Biological Monitoring
-Benthic Macroinvertebrates
-Periphyton, Algae
-Fish

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Summary Slide

- Biological Monitoring
  -Benthic Macroinvertebrates
  -Periphyton, Algae
  -Fish

Clean Water Institute

- The Clean Water Institute (CWI) will provide a forum, a unique link, to the natural resource heritage of North Central Pennsylvania, The West Branch of the Susquehanna River and major tributaries. The goals of the CWI are to provide:
- **SERVICE** to local watershed and environmental groups by developing and coordinating internships and independent study projects where Lycoming College students can assist in data collection and analysis of watershed projects.
- **EDUCATION** and training programs, seminars and workshops on environmental issues, stream restoration, habitat improvement and water quality will be offered to watershed groups, schools and other public forums. An archive of historical water quality data will be assembled and updated with information from ongoing projects and made available to the public.
- **ANALYSIS** by our water testing laboratory will provide watershed groups with technical assistance in design, collection and interpretation of water chemistry, macroinvertebrate, plankton and fish data.

Big Bend Watershed

Reference Materials

- Designing Your Monitoring Program: A Technical Handbook for Community-Based Monitoring in Pennsylvania. Prepared by River Network and PA DEP Bureau of Watershed Management Citizens' Volunteer Monitoring Program. www.dep.state.pa.us (DirectLINK "Volunteer Monitoring")

Reference Materials

- Kellogg, L.L. 1994. Monitor's Guide to Aquatic Macroinvertebrates. 60 pages. A good, introductory pocket-sized guide including a key and descriptions of major invertebrate groups. Save Our Streams, Izaak Walton League of America, 800/BUG-IWLA. Code: SOSB002 Price: $6.00
- EPA Rapid Bioassessment Protocols—EPA technical guidance on biological assessment
  http://www.epa.gov/owow/monitoring/rbp/download.html

Rapid Bioassessment Protocols (EPA)

- Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish
- Second Edition
  - RBP Home | Table of Contents| Download the RBP | Chapter 1 | Chapter 2 | Chapter 3 | Chapter 4 | Chapter 5 | Chapter 6 | Chapter 7 | Chapter 8 | Chapter 9 Chapter 10 | Chapter 11 | Appendix A | Appendix B | Appendix C | Appendix

- Rapid Bioassessment Protocols
For Use in Streams and Wadeable Rivers:
Periphyton, Benthic Macroinvertebrates, and Fish
Second Edition

- Michael T. Barbour
Jeroen Gerritsen
Blaine D. Snyder
James B. Stribling

- EPA 841-B-99-002

http://www.epa.gov/owow/monitoring/rbp/

Rapid Bioassessment Protocols (EPA)

- Chapter 6—Periphyton Protocols
- Chapter 7—Benthic Macroinvertebrate Protocols
- Chapter 8—Fish Protocols

Reasons to Assess Macroinvertebrate Populations

- **Aquatic macroinvertebrates are an important part of the food chain found in and around a body of water.**

  Aquatic macroinvertebrates are a link in the aquatic food chain. In most streams, the energy stored by plants is available to animal life either in the form of leaves that fall in the water or in the form of algae that grows on the stream bottom. The algae and leaves are eaten by macroinvertebrates. The macroinvertebrates are a source of energy for larger animals such as fish, which in turn, are a source of energy for other animals and even man.

Reasons to Assess Macroinvertebrate Populations

- **Aquatic macroinvertebrates differ in their sensitivity to water pollution.**

  Some aquatic macroinvertebrates cannot survive in polluted water. Others can survive or even thrive in polluted water. In a healthy stream, the macroinvertebrate community will include a variety of pollution-sensitive macroinvertebrates. In an unhealthy stream, there may be only a few types of non-sensitve macroinvertebrates present.

Reasons to Assess Macroinvertebrate Populations

- **Aquatic macroinvertebrates provide information about the quality of a stream over long periods of time.**

  It may be difficult to identify stream pollution with water analysis such as pH and dissolved oxygen, which can only provide information for the time of sampling. Even the presence of fish may not provide information about a pollution problem because fish can move away to avoid polluted water and then return when conditions improve. However, most aquatic macroinvertebrates cannot move to avoid pollution. A macroinvertebrate sample may provide information about pollution that is not present at the time of sample collection.

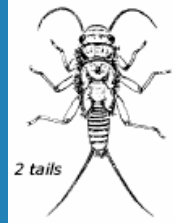
Reasons to Assess Macroinvertebrate Populations

- **Aquatic macroinvertebrates are relatively easy to collect.**

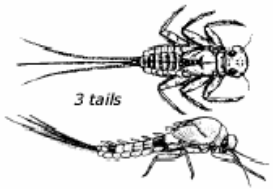
  Useful aquatic macroinvertebrate data is easy to collect without expensive equipment. The data obtained by taking a macroinvertebrate survey can serve to indicate the need for additional data collection on water samples.

Macroinvertebrate Identification Key

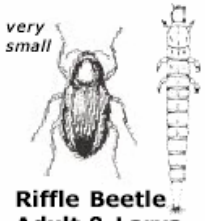
GROUP 1 – Very Intolerant of Pollution



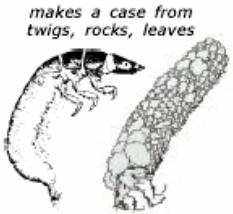
Stonefly Nymph



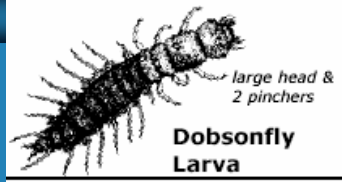
Mayfly Nymph



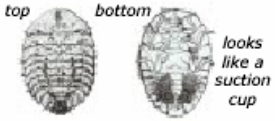
Riffle Beetle Adult & Larva



Caddisfly Larva



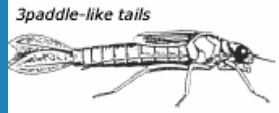
Dobsonfly Larva



Water Penny Larva

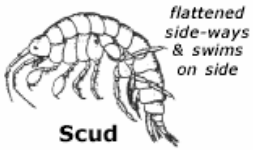
Right-Handed Snail

GROUP 2 – Moderately Intolerant of Pollution

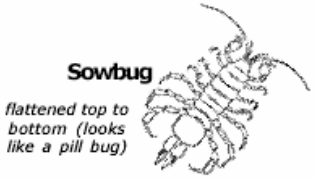


Damselfly Nymph

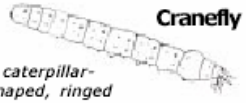
Dragonfly Nymph



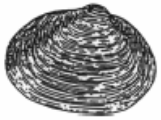
Scud



Sowbug



Cranefly



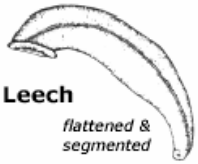
Clam/Mussel

GROUP 3 – Fairly Tolerant of Pollution

Midge Larva

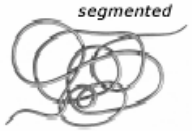
Planaria

Black Fly Larva



Leech

GROUP 4 – Very Tolerant of Pollution



Aquatic Worms

Left-Handed Snail

Rat-tailed Maggot

Blood Worm Midge Larva

What and How Do They Eat?

Macroinvertebrates may be categorized by their feeding groups - the type of food they eat and the manner in which food is obtained/collected.

Shredder: feeds on coarse, dead organic matter (leaves, grasses, algae, and rooted aquatic plants), breaking it into finer material that is released in their feces. Shredders include stonefly nymphs, caddisfly larvae, cranefly larvae.

Collector: feeds on fine, dead organic matter, including that produced by the shredders.

- **Filtering collector:** filters particles out of flowing current. Examples include blackfly larvae and net-building caddisflies.
- **Gathering collector:** gathers matter while crawling along the river bottom. Gatherers include mayfly nymphs, adult beetles, midge larvae.

Grazer: grazes on algae growing on rocks in the substrate or on vegetation. Grazers include snails and water pennies.

Predator: feeds on other invertebrates or small fish. Mouth parts are specially adapted to feed on prey. Dragonflies and damselflies have scoop-like lower jaws, the jaws of hellgrammites (dobsonflies) are pincer-like, and water strider's mouth parts are spear-like. Also includes beetle adults and larvae.

What Do They Look Like?

A simple key to bethic macroinvertebrates is provided on the following pages. The organisms are grouped according to pollution tolerance, starting with the most intolerant families. Figure 14 below may help you identify the distinguishing features of many of the organisms.

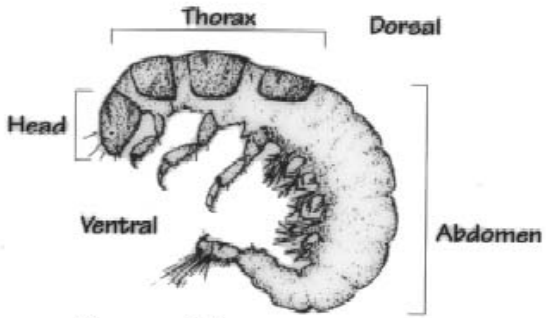
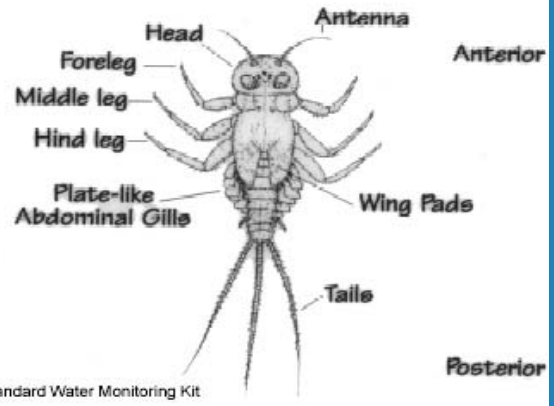


Figure 14

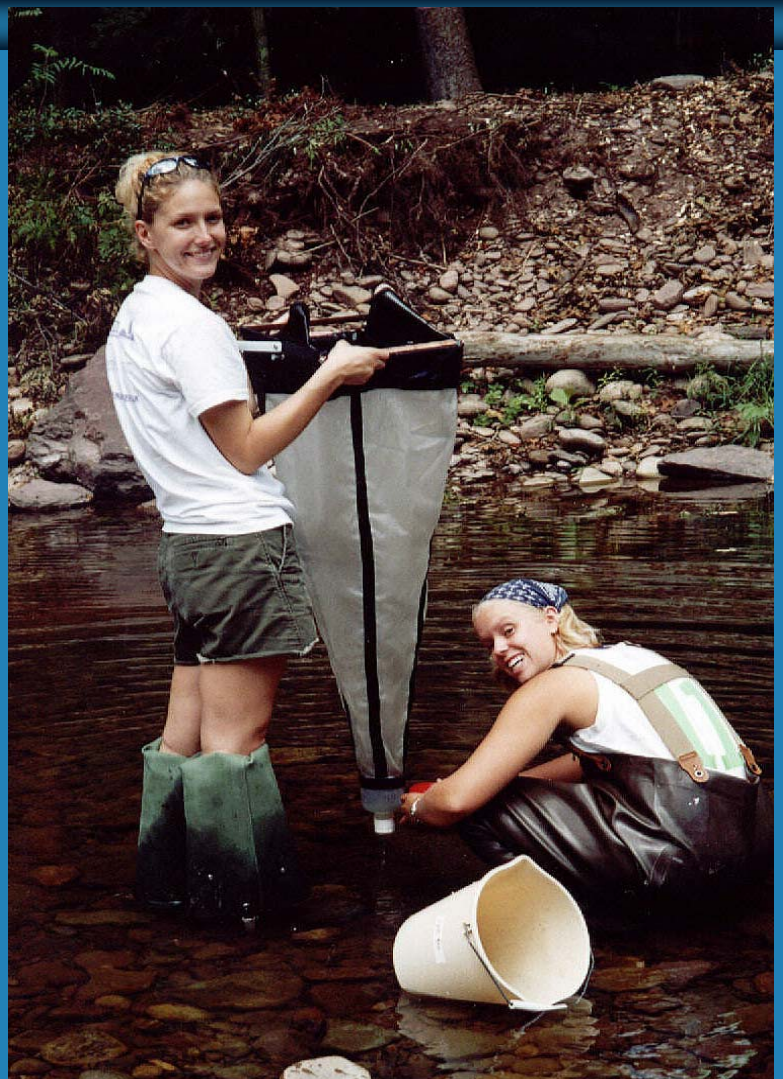


Figures from GREEN Standard Water Monitoring Kit

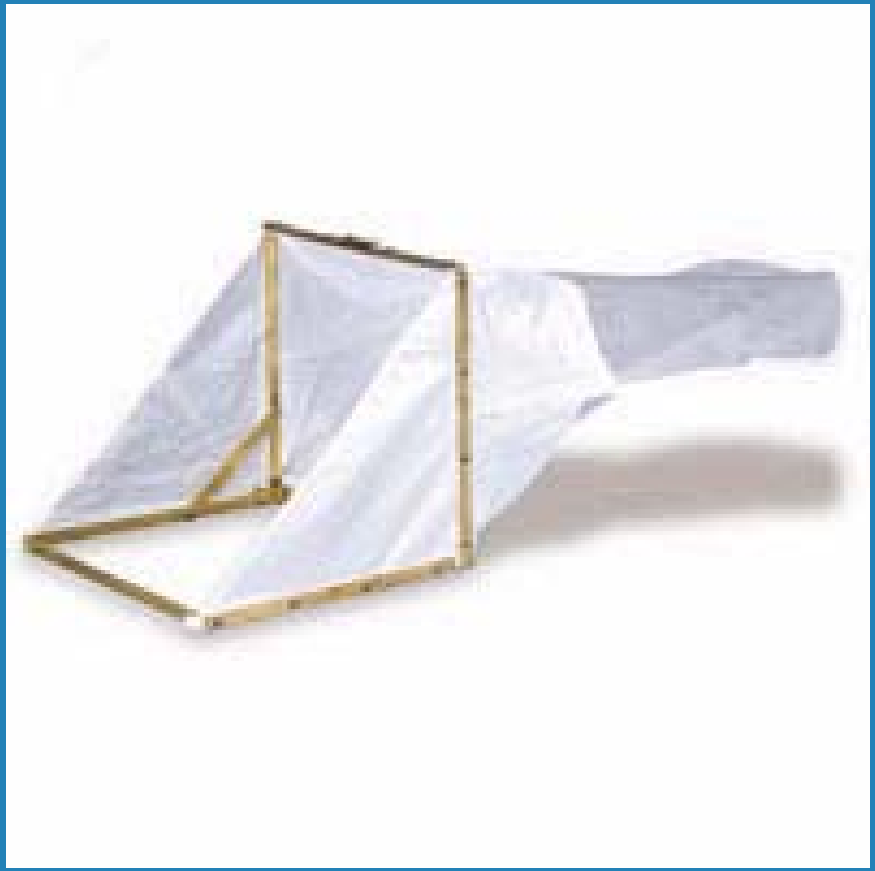
Standard Benthic Macroinvertebrate Sampling Gear Types for Streams (500 µ screen)

- **Kick net:** Dimensions of net are 1 meter (m) x 1 m attached to 2 poles and functions similarly to a fish kick seine. Is most efficient for sampling cobble substrate (i.e., riffles and runs) where velocity of water will transport dislodged organisms into net. Designed to sample 1 m^2 of substrate at a time and can be used in any depth from a few centimeters to just below 1m (Note -- Depths of 1m or greater will be difficult to sample with any gear).
- **Surber:** Dimensions of frame are 0.3 m x 0.3 m, which is horizontally placed on cobble substrate to delineate a 0.09 m^2 area. A vertical section of the frame has the net attached and captures the dislodged organisms from the sampling area. Is restricted to depths of less than 0.3 m.
- **Hess:** Dimensions of frame are a metal cylinder approximately 0.5 m in diameter and samples an area 0.8 m^2. Is an advanced design of the Surber and is intended to prevent escape of organisms and contamination from drift. Is restricted to depths of less than 0.5 m.

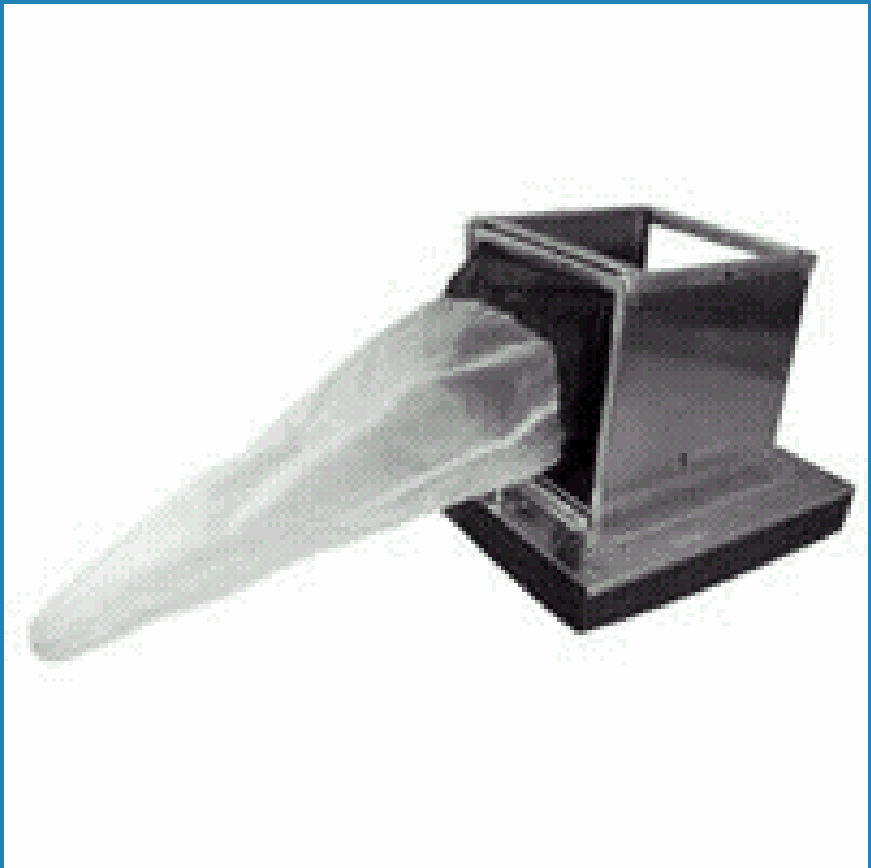
Surber & Kick Net Sampling



Surber Sampler



Hess Sampler



Standard Benthic Macroinvertebrate Sampling Gear Types for Streams (500 µ screen)

- **D-frame dip net:** Dimensions of frame are 0.3 m width and 0.3 m height and shaped as a "D" where frame attaches to long pole. Net is cone or bag-shaped for capture of organisms. Can be used in a variety of habitat types and used as a kick net, or for "jabbing", "dipping", or "sweeping".
- **Rectangular dip net:** Dimensions of frame are 0.5 m width and 0.3 m height and attached to a long pole. Net is cone or bag-shaped. Sampling is conducted similarly to the D-frame.

Dip Nets

Hester Dendy Sampler

Habitat Assessment

Technical Tips: Macroinvertebrate Collecting

by Kevin Kelly and Kristen Travers, Monitoring Matters, Oct 2002

- WHEN COLLECTING MACROINVERTEBRATE ORGANISMS FOR MONITORING PURPOSES, BE CONSISTENT IN ALL YOU DO, INCLUDING:

- Collect in the same season each year. Spring (or autumn) give best results and allow samples to be compared to one another. Collect from similar habitats if samples are to be compared. Use a standard size net – typically a 1 square meter kick screen or 1 foot D-frame.

- Use a standard size mesh, or if you use homemade nets, be consistent with the mesh size of the screen you select. Very fine screening (about 500 micron openings) is usually best. Apply the same sampling effort every time you revisit a site. Try to locate sites at least 100 yards upstream of bridges and other stream obstructions. Obstructions affect velocity, depth, and habitat quality.

- Start downstream and work upstream.

Technical Tips: Macroinvertebrate Collecting

by Kevin Kelly and Kristen Travers, Monitoring Matters, Oct 2002

- Reference collection specimens or “unknowns” for further study should be preserved in straight rubbing alcohol. It works great, is cheap, and is much safer than more traditional preservatives like formaldehyde.
- Don’t label lids of collecting jars. Lids can get swapped around. Label the jar, or better yet, put a paper label, filled out in pencil, inside the jar.
- Keep all equipment in good repair and clean. Don’t “accidentally” let critters take a ride on your net from one site to another site. They could get mixed in with your new sample and skew your results.
- Cleaning nets and equipment is especially critical before moving to a different water body. Prevent introductions of unwanted species such as zebra mussels!

Quality Assurance

- Quality assurance (QA) is a system you put into place to insure that your data will meet standards of quality that you define. Putting everything in writing is a very important QA measure. It helps you keep track of your procedures, provides a written reference for your volunteers, and is a resource for people outside your program to discover what's behind your results. A QA binder specific to your group should be prepared. Things that you should put into this binder include manuals, copies of procedures, equipment and supplies records, sampling locations, field/lab sheets, and your study design.

Quality Control

- Quality control (QC) measures are the specific measures you will take during the collection and analysis of your samples to ensure the accuracy (how close to the real results you are) and precision (how reproducible your results are) of your monitoring. QC procedures should include both “internal measures” analyzed by the project field coordinator (someone selected and trained in your group) and “external measures” analyzed by people and/or labs outside your program.

Suggestions for QC in the Field

- Sample labels must be properly completed, including the sample ID code, data, stream name, sampling location, and collector's name, then placed into the sample container. The outside of the container should include the same information, and chain of custody forms, if needed, should be included.

- After sampling has been completed at a given site, all nets, pans, etc., that have been used should be rinsed, examined carefully, and picked free of organisms and debris. Any additional organisms should be placed into the sample container.

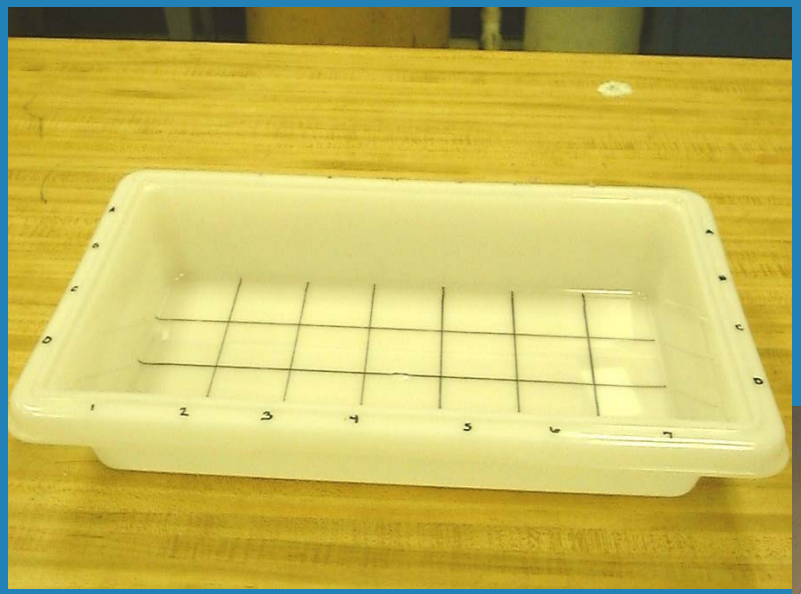
- Replicate (1 duplicate sample) 10% of the sites to evaluate precision or repeatability of the sampling technique or collection team.

Suggestions for QC in Sorting

- Ten percent of the sorted samples in each lot should be examined by laboratory QC personnel or a qualified co-worker. (A lot is defined as a special study, entire index period, or individual sorter.) The QC worker will examine the grids chosen and tray used for sorting and will look for organisms missed by the sorter. Organisms found will be added to the sample vials. If the QC worker finds less than 10 organisms (or 10% in larger sub-samples) remaining in the grids or sorting tray, the sample passes. If more than 10 organisms (or 10%) are found, the sample fails. If the first 10% of the sample fails, a second 10% of the sample lot should be checked by the QC worker. Sorters in training should have their samples 100% checked until the trainer decides that training is complete.

- After laboratory processing is complete for a given sample, all sieves, pans, trays, etc., that have come in contact with the sample should be rinsed thoroughly, examined carefully, and picked free of organisms or debris. Organisms found should be added to the sample residue.

Grid Sorting Pan



Cookie Cutter Sub-sampler

Sorting in Lab

Suggestions for QC for Taxonomy

- A voucher collection of all samples should be maintained. These specimens should be properly labeled, preserved, and stored in the laboratory for future reference. A taxonomist (the reviewer) not responsible for the original identification should spot check samples at a predetermined level.
- Information on samples completed (through identification process) will be recorded in the “sample log” notebook to track the progress of each sample within the lot.
- A library of basic taxonomic literature is essential in aiding identification of specimens and should be maintained and updated as needed.
- Taxonomists should participate in periodic training on specific taxonomic groups to ensure accurate identifications.

Web Sites: Keys/Images of Macroinvertebrates

- Missouri Stream Team—images of macros divided by sensitivity to pollution: http://www.rollanet.org/~streams/macroinv/
- Simple key and analysis method: http://www.state.in.us/dnr/soilcons/riverwatch/vsm/manual.html
- New York Department of Environmental Conservation—macroinvertebrate key/identification. Good color photos. http://www.dec.state.ny.us/website/dow/stream/orderpageone.htm
- Link to several macroinvertebrate keys and resources: http://users.net1plus.com/tdriskell/macroinvertebrates.html
- Slide set of major macroinvertebrate groups can be purchased: http://www.benthos.org/Education/index.cfm

Order-Ephemeroptera (Mayflies)

Order-Trichoptera (Caddisflies)

Order-Plecoptera (Stoneflies)

Order- Coleoptera (Water Beetles)

Order- Odonata (Damselflies & Dragonflies)

Order- Megaloptera (Dobsonflies & Alderflies)

Order- Hemiptera (Water strider, Backswimmer & Water Boatman)

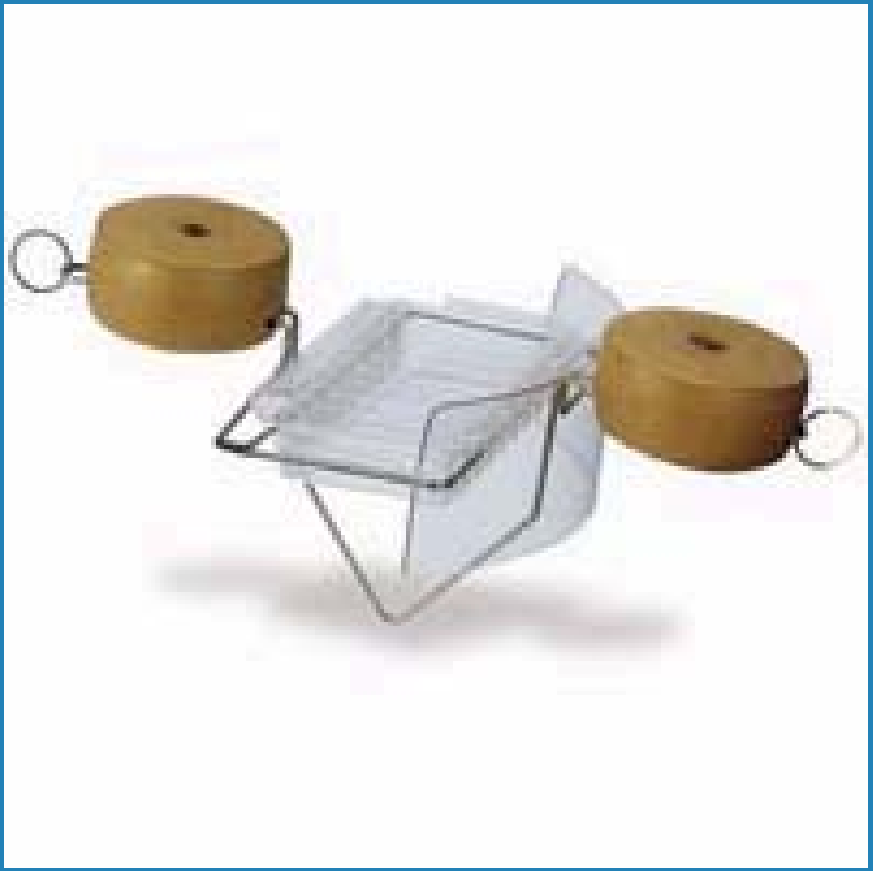
Field Equipment for Periphyton Sampling—Natural Substrates

- stainless steel teaspoon, toothbrush, or similar brushing and scraping tools
- section of PVC pipe (3" diameter or larger) fitted with a rubber collar at one end
- field notebook or field forms*; pens and pencils
- white plastic or enamel pan
- petri dish and spatula (for collecting soft sediment)
- forceps, suction bulb, and disposable pipettes
- squeeze bottle with distilled water
- sample containers (125 ml wide-mouth jars)
- sample container labels
- preservative [Lugol's solution, 4% buffered formalin, "M3" fixative, or 2% glutaraldehyde (APHA 1995)]
- first aid kit
- cooler with ice

Summary of Collection Techniques for Periphyton from Wadeable Streams

- Removable substrates (hard): gravel, pebbles, cobble, and woody debris—Remove representative substrates from water; brush or scrape representative area of algae from surface and rinse into sample jar.
- Removable substrates (soft): mosses, macroalgae, vascular plants, root masses—Place a portion of the plant in a sample container with some water. Shake it vigorously and rub it gently to remove algae. Remove plant from sample container.
- Large substrates (not removable): boulders, bedrock, logs, trees, roots—Place PVC pipe with a neoprene collar at one end on the substrate so that the collar is sealed against the substrate. Dislodge algae in the pipe with a toothbrush, nail brush, or scraper. Remove algae from pipe with pipette.
- Loose sediments: sand, silt, fine particulate organic matter, clay—Invert petri dish over sediments. Trap sediments in petri dish by inserting spatula under dish. Remove sediments from stream and rinse into sampling container. Algal samples from depositional habitats can also be collected with spoons, forceps or pipette.

Periphyton Sampler



Field Equipment/Supplies Needed for Periphyton Sampling—Artificial Substrates

- periphytometer (frame to hold artificial substrata)
- microslides or other suitable substratum (e.g., clay tiles, sanded Plexiglass® plates, or wooden or acrylic dowels)
- sledge hammer and rebars
- toothbrush, razor blade, or other scraping tools
- water bottle with distilled water
- white plastic or enamel pan
- aluminium foil
- sample containers
- sample container labels
- field notebook (waterproof)
- preservative [Lugol's solution, 4% buffered formalin, "M^3" fixative, or 2% glutaraldehyde (APHA 1995)]
- cooler with ice

Electrofishing Configuration and Field Team Organization

- Backpack electrofisher with 2 hand-held electrodes mounted on fiberglass poles, one positive (anode) and one negative (cathode). One crew member, identified as the electrofisher unit operator, carries the backpack unit and manipulates both the anode and cathode poles. The anode may be fitted with a net ring (and shallow net) to allow the unit operator to net specimens. The remaining 1 or 2 team members net fish with dip nets and are responsible for specimen transport and care in buckets or livewells.

- Backpack electrofisher with 1 hand-held anode pole and a trailing or floating cathode. The electrofisher unit operator manipulates the anode with one hand, and has a second hand free for use of a dip net. The remaining 1 or 2 team members also aid in the netting of specimens, and in addition are responsible for specimen transport in buckets or livewells.

- Tote barge (pramunit) electrofisher with 2 hand-held anode poles and a trailing/floating cathode (recommended for large streams and wadeable rivers). Two team members are each equipped with an anode pole and a dip net. Each is responsible for electrofishing and the netting of specimens. The remaining team member will follow, pushing or pulling the barge through the sample reach. A livewell is maintained within the barge and/or within the sampling reach but outside the area of electric current.

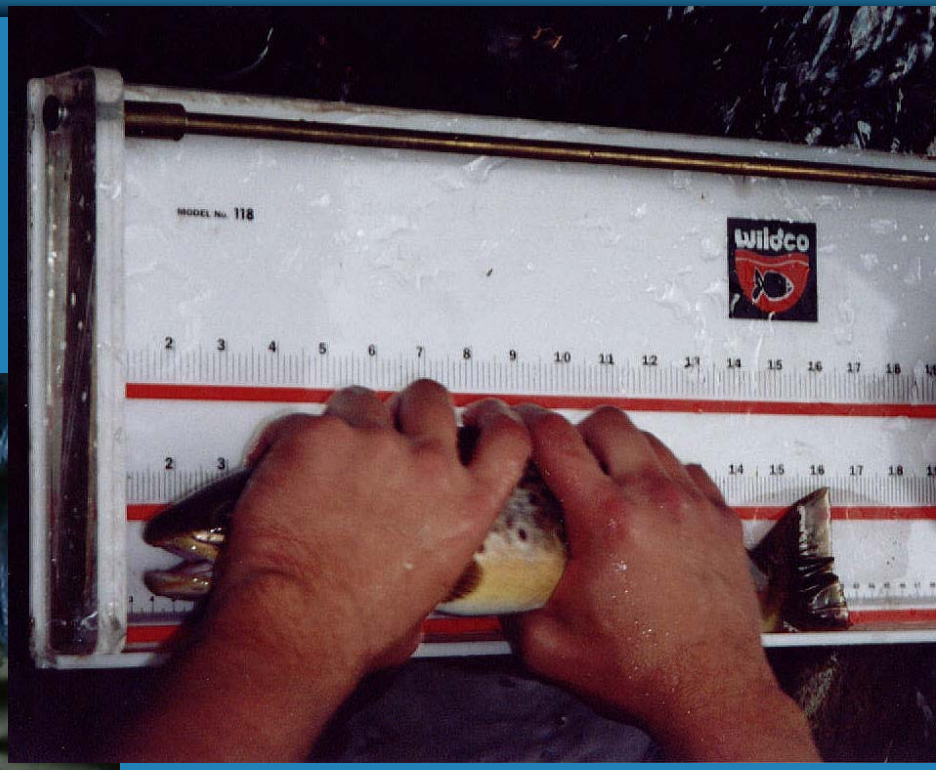
Field Equipment/Supplies Needed for Fish Sampling—Electrofishing

- appropriate scientific collection permit(s)
- backpack or tote barge-mounted electrofisher
- dip nets
- block nets (i.e., seines)
- elbow-length insulated waterproof gloves
- chest waders (equipped with wading cleats, when necessary)
- polarized sunglasses
- buckets/livewells
- jars for voucher/reference specimens
- waterproof jar labels
- 10% buffered formalin (formaldehyde solution)
- measuring board (500 mm minimum, with 1 mm increments)[a]
- balance (gram scale)[b]
- tape measure (100 m minimum)
- fish Sampling Field Data Sheet[c]
- applicable topographic maps
- copies of field protocols
- pencils, clipboard
- first aid kit
- Global Positioning System (GPS) Unit

Back-pack Electroshocking

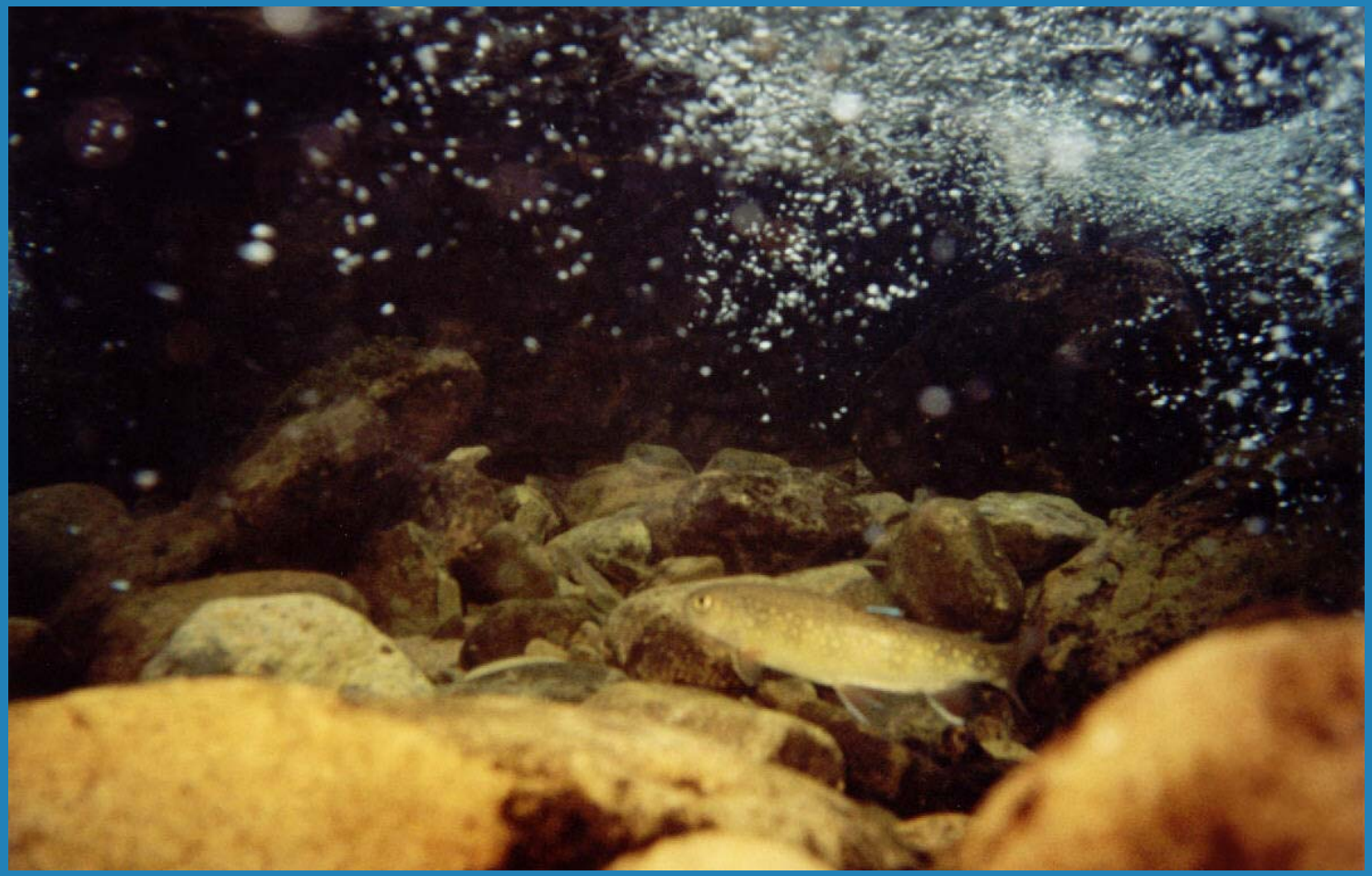
Electroshocking

Measuring/Weighing Trout



Snorkeling

Tagged Trout



Where to Find Biological Equipment and Supplies

Ben Meadows	800-241-6401	www.benmeadows.com
Forestry Supply	800-647-5368	www.forestry-suppliers.com
LaMotte Company	800-344-3100	www.lamotte.com
Wildlife Supply Company (Wildco)	800-799-8301	www.wildco.com
Smith-Root.com	360-573-0202	www.smith-root.com
Carolina Biological	800-334-5551	www.carolina.com
Ward's Biology	800-962-2660	www.wardsci.com

The End