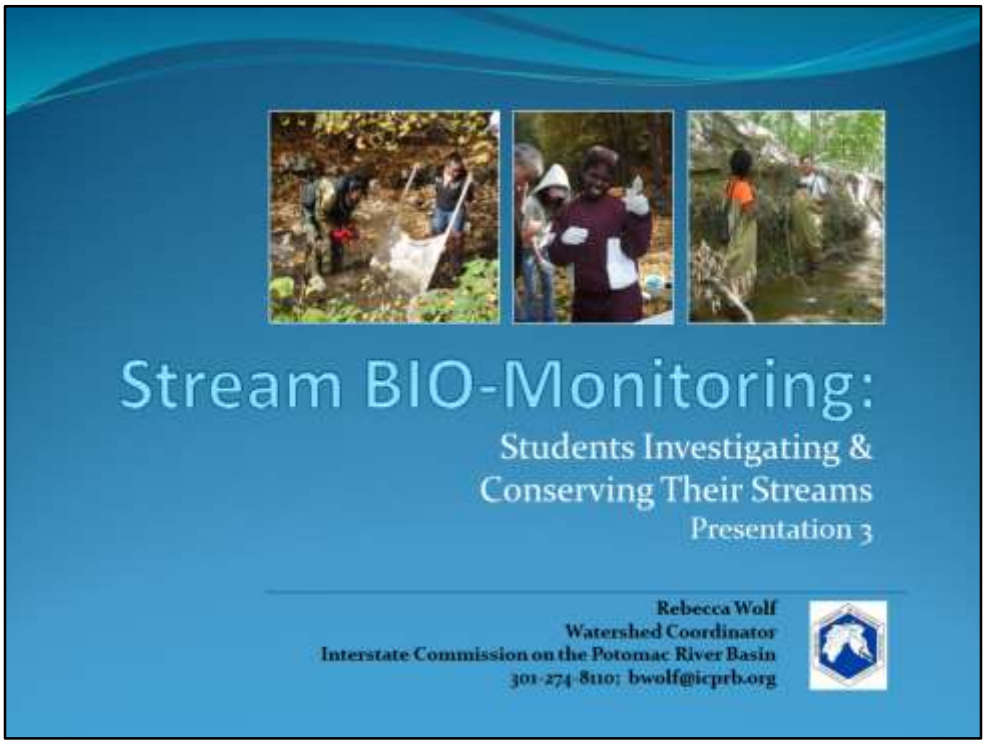
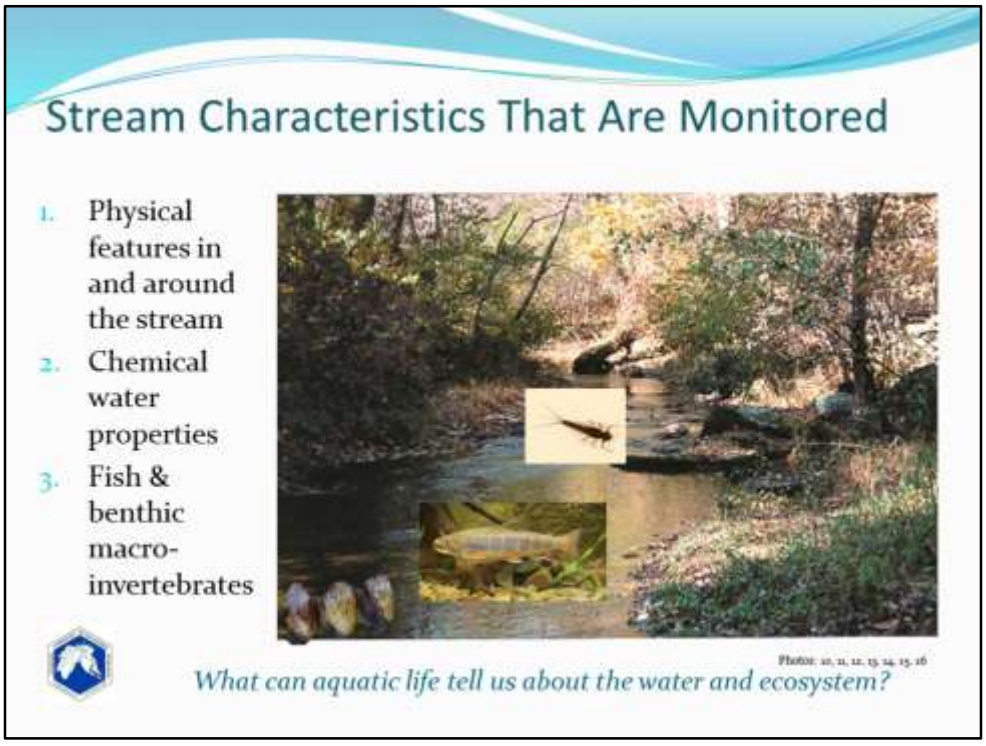


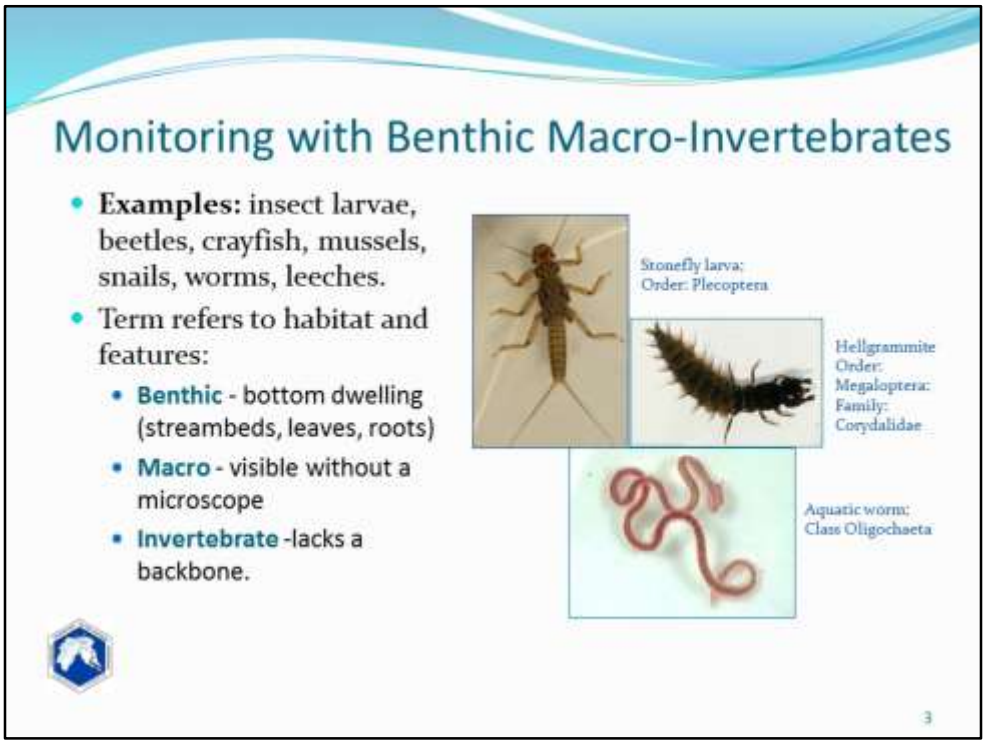
Teacher notes are provided.
For an additional highly readable resource on benthic macroinvertebrate life cycles and habits, see *A guide to Common Freshwater Invertebrates of North America*, J. Reese Voshell, Jr.

My appreciation goes to Dan Boward and the Maryland Biological Stream Survey for the educational resources and support they have provided to me and other through their personal efforts and on-line resources.



Likely, your students are familiar with this stream from previous presentations. We use it again to introduce these concepts:

- To determine the condition of riverine ecosystems, scientists and citizen scientists evaluate three aspects of stream ecosystems: the physical aspects of the stream, including the instream and riparian habitat, stream chemical properties, and aquatic species, particularly fish and benthic macroinvertebrates.
- **The most telling aspect is the diversity and abundance of fish and benthic macroinvertebrates living in the stream, because this reflects the ongoing, long-term condition of the system. Ask if your students have any thoughts on why this might be.**



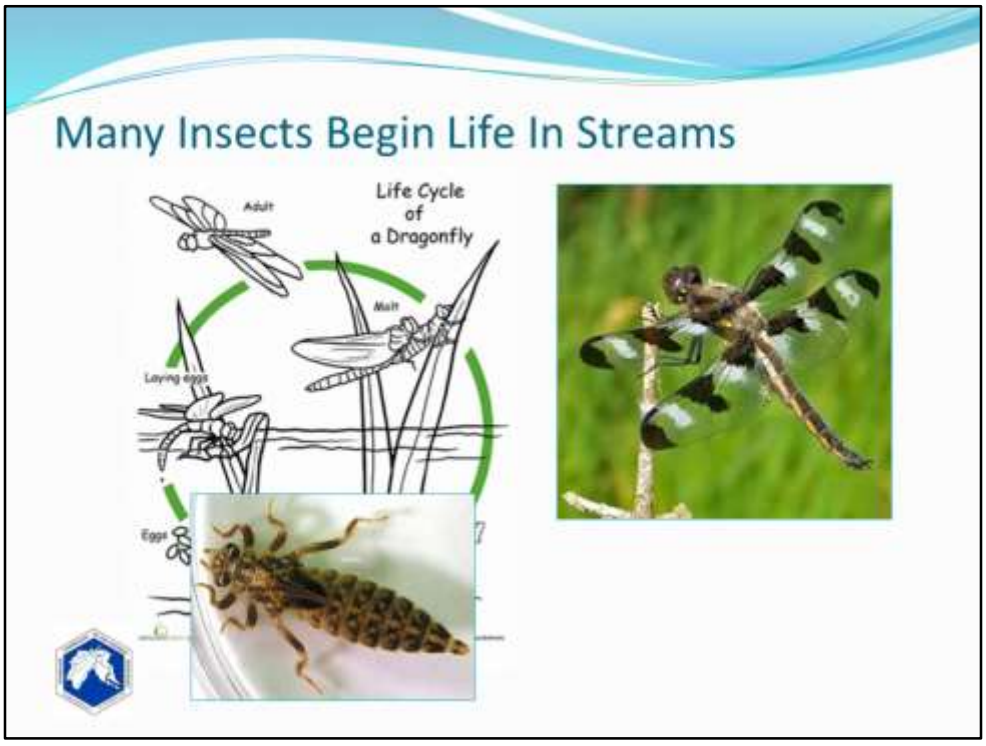
The type of monitoring we will learn today involves collecting benthic macroinvertebrates from various habitats in a stream. This type of monitoring is called BIOMONITORING.

Just as we might guess from the name "benthic macroinvertebrates," these types of organisms live on or near **the bottom** of a stream , or more accurately, on the substrate of stream – which can be on and under a stream bed, on submerged logs and twigs, on roots hanging into a stream, or plants.

Benthic macroinvertebrates are small, usually less that an inch long, but they are **visible without a microscope**, hence, the prefix **macro**.

Being an invertebrate means that they lack a backbone. This also means they are cold blooded and cannot regulate their own body temperature.

The majority of benthic macroinvertebrates you will collect will be insects in their juvenile stage. But when investigating streams, you also will collect crayfish, mussels, snails, worms, and leeches, and other organisms.

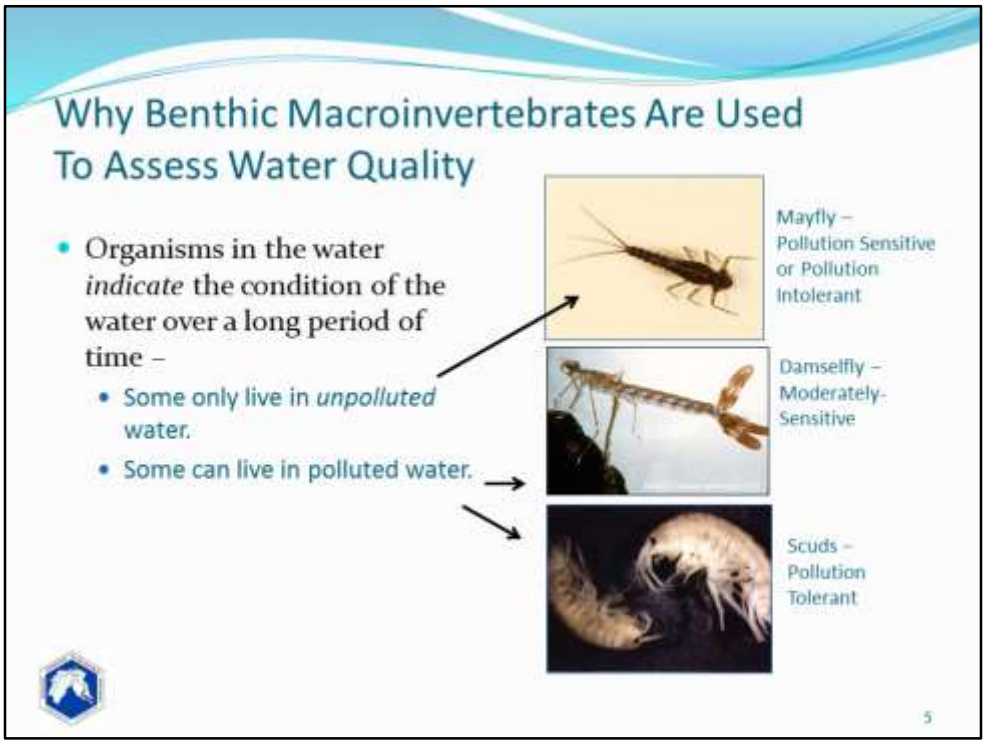


Many insects start their lives in the water. They go through different stages – metamorphosis – from eggs to larvae to adults when they emerge from the water to fly away and mate. (The juveniles of insects that go through *incomplete metamorphosis are called nymphs*.) A dragonfly has a life span of more than a year, but very little of that life is spent as the adult dragonfly we recognize. There are three stages of the dragonfly life cycle, the egg, the nymph, and the adult dragonfly. Most of the life cycle of a dragonfly is lived out in the nymph stage - See more at: http://www.dragonfly-site.com/dragonfly-life-cycle.html#sthash.qvsvlpsG.dpuf

FOR YOUNG AUDIENCE:
When you were a baby you had the same body parts as your parents even though you were smaller. Insects are different. The female adult lays eggs on the water or on plants near the water. When the eggs hatch, a young dragonfly – a dragonfly nymph – comes out.
This is a young dragonfly. It looks a lot different that the adult, doesn't it? It doesn't have big wings, just the pads that will develop into wings. But it won't need wings until it leaves its underwater life. When it is big enough, it will climb on a rock or other surface, shed its old skin, and emerge as a mighty and beautiful dragonfly.

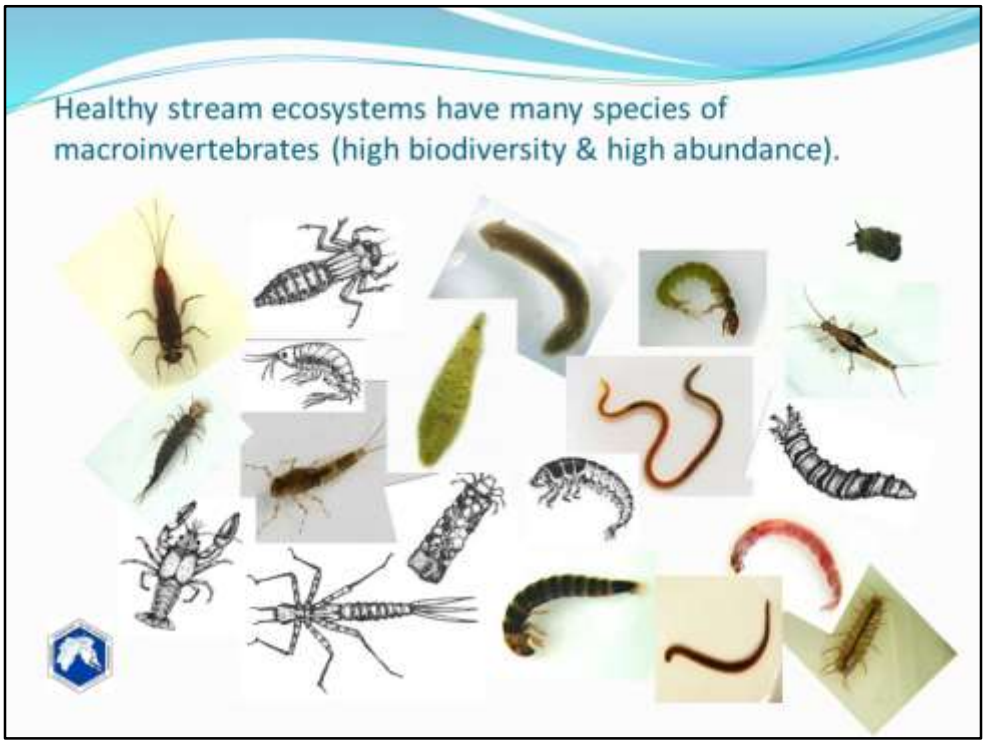
DRAGONFLY FACTS: Female dragonflies lay eggs in or near water, often on floating or emergent plants. When laying eggs, some species will submerge themselves completely in order to lay their eggs on a good surface. The eggs then hatch into naiads (nymphs). Most of a dragonfly's life is spent in the naiad form, beneath the water's surface, using extendable jaws to catch other invertebrates (often mosquito larvae) or even vertebrates such as tadpoles and fish.[5] They breathe through gills in their rectum, and can rapidly propel themselves by suddenly expelling water through the anus.[6]

The larval stage of large dragonflies may last as long as five years. In smaller species, this stage may last between two months and three years. When the naiad is ready to metamorphose into an adult, it climbs up a reed or other emergent plant. Exposure to air causes the naiad to begin breathing. The skin splits at a weak spot behind the head and the adult dragonfly crawls out of its larval skin, pumps up its wings, and flies off to feed on midges and flies. In flight the adult dragonfly can propel itself in six directions; upward, downward, forward, back, and side to side.[8] The adult stage of larger species of dragonfly can last as long as five or six months.



Benthic macroinvertebrates reflect *ongoing* stream conditions, as they spend months to years in the water.
Some organisms are pollution intolerant (or pollution-sensitive). These organisms require optimal conditions and cannot tolerate polluted conditions, such as low dissolved oxygen, high temperatures, or sedimentation. Other organisms can tolerate some pollution.

For these reasons, benthic macroinvertebrates can serve as ***indicators*** of water quality. Scientists call pollution-sensitive species **indicator species**, because their presence or absence indicates the level of health or pollution of a stream.



So we can tell much about the condition of a stream by collecting and keeping data on the amazing organisms living in it. The healthiest streams have *many benthic macroinvertebrates of many different species*, including those that can only live in unpolluted water. In other words, they have **high biodiversity and high abundance.**

Teachers can take time to see if students recognize any of these organisms.

Polluted streams have fewer species.

Only pollution-tolerant organisms.

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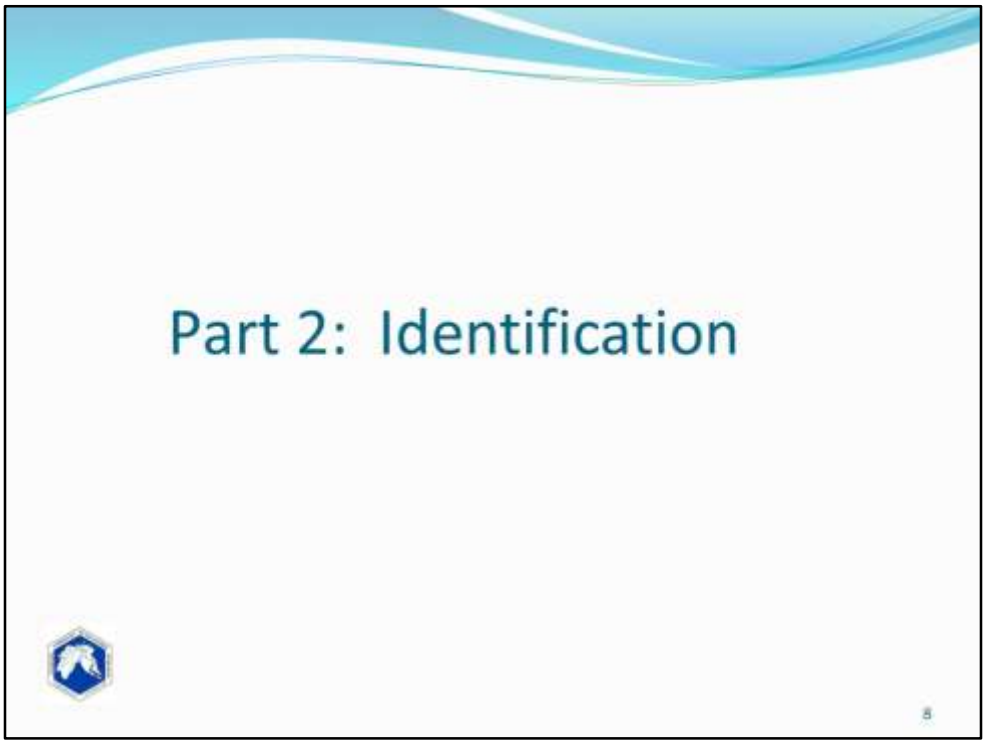


Teachers, if you have preserved samples, you could have students practice ID after this presentation, using the keys and data forms noted in the reference section.

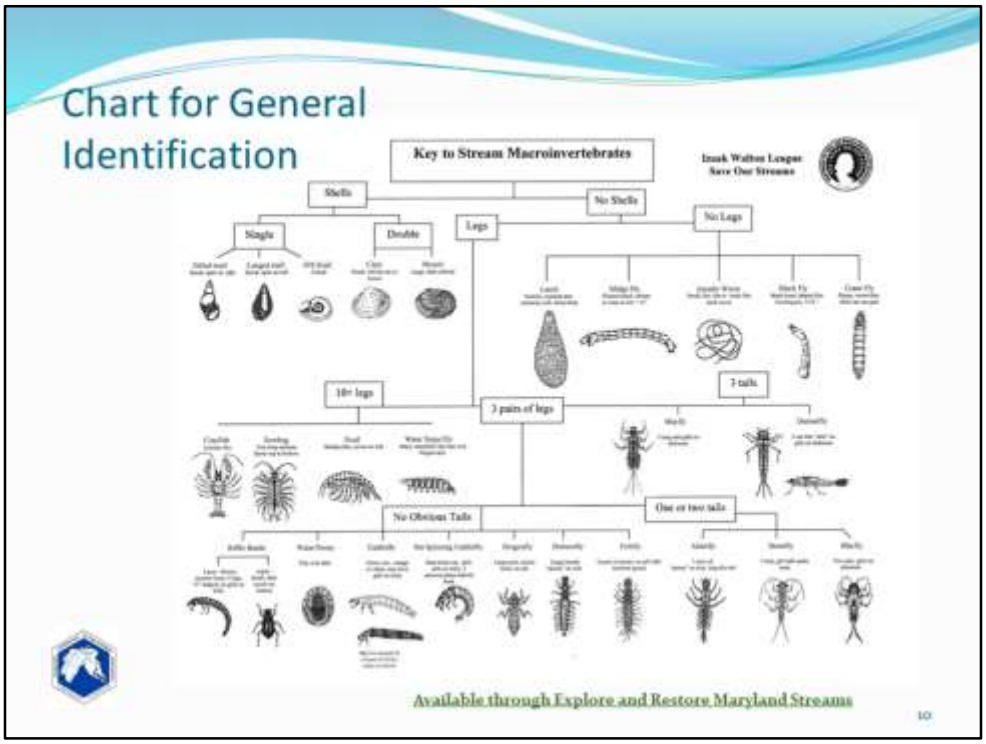
This slide can be skipped, if desired. It is meant to give students an understanding that when they identify a dragonfly, it is a species of dragonfly in the Order Odonata (which has suborders and families).

Scientists use scientific names, so that scientists around the world will have the same name for the same species. This is important, because common names can be different in different parts of the United States. You'll see that the common names for snails on the DNR and IWL keys are even different!

It is sufficient for citizen scientists to identify organisms to their order or family level. There are many different types (species) of organisms with each order or family.

It also is sufficient for citizen scientists to use common names.

We are *Homo sapiens*…..
Class: Mammalia
Order: Primates
Family: Hominidae
Genus: Homo
Species: H. sapiens
Subspecies: H. s. sapiens



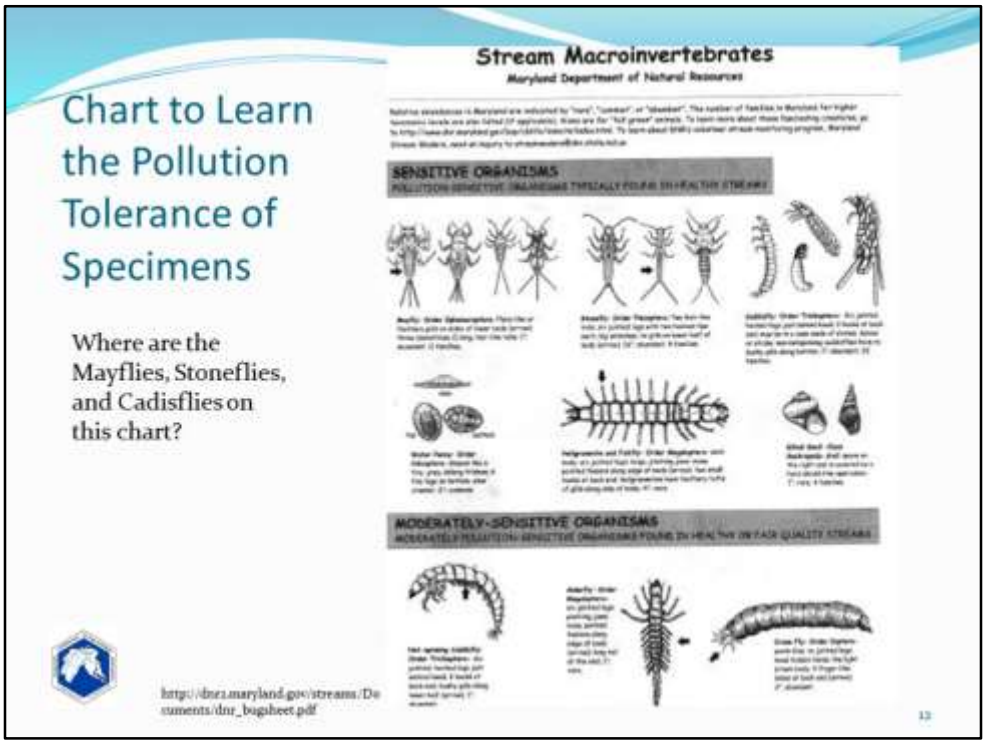
Dichotomous keys, such as this, are commonly used to identify many different things – plants, trees, fish. This one is designed to help us identify the types of benthic macroinvertebrates that we collect. **Go through this key with the students to ensure they understand how to use it.**

This key can be downloaded and handed out at this time, if wished. See resources at the end of this presentation.

Three orders of insect larvae are the most important in determining the stream condition. These INDICATOR organisms belong to three orders –

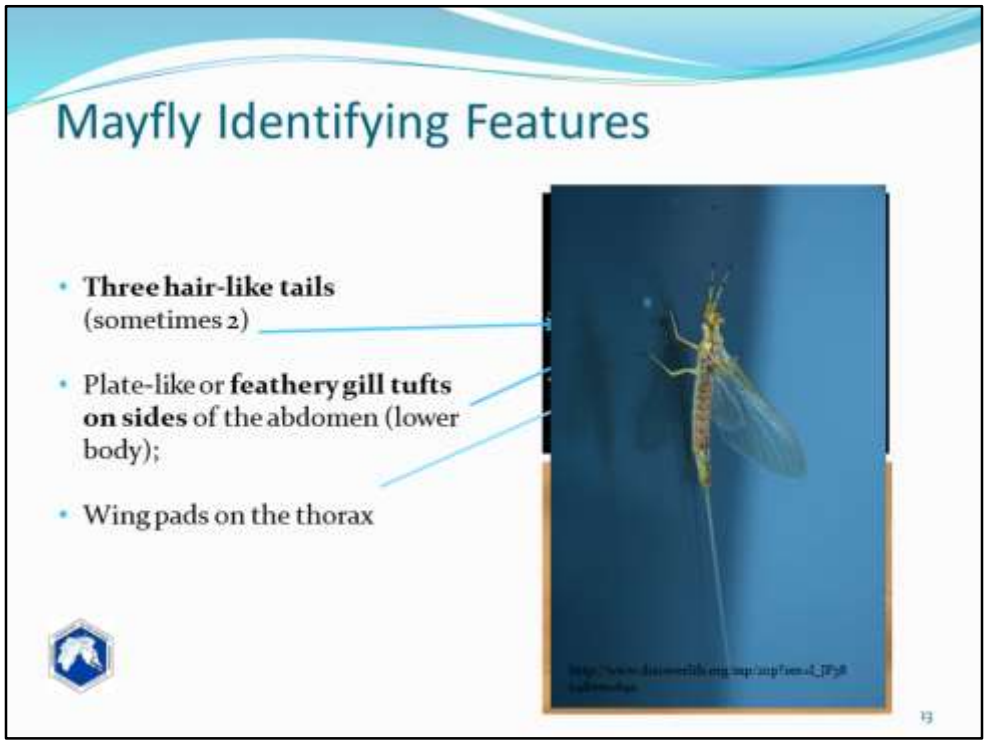
- the Mayflies in the Order Ephemeroptera;
- Stonefly in the order Plecoptera,
- and Caddisflies in the order Trichoptera.

If you are in a stream with an abundance of **EPTs (as they are known for short)**, it is likely the stream conditions are good for aquatic life.



The Maryland Department of Natural Resources gives this chart to citizen scientists to learn of the different levels of pollution tolerance of species.

Go over this chart with students. Have them read the headings or have one pick out an organism, and have the others find its tolerance.

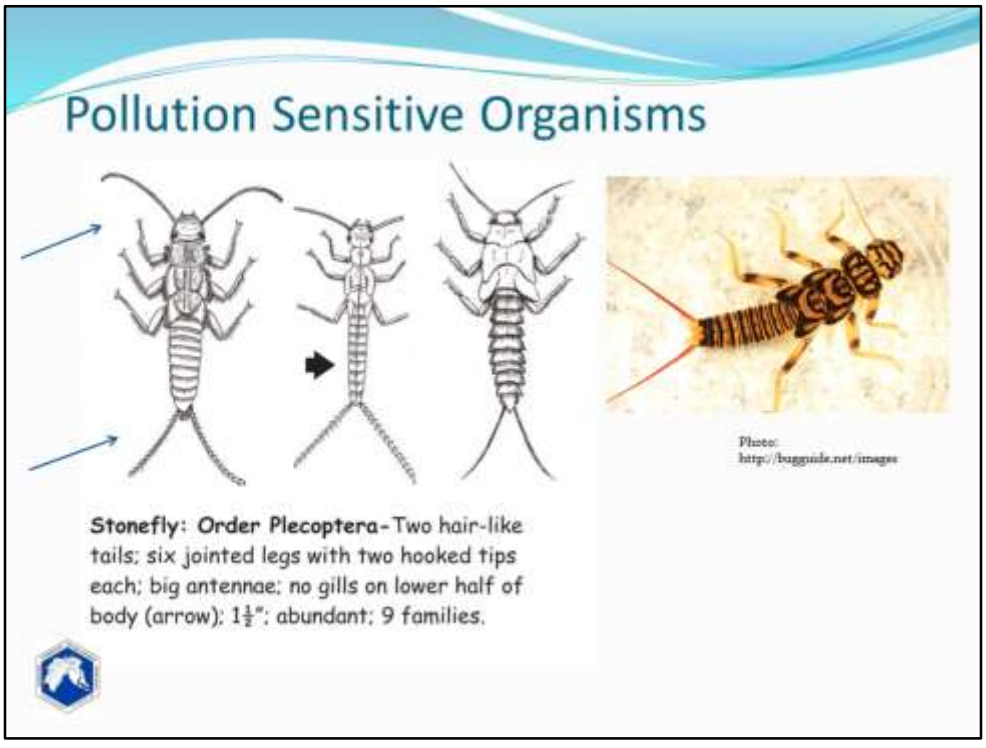


You can use the benthic macroinvertebrate sheet from the MD DNR while viewing the next group of slides. The sheet includes descriptions about the insect larvae and groups them according to their levels of pollution tolerance. (Teachers: see link in the resources for this sheet.)

As shown earlier, one of the most pollution-sensitive species is in the mayfly order – known as Ephemeroptera. Most mayflies need cool, well oxygenated water, unpolluted water.

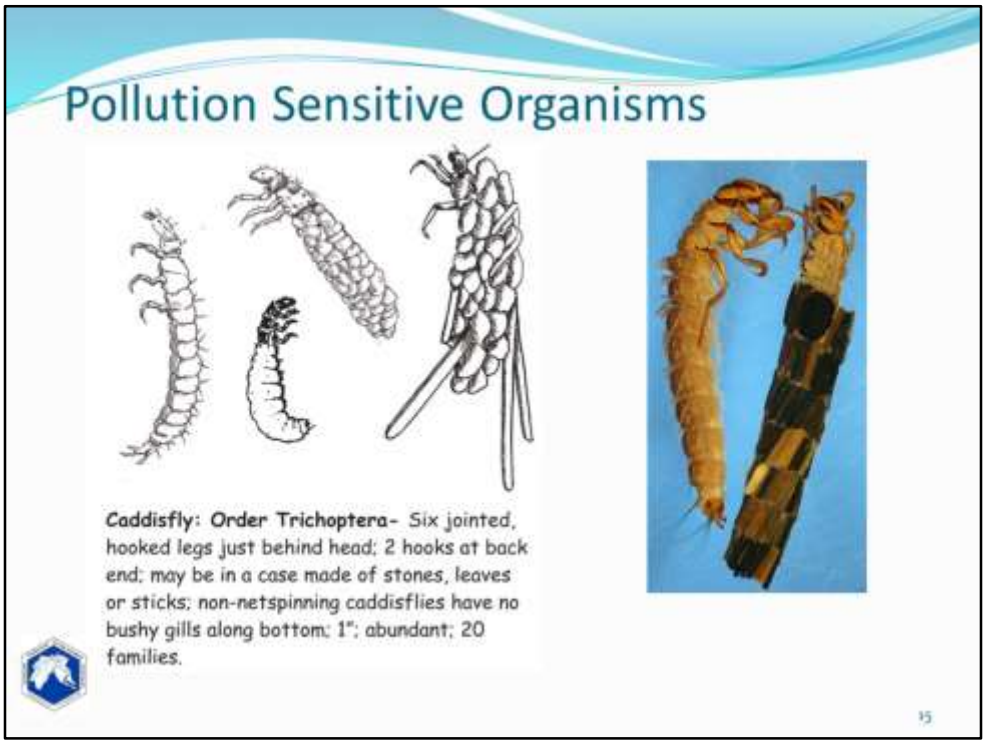
An easy way to remember the name is that most mayflies have 3 tails, and the word may has 3 letters.

The explanation behind their common name is that many mayfly species emerge from the water in May, when they shed their skins and become full adults. The explanation for the scientific name of the order is their BRIEF audult stage. Most adults live about 24 hours. Adults do not feed, as they have no mouthparts. Their purpose is to mate and reproduce.



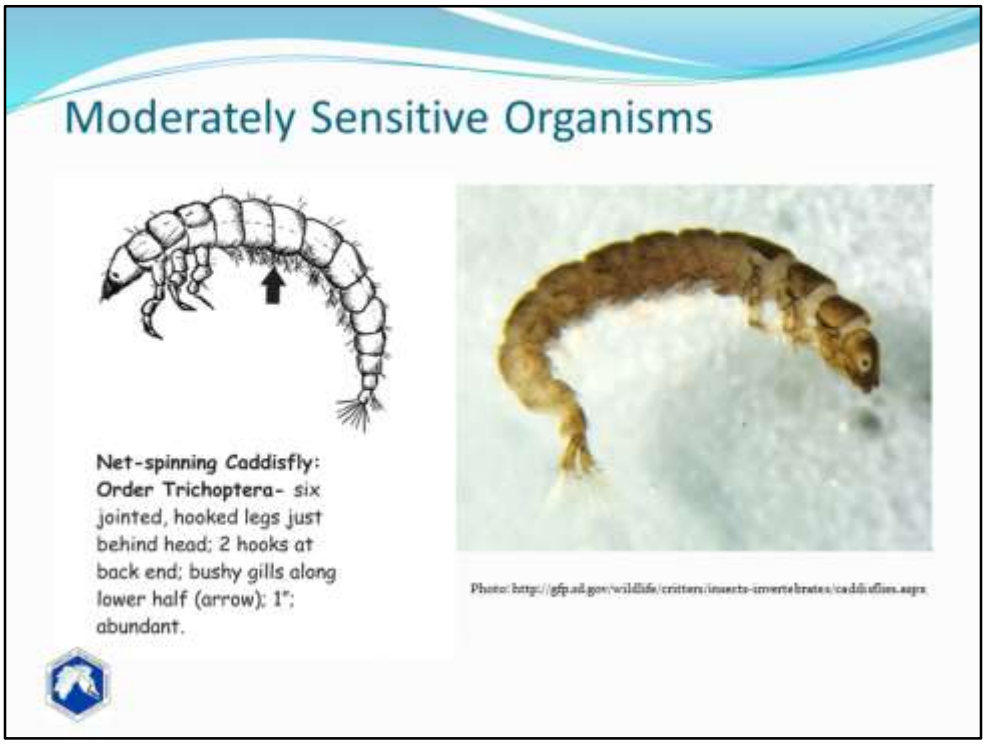
Find this on both the key and the tolerance chart.

The greatest diversity of stoneflies is sound in small, cool streams, where the water temperature remains cool and dissolved oxygen remains near saturation. Such streams are usually shaded. They prefer boulders, cobble, pebbles, and pieces of water-soaked wood, and decaying leaf packs snagged within swift currents.



Find this on the keys.

These are different caddisfly species larvae that use their sild threads to glue small bits of leaves, twigs, or rocks together to form a case that shelters them from predators and camoflages them from prey..

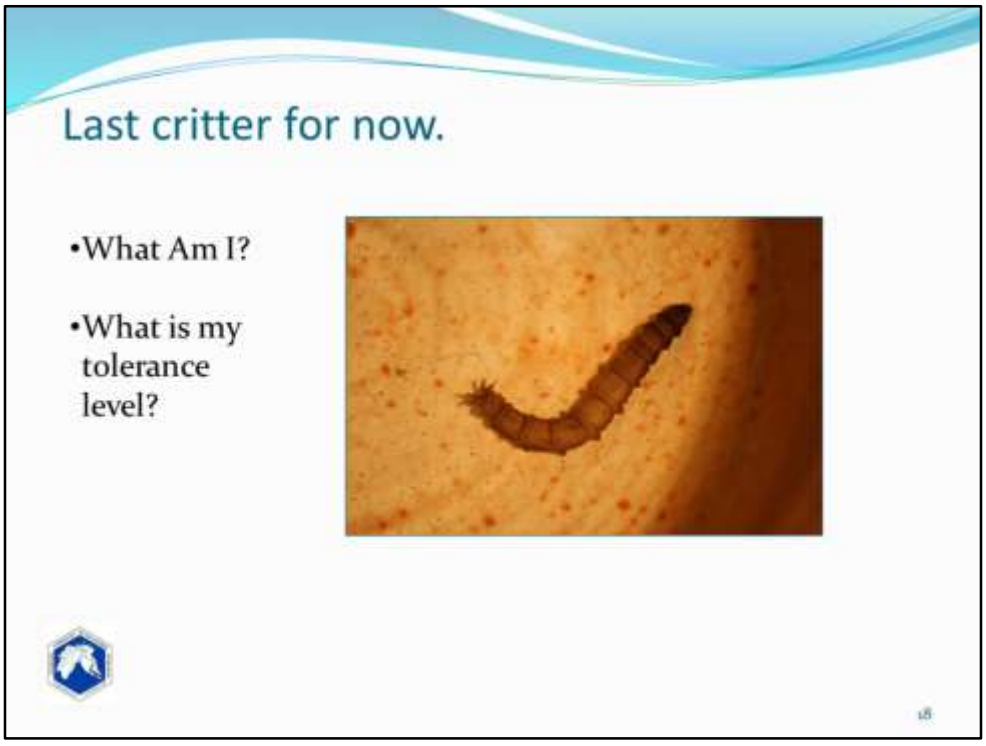


Find this on the keys.

Caddisfly larvae can spin silken threads, similar to spiders. The net-spinners attach themselves to objects in the stream, so they don't get carried downstream by the current. They also construct nets to catch their food (algae, small invertebrates and detritus). Different types of caddisflies spin different mesh sizes and shapes based on which type of food they are targeting.

What are these?

Dragonflies and damselflies. Both the nymphs and the adults are great predators. They are the only creatures with extendable lower lips. The lip has a hinge in the middle that allows it to bend. To feed, a larva rapidly shoots the lower lip out and captures its prey – often a mosquito or fly. If too big, the sharp, pointed mouthparts can tear apart its prey. Having such a dexterous mouth, enables the dragonfly and damselfly to use all 6 legs, and keep their grasps on the substrate while feeding. (suborder Zygoptera).



Spiracles on the end are openings to this cranefly larvae's breathing system.

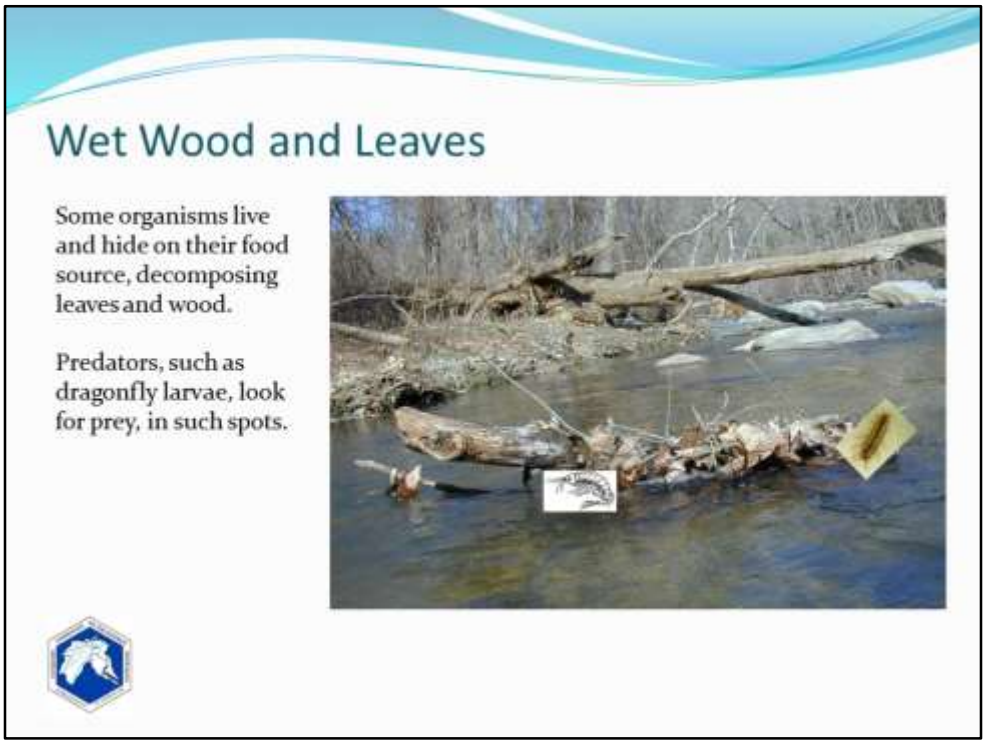
Some are common in leaf packs. These shredders and detritivores help break down the leaves that fall from trees (and other plant and animal waste), making the energy and nutrients contained in the leaves available to other aquatic organisms.

Part 3:
In-stream Habitats for Benthic Macroinvertebrates

Many aquatic organisms prefer riffle areas — the parts of streams where there are rocks, cobble, or gravel. The water moves faster and breaks over the rocks in these areas, causing more oxygen to be in the water. Insect larvae with gills need plenty of oxygen, and they can get it in these spots. Because the water flows over these shallower areas more quickly, it removes sediments from the substrate. Consequently, there is less likelihood of sand and grit harming or clogging the delicate gills of insects.

There also is a great diversity of habitats in these areas. This supports a diversity of species. Larvae can use the rocks to hide from predators or prey. Some burrow into the soil; others perch on the cobble.

This presentation can only provide generalizations on the feeding and habitat preferences of benthic macroinvertebrates. For more information, see **A Guide to Common Freshwater Invertebrates of North America**, J. Reese Voshell, Jr.



Submerged logs and wet decaying clumps of leaves (leaf packs) support macroinvertebrates that eat decaying leaves and wood or algae and plant and animal debris on the leaves and wood. Basically, they live on their food source, as the leaves also can make good hiding places. Some have mouth parts that enable them to shred plant material to smaller pieces; others have mouth parts that enable them to scrape algae from the surfaces of logs and rocks.

Root "Wads"

- Underwater roots can be covered with algae and tiny particles of plants and waste.
- They provide food for organisms that graze and scrape the surfaces.
- Naturally, predators are also in the roots.

Underwater plants

Organisms, such as snails, eat the algae on the plants or the plants themselves.

Some benthic macroinvertebrates lay eggs on the grasses.

Photo: D. Boward, MBSS, MD DNR

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Part 4:
Sampling Procedures:

- Collect 20 one-foot samples from a 100-meter stretch, using a D-net.
  - Collect from a relative percentage of the best habitat.
    - Move from downstream to upstream.

Riffles

- Place net opening so that it catches downstream flow and organisms.
- Put net firmly in the streambed downstream from area you will sample (so that water is flowing into the net).
- Pick up and rub the surfaces of large cobbles (> 3 cm).

The Riffle Shuffle

- Put your feet in front of the net (no more than two feet in front)
- *Disturb the area 5-8 cm below surface by shuffling.*

Photo: Maryland Biological Stream Survey

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The Wet-Leaf Grab

- Sample older, wet packs of leaves in river, not fresh leaves.
- One moderate hand-full = one sample.
- Can sort for organisms in bucket or save to do later.

Photos: Maryland Biological Stream Survey

The Woody Debris Rub

- Sample wet, stable wood, not floating twigs.
- Best to sample wood in areas with flowing water (rather than still).
- Place D-net downstream and rub wood with gloved hand, brush, or net, so that you catch organisms.

The Root Comb

- Place D-net downstream of root wad.
- Comb hand through roots.
- Or jab with net and sweep water to catch critters.

Photo: Maryland Biological Stream Survey

Let's Go Do It!

Photo: Izaac Walton League of America

Resources for Benthic Macroinvertebrate Sampling

HIGH SCHOOL TEACHERS:

Explore and Restore Maryland Streams, Maryland Department of Natural Resources *Biological Assessment of Stream Health.*
For forms for doing biological and other surveys:

- Overall Student Data Sheet for All Stream Activities.
- Coastal Overall Student Data Sheet (for streams in the coastal plain geographic province)

Maryland Streamwaders Macroinvertebrates by Tolerance Levels. KEY
http://dnr2.maryland.gov/streams/Documents/dnr_bugsheet.pdf

Maryland Stream Health Map – view data collected on a stream near your school, using interactive maps and charts of the results. http://dnr2.maryland.gov/streams/Pages/streamhealth/default.aspx

Macroinvertebrate Guides:

- *A Guide To Common Freshwater Invertebrates* of North America, J. Reese Voshell, Jr. – Covers life habits and basic anatomy, color illustrations.
- *Guide to Aquatic Insects & Crustaceans*, Izaak Walton League of America – includes diachotomous key, descriptions of functional groups (feeding methods of different benthic macroinvertebrates).

K- MIDDLE SCHOOL TEACHERS

- **The Cacapon Institute**'s interactive "Potomac Highland Watershed School" provides gamelike approach to learning about benthic macroinvertebration identification and collection. (http://cacaponinstitute.org/e_classroom.htm)
- **The Audobon Naturalist Society Green Kids:** complete lesson plans and power points for grades 4-5, covering stream habitat, monitoring procedures, and equipment. See GreenKids Stream Lesson Plans (http://ansbookshop.org/index.php/nature-programs/schools-teachers/greenkids-school-partnerships#lessons)
- **Creek Freak Program, Izaac Walton League of America** – Comprehensive teacher and student lessons for hands-on extensive inquiries of stream ecosystems. Grades 5-8.

Interstate Commission on the Potomac River Basin, https://www.potomacriver.org

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