# Fish Data Collection Protocols for Lotic Waters in Minnesota

Sample Collection, Sample Processing, and Calculation of Indices of Biotic Integrity

Minnesota Pollution Control Agency

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# Contents

# Introduction

This document describes the protocols for sampling fish from lotic waters (e.g., streams, rivers, and ditches), processing samples, and calculating index of biotic integrity (IBI) scores. These methods must be followed for the data to be used as part of 1) assessment of aquatic life (Class 2) beneficial uses as part of the intensive watershed monitoring program, 2) data supplementation to aid the stressor identification process, 3) development of regional biological criteria, and 4) calibration of biological criteria. The use of biological data for determining attainment or nonattainment of beneficial uses, including the use of IBIs, is described in Minn. R. 7050.0150, subp. 6. A description of how biological information is used for assessment of beneficial uses is described in the 2016 Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment 305(b) Report and 303(d) List (MPCA 2016). Before using these standard operating proceedures (SOPs), field crews, sample processors, and others involved in the collection of fish data should familiarize themselves with these protocols.

# Fish community sampling protocol for stream monitoring sites

This section describes the methods used by the Minnesota Pollution Control Agency's (MPCA) Biological Monitoring Program to collect fish community information at stream monitoring sites for the purpose of assessing water quality and developing biological criteria. This procedure applies to all monitoring sites for which an integrated assessment of water quality is to be conducted. An integrated assessment involves the collection of biological (fish and macroinvertebrate communities), physical habitat, and chemical information to assess stream condition.

Sites may be selected for monitoring for a number of reasons including, but not limited to: 1) sites selected for condition monitoring as part of Intensive Watershed Monitoring (IWM), 2) sites randomly selected as part of the Environmental Monitoring and Assessment Program (EMAP), 3) sites selected for the development and calibration of biological criteria, and 4) sites selected for stressor identification. Although the reasons for monitoring a site vary, the fish community sampling protocol described in this document applies to all monitoring sites, unless otherwise noted.

Fish community sampling is conducted in conjunction with the water chemistry and physical habitat assessment protocols (see the following SOPs: MPCA 2014c [Water Chemistry Assessment Protocol for Stream Monitoring Sites] and; MPCA 2014d [MPCA Stream Habitat Assessment (MSHA) Protocol for Stream Monitoring Sites]. An additional protocol that may be used during a site visit includes: MPCA 2012 [Stream Condition and Stressor Identification (SCSI) protocol for Stream Monitoring Sites]). Fish sampling should occur after water chemistry collection so as not to disrupt the sediments prior to collecting water samples. However, the fish sampling should be conducted prior to any physical habitat assessment so as not to disturb the fish community prior to sampling.

## Requirements

Qualifications of crew leaders: The crew leader must be a professional aquatic biologist with a minimum education of a Bachelor of Science degree in aquatic biology or closely related specialization. He or she must have a minimum of six months field experience in fish community sampling methodology and fish taxonomy. Field crew leaders should also possess excellent map reading skills and a demonstrated proficiency in the use of a GPS (Global Positioning System) receiver and orienteering compass.

Qualifications of field technicians/interns: A field technician/intern must have at least one year of college education and coursework in environmental and/or biological science.

General qualifications: All personnel conducting this procedure must have the ability to perform rigorous physical activity. It is often necessary to wade through streams and/or wetlands, canoe, or hike for long distances to reach a sampling site

## Responsibilities

Field crew leader: Implement the procedures described in this section and ensure that the data generated meets the standards and objectives of the Biological Monitoring Program.

Technicians/interns: Implement the procedures described in this section, including maintenance and stocking of equipment, data collection and recording.

## Quality assurance and quality control

Compliance with this procedure will be maintained through annual internal reviews. Technical personnel will conduct periodic self-checks by comparing their results with other trained personnel. Calibration and maintenance of equipment will be conducted according to the guidelines specified in the manufacturer's manuals.

In addition to adhering to the specific requirements of this sampling protocol and any supplementary site specific procedures, the minimum Quality Assurance (QA) and/or Quality Control (QC) requirements for this activity are as follows:

A. Control of deviations: Deviations shall be sufficiently documented to allow repetition of the activity as performed.
B. QC samples: Five to ten percent of sites sampled in any given year are re-sampled as a means of determining sampling error and temporal variability.
C. Verification: The field crew leader will conduct periodic reviews of field personnel to ensure that technical personnel are following procedures in accordance with this SOP.

## Training

A. All inexperienced personnel will receive instruction from a trainer designated by the program manager. Major revisions in this protocol require that all personnel be re-trained in the revised protocol by experienced personnel.
B. The field crew leader will provide instruction in the field and administer a field test to ensure personnel can execute this procedure.

# Fish sampling proceedures

## A. Equipment check list

Verify that all necessary items are present before commencement of this procedure (Table 1).

**Table 1. Equipment Check List – This table identifies all equipment needed in the field in order to implement the sampling protocol as described.**

| √ | ***Item and purpose*** |
|---|---|
| | *Electrofisher* – for sampling the fish community, use appropriate gear type (includes control box, generator, anode(s), and cathode) |
| | *Nets* – for collection of fish; 1/8" mesh, fiberglass handles |

| √ | ***Item and purpose*** |
|---|---|
| | *Rubber gloves* – for safety during electrofishing; electrically rated |
| | *Holding tank* – for holding fish during electrofishing; of sufficient size to minimize stress |
| | *Wet containers* – for holding fish during processing; of sufficient size and number to minimize stress |
| | *Balance or spring scales* – for weighing fish |
| | *Measuring board* – for measuring total length of fish |
| | *Waders* – for safety during electrofishing |
| | *Polarized sunglasses* – for aid in capturing fish |
| | *Clipboard* – to store forms and record data |
| | *Forms* – for recording data |
| | *Pencil* – for filling out forms |
| | *Permanent marker* – for labeling voucher bottle |
| | *Taxonomic key* – to assist in identifying fish |
| | *Voucher bottle* – for storing preserved specimens |
| | *Formalin* – for preserving voucher specimens |
| | *Labels* – to label voucher jars |
| | *Camera* – to document fish species collected that are too large to preserve |

# B. Data collection method

The location and length of the sampling reach is determined during site reconnaissance (see MPCA 2014b [Reconnaissance Procedures for Initial Visit to Stream Monitoring Sites]). The reach length, 35 times the mean stream width (MSW), is based on the distance necessary to capture a representative and repeatable sample of the fish community within a stream segment (Lyons 1992). Reach lengths are a minimum of 150 meters and a maximum of 500 meters. Sampling is conducted during daylight hours within the summer index period of mid-June through mid-September. Sampling should occur when streams are at or near base-flow because flood or drought events can have a profound effect on fish community structure and sampling efficiency.

For wadeable streams, fish community sampling is conducted in conjunction with the physical habitat assessment protocol (see SOP--"Quantitative Physical Habitat Assessment Protocol for Wadeable Stream Monitoring Sites or MPCA Stream Habitat Assessment (MSHA) Protocol for Stream Monitoring Sites"). Fish sampling should be conducted before the physical habitat assessment so as not to disturb the fish community prior to sampling. Sample all habitat types available to fish within the reach in the approximate proportion that they occur. An effort is made to collect all fish observed. Fish < 25 mm in total length are not counted as part of the catch.

All fish that are alive after processing should be immediately returned to the stream, unless they are needed as voucher specimens. Considerable effort should be expended to minimize handling mortality, such as using a live well, quickly sorting fish into numerous wet containers, and replacing their water supply.

Fish survey results are recorded on the Fish Survey Record data sheet (Appendix A). Guidelines for filling out this data sheet are described in the following pages.

# C. Fish survey record data sheet

This data sheet summarizes the location, sampling characteristics, and fish community composition of the sampling site (see Appendix A). The variables recorded are as follows:

## C.1. Location and sampling characteristics

A. Field Number – A seven-digit code that uniquely identifies the station. The first two digits identify the year of sampling, the second two identify the major river basin, and the last three are numerically assigned in sequential order (example 02UM001).

B. Stream Name – The name of the stream as shown on the most recent USGS 7.5” topographic map. Include all parts of the name (i.e. “North Branch,” “Creek,” “River,” “Ditch,” etc.).

C. Date – The date fish sampling is conducted in month/day/year format (MM/DD/YYYY).

D. Crew – The personnel who conducted fish community sampling.

E. Gear Type – The specific type of electrofisher utilized for fish collection. The MPCA’s Biological Monitoring Program utilizes four electrofishing gear types. Care is taken to select the gear type that will most effectively sample the fish community. Gear selection is dictated by stream width, depth, and accessibility. General guidelines for determining the appropriate gear type and their use are as follows:

 **Backpack:** Generally used in small, wadeable streams (typically < 8 m MSW and < 50 mi$^2$ drainage area). A single electrofishing run is conducted in an upstream direction. In very small streams (<2 m wide) it is possible to sample most of the available habitat, but in larger streams it is often necessary to meander between habitat types. Two personnel are necessary - one to carry the unit and operate the anode, and another to collect the fish. In most small streams, a minimum of 1200 seconds of electrofishing should be conducted to collect a representative sample. Indicate the type of backpack electrofisher utilized by circling the appropriate option, Smith-Root generator, LR-24, or Halltech model.

 **Double Backpack:** Used in larger wadeable streams and rivers (typically > 8 m MSW and 50-500 mi$^2$ drainage area) where access limits the ability to use the stream electrofisher. This electrofishing method is considered last, and typically is only utilized on randomly selected sites where access is very difficult or in wide, shallow, riffle and boulder strewn reaches. A single electrofishing run is conducted in an upstream direction using two backpack units simultaneously. Four personnel are necessary - two to carry the units and operate the anodes, and two personnel to net and carry the fish. Total time fished is determined by adding the times of both electrofishing units. Indicate the type of backpack electrofisher utilized.

 **Stream-electrofisher:** Used in larger, wadeable streams and rivers (typically > 8 m MSW and 50-500 mi$^2$ drainage area). The stream-electrofisher is a towable unit that can effectively sample larger streams because it has additional power capabilities and employs two anodes, thus increasing the electrified zone. Five personnel are required for operation - one to control the electrofisher, two to direct the anodes, and two to net and carry the fish. A single electrofishing run is conducted in an upstream direction weaving between habitat types. The amount of time electrofished is variable due to differences in reach length, stream width, and habitat complexity; however, most circumstances would require a minimum of 2000 seconds of electrofishing to be conducted. In rare instances, when stream-electrofisher access is too difficult or the site is a wide, shallow riffle prohibiting utilization of a tote barge, it may be necessary to sample larger streams utilizing two backpack electrofishers simultaneously.

 **Mini-boom:** Used in non-wadeable streams and rivers that are either too small or do not afford the access necessary to utilize a boom-electrofisher. The mini-boom electrofisher is a jon-boat that is light enough to be portaged, yet provides a stable work platform. Personnel consist of one person to operate the boat, monitor the control box, and ensure the safety of a single fish collector on the bow. In most cases, a minimum of 3000 seconds of electrofishing should be conducted to collect a representative sample. A single electrofishing run is conducted in a downstream direction weaving between habitat types, both stream banks, and mid-channel areas ensuring that the entire reach is thoroughly sampled. In larger streams (500 m reach lengths), the sampling effort should essentially equate to electrofishing the entire left bank, right bank, and mid-channel as prescribed in the boom-electrofisher protocol.

**Boom-electrofisher:** Used in large, accessible rivers. Three electrofishing runs are made in a downstream direction, one each along the right bank, left bank, and mid-channel. Personnel consist of one person to drive the boat, monitor the control box, and ensure the safety of the two fish collectors on the bow. Each electrofishing run is typically at least 1200 seconds of effort, or a minimum of 3600 seconds for all three passes combined.

F. Channel Position – If the site is sampled with a boom-electrofisher, circle the appropriate channel position of the electrofishing run (determined while facing downstream); right bank, left bank, or mid-channel. A separate Fish Survey Record data sheet is used for each of the three runs.

G. Distance – The length of stream sampled for fish, measured to the nearest meter following the center of the stream channel. If the entire reach is electrofished, the distance sampled for fish is the same as the station length recorded on the Visit Summary data sheet (see SOP--"Physical Habitat and Water Chemistry Assessment Protocol for Wadeable Stream Monitoring Sites"). In the event the entire station cannot be electrofished, measure the portion of the reach that was not sampled and subtract this distance from the station length to calculate the distance sampled for fish. Possible explanations include the occurrence of a culvert or beaver impoundment within the reach.

H. Time Fished – The number of seconds electrofished. Reset the timer on the electrofisher before each sampling event.

I. Identified By – The person(s) whose field identified the fish collected, must meet the minimum requirements of a field crew leader described previously.

J. Visit Comments – Record any additional information about the fish sampling visit in the space provided.

## C.2. Fish community composition

A. Species – The common name of each fish species collected during the electrofishing run. If a fish cannot be identified to species with certainty, identify to the lowest possible taxon (e.g., to genus) and voucher for later lab identification.

B. Length Range – The minimum and maximum length for each fish species collected (fish < 25 mm are excluded). Measure to the nearest millimeter using Maximum Total Length protocol: the distance from the anterior-most part of the fish to the posterior-most tip of the caudal fin while it is being compressed. If only one individual of a fish species is captured, record the length as both the minimum and maximum total length.

C. Weight – The total wet weight of each fish species collected. Together, weigh all individuals of the same species to the nearest 0.5 gram. Multiple batch weights may be necessary if scale capacity is exceeded; these can be recorded on the back of the data sheet in the space provided. Only species totals should be recorded here.

D. Number – The total number of individuals of each fish species.

E. Anomalies or YOY – Record the total number and type of anomalies observed on all individuals of a fish species. Recognized anomalies and their codes are located on the bottom of the Fish Survey Record data sheet. In addition, instances in which young of year (YOY) trout species are collected note the total number of YOY individuals.

F. Voucher – The number of specimens of each fish species retained for verification and deposition in the Minnesota Bell Museum of Natural History. For fish that are identified with certainty to species level, several individuals of each species should be preserved in 10% formalin solution (37% formaldehyde: water) in the "A-jar." For each species of fish, document the number of individuals preserved in this data field. The person recording the fish information is in charge of the voucher bottle, and specimens will only be added to the voucher bottle upon the recorder's approval, to ensure accuracy of numbers. All fish that could not be identified to the species level should be preserved in a separate container (B-jar) in 10% formalin solution. Record the number preserved.

Voucher containers should be labeled externally and internally. On the outside of the jar, write the field number, sampling date, and jar identification (A or B) with a permanent marker. Place a label inside each jar identifying the field number, sampling date, stream name, jar identification, county, gear type, and collectors. Write this information on an index weight label in pencil or a solvent proof marker. If an "A" and "B" jar are used they should be taped together.

For specimens that are too large to preserve, a photograph may be taken to serve as a voucher. Place a card with the site field number and sampling date visibly into the picture frame with the fish positioned in a manner that allows key characteristics to be identified. Indicate that a photograph was taken by writing "photo" in the voucher column.

### C.3. Individual or batch measurements

Often times it is necessary to weigh large fish individually or conduct multiple batch weights for a species of fish. These measurements can be recorded in this section of the data sheet. The data fields are the same as those described above. After fish processing is complete, combine the information for fish of the same species so that only species totals are recorded in the previous section.

# Calculation of Minnesota stream fish Index of Biotic Integity

The IBI is used by the 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 (see protocols described above). A complete description of the development of FIBIs can be found in MPCA (2014a).

## 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 B.

**Geographic Region:** The FIBI stream typology framework divides Minnesota into two regions (North and 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.

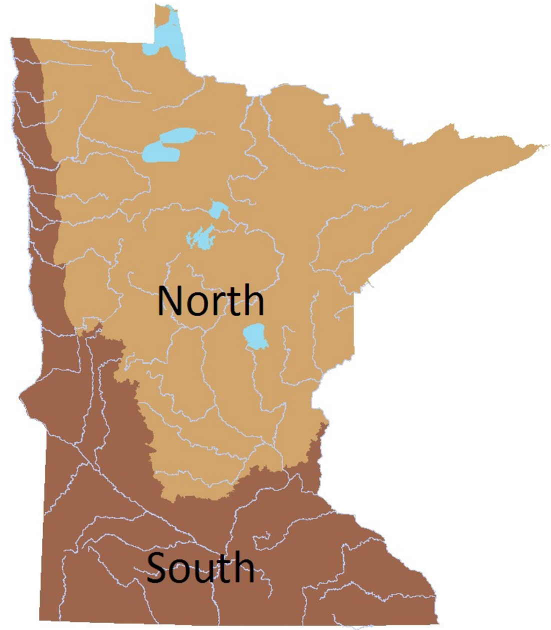


**Figure 1. Regional framework for FIBI development and application.**

**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 Minn. R. 7050.0470 and 7050.0430.

# Fish community data

Stream fish data must be collected using MPCA protocols (see protocols described above) 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 C.

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 2). Appendix D provides information regarding each FIBI and associated metrics.

**Table 2. 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 a 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).

Abundance of two schooling species (*Notropis atherinoides* and *Dorosoma cepedianum*) are excluded from relative abundance metrics due to the tendency of these species to naturally occur in large numbers such that proportions of other taxa may be heavily skewed, depending on whether a school is encountered while sampling.

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 D. 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 a 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 D. “Corrected” metric values are calculated as follows:

Corrected metric value = *(metric value) - ((([slope]*(Log([natural gradient value]))+([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: $metric\ score = \frac{metric\ value - 5th\ percentile\ value}{95th\ percentile\ value - 5th\ percentile\ value} * 10$

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

To limit the influence of extreme metric values, the $5^{th}$ and $95^{th}$ 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 $95^{th}$ 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 $95^{th}$ percentile (maximum) are given the minimum a score of 0. Upper and lower limits for each metric are documented in Appendix D.

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 D.

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:

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

# References

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MPCA (2016) Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment 305(b) Report and 303(d) List: 2016 Assessment and Listing Cycle. Minnesota Pollution Control Agency, St. Paul, MN (Available at: https://www.pca.state.mn.us/sites/default/files/wq-iw1-04i.pdf).

# Appendix A. Fish survey field sheets

## FISH SURVEY RECORD MPCA

| | |
|---|---|
| Field Number: | Stream Name: |
| Date (mm/dd/yyyy): | Crew: |
| Gear Type (circle one): Backpack* Stream-electrofisher Boom-electrofisher Mini-Boom<br>*Type of Backpack (circle one): Generator LR-24 Halltech | |
| Channel Position: Right Bank Mid-Channel Left Bank<br>(circle one if boom-electrofisher site) | |

| | | |
|---|---|---|
| Distance (m): | Time Fished (sec): | Identified By: |
| Visit Comments: | | |
| | | |

| Species (common name) | Length Range (mm) | Weight (g) | Number | Anomalies or YOY | Voucher Number | Voucher Pics |
|---|---|---|---|---|---|---|
| 1. | | | | | | |
| 2. | | | | | | |
| 3. | | | | | | |
| 4. | | | | | | |
| 5. | | | | | | |
| 6. | | | | | | |
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| 10. | | | | | | |
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| 15. | | | | | | |
| 16. | | | | | | |
| 17. | | | | | | |
| 18. | | | | | | |
| 19. | | | | | | |
| 20. | | | | | | |
| 21. | | | | | | |
| 22. | | | | | | |
| 23. | | | | | | |
| 24. | | | | | | |
| 25. | | | | | | |
| 26. | | | | | | |
| 27. | | | | | | |
| 28. | | | | | | |

Anomalies: **A**-anchor worm; **B**-black spot; **C**-leeches; **D**-deformities; **E**-eroded fins; **F**-fungus; **G**-yellow grub; **L**-lesions; **N**-blind; **P**=parasites; **PL**-parasite lesion; **Y**-popeye; **S**-emaciated; **W**-swirled scales; **T**-tumors; **Z**-other. (Heavy [**H**] or Light [**L**] code may be combined with above codes).

(Cont.)

| Species (common name) | Length Range (mm) | Weight (g) | Number | Anomalies or YOY | Voucher Number | Voucher Pics |
|---|---|---|---|---|---|---|
| 29. | | | | | | |
| 30. | | | | | | |
| 31. | | | | | | |
| 32. | | | | | | |
| 33. | | | | | | |
| 34. | | | | | | |
| 35. | | | | | | |
| 36. | | | | | | |
| 37. | | | | | | |
| 38. | | | | | | |

## INDIVIDUAL OR BATCH MEASUREMENTS

| Species (common name) | Length Range (mm) | Weight (g) | Number | Anomalies or YOY | Voucher Number | Voucher Pics |
|---|---|---|---|---|---|---|
| 1. | | | | | | |
| 2. | | | | | | |
| 3. | | | | | | |
| 4. | | | | | | |
| 5. | | | | | | |
| 6. | | | | | | |
| 7. | | | | | | |
| 8. | | | | | | |
| 9. | | | | | | |
| 10. | | | | | | |
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| 30. | | | | | | |
| 31. | | | | | | |
| 32. | | | | | | |

(Revised May 2015)

# Appendix B. 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 C. Taxon attributes used to calculate FIBI metrics.

| Taxon | BenInsect-Tol | Coldwater | CWIntolerant | CWSensitive | CWTol | DarterSculp | DetNWQ | Exotic | Generalist | Headwater | Herbv | 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 | |
| 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 | | | | | | | |
| channel shiner | | | | | | | | | | | | X | X | | X | | X | | | | | | | | X | | X | | | | |

| Taxon | BenInsect-Tol | Coldwater | CWIntolerant | CWSensitive | CWTol | DarterSculp | DetNWQ | Exotic | Generalist | Headwater | Herbv | InsectCyp | Insect-Tol | Intolerant | MA<2 | MA>3 | Minnows-Tol | NativeCold | NestNoLith | Omnivore | Percfm | Pioneer | Piscivore | Sdet | Sensitive | SLithop | SLvd | SSpn | Tol | Vtol | Wetland |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 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 | | | | | | | | | | | | | | |
| Gen: topminnows | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | |
| ghost shiner | | | | | | | X | | | | | X | X | X | X | | X | | | | | | | | X | | | X | | | |

| Taxon | BenInsect-Tol | Coldwater | CWIntolerant | CWSensitive | CWTol | DarterSculp | DetNWQ | Exotic | Generalist | Headwater | Herbv | InsectCyp | Insect-Tol | Intolerant | MA<2 | MA>3 | Minnows-Tol | NativeCold | NestNoLith | Omnivore | Percfm | Pioneer | Piscivore | Sdet | Sensitive | SLithop | SLvd | SSpn | Tol | Vtol | Wetland |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | | | | | | |
| mud darter | X | | | | | X | | | | | | | X | | X | | | | | | X | | | | X | | X | | | | |
| muskellunge | | | | | | | | | | | | | | X | | X | | | | | | | X | | X | | | | | | |
| ninespine stickleback | | | | | | | | | | | | | X | | X | | | | X | | | | | | | | | | | | |

| Taxon | BenInsect-Tol | Coldwater | CWIntolerant | CWSensitive | CWTol | DarterSculp | DetNWQ | Exotic | Generalist | Headwater | Herbv | InsectCyp | Insect-Tol | Intolerant | MA<2 | MA>3 | Minnows-Tol | NativeCold | NestNoLith | Omnivore | Percfm | Pioneer | Piscivore | Sdet | Sensitive | SLithop | SLvd | SSpn | Tol | Vtol | Wetland |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | | | | | |
| paddlefish | | | | | | | | | | | | | | X | | X | | | | | | | | | X | X | | | | | |
| pallid shiner | | | | | | | | | | | | X | X | X | | | X | | | | | | | | X | | | | | | |
| pearl dace | | | | 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 | | | |
| pugnose shiner | | | | | | | 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 | | | | | |
| 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 | | | | | | |
| 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 | | | | | | | | |
| shoal chub | X | | | | | | | | | | | X | X | | X | | X | | | | | | | | X | | X | | | | |
| shorthead redhorse | X | | | | | | | | | | | | X | | | X | | | | | | | | X | | X | | | | | |
| shortjaw cisco | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | |
| shortnose gar | | | | | | | | | | | | | | | | X | | | | | | | X | | | | | | | | |

| Taxon | BenInsect-Tol | Coldwater | CWIntolerant | CWSensitive | CWTol | DarterSculp | DetNWQ | Exotic | Generalist | Headwater | Herbv | InsectCyp | Insect-Tol | Intolerant | MA<2 | MA>3 | Minnows-Tol | NativeCold | NestNoLith | Omnivore | Percfm | Pioneer | Piscivore | Sdet | Sensitive | SLithop | SLvd | SSpn | Tol | Vtol | Wetland |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | | | 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 | | | |
| 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 | | |

| Taxon | BenInsect-Tol | Coldwater | CWIntolerant | CWSensitive | CWTol | DarterSculp | DetNWQ | Exotic | Generalist | Headwater | Herbv | InsectCyp | Insect-Tol | Intolerant | MA<2 | MA>3 | Minnows-Tol | NativeCold | NestNoLith | Omnivore | Percfm | Pioneer | Piscivore | Sdet | Sensitive | SLithop | SLvd | SSpn | Tol | Vtol | Wetland |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| yellow bass | | | | | | | | | | | | | | | | X | | | | | X | | X | | | | | | | | |
| yellow bullhead | | | | | | | | | X | | | | | | | | | | X | X | | | | X | | | | X | | | X |
| yellow perch | | | | | | | | | | | | | X | | | X | | | | | X | | | | | | | | | | |

# Appendix D. FIBI metrics and scoring criteria.

## Table D1. 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 D2. 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<br>≥2% = -5 |

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

## Table D3. 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<br>≥2% = -5 |

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

## Table D4. 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 D5. 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<br>≥2% = -5 |

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

## Table D6. 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<br>≥2% = -5 |

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

## Table D7. 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 | |
| Ominivore_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<br>≥2% = -5 |

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

## Table D8. 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 D9. 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 |
| Ominivore_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