

Calculation of Minnesota Stream Fish IBIs - Draft

February 8, 2017

The Index of Biotic Integrity (IBI) is used by the Minnesota Pollution Control Agency (MPCA) to determine if streams are meeting their aquatic life use goals. Calculation of an IBI involves synthesis of fish community information into a numerical expression of stream health. In order to apply the MPCA stream fish IBI (FIBI), it is essential that all data is collected using MPCA standard operating procedures ([MPCA 2009](#)). A complete description of the development of FIBIs can be found in MPCA ([2014](#)).

Stream Types

Prior to determining the FIBI score, the sampling location must be categorized into a stream type. MPCA has stratified Minnesota streams into nine types corresponding to regional patterns in the composition of stream fishes; a unique FIBI and biocriterion have been developed for each type. Stream type is differentiated by geographic region, contributing drainage area, reach-scale gradient, and thermal regime. Classification criteria are described in the following paragraphs and a step-by-step classification approach is outlined in Appendix A.

Geographic Region: The FIBI stream typology framework divides Minnesota into two regions (North, South). Regionalization largely follows major watershed boundaries and reflects significant post-glacial barriers to fish migration (e.g., St. Anthony Falls) (Figure 1). The “northern” FIBI region includes the Lake Superior basin, Rainy River basin, the portion of the Upper Mississippi River basin upstream of St. Anthony Falls, the portion of the St. Croix River basin upstream of Taylor’s Falls, and the portion of the Red River basin lying outside of the Glacial Lake Agassiz Basin level 4 ecoregion. The “southern” FIBI region includes the entirety of the Minnesota River, Lower Mississippi River, Des Moines, and Cedar River basins, the portion of the Upper Mississippi River basin below St. Anthony Falls, the portion of the St. Croix River basin below Taylor’s Falls, and the portion of the Red River basin lying within the Glacial Lake Agassiz Basin level 4 ecoregion.

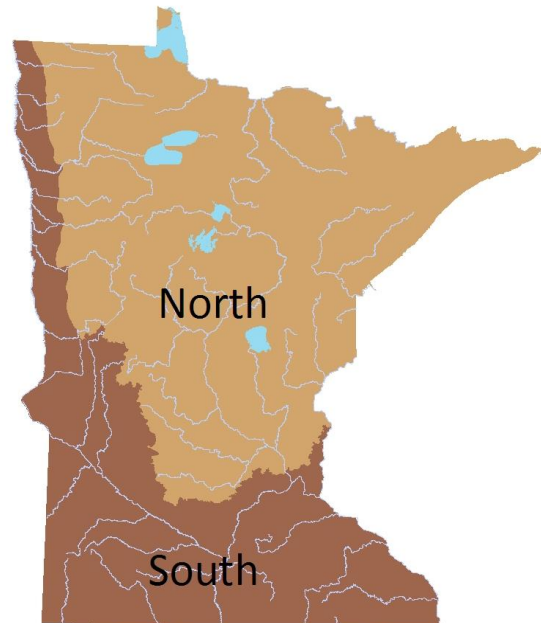


Figure 1. Regional framework for FIBI development and application.

Drainage area: Contributing drainage area (square miles) must be determined for all stream fish sampling locations. Drainage area is used for classification purposes and, in some cases, the metric scoring process.

Gradient: Reach-scale gradient (meters/kilometer) is required for most stream fish sampling locations. Gradient is used for classification purposes and, in some cases, the metric scoring process. MPCA recommends determining reach-scale gradient based on the endpoint elevations of a 1000 meter stream segment that brackets the midpoint of the fish sampling reach.

Temperature – For the purposes of FIBI classification, MPCA recognizes two temperature types: coldwater (2A) and non-coldwater (2B). Thermal classifications for Minnesota streams can be found in Minnesota Administrative Rules [7050.0470](#) and [7050.0430](#).

Fish community data

Stream fish data must be collected using MPCA protocols ([MPCA 2009](#)) and identified to the lowest feasible taxonomic level (typically species). MPCA has utilized a variety of published and non-published sources to assign trophic, reproductive, habitat, tolerance, and life history traits to fish species known to inhabit Minnesota’s rivers and streams. These species-level attributes should be used to calculate FIBI metric values, and are listed in Appendix B.

In some cases, a species-level taxonomic determination may not be feasible and individual fish may be identified at a coarser taxonomic level (e.g., immature redhorse may be identified as *Moxostoma spp.*). For the purposes of taxa richness and taxa percentage metrics, the determination of whether to “count” these individuals as a unique taxon depends on whether other members of the same taxonomic group are present and identified at a finer taxonomic resolution. For example, if the only redhorse collected in a sample are immature and cannot be identified to the species level, the genus *Moxostoma* should be considered a unique taxon. However, if other redhorse individuals in the same sample can be identified to the species level, the immature specimens should not be considered a unique taxon.

Calculating Metric Values

Metric values are the raw numerical expression of taxonomic or autecological information at the community level. Fish IBI metrics fall into three general categories: taxa richness, taxa percentage, and relative abundance (Table 1). Appendix C provides information regarding each FIBI and associated metrics.

Table 1. Metric types used in FIBI.

Metric Type	Description	Example
Taxa Richness	The number of unique taxa observed in a sample that share a common attribute	Number of piscivorous taxa
Taxa Percentage	The number of taxa observed in a sample that share a common attribute divided by the total number of unique taxa in the sample	Proportion of piscivorous taxa among all taxa in the sample
Relative Abundance	The number of individuals observed in a sample that share a common attribute divided by the total number of individuals in the sample	Proportion of piscivorous individuals among all individuals in the sample

Taxa Richness — Taxa richness metrics represent the number of taxa sharing a common ecological or taxonomic attribute. As described above, only “unique” taxa should contribute to taxa richness metrics.

Example: Piscivorous Taxa (number of piscivorous taxa): if there are 4 unique piscivorous taxa in a sample, the “Piscivore” taxa richness metric value would be 4.

Taxa Percentage – Taxa percentage metrics represent the proportion of taxa sharing a common ecological or taxonomic attribute, relative to the total number of taxa in the sample. As described above, only “unique” taxa should contribute to taxa percentage metrics.

Example: Piscivore_TxPct (percent piscivorous taxa): if there are 4 unique piscivorous taxa in a sample of 20 total unique taxa, the “Piscivore_TxPct” metric value would be 20% (4/20).

Relative abundance – Relative abundance metrics represent the abundance of individuals sharing a common taxonomic or ecological attribute, relative to the total number of individuals in the sample. When calculating relative abundance, all individuals that meet the group criteria should be included, not only those that are considered “unique” taxa (as with taxa richness and taxa percent metrics).

Example: Piscivore_Pct (relative abundance of piscivorous individuals): if there are 20 piscivorous individuals in a sample of 100 total individuals, the “Piscivore_Pct” metric value would be 20% (20/100).

Calculating Metric Scores

In some cases, transformations are used to reduce skew in metric value distributions; metric values should be transformed as indicated in Appendix C. In other cases, metrics are known to be correlated with natural gradients (e.g., drainage area, reach gradient), which may amplify, reduce, or otherwise obscure metric response to anthropogenic disturbance. In these cases, a “corrected” metric value is obtained by calculating a residual from an ordinary least squares (OLS) regression, and using that residual value as the new metric value. Metric values should be corrected for natural gradients as indicated in Appendix C. “Corrected” metric values are calculated as follows:

$$\text{Corrected metric value} = (\text{metric value}) - ((([\text{slope}] * (\text{Log}([\text{natural gradient value}]))) + ([\text{Constant}]))$$

Most metrics are scored on a continuous scale from 0 to 10. Metric scores are derived using different equations, depending on the directionality of each metric’s response to disturbance. Metrics that respond negatively to disturbance (“positive metrics”) will have metric scores positively correlated with metric values. Metrics that respond positively to disturbance (“negative metrics”) will have metric scores inversely related to metric values.

Metric scores are interpolated linearly between minimum and maximum metric values.

Formula for calculating positive metric scores:
$$\text{metric score} = \frac{\text{metric value} - 5^{\text{th}} \text{ percentile value}}{95^{\text{th}} \text{ percentile value} - 5^{\text{th}} \text{ percentile value}} * 10$$

Formula for calculating negative metric scores:
$$\text{metric score} = \frac{95^{\text{th}} \text{ percentile value} - \text{metric value}}{95^{\text{th}} \text{ percentile value} - 5^{\text{th}} \text{ percentile value}} * 10$$

To limit the influence of extreme metric values, the 5th and 95th percentile values are treated as *de facto* “maximum values” for each metric. For positive metrics, values less than the 5th percentile (minimum) are assigned the minimum score of 0, while those with values greater than the 95th percentile (maximum) are assigned the maximum score of 10. For negative metrics, values less than the 5th percentile (minimum) are given the maximum score of 10, while those with values greater than the 95th percentile (maximum) are given the minimum a score of 0. Upper and lower limits for each metric are documented in Appendix C.

Discrete scoring is used in cases where metric score distributions remain heavily skewed following transformation and implementation of the continuous scoring process. Discretely-scored metrics receive

a score of 0, 5, or 10 based on breakpoints in metric score distributions. Discretely-scored metrics and associated breakpoints are documented in Appendix C.

Very low catch rates, either in terms of number of individuals or number of taxa, are generally indicators of severe degradation in permanent, warm and coolwater Minnesota streams. In these cases, the presence of a few individuals may artificially inflate the FIBI score and possibly mask a serious impairment. This is particularly concerning for proportional metrics (individual percentage and taxa percentage), where very low counts of “non-tolerant” individuals may result in extremely high metric scores for negative metrics. To address this issue, MPCA utilizes “low end scoring” criteria, under which individual percentage metrics in non-coldwater IBIs receive a score of 0 when fewer than 25 individuals were captured, and taxa richness and taxa percentage receive a score of 0 when fewer than 6 taxa were captured. Low end scoring taxa richness and taxa percentage metric adjustments are applied to the Southern Rivers, Southern Streams, Northern Rivers and Northern Streams FIBIs. Because fish assemblages of small, perennial headwaters may be relatively depauperate under natural conditions, the low end scoring threshold for taxa richness and taxa percentage metrics in Northern Headwaters, Southern Headwaters, and Low Gradient IBIs is reduced to fewer than 4 taxa. Low End Scoring criteria are not applied to Southern Coldwater and Northern Coldwater IBIs because these systems may exhibit extremely low taxa richness or number of individuals under natural, undisturbed conditions.

The composite IBI score is the sum of metric scores, scaled to a 0-100 range. The formula for scaling IBI scores is as follows:

$$IBI\ score = sum\ of\ metric\ scores * \frac{10}{\# \text{ metrics in IBI}}$$

References

- MPCA. (2009). Fish community sampling protocol for stream monitoring sites (wq-bsm3-03). St. Paul: Minnesota Pollution Control Agency. (Available at: <https://www.pca.state.mn.us/sites/default/files/wq-bsm3-03.pdf>)
- MPCA. (2014). Development of fish indices of biological integrity (FIBI) for Minnesota rivers and streams. St. Paul: Minnesota Pollution Control Agency (Available at: <https://www.pca.state.mn.us/sites/default/files/wq-bsm2-03.pdf>).

Appendix A. Classification criteria for determining the appropriate FIBI for a Minnesota stream or river.

1a. Northern.....5

1b. Southern.....2

Southern

2a. coldwater.....**Southern Coldwater**

2b. warmwater.....3

3a. Drainage area >300 sq mi.....**Southern Rivers**

3b. Drainage area <300 sq mi.....4

4a. Drainage area >30 sq mi..... **Southern Streams**

4b. Drainage area <30 sq mi.....5

5a. Gradient >0.50 m/km.....**Southern Headwaters**

5b. Gradient <0.50 m/km.....**Low-Gradient**

Northern

5a. coldwater.....**Northern Coldwater**

5b. warmwater.....6

6a. Basin = Red.....7

6b. Basin = other.....8

7a. Drainage area >350 sq mi.....**Northern Rivers**

7b. Drainage area <350 sq mi.....9

8a. Drainage area >500 sq mi.....**Northern Rivers**

8b. Drainage area <500 sq mi.....9

9a. Drainage area >50.....**Northern Streams**

9b. Drainage area <50.....10

10a. Gradient >0.50 m/km.....**Northern Headwaters**

10b. Gradient <0.50 m/km.....**Low-Gradient**

Appendix B. Taxon attributes used to calculate FIBI metrics.

Taxon	BenInsect-Tol	Coldwater Taxa	CWIntolerant	CWSensitive	DarterSculp	DetNW/O	Exotic	Generalist	Headwater	Herbiv	InsectCyp	Insect-Tol	Intolerant	MA<2	MA>3	Minnows-Tol	NativeCold	NestNoLith	Omnivore	Percfm	Pioneer	Piscivore	Sdet	Sensitive	Slithop	SLvd	SSpn	Tol	Vtol	Wetland
alewife							X								X															
American brook lamprey			X	X					X				X		X									X						
American eel																						X								
Atlantic salmon		X					X								X							X								
banded darter	X				X							X		X						X				X	X		X			
banded killifish												X		X													X			
bighead carp					X		X								X								X			X	X	X		
bigmouth buffalo								X							X				X			X						X	X	
bigmouth shiner					X						X			X								X			X	X	X	X		
black buffalo						X		X											X			X								
black bullhead					X			X											X			X					X	X	X	
black crappie																		X	X		X									
black redhorse	X			X								X	X		X									X	X					
blackchin shiner											X	X	X	X		X							X	X			X			
blacknose dace								X	X					X											X	X		X		
blacknose shiner											X	X	X	X		X							X		X					
blackside darter	X				X							X		X						X					X					
blackstripe topminnow												X		X													X			
blue catfish																		X				X								
blue sucker	X											X	X											X	X					
bluegill												X		X				X	X								X			
bluntnose darter	X				X							X																		
bluntnose minnow					X	X		X						X				X		X		X			X	X	X	X	X	
bowfin															X								X							
brassy minnow					X	X				X				X									X			X	X			
brook silverside												X		X										X		X				
brook stickleback									X					X				X								X	X		X	
brook trout		X	X	X									X		X		X					X		X						
brown bullhead								X										X	X				X			X		X		
brown trout		X		X			X								X								X	X						
bullhead minnow								X						X		X		X								X				
burbot												X		X									X	X	X					
carmine shiner						X					X	X		X		X								X	X	X				
central mudminnow					X									X													X	X	X	
central stoneroller					X					X																	X			
channel catfish															X			X					X	X						

Taxon	BenInsect-Tol	Coldwater_Taxa	CWIntolerant	CWSensitive	DarterSculp	CWTol	DefINWO	Exotic	Generalist	Headwater	Herbv	InsectCyp	Insect-Tol	Intolerant	MA<2	MA>3	Minnows-Tol	NativeCold	NestNolith	Omnivore	Perfm	Pioneer	Piscivore	Sdet	Sensitive	Slithop	SLvd	Sspn	Tol	Vtol	Wetland
channel shiner												X	X		X		X							X		X					
chestnut lamprey														X		X							X		X						
chinook salmon		X						X								X							X								
coho salmon		X						X								X							X								
common carp					X		X	X	X						X					X				X					X	X	
common shiner									X						X		X							X		X					
creek chub									X						X							X							X		
crystal darter	X				X							X	X	X							X				X	X	X	X			
deepwater sculpin	X				X							X	X			X									X						
emerald shiner												X	X		X		X							X		X	X				
Fam: gars																							X								
Fam: lamprey																									X						
Fam: mooneyes													X																		
Fam: pikes																							X								
Fam: sturgeons	X												X													X					
fantail darter	X		X		X					X			X		X						X			X			X				
fathead minnow				X	X		X	X							X			X	X	X	X	X	X	X		X	X	X	X	X	
finescale dace			X						X		X	X			X		X							X			X			X	
flathead catfish																X		X					X								
flathead chub												X	X		X		X										X				
freshwater drum													X			X					X										
Gen: buffalos									X											X											
Gen: bullheads									X											X										X	
Gen: carpsuckers									X											X											
Gen: Catostomus																										X					
Gen: common sunfishes													X																		
Gen: crappies																							X								
Gen: Etheostoma	X				X								X																		
Gen: madtoms	X												X																		
Gen: Micropterus																							X								
Gen: Notropis																	X														
Gen: Percina	X				X								X													X					
Gen: Phoxinus									X																						
Gen: redhorses	X												X													X					
Gen: Rhinichthys																										X					
Gen: Sander																							X			X					
Gen: sculpins	X	X		X	X							X						X						X							
Gen: stonerollers											X						X														

Taxon	BenInsect-Tol	Coldwater_Taxa	CWIntolerant	CWSensitive	CWTol	DarterSculp	DefNWQ	Exotic	Generalist	Headwater	Herbiv	InsectCyp	Insect-Tol	Intolerant	MA<2	MA>3	Minnows-Tol	NativeCold	NestNolith	Omnivore	Perfm	Pioneer	Piscivore	Sdet	Sensitive	Slithop	SLvd	Sspn	Tol	Vtol	Wetland
Gen: topminnows													X																		
ghost shiner							X					X	X	X	X		X							X				X			
gilt darter	X					X							X	X	X						X			X	X						
gizzard shad																X								X				X			
golden redhorse	X												X			X								X	X						
golden shiner									X						X		X											X		X	
goldeye													X			X															
goldfish					X			X	X							X				X				X				X	X	X	
grass carp					X			X			X				X									X					X		
gravel chub	X											X	X	X	X		X							X	X	X	X				
greater redhorse	X												X	X		X									X	X					
green sunfish					X				X						X			X	X	X									X	X	
highfin carpsucker							X		X							X				X				X	X						
hornyhead chub												X	X		X		X							X	X			X			
hybrid sunfish					X																								X		
ide					X			X								X													X		
iowa darter	X					X							X		X						X				X		X			X	
johnny darter	X					X							X		X				X		X	X									
kokanee								X															X								
lake chub			X	X								X	X	X		X	X								X	X					
lake herring																X															
lake sturgeon	X												X	X		X									X	X					
lake trout		X														X		X					X								
lake whitefish													X			X															
lamprey ammocoete														X											X						
largemouth bass																			X	X	X										
largescale stoneroller											X				X		X							X							
least darter	X					X							X	X	X						X			X		X	X				
logperch	X					X							X	X	X						X			X	X						
longear sunfish													X	X	X				X		X			X							
longnose dace	X		X	X								X	X	X			X							X	X						
longnose gar																X							X					X			
longnose sucker	X		X	X									X	X		X									X	X					
mimic shiner												X	X	X			X							X	X	X	X				
Mississippi silvery minnow											X			X			X								X						
mooneye													X												X						
mottled sculpin	X	X		X		X				X			X		X			X						X							

Taxon	BenInsect-Tol	Coldwater_Taxa	CWIntolerant	CWSensitive	DarterSculp	DefNWQ	Exotic	Generalist	Headwater	Herbiv	InsectCyp	Insect-Tol	Intolerant	MA<2	MA>3	Minnows-Tol	NativeCold	NestNolith	Omnivore	Perfm	Pioneer	Piscivore	Sdet	Sensitive	Slithop	SLvd	Sspn	Tol	Vtol	Wetland
mud darter	X				X							X		X						X			X		X					
muskellunge													X		X							X		X						
ninespine stickleback												X		X			X					X								
northern brook lamprey			X	X									X		X									X						
northern hogsucker	X											X			X								X	X	X					
northern pike														X								X							X	
northern redbelly dace									X	X				X		X							X		X	X			X	
orangespotted sunfish					X									X						X						X	X	X		
Ozark minnow										X		X	X	X		X							X	X	X					
paddlefish												X		X										X	X					
pallid shiner										X	X	X				X								X						
pearl dace			X					X		X	X		X	X	X	X						X	X						X	
pink salmon		X					X															X								
pirate perch												X		X																
plains topminnow												X		X										X		X				
pugnose minnow						X					X	X	X	X	X	X	X						X	X	X	X	X			
pugnose shiner						X			X			X		X	X	X								X		X				
pumpkinseed												X		X			X		X											
pygmy whitefish												X																		
quillback						X		X							X				X				X							
rainbow darter	X			X	X							X		X						X				X	X		X			
rainbow smelt							X															X					X			
rainbow trout		X		X			X								X							X		X						
red shiner				X				X						X												X	X	X		
redfin shiner											X	X		X		X								X		X				
redside dace			X	X				X		X	X	X	X	X	X	X								X	X					
river carpsucker						X		X							X				X				X							
river darter	X				X							X	X	X						X				X	X	X				
river redhorse	X											X	X		X									X	X					
river shiner										X	X		X		X								X		X	X				
rock bass															X		X		X		X	X	X							
round goby							X								X		X					X					X			
round whitefish											X				X															
ruffe				X			X							X													X	X		
sand shiner				X		X				X				X									X			X	X	X		
sauger															X					X		X		X						
saugeye																				X		X		X						
sea lamprey						X	X								X								X							

Taxon	BenInsect-Tol	Coldwater_Taxa	CWIntolerant	CWSensitive	CWTol	DarterSculp	DefNWQ	Exotic	Generalist	Headwater	Herbiv	InsectCyp	Insect-Tol	Intolerant	MA<2	MA>3	Minnows-Tol	NativeCold	NestNolith	Omnivore	Perfm	Pioneer	Piscivore	Sdct	Sensitive	Slithop	SLvd	Sspn	Tol	Vtol	Wetland
shoal chub	X											X	X		X		X							X		X					
shorthead redhorse	X												X			X								X		X					
shortjaw cisco																X															
shortnose gar																	X						X								
shovelnose sturgeon	X												X			X										X					
silver carp					X			X																				X	X		
silver chub	X											X	X		X		X														
silver lamprey																X							X		X						
silver redhorse	X												X			X								X		X					
skipjack herring																							X								
slender madtom	X						X						X	X											X						
slenderhead darter	X					X							X		X						X				X	X					
slimy sculpin	X	X	X	X		X				X			X	X		X		X							X						
smallmouth bass														X		X			X		X		X		X						
smallmouth buffalo									X							X				X				X							
southern brook lamprey			X	X			X							X		X									X						
southern redbelly dace										X	X					X	X							X		X	X	X			
splake		X														X		X					X								
spoonhead sculpin	X					X							X	X		X									X						
spotfin shiner							X					X	X		X		X							X				X			
spottail shiner												X	X		X		X								X						
spotted sucker	X												X	X		X								X	X	X					
starhead topminnow													X	X	X										X			X		X	
stonecat	X															X									X			X			
SubFam: buffalo/carpsuckers									X											X											
SubFam: salmonids																							X								
suckermouth minnow	X											X	X		X		X							X		X		X			
tadpole madtom	X												X		X					X								X		X	
threespine stickleback					X			X								X				X							X		X		
tiger musky																								X							
tiger trout		X																					X								
Topeka shiner										X		X	X	X	X		X								X		X				
trout-perch	X												X		X												X				
tubenose goby								X					X																		
walleye																X					X		X			X					
warmouth															X						X		X								
weed shiner							X				X		X	X		X								X	X	X	X				

Taxon	BenInsect-Tol	Coldwater_Taxa	CWIntolerant	CWSensitive	CWTol	DarterSculp	DefNWQ	Exotic	Generalist	Headwater	Herbiv	InsectCyp	Insect-Tol	Intolerant	MA<2	MA>3	Minnows-Tol	NativeCold	NestNolith	Omnivore	Percfm	Pioneer	Piscivore	Sdet	Sensitive	SLithop	SLyvd	SSpn	Tol	Vtol	Wetland
western sand darter	X					X							X	X	X						X			X	X	X	X				
white bass															X						X		X								
white crappie															X				X		X		X								
white perch								X					X			X				X											
white sucker							X		X							X				X				X		X			X		
yellow bass																X					X		X								
yellow bullhead									X										X	X				X			X				X
yellow perch													X			X					X										

DRAFT

Appendix C. FIBI metrics and scoring criteria.

Table C1. Metric information for the Southern Rivers FIBI

Metric	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Insectivore-Tol_Pct	IndPct	Percent insectivorous individuals (excludes tolerant species)	Tr	P	C	12.01	82.00	
SimpleLithophil	Richness	Number of simple lithophilic taxa, scoring adjusted for gradient	R	P	C	-6.71	2.59	slope=3.945 intercept=11.187
GeneralistFeeder_Pct	IndPct	Percent generalist feeder individuals	Tr	N	C	5.64	64.72	
VeryTolerant_TxPct	TXPct	Percent very tolerant taxa	To	N	C	5.04	33.33	
SerialSpawner_TxPct	TXPct	Percent serial spawner taxa	R	N	C	14.40	38.04	
Tolerant_Pct	IndPct	Percent tolerant individuals	To	N	C	5.38	82.30	
ShortLived_Pct	IndPct	Percent short-lived individuals	LH	N	C	0.83	60.10	
Sensitive_TxPct	TXPct	Percent sensitive taxa, scoring adjusted for gradient	To	P	C	-23.59	15.82	slope=16.042 intercept=33.5
Detritivore_TxPct	TXPct	Percent detritivorous taxa	Tr	N	C	15.38	41.62	
Piscivore	Richness	Number of piscivorous taxa	Tr	P	C	1.00	7.90	
DominanceTwoTaxa_Pct	IndPct	Combined relative abundance of the two most abundant taxa	Comp	N	C	30.39	75.00	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table C2. Metric information for the Southern Streams FIBI

Metric	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
BenthicInsectivore-Tol_TxPct	TXPct	Percent benthic insectivore taxa (excludes tolerant species)	Tr	P	C	0.00	40.00	
Sensitive_TxPct	TXPct	Percent sensitive taxa	To	P	C	0.00	45.11	
Detritivore_TxPct	TXPct	Percent detritivorous taxa	Tr	N	C	14.13	46.38	
ShortLived	Richness	Number of short-lived taxa	LH	N	C	1.00	7.00	
Tolerant_TxPct	TXPct	Percent tolerant taxa	To	N	C	27.99	84.81	
MatureAge<2_Pct	IndPct	Percent early-maturing individuals	R	N	C	29.68	97.68	
Tolerant_Pct	IndPct	Percent tolerant individuals	To	N	C	27.93	75.00	
DominanceTwoTaxa_Pct	IndPct	Combined relative abundance of the two most abundant taxa	Comp	N	C	34.00	75.00	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table C3. Metric information for the Southern Headwaters FIBI

Metric	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Sensitive	Richness	Number of sensitive taxa	To	P	C	0.00	4.00	
Detritivore_TxPct	TXPct	Percent detritivorous taxa	Tr	N	C	0.00	50.00	
GeneralistFeeder_TxPct	TXPct	Percent generalist feeder taxa	Tr	N	C	31.92	76.53	
SerialSpawner_Pct	IndPct	Percent serial spawner individuals	R	N	C	0.00	76.92	
VeryTolerant_TxPct	TXPct	Percent very tolerant taxa	To	N	C	0.00	58.71	
ShortLived_Pct	IndPct	Percent short-lived individuals	LH	N	C	0.14	98.73	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table C4. Metric information for the Northern Rivers FIBI

Metric	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Sensitive_TxPct	TXPct	Percent sensitive taxa, scoring adjusted for gradient	To	P	C	-16.39	7.04	slope=11.902 intercept=43.121
Sensitive_Pct	IndPct	Percent sensitive individuals, scoring adjusted for gradient	To	P	C	-33.70	17.75	slope=22.503 intercept=51.121
Detritivore_Pct	IndPct	Percent detritivorous individuals	Tr	N	C	0.39	46.93	
VeryTolerant_TxPct	TXPct	Percent very tolerant taxa	To	N	C	0.00	20.00	
Exotic_Pct	IndPct	Percent exotic individuals	Comp	N	D			≥10% = 0 ≥5% = 5 <5% = 10
SerialSpawner_TxPct	TXPct	Percent serial spawner taxa	R	N	C	8.70	29.22	
Insectivore-Tol_Pct	IndPct	Percent insectivorous individuals (excludes tolerant species)	Tr	P	C	28.94	74.99	
NonLithophilicNester_Pct	IndPct	Percent non-lithophilic nest-building individuals	R	N	C	8.74	46.14	
SimpleLithophil_TxPct	TXPct	Percent simple lithophilic taxa	R	P	C	26.28	48.32	
DominanceTwoTaxa_Pct	IndPct	Combined relative abundance of the two most abundant taxa	Comp	N	C	34.86	50.00	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table C5. Metric information for the Northern Streams FIBI

Metric	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Sensitive_TxPct	TXPct	Percent sensitive taxa	To	P	C	5.69	44.00	
Intolerant_Pct	IndPct	Percent intolerant individuals	To	P	C	0.00	41.98	
Insectivore-Tol_TxPct	TXPct	Percent insectivorous taxa (excludes tolerant species)	Tr	P	C	26.12	50.50	
MatureAge>3-Tol_Pct	IndPct	Percent late-maturing individuals (excludes tolerant species)	R	P	C	0.00	34.09	
GeneralistFeeder	Richness	Number of generalist taxa	Tr	N	C	2.20	7.00	
SerialSpawner_TxPct	TXPct	Percent serial spawner taxa	R	N	C	6.25	33.33	
Detritivore_Pct	IndPct	Percent detritivorous individuals	Tr	N	C	1.01	38.98	
VeryTolerant	Richness	Number of very tolerant taxa	To	N	C	1.00	5.00	
DarterSculpinSucker_TxPct	TXPct	Percent darter, sculpin, and sucker taxa	Comp	P	C	6.42	27.78	
SimpleLithophil_Pct	IndPct	Percent simple lithophilic individuals	R	P	C	3.11	67.34	
DominanceTwoTaxa_Pct	IndPct	Combined relative abundance of the two most abundant taxa	Comp	N	C	37.64	50.00	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table C6. Metric information for the Northern Headwaters FIBI

Name	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Sensitive	Richness	Number of sensitive taxa	To	P	C	0.00	4.00	
Minnow-Tol_Pct	IndPct	Percent cyprinid individuals (excludes tolerant species)	Comp	P	C	0.00	51.48	
Insectivore-Tol_TxPct	TXPct	Percent insectivorous taxa (excludes tolerant species)	Tr	P	C	0.00	42.87	
NumPerMeter-Tol	CPUE	Number of fish per meter (excludes tolerant species)	Comp	P	C	0.01	1.82	
InsectivorousCyprinid_Pct	IndPct	Percent insectivorous cyprinid individuals	Tr	P	C	0.00	20.85	
HeadwaterSpecialist-Tol	Richness	Number of headwater taxa (excludes tolerant taxa)	H	P	C	0.00	3.00	
DarterSculpin	Richness	Number of darter and sculpin taxa	Comp	P	C	0.00	2.00	
SimpleLithophil	Richness	Number of simple lithophilic taxa	R	P	C	0.00	4.28	
Tolerant_TxPct	TXPct	Percent tolerant taxa	To	N	C	33.33	80.00	
Pioneer_TxPct	TXPct	Percent pioneer taxa	LH	N	C	10.00	33.33	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table C7. Metric information for the Low Gradient FIBI

Name	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Minnow-Tol_Pct	IndPct	Percent cyprinid individuals (excludes tolerant species)	Comp	P	C	0.00	52.29	
Wetland-Tol	Richness	Number of wetland taxa (excludes tolerant species)	H	P	C	0.00	4.10	
Sensitive	Richness	Number of sensitive taxa	To	P	C	0.00	4.00	
NumPerMeter-Tol	CPUE	Number of fish per meter (excludes tolerant species)	Comp	P	C	0.00	1.89	
HeadwaterSpecialist-Tol_Pct	IndPct	Percent headwater individuals (excludes tolerant species)	H	P	C	0.00	34.77	
SimpleLithophil	Richness	Number of simple lithophilic taxa	R	P	C	0.00	4.00	
Omnivore_TxPct	TXPct	Percent omnivorous taxa	Tr	N	C	0.00	40.00	
Tolerant_TxPct	TXPct	Percent tolerant taxa	To	N	C	33.33	85.80	
Pioneer_TxPct	TXPct	Percent pioneer taxa	LH	N	C	0.00	35.71	
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	composition	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table C8. Metric information for the Southern Coldwater FIBI

Name	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
ColdwaterNative_Pct	IndPct	Percent native, coldwater individuals	H	P	C	0.00	1.96	(log10 +1) transformation of values prior to scoring
SensitiveColdwater_Pct	IndPct	Percent sensitive individuals (specific to coldwater streams, adjusted for drainage area)	To	P	C	-76.14	17.59	slope = -27.382 intercept = 114.322
Detritivore_TxPct (SDet_TxPct)	TXPct	Percent taxa that consume detritus as part of their diet (adjusted for drainage area)	Tr	N	C	-14.35	28.09	slope = 16.211 intercept = -5.276
TolerantColdwater	Richness	Number of tolerant taxa (specific to coldwater streams, adjusted for drainage area)	To	N	C	-1.04	4.24	slope = 1.089 intercept = -0.827
Pioneer_Pct	IndPct	Percent pioneer individuals	LH	N	C	0.00	55.02	
Herbivore_Pct	IndPct	Percent herbivorous individuals	Tr	N	D			≥8.06% = 0 ≥3.07% = 5 <3.07% = 10
ColdwaterNative_TxPct	TXPct	Percent native, coldwater taxa (adjusted for drainage area)	H	P	C	-32.45	28.48	slope = -24.242 intercept = 54.017
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score

Table C9. Metric information for the Northern Coldwater FIBI

Metric	Type	Description	Category	Response	Scoring	Floor	Ceiling	Notes
Coldwater	Richness	Coldwater taxa	H	P	C	0.00	2.00	
IntolerantColdwater_Pct	IndPct	Percent intolerant individuals (specific to coldwater	To	P	C	0.00	83.65	
SensitiveColdwater_TxPct	TXPct	Percent sensitive taxa (specific to coldwater streams, adjusted for gradient)	To	P	C	-27.66	25.90	slope = 23.788 intercept = 24.437
TolerantColdwater_Pct	IndPct	Percent tolerant individuals (specific to coldwater streams)	To	N	C	0.00	1.49	(log10 +1) transformation of values prior to scoring
NonLithophilicNester_Pct	IndPct	Percent non-lithophilic nest-building individuals	R	N	C	0.00	1.68	(log10 +1) transformation of values prior to scoring
Omnivore_TxPct	TXPct	Percent omnivorous taxa	Tr	N	C	0.00	20.00	
Pioneer_TxPct	TXPct	Percent pioneer taxa	LH	N	C	0.00	33.33	
Perciformes_Pct	IndPct	Percent of individuals belonging to Order Perciformes	Comp	N	C	0.00	1.52	(log10 +1) transformation of values prior to scoring
FishDELT_Pct*	IndPct	Percent of individuals with Deformities, Eroded fins, Lesions, Tumors	Comp	N	D			≥4% = -10 ≥2% = -5

*FishDELT_Pct metric is a negative adjustment applied (if applicable) after calculating the composite (0-100 scale) FIBI score