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Lake Index of Biological Integrity (IBI) Nearshore Sampling Manual

DEPARTMENT OF NATURAL RESOURCES

WILDLIFE & SPORT FISH RESTORATION

CLEAN WATER LAND & LEGACY AMENDMENT

Fisheries Lake IBI Program
Minnesota Department of Natural Resources
1601 Minnesota Drive
Brainerd, MN 56401

Cover photo—IBI interns seining along a shoreline on Ten Mile Lake.

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Purpose

To describe the methods used by the Minnesota Department of Natural Resources (MNDNR) Lake Index of Biological Integrity (IBI) Program to collect fish community information using seining and backpack electrofishing at nearshore lake monitoring sites.

General Information

The Lake IBI Program has previously developed fish-based IBIs for four types of Minnesota lakes (Bacigalupi et al. 2021). Results from ongoing lake IBI monitoring are now used to assess aquatic life during the Minnesota Pollution Control Agency's (MPCA) watershed assessment process. To ensure consistency in data collection, this manual provides information regarding the procedures used during an IBI survey to sample the nearshore fish community using backpack electrofishing units, seines, and in some instances, quarter-inch trap nets. Sampling procedures for the other gear types used in an IBI but collected during a standard survey (i.e., gill netting and trap netting) are outlined in the Manual of Instructions for Lake Survey (MNDNR 2017).

Requirements

- Qualifications of crew leaders: The crew leader must be a professional aquatic biologist with a minimum of a Bachelor of Science degree in biology, fisheries, fish and wildlife, or a closely related specialization, including completion of specific fisheries coursework. They must have completed training in fish community sampling methodology and fish taxonomy. Field crew leaders should also be familiar with operation of boats and outboard motors and possess excellent map reading skills and a demonstrated proficiency in the use of a GPS.
- Qualifications of interns: An intern must be a student at an accredited educational institution, possess excellent human relation and communication skills, and be majoring in biology, natural resources, fisheries or wildlife management, recreation resource management, ecology, environmental science, or a related degree.
- General qualifications: All personnel conducting this procedure must have the ability to perform rigorous physical activity, including wading through dense vegetation, muck, boulders, etc. while wearing a backpack electrofishing unit or pulling a seine.

Responsibilities

- Field crew leader: Implements the procedures outlined in this manual and ensures that the data generated meets the standards and objectives of the Lake IBI Program.
- Interns: Implement the procedures outlined in this manual, including preparing and maintaining equipment, and collecting and recording data.
- Crew size: A minimum of two individuals (i.e., one field crew leader and one specialist, technician, or intern) are necessary to conduct nearshore sampling associated with an IBI survey. A crew of three or more individuals can be helpful for sampling difficult sites.

Quality Assurance and Quality Control (QA/QC)

Compliance with the procedures outlined in this manual will be maintained through periodic reviews. Crew leaders and interns will conduct periodic self-checks by comparing their results with other trained personnel (i.e., other field crew leaders) and with results from the voucher verification process. 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 manual, the minimum QA/QC requirements for this activity are as follows:

- Control of deviations: Deviation shall be sufficiently documented to allow repetition of the activity as performed.
- QC samples: Ten percent of lakes sampled in any given year are re-sampled within the season or in the subsequent season as a means of determining sampling error and temporal variability. The IBI Program Supervisor will assign resurveys and coordinate with affected Area Fisheries Offices. In most cases IBI Program crews will conduct the repeat surveys.
- Verification: The field crew leader will conduct periodic reviews of interns to ensure that procedures in this manual are followed.

Training

All inexperienced personnel will receive instruction from a trainer designated by the IBI Program Supervisor. Major revisions in this protocol require that all personnel be re-trained in the revised protocol by experienced personnel.

The field crew leader will provide instruction in the field and administer a field test to ensure personnel can execute this procedure.

Equipment List

- ☐ Boat
- ☐ PFDs
- ☐ Waders
- ☐ Backpack electrofishing unit and associated cathode and anode (with either a diamond or a round electrode)
- ☐ Kill switch for backpack electrofishing unit, if using from the boat
- ☐ Rubberized or PVC linesmen gloves
- ☐ Polarized sunglasses
- ☐ 1–2 large dip nets (1/8-inch mesh net)
- ☐ Seines:
    - ☐ 15-foot bag seine = 15 feet x 5 feet, 1/8-inch mesh
    - ☐ 50-foot bag seine = 50 feet x 5 feet, 1/8-inch mesh
- ☐ Quarter inch trap nets with floats and anchors (for Lake Class 1–19 lakes only; see **Appendix A**. Fish Sampling Adjustments for Shield Lakes)
- ☐ GPS
- ☐ Sorting buckets (5 or more)
- ☐ Small minnow dip net and/or sieve
- ☐ 100-foot rope with tent spikes on each end, or tape measure
- ☐ Field computer
- ☐ Push pole (12-foot pole with foot attachment)
- ☐ Digital camera (or use Panasonic camera)
- ☐ Batteries for:
    - ☐ GPS

- ☐ Backpack electrofishing unit
- ☐ Camera

- ☐ Fish identification tools
- ☐ Plastic bottles (approved for chemical storage) *(e.g., Fisher Scientific catalog number 02-895-1C)*
- ☐ Formalin (10%)
- ☐ PPE for formalin handling (gloves and goggles)
- ☐ Clam boil or other loose mesh bags for unknown voucher specimens—*optional, only use for unknowns*
- ☐ Field data sheets (**Appendix B**. Seining and Electrofishing Field Data Sheet and Voucher Bottle Labels) printed on waterproof paper (e.g., *Rite in the Rain (http://www.riteintherain.com/) catalog number 8511*)
- ☐ Voucher bottle labels (**Appendix B**. Seining and Electrofishing Field Data Sheet and Voucher Bottle Labels) printed on Resistall paper (e.g., *University Products (Holyoke, MA) catalog number 219-368511*)

*See Section of Fisheries Safety Manual (MNDNR 2020) for backpack electrofishing approved gear.

Lake Selection

A lake may be considered for evaluation by a fish-based IBI if all of the following criteria are met:

- Is classified as Schupp Lake Class 20–25 or 27–43 lake
- Has surface area greater than or equal to 100 acres
- Has not experienced significant naturally induced winterkill (resulting from shallow minimum depth and involving suspected loss of species and lack of year classes within the previous decade) or has not been reclaimed
- Is not legally classified as a reservoir or does not have a strong riverine influence (indicated by a fish community dominated by riverine species)

Lakes that are eligible for an IBI survey should be surveyed within the MPCA watershed assessment window. Preferably, nearshore surveys (i.e., backpack electrofishing and seining) and standard lake surveys (i.e., trap netting and gill netting) should be done in the same sampling season; however, a six-year window is acceptable for pairing gears.

Sampling Stations

Nearshore sampling stations are equally spaced along the shoreline of a lake from a random starting point. Once established, these sampling station locations are to be used for future nearshore surveys. The number of sampling stations required per lake is based on the lake (or basin's) surface acreage (Table 1). Additional details regarding methods used during IBI development to determine the number of nearshore sampling stations needed per lake are found in Bacigalupi et al. (2021).

Table 1. Number of nearshore sites sampled based on lake size.

Lake Surface Area (acres)	Number of Sites
< 500	10
500–1,199	14
1,200–1,999	18
> 2,000	24

Once a lake is selected for IBI sampling, sampling sites must be generated if they do not exist. Points are generated prior to the sampling season and loaded into Fisheries Survey Module (FSM) by a DNR Fisheries GIS Specialist. Contact IBI Program Supervisor if points are needed for a lake that does not have them.

A desktop review of site locations should be completed to ensure sampling stations are located in areas of the lake that are accessible by boat. If not, the DNR Fisheries GIS Specialist can regenerate points based on modified lake delineations.

Data Entry into Fisheries Survey Module (FSM)

A targeted survey should be created in FSM that will contain the nearshore survey components and associated fish data. For any repeat nearshore surveys conducted within the same year, separate targeted surveys with different survey ID dates should be created.

Required electrofishing and seining components should be added as needed while completing the nearshore survey. Only components that are sampled should be added. For example, if seining is not possible at a site due to reasons specified in the **Sampling Difficulties** section below, do not add a seining component for that sampling station. Add a crew note to the survey describing which stations were not seined and the conditions that prevented seining.

For each backpack electrofishing (i.e., EFB) component, ensure that the fields outlined in blue in Figure 1 are filled in at minimum and that all checkboxes are checked. Include a short description of the habitat sampled and site conditions in the crew notes. Other fields are optional but should also be filled in when possible, although many are only applicable to streams.

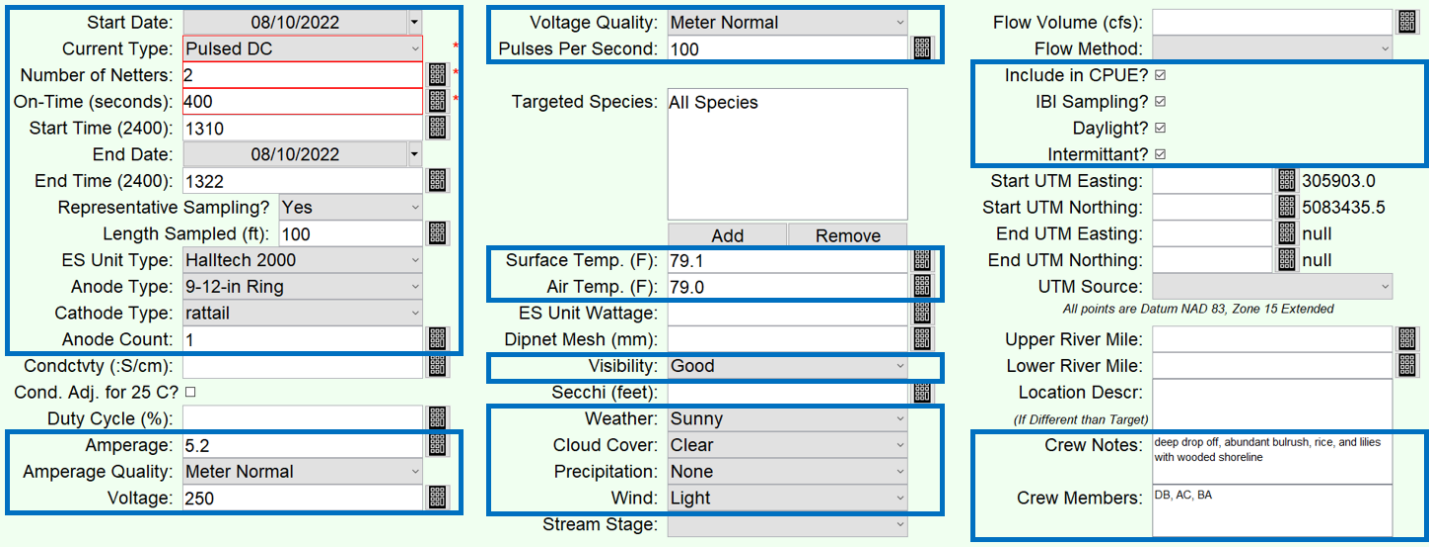

Figure 1. Example backpack electrofishing (EFB) component in Fisheries Survey Module (FSM), with IBI survey required fields outlined in blue.

For each seining component (i.e., S58 or S18), ensure that the fields outlined in blue in Figure 2 are filled in at minimum and that all checkboxes are checked. Record the appropriate substrate types and vegetation density at the station.

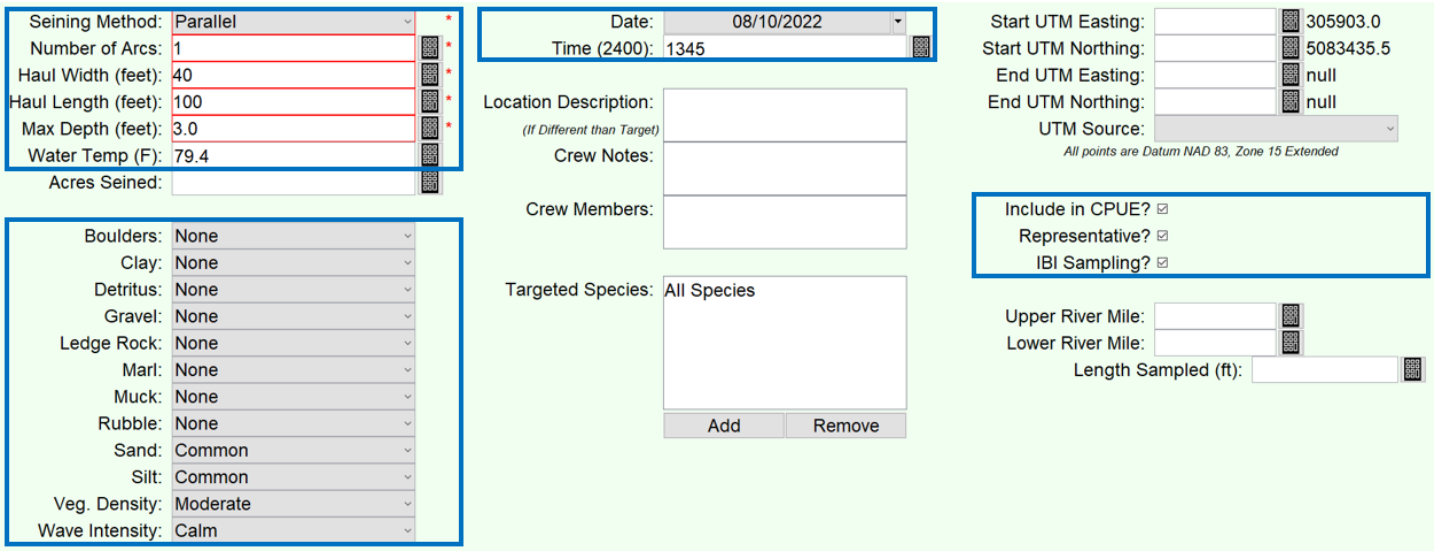

Figure 2. Example seining (S58 or S18) component in Fisheries Survey Module (FSM), with IBI survey required fields outlined in blue.

All fishes sampled in each nearshore gear type should be entered in the appropriate Unmeasured Fish table. Enter species name, total count, count of vouchered individuals, and count of individuals with external deformities, erosion, lesions, or tumors (DELTs). If individuals are young of the year (YOY), check the "YOY" checkbox. Do not count or enter information for YOY fish under 25 mm (approximately 1 inch).

If a site is moved (refer to When a site presents an atypical situation, try to find somewhere to sample within the site. Seining will generally yield a greater diversity of fishes than backpack electrofishing. Before moving or skipping a site, attempt to find a way to sample some portion or the entire site by backpack electrofishing, seining, or both. This is not an all-inclusive list of situations that will be encountered. Use professional judgment or contact FIBI Program staff and

ask their professional opinion. Additional examples of difficult sampling situations and guidelines can also be found in **Appendix D**. Examples of Difficult Sampling Situations.

Site Difficulties section below for examples of when appropriate to move a site), the starting GPS coordinates at the relocated site should be added into the gear component screen and a comment should be added in the crew notes. A location description for the relocated site can also be added. In order to retain the location for the relocated station for future surveys, the location coordinates should also be updated in the "Manage Target Station List" screen for the EFB, S18, and S58 components associated with that station number.

To increase repeatability during future surveys, photos can be taken of each site and uploaded into FSM. Individual station photos should be labeled with the station number, combined into one file, and added as a survey attachment in the Survey Detail screen. Individual photos can also be added to each EFB component as an attachment; however, exporting a combined file from the Survey Detail screen is easier and preferred. In either case, do not check the "Include in reports" box for these files.

Additional FSM data entry instructions not covered here can be found in the Manual of Instructions for Lake Survey (MNDNR 2017). For general lake survey support, contact the Lake Survey Program Coordinator.

Protocol for Sampling Fish

Nearshore sampling of fish should occur from approximately June 15–September 15, where survey repeatability has been demonstrated. The season may start later or end earlier if local weather conditions dictate. Where possible, prioritize IBI sampling for July or August and when nearshore surface water temperatures average 70°F or above.

Navigate to the sampling station, attempting to be within 100 feet of the site location according to the GPS, without missing unique habitats. If access to the site is impossible or extremely difficult, the site should be moved to the nearest location with similar habitat where sampling is possible (see **Site Difficulties** section below for more details). Although sites can me moved, it is important to sample difficult habitats even if needing to use a shorter or narrower seine haul or a boat-assisted seine—in many cases, unique fish species are sampled in these locations.

Before deploying any sampling gear, measure the site. This step can be omitted once all crew members are confident with estimating 100 feet. It is advised that site length is periodically verified throughout the sampling season. At the first site determine if seining or backpack electrofishing will be completed first. The type of sampling gear used first will alternate at each site.

The goal for the lake IBI is to obtain a repeatable, representative sample of the fish community in each lake. In terms of nearshore sampling, the "targeted" area for each station is approximately 100 feet along the shoreline and up to 50 feet lakeward. Sampleable lakeshore habitat does not often lend itself well to these constraints; therefore, modifications to the "targeted" area may be necessary. It might help to think of the nearshore sampling station as one unit of effort, where two types of equipment and various ways of deploying each can be used to effectively sample the station.

Backpack Electrofishing

The sampling station should first be inspected to determine if it can be safely electrofished via wading along the shoreline (e.g., reasonable footing, appropriate depth). If determined that the site cannot be sampled safely via wading, refer to the **Backpack Electrofishing from the Boat** section. If the site can be sampled safely, then proceed in the following manner.

First, determine which crew member will wear the backpack electrofishing unit (i.e., "operator") and which will net fishes (i.e., "netter"). The operator should enter the water without the backpack electrofishing unit. A netter that is still in the boat should assist the operator with putting on the backpack electrofishing unit, reducing the risk of submerging

the unit. While the backpack electrofishing unit is still turned off, the netter can reset the timer and check the settings on the unit. Settings can be adjusted once electrofishing begins—let the fish response (i.e., if they are sufficiently stunned for netting) dictate whether the settings are appropriate. The operator and netter(s) should confirm they are wearing rubber or PVC gloves and polarized sunglasses prior to commencing electrofishing.

Once all safety precautions are taken, the operator can begin electrofishing. The operator should move away from the boat parallel to the shoreline and should move the anode in a sweeping motion. During this first pass, it is important to electrofish the area immediately adjacent to the shoreline since it is at times difficult to seine right up to the water's edge. All fish should be netted and placed in a bucket. Once the far end of the station (i.e., 100 feet) is reached, the operator and netter(s) should turn around and walk back towards the boat. The location of the second pass should be slightly further from shore than the first, yet the sweeps from both passes should overlap slightly. The pace for each pass should be slightly slower than a regular walking pace. Intermittent electrofishing can be used to improve success. For example, if fish are moving ahead of the field, attempts can be made to corral them, or the anode can be removed from the water and quickly re-submerged near the fish and/or structure.

After both passes are completed, totaling 200 feet, the backpack electrofishing unit should be shut off and lifted from the operator's back by a crew member that is in the boat. All required fields outlined in Figure 1 should be entered in the EFB component in FSM at this time if not already completed. The time should be noted and entered accordingly. Similarly, "100" should be entered into the "Length Sampled (ft)" field if the full length of the station was electrofished. The fish caught should be identified, enumerated, and recorded, as outlined in the **Data Entry into Fisheries Survey Module (FSM)** section.

Seining

The sampling station should first be inspected to determine if it can be safely and effectively seined (e.g., reasonable footing, appropriate depth). If determined that the site cannot be sampled safely or effectively with a traditional seine haul, refer first to the **When a** site presents an atypical situation, try to find somewhere to sample within the site. Seining will generally yield a greater diversity of fishes than backpack electrofishing. Before moving or skipping a site, attempt to find a way to sample some portion or the entire site by backpack electrofishing, seining, or both. This is not an all-inclusive list of situations that will be encountered. Use professional judgment or contact FIBI Program staff and ask their professional opinion. Additional examples of difficult sampling situations and guidelines can also be found in **Appendix D**. Examples of Difficult Sampling Situations.

Site Difficulties section to ensure that an adequate number of sites are seined and then to the **Seining Difficulties** section for techniques that can be considered. If the site can be sampled safely and effectively with a traditional seine haul, then proceed in the following manner.

Seining should be completed following the parallel seining protocol in the Manual of Instructions for Lake Survey (MNDNR 2017) whenever conditions allow. Essentially, the seine should be extended into the lake on a line perpendicular to shore to the full length of the seine or as far from shore as water depth allows. The shallow end should remain at or near shore when conditions permit. The seine should be hauled parallel along the shore for the length of the station, at which time the outer end is swept in an arc toward the shoreline and the seine is pulled up to the shoreline and lifted out of the water. All required fields outlined in Figure 2 should be entered in the S58 or S18 component in FSM at this time if not already completed. The fish caught should be identified, enumerated, and recorded, as outlined in the **Data Entry into Fisheries Survey Module (FSM)** section. Refer to the **Seining Difficulties** section for guidance about what to do in an atypical or difficult seining situations (such as deep drop-offs or narrow boat channels).

Whenever possible, the 50-foot seine (i.e., S58) should be used and the full length of the station (i.e., 100 feet) should be sampled. The ends can be rolled over to shorten the seine if there are obstructions in the water or if deep water limits full deployment—note actual width deployed in FSM "Haul Width" field. If the site is very difficult and precludes seining with the 50-foot seine, the 15-foot seine (i.e., S18) should be used and the same amount of area (i.e., 50 feet or to deep water x 100 feet) should be sampled in multiple pulls if the site allows it (refer to the **Seining Difficulties** section for details). For instance, if there is woody habitat or a dock in the middle of a site, two or more pulls may be required to complete a site.

Sampling Difficulties

When a site presents an atypical situation, try to find somewhere to sample within the site. Seining will generally yield a greater diversity of fishes than backpack electrofishing. Before moving or skipping a site, attempt to find a way to sample some portion or the entire site by backpack electrofishing, seining, or both. This is not an all-inclusive list of situations that will be encountered. Use professional judgment or contact FIBI Program staff and ask their professional opinion. Additional examples of difficult sampling situations and guidelines can also be found in **Appendix D**. Examples of Difficult Sampling Situations.

Site Difficulties

Whenever possible, sites should not be moved, or seine hauls skipped. Sometimes the difficult sites can yield unique fish species that are not found in the rest of the lake. Effort should be taken to access and sample these sites, while still remaining legal and safe. However, if a site needs to be moved, it should be moved to the closest "sampleable" location with as similar characteristic to the original site as is practical. In some cases, this may be the outside edge of an emergent fringe.

Reasons to move a sampling station, skip a seine haul, or alter the standard sampling methods at a sampling station may include:

- Inaccessibility to the shoreline by either walking, boating, or push-poling.
    - If dense cattails, lilies, wild rice, or other aquatic vegetation are present, backpack electrofishing from the boat may be required. If not equipped to do so safely, a site can also be moved.
- Deep water immediately adjacent to shore.
    - If bog fringe, backpack electrofishing from the boat may be required. If not equipped to do so safely, a site can also be moved
    - Can consider parallel, boat-assisted seine when possible for one crew member to safely wade in water.
- High density of docks (e.g., marina) or beach.
    - Move the site to the nearest sampleable location.
- High winds/waves on shore.
    - Reduces efficiency of netting fish and presents possible footing danger.
    - Can be sampled once winds die down if situation allows.
- Animals or people in the water.
    - Can be sampled once animals or people are no longer in the water if situation allows.

Backpack Electrofishing from the Boat

Unlike seining, backpack electrofishing should occur at all sampling sites required for a lake of a given size (Table 1), using backpack electrofishing from the boat when needed. Note that an EFB component type should still be selected in FSM for this technique. Sampling sites may be moved if necessary, particularly to accommodate the minimum number of seine stations required for a lake. Nonetheless, backpack electrofishing from the boat can be used in situations where:

- Wading at a site would be dangerous (e.g., loose or slippery rocks, soft substrate, large trees in the water).
- Water depth at a site is too deep for wading.
- Any crew member has reservations about wading the site.

Due to nontraditional usage of the backpack electrofishing unit, modifications were made to assure all users' safety. If the decision is made to backpack electrofish from the boat, a remote kill switch must be connected to the backpack electrofishing unit. The boat driver should operate the remote kill switch and test its operation before beginning sampling.

To accomplish this type of sampling safely, the backpack should be secured in some way to the boat and the kill switch connected. All crew members in the boat should put on rubber or PVC gloves, including the person who pushes the boat along with either a push pole or the outboard (i.e., "driver"). The backpack operator should be located at the front of the boat and is responsible for the movements of the anode and cathode. The netter should be behind the backpack and operator (i.e., middle of the boat) and is responsible for setting up a bucket in an area where they can easily place the fish once collected. The driver should be at the back of the boat, moving the boat along with a push pole or the outboard (if vegetation and water clarity are not a factor). This task can be completed with only two crew members but should be done more slowly as it can be difficult for one person to operate both the backpack and the net.

Once crew members are in place, the operator should place the cathode and anode over the side of the boat, ensuring that the metal portion of the cathode is not touching the boat. The operator should then turn on the unit and indicate that they will begin electrofishing, doing so for a short period of time to ensure fish are sufficiently stunned. Once ready, the backpack operator and netter signal the driver to begin moving the boat forward. The main responsibilities of the driver are to ensure the boat moves as smoothly as possible while moving at a pace similar to a walking pace and to alert the operator and netter of any obstacles in the way, such as tree branches.

Because of the difficulties and inefficiencies associated with backpack electrofishing out of the boat, the length of the station should be doubled to 200 feet from the starting point. The driver can meander between depths while moving the boat along the shoreline. Once the boat has traveled 200 feet down the shoreline, the driver should turn the boat around and make another pass further from shore, such as on the outside edge of the vegetation, and towards the starting point. More commonly, if unable to travel back to the starting point because of site constraints, the length of the station can be extended such that 400 feet are sampled overall on one direction. Once electrofishing is completed, the operator should turn off the unit and bring the anode and cathode into the boat. The backpack electrofishing unit should then be released from the boat and placed in an area for transport. The time should be noted and entered accordingly. The distance traveled between the starting point and the furthest point sampled (e.g., 200 or 400 feet) should be entered into the "Length Sampled (ft)" field and a comment specifying that backpack electrofishing from the boat was used should be added to the "Crew Notes" field in FSM. The fish caught should be identified, enumerated, and recorded.

Seining Difficulties

Seining should be completed at as many sites as possible and at a minimum of half of the sample sites required for a lake of a given size (Table 1). Sampling stations may be moved if necessary. However, seining even a very small area (e.g., 10 feet by 20 feet) or using a non-traditional approach (e.g., fixed pole, perpendicular, or boat-assisted seining) can often effectively sample species in difficult habitats. This will require some professional judgment by crew members. In some cases, the shoreline of the lake will be such that it will not be possible to meet these criteria, at which seining at the site may be skipped provided that at least half of the sample sites on the lake are seined. For sites where seining is skipped, a comment that seining was skipped and a justification/general description of sampling difficulties should be added to the "Crew Notes" field in the EFB component for that station. If sampling Lake Class 1–19 lakes, disregard this paragraph and follow the protocols as described in **Appendix A**. Fish Sampling Adjustments for Shield Lakes.

Dense Submerged or Floating-leaf Vegetation

Dense submerged or floating-leaf vegetation can limit effectiveness of a seine haul. In some instances, the 15-foot seine rather than the 50-foot seine can be used more effectively. Regardless of which seine is used, it should be deployed in the normal manner; however, when moving through the vegetation the lead line should be kept as taut as possible and the seine should be moved forward in quick, short bursts (i.e., referred to as ripping the seine) through the vegetation. It is very common that the seine will roll around the lead line. If this occurs there are several options:

- Pull multiple short seines through the site to limit the chance of the net rolling.
- Continue moving though the site and have a third crew member assist by periodically pulling the bag of the net to reduce the rolling.
- Once the seine starts rolling, both crew members grab the lead line, walk back away from each other, and lift rapidly so that fish remain trapped in the seine.

Once the seine is pulled to shore, large amounts of vegetation may be present in the net. If this occurs, the vegetation must be screened very carefully. It is very easy to miss fishes in vegetation. If necessary, 2–3 seine hauls should be completed if using the 15-foot seine to cover the entire station.

Dense Emergent Vegetation

Emergent vegetation, usually cattails and bulrush, tend to lift the lead line off the bottom. There are two options for seining in emergent vegetation:

- If the density of the vegetation is low, the seine may be "ripped" over the vegetation. This practice works better in very sparse cattail and moderately sparse bulrush.
- If the emergent vegetation is too dense, it may be possible to either find open space in the vegetation or sample on the outside of the vegetation. In some cases, there is a gap next to shore, near a dock, or the water is shallow enough to allow seining on the outside edge of the emergent vegetation.

If depth and vegetation are confounding factors, seine using either the push-pole or boat motor to extend the seine from the shore or edge of the vegetation and sweep around (i.e., fixed pole seining).

Coarse Woody Habitat (CWH)

CWH can get caught in, snag, or rip a seine, and the risk is largely dependent on the amount and diameter present at the site. If there is a small amount and small diameter CWH that will not snag or rip the net, seine the site as normal. However, if it is likely that amount and diameter of the CWH will snag and/or rip the net there are several options:

- Have a third crew member assist by guiding the net to avoid being snagged and untangling the net if it does get caught.
- Pull multiple seine hauls between CWH.
- Attempt to find an area, even a small area, where a seine haul can be completed.

Rocky Shorelines

Rocks can get caught in, snag, or rip a seine, and the risk is largely dependent on the amount and size present at the site. Depending on rock size, seining can be completed using one of the following options:

- If the rocks are smaller than softballs, proceed to seine in a normal fashion. However, it is common to pick up a rock or two while seining.
- If the rocks are between the size of softballs and basketballs, attempt to seine as close to normal as possible. However, it will be more common to get snagged on rocks. Have the third crew member assist with unhooking the net from obstacles.
- If the rocks are larger than basketball size, seining efficiency decreases as rock size increases. If possible, find a stretch within the site that has smaller rocks and seine that area. If not, seining may not be possible.

Steep Shorelines

Steep shorelines might not be possible to seine using traditional methods because only one of the two crew members required to pull the seine can effectively wade in the water before it becomes too deep. In these cases, the crew can utilize a parallel, boat-assisted seining technique. This technique is similar to the parallel seining protocol; however, the boat itself serves as the crew member on the deep side of the seine. The float line on the deep end of the seine can be attached directly to the bow using a carabiner. The lead line can be attached by a carabiner to an anchor that is connected to the bow of the boat by a short (i.e., 4 feet) rope. With one crew member in the water at the shoreline and holding the shallow end of the seine, the boat operator should move the boat perpendicular to shore to the full length of the seine. The boat operator and crew member that is wading along the shoreline will move the seine parallel to the shoreline until the length of the station is reached, at which point the boat operator will position the boat such that the crew member in the water can detach the deep end of the seine from the boat. The boat operator will then park the boat along the shoreline and assist the other crew member with pulling in the seine and lifting it out of the water. Additional documentation for this technique, including a video demonstration, can be obtained by contacting the IBI Program Supervisor.

Large Sample Sizes/Subsampling

Subsampling is not permitted. All fish must be identified and sorted into separate lots/buckets at each station. In most cases each fish will be counted. For very large catches (i.e., several hundred to several thousand individuals), fish should be sorted to species and then the count estimated volumetrically with a small net, plastic container, or similar.

Protocol for Collecting and Preserving Voucher Specimens

Preparing Voucher Labels, Bottles, and Bags

Labels should be included with each voucher bottle and must contain the following information: Full DOW (00-0000-00), Lake Name, County, State, Survey Date (e.g., 25 June 2022), Collector, Station Number, Gear(s) Used, and Bottle __ of __

(for the survey). Refer to **Appendix B**. Seining and Electrofishing Field Data Sheet and Voucher Bottle Labels for an example of a voucher bottle label. Excel versions are also available—contact IBI Program Supervisor if needed.

- Labels should be printed on Resistall paper using LaserJet ink, as labels will remain with specimens for years. Any writing on the labels should be done in pencil.
- One label should be attached to the outside of each voucher bottle using clear packaging tape and another identical one should be inserted into the bottle. Any old labels or writing should be removed from the bottle.
- Each bottle should be labeled as containing 10% formalin. Preprinted formalin labels are available for purchase at several websites.
- A separate bottle must be used for fish sampled at each station (i.e., fish sampled at multiple stations cannot be combined into the same voucher bottle). For the most part fish can be loose in the bottle instead of bagged as discussed below.
- For preservation purposes and the safety of those doing the voucher verification, bags should only be used to separate unknown fish or fish that are suspected as misidentified. The preferred bag is clam boil or similar loose mesh bags due to formalin retention and formalin exposure. Do not purchase additional fine mesh muslin bags. Do not use whirl-packs. Muslin or cotton bags should be immersed in water prior to adding specimens, as some species may lose their scales more easily in a dry bag.
- In bottles that are relatively full of specimens, it is important that sufficient formalin be added to ensure proper fixation. Do not over fill bottles with fish. If one bottle is insufficient, a second bottle can be used for the station. However, specimens should be consolidated into a larger bottle before sending on for verification if possible.

Voucher Requirements

Fish should be vouchered using the following strategies and corresponding to the number required for each lake or station, as indicated in **Appendix C**. List of Fish Species and Voucher Requirements.

- Live or freshly dead adult fish with intact fins should be selected when available for vouchering. Representative specimens preserved in good condition are much easier to identify. Fish under 25 mm (approximately 1 inch) should not be vouchered or included in counts.
- A minimum of 2 individuals of each fish species in category A (e.g., most game fish and other easily identifiable fish) should be vouchered per lake (**Appendix C**. List of Fish Species and Voucher Requirements). Put these fish into the bottle for the appropriate station rather than a separate bottle.
- A minimum of 5 individuals of each fish species in category B (e.g., bullheads, sunfish, darters, and minnows) should be vouchered per station (**Appendix C**. List of Fish Species and Voucher Requirements). More than 5 individuals can be vouchered per station if uncertain about identification since a larger sample size will better facilitate corrections, if necessary. Any species not listed in category A or B should also be vouchered at 5 or more individuals per station.
- Preserve any fishes when any of the following criteria are met: species identification is uncertain, a species not previously documented in the lake has been sampled, or collection results in range expansion of the species.
- If a fish is too large to voucher and is novel to the survey, several photographs with identifying features can be taken instead. This is especially important if it is a new species for the lake or would result in range expansion of the species. Name the file with the following convention [Year_SurveyDate_DOW_Station_Collector_Species],

such as 2012_April16_18000100_EFB1_JBacigalupi_Bluegill. Contact IBI Program Supervisor for location on I:Drive to upload photos to.

Currently, voucher specimens are only required to be taken during nearshore sampling. However, if identification of fish encountered during gill net or trap net sampling is uncertain or if fish encountered in those gears would result in a range expansion, photograph and catalog as above.

References

Bacigalupi, J., D. F. Staples, M. T. Treml, and D. L. Bahr. 2021. Development of fish-based indices of biological integrity for Minnesota lakes. Ecological Indicators 125:107512.

MNDNR (Minnesota Department of Natural Resources). 2017. Manual of instructions for lake survey. MNDNR Special Publication 180, St. Paul, Minnesota.

MNDNR. 2020. Section of Fisheries safety manual. MNDNR, St. Paul, Minnesota.

Appendix A. Fish Sampling Adjustments for Shield Lakes

The following techniques should be used when sampling Canadian Shield lakes (Schupp Lake Classes 1–19).

Each nearshore sampling station should be sampled with the backpack electrofishing unit and quarter-inch trap nets (TQU) when possible. Backpack electrofishing methods are outlined in the **Backpack Electrofishing** section above and trap netting methods are outlined in the Manual of Instructions for Lake Survey (MNDNR 2017). Seining is not required at each nearshore sampling station. The field crew should select sites that allow for seining on each lake, choosing as diverse of habitats as is practical. The total number of seines should be as follows: three seine sites for a 10–14 station lake and five sites for an 18–24 station lake (Table 1). If the lake does not allow for enough seining sites, seine as many as possible.

If the nearshore survey is completed by an IBI Program crew, TQU stations should be numbered TQU201, TQU202, and so on to avoid confusing them with other survey stations previously established by Area Fisheries offices for other purposes. Area Fisheries offices can number TQU stations according to their preferences. S18 or S58 gear codes should be used for the seines, and they can be numbered S58301, S58302, and so on.

Appendix B. Seining and Electrofishing Field Data Sheet and Voucher Bottle Labels

(Forms begin on the next page. Editable Excel forms available for voucher bottle labels—contact IBI Program Supervisor)

Lake Name ________________________ Survey ID Date ____________________ Page ________________________
DOW ________________________ Crew Members ____________________ Crew Notes ________________________

	EFB Station		S Station		EFB Station		S Station	
	Date		S Type	[S58][S18]	Date		S Type	[S58][S18]
	Start Time		Method	[Pa][Fi][Pe]	Start Time		Method	[Pa][Fi][Pe]
	End Time		Width (ft)		End Time		Width (ft)	
	On-Time		Length (ft)		On-Time		Length (ft)	
	Length (ft)		Depth (ft)		Length (ft)		Depth (ft)	
	Amperage		Surface Temp (F)		Amperage		Surface Temp (F)	
	Voltage		Boulders	[A][C][R][N]	Voltage		Boulders	[A][C][R][N]
	Frequency		Clay	[A][C][R][N]	Frequency		Clay	[A][C][R][N]
	Surface Temp (F)		Detritus	[A][C][R][N]	Surface Temp (F)		Detritus	[A][C][R][N]
	Air Temp (F)		Gravel	[A][C][R][N]	Air Temp (F)		Gravel	[A][C][R][N]
	Visibility	[G][M][P]	Ledge Rock	[A][C][R][N]	Visibility	[G][M][P]	Ledge Rock	[A][C][R][N]
	Weather		Marl	[A][C][R][N]	Weather		Marl	[A][C][R][N]
	Cloud Cover		Muck	[A][C][R][N]	Cloud Cover		Muck	[A][C][R][N]
	Precipitation		Rubble	[A][C][R][N]	Precipitation		Rubble	[A][C][R][N]
	Wind		Sand	[A][C][R][N]	Wind		Sand	[A][C][R][N]
	Crew Notes		Silt	[A][C][R][N]	Crew Notes		Silt	[A][C][R][N]
			Veg Density	[D][M][L][N]			Veg Density	[D][M][L][N]
			Wave Int	[C][L][M][S]			Wave Int	[C][L][M][S]
			Date				Date	
			Time				Time	

S Type: [S58] 50' and 1/8" mesh, [S18] 15' and 1/8" mesh Seining Method: [Pa]rallel, [Fi]xed Pole, [Pe]rpindicular Substrate: [A]bundant, [C]ommon, [R]are, [N]one
Vegetation: [D]ense, [M]oderate, [L]ight, [N]one Wave Int: [C]alm, [L]ight, [M]oderate, [S]trong Visibility: [G]ood, [M]oderate, [P]oor

Species	Count	Voucher	YOY	DELTs	Count	Voucher	YOY	DELTs	Count	Voucher	YOY	DELTs	Count	Voucher	YOY	DELTs
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Entered_______ Entered_______ Entered_______ Entered _______

DOW #:
Lake Name:
County:
State: MN
Date:
Collector:
Station #: 1
Gear(s):
Jar #/Total: # of
Contains 10% Formalin

DOW #:
Lake Name:
County:
State: MN
Date:
Collector:
Station #: 2
Gear(s):
Jar #/Total: # of
Contains 10% Formalin

DOW #:
Lake Name:
County:
State: MN
Date:
Collector:
Station #: 3
Gear(s):
Jar #/Total: # of
Contains 10% Formalin

DOW #:
Lake Name:
County:
State: MN
Date:
Collector:
Station #: 4
Gear(s):
Jar #/Total: # of
Contains 10% Formalin

DOW #:
Lake Name:
County:
State: MN
Date:
Collector:
Station #: 5
Gear(s):
Jar #/Total: # of
Contains 10% Formalin

DOW #:
Lake Name:
County:
State: MN
Date:
Collector:
Station #: 6
Gear(s):
Jar #/Total: # of
Contains 10% Formalin

DOW #:
Lake Name:
County:
State: MN
Date:
Collector:
Station #: 7
Gear(s):
Jar #/Total: # of
Contains 10% Formalin

DOW #:
Lake Name:
County:
State: MN
Date:
Collector:
Station #: 8
Gear(s):
Jar #/Total: # of
Contains 10% Formalin

DOW #:
Lake Name:
County:
State: MN
Date:
Collector:
Station #: 9
Gear(s):
Jar #/Total: # of
Contains 10% Formalin

DOW #:
Lake Name:
County:
State: MN
Date:
Collector:
Station #: 10
Gear(s):
Jar #/Total: # of
Contains 10% Formalin

DOW #:
Lake Name:
County:
State: MN
Date:
Collector:
Station #:
Gear(s):
Jar #/Total: # of
Contains 10% Formalin

DOW #:
Lake Name:
County:
State: MN
Date:
Collector:
Station #:
Gear(s):
Jar #/Total: # of
Contains 10% Formalin

Appendix C. List of Fish Species and Voucher Requirements

Common Name	Species	Category	# Vouchers Required
Banded Killifish	*Fundulus diaphanus*	A	2 per LAKE
Bigmouth Buffalo	*Ictiobus cyprinellus*	A	2 per LAKE
Black Crappie	*Pomoxis nigromaculatus*	A	2 per LAKE
Bowfin	*Amia calva*	A	2 per LAKE
Brook Silverside	*Labidesthes sicculus*	A	2 per LAKE
Brook Stickleback	*Culaea inconstans*	A	2 per LAKE
Brook Trout	*Salvelinus fontinalis*	A	2 per LAKE
Brown Trout	*Salmo trutta*	A	2 per LAKE
Burbot	*Lota lota*	A	2 per LAKE
Central Mudminnow	*Umbra limi*	A	2 per LAKE
Central Stoneroller	*Campostoma anomalum*	A	2 per LAKE
Channel Catfish	*Ictalurus punctatus*	A	2 per LAKE
Chestnut Lamprey	*Ichthyomyzon castaneus*	A	2 per LAKE
Cisco	*Coregonus artedi*	A	2 per LAKE
Common Carp	*Cyprinus carpio*	A	2 per LAKE
Flathead Catfish	*Pylodictis olivaris*	A	2 per LAKE
Freshwater Drum	*Aplodinotus grunniens*	A	2 per LAKE
Gizzard Shad	*Dorosoma cepedianum*	A	2 per LAKE
Lake Sturgeon	*Acipenser fulvescens*	A	2 per LAKE
Lake Trout	*Salvelinus namaycush*	A	2 per LAKE
Lake Whitefish	*Coregonus clupeaformis*	A	2 per LAKE
Largemouth Bass	*Micropterus salmoides*	A	2 per LAKE
Logperch	*Percina caprodes*	A	2 per LAKE
Longnose Gar	*Lepisosteus osseus*	A	2 per LAKE
Longnose Sucker	*Catostomus catostomus*	A	2 per LAKE
Muskellunge	*Esox masquinongy*	A	2 per LAKE
Northern Hog Sucker	*Hypentelium nigricans*	A	2 per LAKE
Northern Pike	*Esox lucius*	A	2 per LAKE
Quillback	*Carpiodes cyprinus*	A	2 per LAKE
Rainbow Smelt	*Osmerus mordax*	A	2 per LAKE
Rainbow Trout	*Oncorhynchus mykiss*	A	2 per LAKE
River Carpsucker	*Carpiodes carpio*	A	2 per LAKE
Rock Bass	*Ambloplites rupestris*	A	2 per LAKE
Sauger	*Sander canadensis*	A	2 per LAKE
Shortnose Gar	*Lepisosteus platostomus*	A	2 per LAKE
Smallmouth Bass	*Micropterus dolomieu*	A	2 per LAKE
Smallmouth Buffalo	*Ictiobus bubalus*	A	2 per LAKE
Splake	*Salvelinus sp. X Salvelinus sp.*	A	2 per LAKE
Tiger Muskellunge	*Esox sp. X Esox sp.*	A	2 per LAKE
Trout-perch	*Percopsis omiscomaycus*	A	2 per LAKE
Walleye	*Sander vitreus*	A	2 per LAKE
White Bass	*Morone chrysops*	A	2 per LAKE
White Crappie	*Pomoxis annularis*	A	2 per LAKE
White Sucker	*Catostomus commersonii*	A	2 per LAKE
Yellow Bass	*Morone mississippiensis*	A	2 per LAKE
Yellow Perch	*Perca flavescens*	A	2 per LAKE
Bigmouth Shiner	*Notropis dorsalis*	B	5 per STATION

Common Name	Species	Category	# Vouchers Required
Black Bullhead	*Ameiurus melas*	B	5 per STATION
Blackchin Shiner	*Notropis heterodon*	B	5 per STATION
Blacknose Dace	*Rhinichthys atratulus*	B	5 per STATION
Blacknose Shiner	*Notropis heterolepis*	B	5 per STATION
Blackside Darter	*Percina maculata*	B	5 per STATION
Bluegill	*Lepomis macrochirus*	B	5 per STATION
Bluntnose Minnow	*Pimephales notatus*	B	5 per STATION
Brassy Minnow	*Hybognathus hankinsoni*	B	5 per STATION
Brown Bullhead	*Ameiurus nebulosus*	B	5 per STATION
Common Shiner	*Luxilus cornutus*	B	5 per STATION
Creek Chub	*Semotilus atromaculatus*	B	5 per STATION
Emerald Shiner	*Notropis atherinoides*	B	5 per STATION
Fantail Darter	*Etheostoma flabellare*	B	5 per STATION
Fathead Minnow	*Pimephales promelas*	B	5 per STATION
Finescale Dace	*Chrosomus neogaeus*	B	5 per STATION
Goldfish	*Carassius auratus*	B	5 per STATOIN
Golden Redhorse	*Moxostoma erythrurum*	B	5 per STATION
Golden Shiner	*Notemigonus crysoleucas*	B	5 per STATION
Greater Redhorse	*Moxostoma valenciennesi*	B	5 per STATION
Green Sunfish	*Lepomis cyanellus*	B	5 per STATION
Hornyhead Chub	*Nocomis biguttatus*	B	5 per STATION
Hybrid Sunfish	*Lepomis sp. X Lepomis sp.*	B	5 per STATION
Iowa Darter	*Etheostoma exile*	B	5 per STATION
Johnny Darter	*Etheostoma nigrum*	B	5 per STATION
Least Darter	*Etheostoma microperca*	B	5 per STATION
Longnose Dace	*Rhinichthys cataractae*	B	5 per STATION
Mimic Shiner	*Notropis volucellus*	B	5 per STATION
Mottled Sculpin	*Cottus bairdii*	B	5 per STATION
Northern Redbelly Dace	*Chrosomus eos*	B	5 per STATION
Northern Sunfish	*Lepomis megalotis*	B	5 per STATION
Orangepotted Sunfish	*Lepomis humilis*	B	5 per STATION
Pearl Dace	*Margariscus nachtriebi*	B	5 per STATION
Pugnose Minnow	*Opsopoeodus emiliae*	B	5 per STATION
Pugnose Shiner	*Notropis anogenus*	B	5 per STATION
Pumpkinseed	*Lepomis gibbosus*	B	5 per STATION
Rainbow Darter	*Etheostoma caeruleum*	B	5 per STATION
River Redhorse	*Moxostoma carinatum*	B	5 per STATION
Sand Shiner	*Notropis stramineus*	B	5 per STATION
Shorthead Redhorse	*Moxostoma macrolepidotum*	B	5 per STATION
Silver Redhorse	*Moxostoma anisurum*	B	5 per STATION
Slenderhead Darter	*Percina phoxocephala*	B	5 per STATION
Slimy Sculpin	*Cottus cognatus*	B	5 per STATION
Spotfin Shiner	*Cyprinella spiloptera*	B	5 per STATION
Spottail Shiner	*Notropis hudsonius*	B	5 per STATION
Stonecat	*Noturus flavus*	B	5 per STATION
Tadpole Madtom	*Noturus gyrinus*	B	5 per STATION
Weed Shiner	*Notropis texanus*	B	5 per STATION
Yellow Bullhead	*Ameiurus natalis*	B	5 per STATION

Appendix D. Examples of Difficult Sampling Situations

Difficult sampling situations are routinely encountered when completing nearshore fish surveys. The examples and strategies outlined below can be used as general guidelines when encountering difficult sampling situations, although the list is not intended to be exhaustive or prescriptive in nature.

	**Sandy substrate and high water clarity** Seining with a 50-foot seine was completed along the shoreline as normal. Backpack electrofishing was also completed but was challenging due to fish avoidance. Intermittent electrofishing was used to improve success. As fish moved ahead of the crew and electrical field, attempts were made to corral them, and the anode was removed from the water and quickly re-submerged near the fish and/or structure.
	**Excessive algae or turbidity** Seining with a 50-foot seine was completed along the shoreline as normal. Backpack electrofishing was also completed but was challenging due to limited visibility to dip net fish, particularly benthic species that tended to roll and stay near the bottom. Holding the anode just below the surface helped to pull fish higher into the water column for dip netting.
	**Heavily vegetated bay** A large expanse of aquatic vegetation prevented motoring or push-poling to the sampling station. Because achieving greater than 50% of seine hauls on the lake was possible, seining was skipped and backpack electrofishing from the boat was used for 400 feet along the edge of the vegetation, perpendicular to where the sampling station was located on shore. If achieving greater than 50% of seine hauls on the lake would have been challenging, the sampling station could have been moved to the nearest location with similar habitat where sampling with both gears was possible.

	**Bog with floating-leaf vegetation** Seining and backpack electrofishing via wading were not possible due to soft sediments, water depth, and a steep drop-off. Backpack electrofishing from the boat was completed and fixed-pole seining was utilized because the floating-leaf vegetation was rather sparse and the shoreline dropped off quickly. To fixed-pole seine, one crew member stood on the bog edge, one crew member used the push-pole to maneuver the boat in an arc (the boat motor could also be used in some situations), and the third crew member ensured the lead line remained below the water surface and the seine did not roll.
	**Sparse floating-leaf vegetation** Backpack electrofishing was completed along the shoreline as normal. Three 15-foot seine hauls were completed. Each was ripped through the vegetation perpendicular to shore, starting on the lakeward side where depth and substrate allowed. Fish captured in each seine haul were emptied into a single bucket that was carried by a third crew member, which reduced the need to wade back and forth to the boat multiple times.
	**Mixed emergent and floating-leaf vegetation** Backpack electrofishing via wading was not possible due to risk of backpack submersion, as the site was moderately deep. Backpack electrofishing from the boat was utilized along the outer edge of the vegetation, extending the distance sampled to 400 feet away from the starting point. Although too deep to safely backpack electrofish via wading, seining was still possible, and the 15-foot seine was used to sample a small opening in the vegetation (approximately 15 feet by 20 feet).

	**Moderate hardstem bulrush and sparse floating-leaf vegetation** Backpack electrofishing was completed along the shoreline as normal. Moderate hardstem bulrush would have rolled the 50-foot seine or limited seine effectiveness across much of the sampling station; however, a 15-foot seine was ripped through the area of sparse lilies between stands of hardstem bulrush.
	**Hardstem bulrush with shallow sandy substrate** Backpack electrofishing was completed along the shoreline as normal. Dense hardstem bulrush extending to a steep shoreline break resulted in skipping the seine haul at this station, as the seine would have rolled or been pushed out of the water completely. If achieving 50% or more seine hauls on the lake would have been challenging, the sampling station could have been moved to the nearest location with similar habitat where sampling with both gears was possible. Further, small gaps or openings on the inside edge of the hardstem bulrush are occasionally present within similar stations and can be sampled with a 15-foot seine.
	**Dense stands of cattail and hardstem bulrush with sandy substrate** Backpack electrofishing was completed along the shoreline as normal. Water was shallow enough at the outside edge of the hardstem bulrush stand to facilitate using the 50-foot seine; however, the full width of the seine was not utilized due to increasing depth. This resulted in some slack in the seine. If the depth were to have increased too rapidly along the edge to facilitate two crew members and a reasonable seine width, a parallel, boat-assisted seine haul could have been completed instead.

	**Coarse woody habitat and sparse floating-leaf vegetation** Backpack electrofishing was completed along the shoreline as normal. Two 15-foot seine hauls were completed in openings in the floating-leaf vegetation where coarse woody habitat was not as abundant. Fish captured in each seine haul were emptied into a single bucket that was carried by a third crew member, who also assisted with freeing the seine from snags as needed.
	**Coarse woody habitat with deep water** Seining and backpack electrofishing via wading were not possible due to abundant coarse woody habitat, water depth, and a steep drop-off. Seining was skipped because achieving greater than 50% of seine hauls on the lake was possible. If achieving greater than 50% of seine hauls on the lake would have been challenging, the sampling station could have been moved to the nearest location with similar habitat where sampling with both gears was possible. Backpack electrofishing from the boat was completed along 200 feet of shoreline among the coarse woody habitat and back to the starting point among the submerged vegetation just beyond the coarse woody habitat.
	**Rocky shoreline** Backpack electrofishing was completed along the shoreline as normal. The 50-foot seine was utilized, with a third crew member following the seine to free it from rock snags as needed.