<i>Percina shumardi</i> .

^a Reader note that there are inconsistencies between some tolerance rankings with Table C.1 (UEPA 1989).

^b The United States has 150 species of darters and sculpins, the great majority of which are intolerant species. Possible exceptions include:

From EPA. *Methods for Chemical Analysis of Water and Wastes*. EPA-600/4-79-020, U.S. Environmental Protection Agency, Cincinnati, Ohio. 1983b.

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