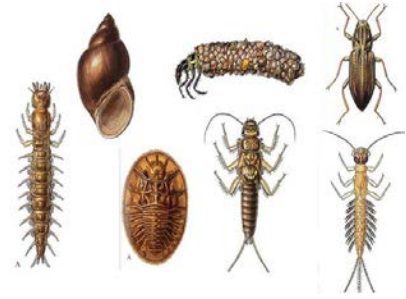


Macroinvertebrate Station

OBJECTIVES:

Students will:

- Learn the important roles of macroinvertebrates in streams as
 - indicators of water quality
 - an integral part of the stream food web linked to riparian health and salmon rearing
- Collect samples and determine the health of a stream using macroinvertebrate assessments.
- Practice scientific inquiry (ask questions, follow procedures, collect and analyze data).



MATERIALS:

- D-frame nets
- Small 'fish tank' nets
- Tubs for initial sorting of samples
- Ice cube trays or petri dishes for specific sorting
- Hand lens or 2-way magnifying viewer
- Turkey basters or eye droppers for picking up macroinvertebrates
- Tolerant / Intolerant to pollution ID cards
- Field guides
- Clipboard, data sheets, pencils

VOCABULARY:

- macroinvertebrate
- bioindicator
- food web
- functional feeding groups (shredders, scrapers/grazers, collectors, predators)

PREPARATION:

1. Determine where macroinvertebrate sampling will occur (well away from and downstream of spawning salmon and redds).
2. Set up 2 tables on a flat area by the river. Make sure there is enough room for students to stand around all 4 sides of the table if possible.
3. Set up a full set of materials on each table:
 - Small 'fish tank' nets
 - Ice cube trays or petri dishes for specific sorting
 - Hand lens or 2-way magnifying viewer
 - Turkey basters or eye droppers for picking up macroinvertebrates
 - Tolerant / Intolerant to pollution ID cards
 - Field guides
 - Clipboard, data sheets, pencils

4. Keep the D-frame nets and tubs to the side where they won't be tripped over.
5. Depending on site specific conditions, students may or may not be allowed to enter the water (be sure to check with your site manager). If students are not to enter the water, samples should be collected by adults prior to the arrival of students.

INTRODUCTION: (10 minutes)

- Ask students what salmon eat. If no one mentions the word **macroinvertebrate** introduce the term at the end.
- Ask students where we would find these macroinvertebrates.
- Explain that aquatic macroinvertebrates are not only an important food source for salmon, but are excellent **bioindicators** of the health of the stream; different macroinvertebrates can tolerate different conditions such as temperature range, water clarity, and water pollution.
- Ask students: If we find a lot of macroinvertebrates that can't tolerate pollution, what would that tell us about the water quality in the stream?
- Explain that macroinvertebrates are an important part of the **food web** because they occupy many different niches and accomplish many important jobs. Some are eaten directly by fish and other predators, and some break down leaves and plant material and make nutrients available in the stream for more plants to grow.
- Tell students that they will be collecting macroinvertebrates from the stream and sorting them based on their **functional feeding groups: shredders, scrapers/grazers, collectors, predators** (how they get their own food). They'll then record their data on the data sheets and analyze their results to determine the health of the stream. The field guides and cards will help identify the macroinvertebrates.
- Demonstrate the correct way to use the D- nets to collect macroinvertebrates.

NOTE: Adult chaperones don't always control the students so be assertive if necessary. Don't allow the chatty or restless students to dominate the group. For example, if two students won't stop whispering to each other, separate them to either side of the group.

ACTIVITY (30 minutes)

1. Review safety precautions and rules:
 - SAFETY IS CRUCIAL AT THE STREAM!
 - Students may not enter water above the calf, and in some cases, should not go deeper than the ankle.
 - Avoid fast-moving water.
 - Take care when walking on slippery rocks.
 - Never drink the water.
 - Place nets safely to the side, when not being used, where they will not be tripped over.
2. If you have more than 5 students, split them into small teams of about 3 and assign each team a spot along the stream. This is best if adult volunteers are able to assist the teams.
3. Identify the microhabitat (riffle, pool) to be sampled.
4. Collect sample from 1-square foot area immediately upstream from the net opening. To do this, approach site from downstream. Hold net downstream from area to be sampled, perpendicular to flow. Upstream, begin rubbing rocks, or leaf litter to remove any invertebrates. Or shuffle the stream bottom in place using your feet. The invertebrates should flow into the net. Replace the rocks.

5. Repeat up to 3 other locations if necessary.
6. Have students place D-nets to the side and return to the tables.
7. Demonstrate how to remove net contents into a large shallow tray for sorting into groups in ice cube trays.
8. Show students how to use basters or droppers to move individual macroinvertebrates. Use magnifiers to observe body parts such as different types of gills and mouth parts.
9. After a few minutes of sorting, remind students to use the identification cards and begin filling out the data sheets.
10. Count the different kinds of invertebrates in each sensitivity group and record onto the data sheet.
http://www.streamwebs.org/sites/streamwebs/files/files/Macros_OSU.pdf Use the field guides to help with identification. *Identifying species can be difficult and is not a priority – sorting into similar groups and understanding some of the differences is more important.* Macros can also be sorted by habitat type or where found in the stream.
11. At about 10 minutes before the end of the session, discuss the results and ask some discussion questions (see below).
12. At 5 minutes before the end of the session, clean up as and gently return macroinvertebrates to the stream.

DISCUSSION (5 minutes)

Have students use the completed data sheets to determine the general health of the stream.

- Which functional feeding group best reflects the insect community found in the stream?
- What does this tell us about the health of the stream for salmon?
- Does this make sense based on what they learned during the other stations that day?

EXTENSION ACTIVITIES:

Discuss:

- What measures can be taken to protect a stream with healthy macroinvertebrate populations that support salmonids?
- What measures can be taken to help restore a system that has been degraded and has lost the diversity of insects that are part of a healthy watershed for fish?

CLEAN-UP:

1. Put all items back into appropriate tubs, clean off any debris, and set them aside for next group.
2. If using laminated ID sheets erase all writing.
3. At end of day, rinse and dry supplies and place them back into the bin.

BACKGROUND INFORMATION

Macroinvertebrates are animals that lack a backbone (“invertebrate”) and can be seen with the unaided eye (“macro”). They include insects such as mayflies, mosquitoes, and beetles, as well as mussels, leeches, sideswimmers, and worms. Aquatic macroinvertebrates spend the majority, if not all of their lives in streams, wetlands, lakes and other aquatic environments.

Aquatic macroinvertebrates are animals, just like we are, and like us they need oxygen to breathe. Aquatic macroinvertebrates can acquire dissolved oxygen across the surface of their bodies, but many types such as mayflies, damselflies, and stoneflies have elaborate branched, tufted or leaf like gills that help them obtain dissolved oxygen from the water. Still others have breathing tubes or siphons that they stick up above the surface of the water to breathe (water scorpions, mosquito larvae), while some water beetles capture bubbles of air at the water’s surface and dive down with their own portable “scuba tank”.

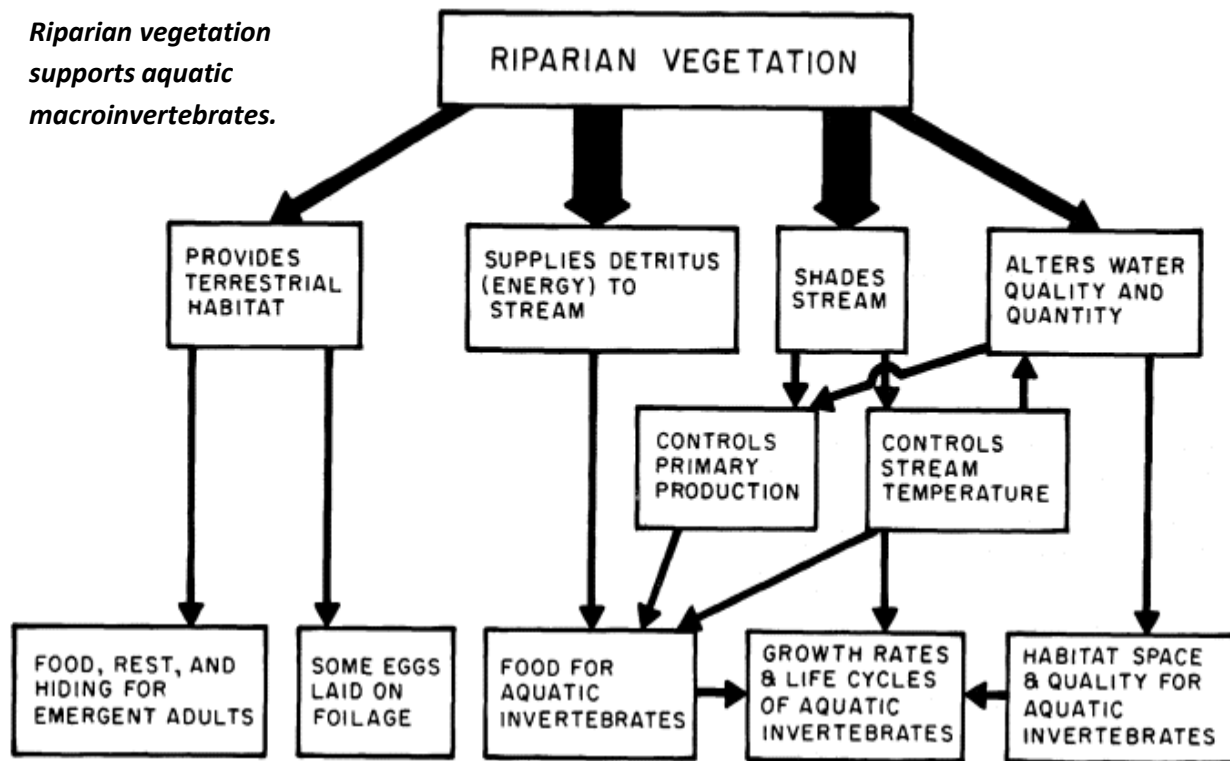
Sensitivity: Measuring water quality alone (temperature, pH, heavy metals, etc.) doesn’t give a complete picture of stream health. It isn’t possible to test for every different contaminant that might be present in a stream or lake, but invertebrates live in that water all of the time. They are constantly exposed to whatever chemicals, sediments, or changes in the temperature may be occurring, and may respond by dying out, migrating away, or reproducing in even higher numbers, depending on the type of invertebrate.

Aquatic macroinvertebrates are excellent “bioindicators”: they are found everywhere, generally in large numbers, and are easy to collect; they are confined to the aquatic environment for most or all of their life cycle; they integrate the effects of many stressors (sediment, temperature, pollution etc.) over their life span; different species have different known responses to specific stressors and they are a critical part of the stream food web. Changes in the presence, composition and relative abundances of specific groups of macroinvertebrates can signal pollution or disturbance occurring in a watershed. Government and other groups that monitor water quality are using this method more and more.

Food web: Macroinvertebrates are critically important in the aquatic food web. Some serve directly as food for predators such as fish, amphibians, birds, and other invertebrates; others help make more food available in the aquatic system by breaking down leaves and plant material. Fish populations depend on healthy macroinvertebrate populations to survive. The availability of macroinvertebrates as food is determined by both the physical and biological condition of the stream, riparian areas and the whole watershed. (See Macroinvertebrates and the Aquatic Food Web below)

River continuum is the way in which smaller and smaller particles of sediment and organic debris are expected to be found further downstream in the watershed. For this reason, different functional feeding groups of macroinvertebrates are expected in different parts of the watershed. (See The River Continuum below)

Riparian vegetation supports aquatic macroinvertebrates.



Macroinvertebrates and the Aquatic Food Web

Macroinvertebrates are critically important in the aquatic food web. Some serve directly as food for predators such as fish, amphibians, birds, and other invertebrates; others help make more food available in the aquatic system by breaking down leaves and plant material. Fish populations depend on healthy macroinvertebrate populations to survive. The availability of macroinvertebrates as food is determined by both the physical and biological condition of the stream, riparian areas and the whole watershed.

Macroinvertebrates have a wide variety of shapes, sizes, appearances, and mouth parts, and this diversity reflects a diversity of feeding habits as well. Macroinvertebrates may feed on living material (algae, plants, or other invertebrates), as well as on dead or decomposing material and particles of organic detritus, and they are often classified according to the way in which they obtain nutrients. The major different functional feeding groups (FFG) are shredders, collectors, scraper/grazers, and predators. These distinctions are somewhat artificial, as some may fit into more than one category (i.e. scrapers may eat detritus while they graze on algae), but they are still a valuable method of classifying the stream macroinvertebrate community. By looking at the feeding habits of these invertebrates, you can begin to sort out different roles these animals play in the ecology of watersheds.

The main categories of functional feeding groups include:

Shredders

Chew on intact or large pieces (>1 mm) of plant material.

Examples: giant stoneflies, Northern caddisflies

Found in: leaf packs, water-logged wood, headwater streams and areas with a high percentage of canopy cover.

Scrapers/grazers

Scrape off and consume thin layer of algae growing on solid substrates in shallower waters

Examples: snails, flatheaded mayflies, water pennies

Found in: more open areas with enough sunlight to support algal growth; rocks in open- canopied areas, mid-stream reaches

Collectors (collector/filterers and collector/gatherers)

Consume very small pieces of detritus (<1 mm)

Examples: common netspinner caddisflies, back flies, brush-legged mayflies, mussels

Found in: rocks and mud; common in all reaches, but make up larger proportion in lower reaches where sediment collects

Predators

Feed on living animals; may swallow smaller prey whole, tear pieces out of larger prey, or suck out body fluids

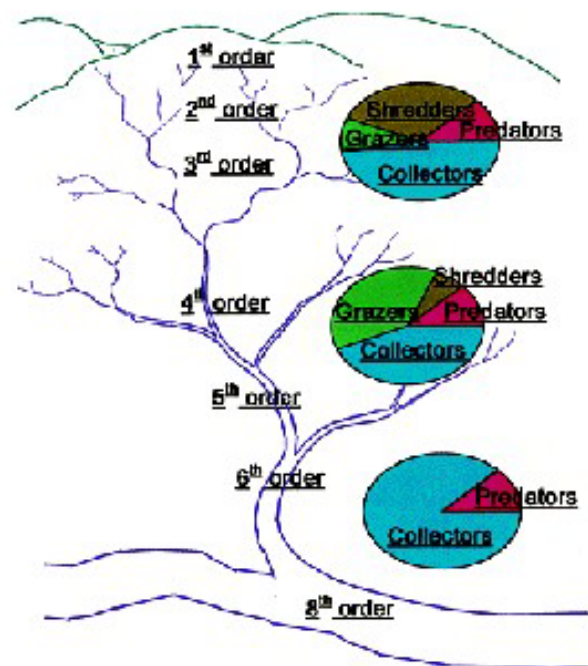
Examples: predaceous diving beetles, dragonfly larvae, common stoneflies

Found in: all habitat types, in smaller proportion relative to other feeding groups

The River Continuum

The river continuum concept (RCC) is a model that describes running water systems using elements such as stream width, depth, velocity, channel shape, and associated biological communities. Because stream morphology, vegetation, and energy inputs change from headwaters to mouth, biological communities in a stream also change in a somewhat predictable pattern. This pattern is influenced by channel structure, gradient, bank stability, sediment loads, riparian vegetation, light penetration, and temperature.

A stream is a continuum that transports progressively smaller food materials from the headwaters to the lower reaches. Each year, large amounts of organic material fall into the headwaters of forested streams. Only 20-35% of this material is flushed downstream; the remaining organic input is retained and used by stream organisms. It can be processed by bacteria and fungi, physically abraded, or consumed by insects. As it is processed, organic debris is broken into smaller pieces, which increases their surface area and subjects them to further degradation by microbial action.



In this way, small 1st- and 2nd-order streams send partially prepared food into larger, higher order streams. Processing continues as small debris moves downstream through the system. Because different invertebrate functional feeding groups process different-sized food particles, different FFG communities are expected in different stream reaches.

Forests at the headwaters (1st- to 3rd-order streams) have less influence as a stream gets larger. With less input from the riparian habitat, the energy base relies more on algae that is produced as additional sunlight penetrates through the open canopy, and on processed material carried in from intermediate or midreach (3rd- to 5th-order) streams. As the kind of organic material changes, the proportion of shredders decreases and the proportion of collectors and scrapers increases.

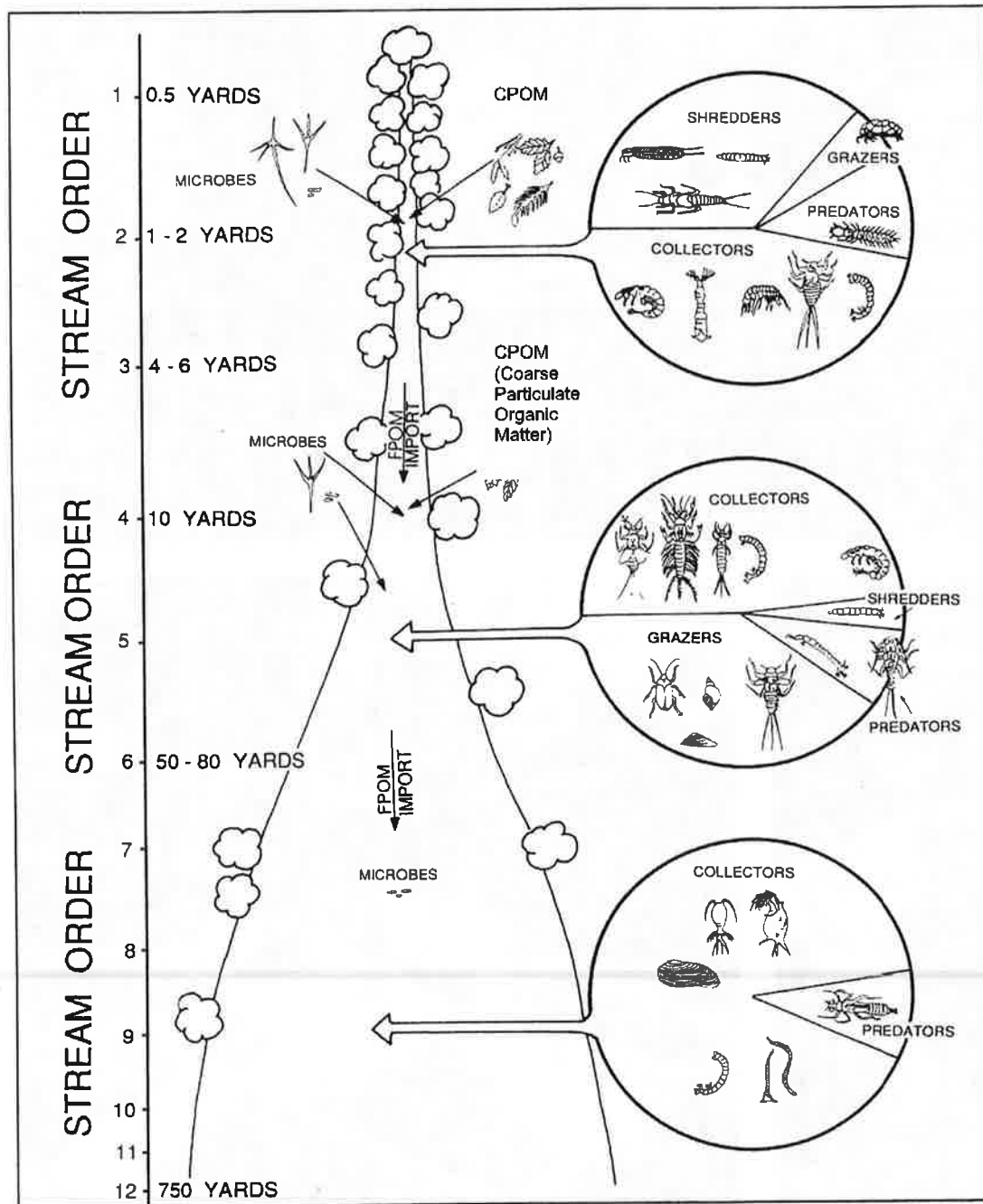
The midreaches of a stream system have a greater diversity of species than is found either upstream or downstream. The reason is not completely understood, but may be due to the fact that midreach water temperatures can change more than those of headwaters or larger rivers. The variety of organic substrates and physical components found in midreach streams may also have an effect.

Turbidity increases in the lower reaches (6th- and higher-order streams) due to greater loads of fine sediments from tributaries and downstream movement of processed particulate matter. Collectors dominate these reaches, and the diversity of other organisms decreases. Increased turbidity reduces light penetration and thereby reduces the efficiency and photosynthetic production of algae in larger streams. Large plankton communities are important in these areas.

There are exceptions to the pattern outlined in The River Continuum, but the concept shows what might be expected in a stream system. If a community is "out of place" or missing, it can be a red flag, encouraging further investigation.

The River Continuum Concept (after Vannote *et al.*, 1980).

Changes in functional feeding groups accompany changes in stream morphology and energy inputs.

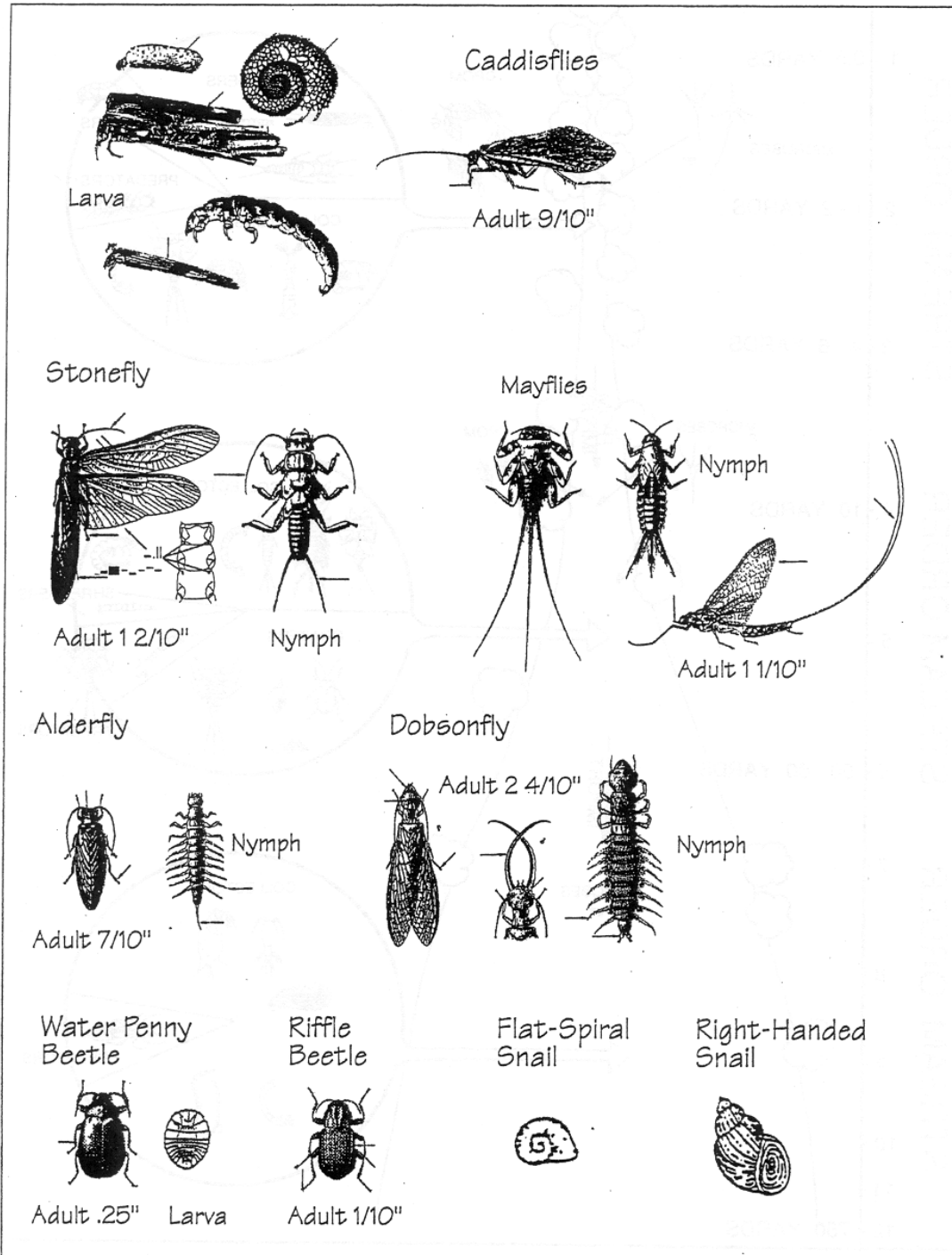


INSECT GROUPS ARRANGED BY TOLERANCE TO POLLUTION

Group 1: Intolerant

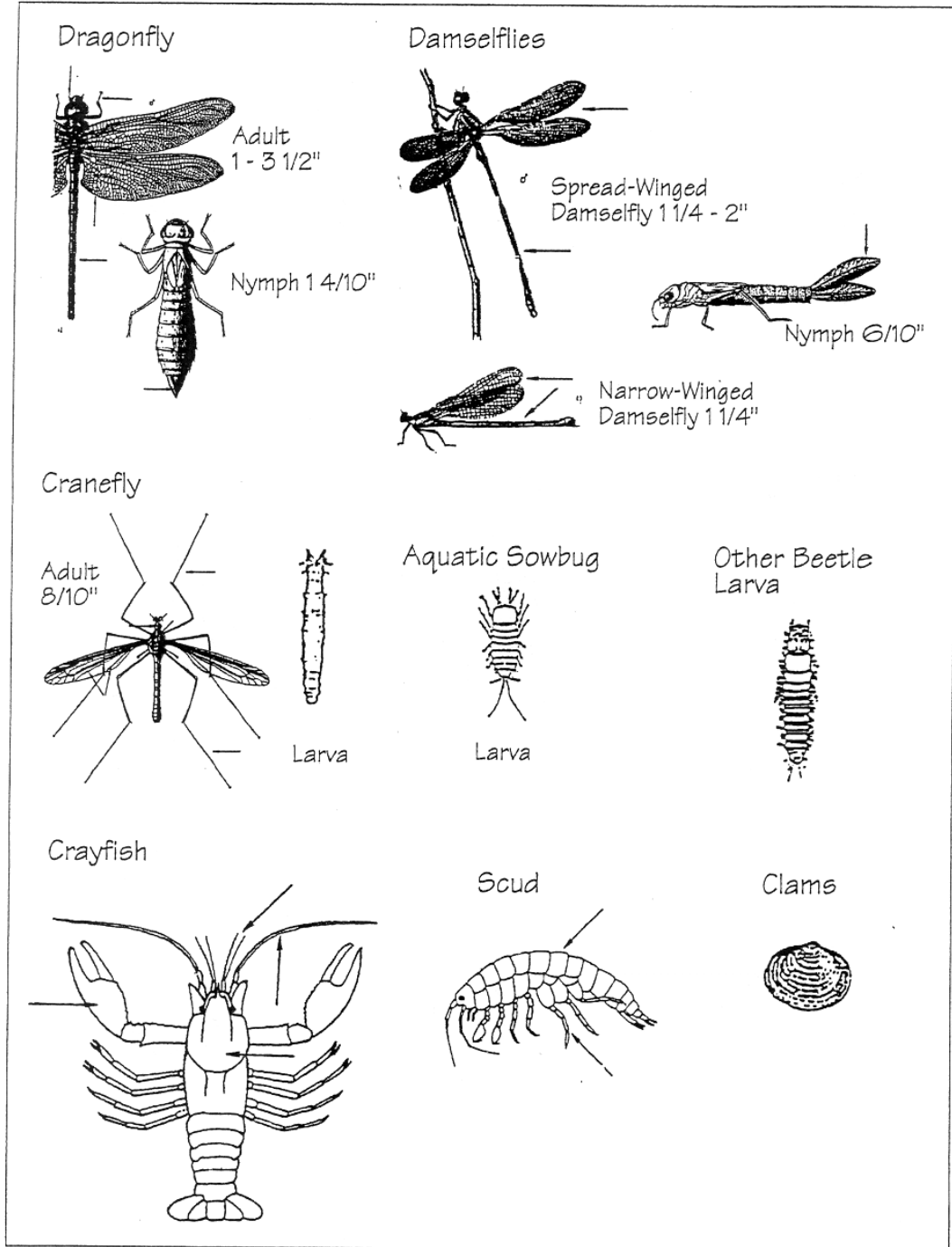
These organisms are sensitive to pollution.

Their dominance generally suggests good water quality.



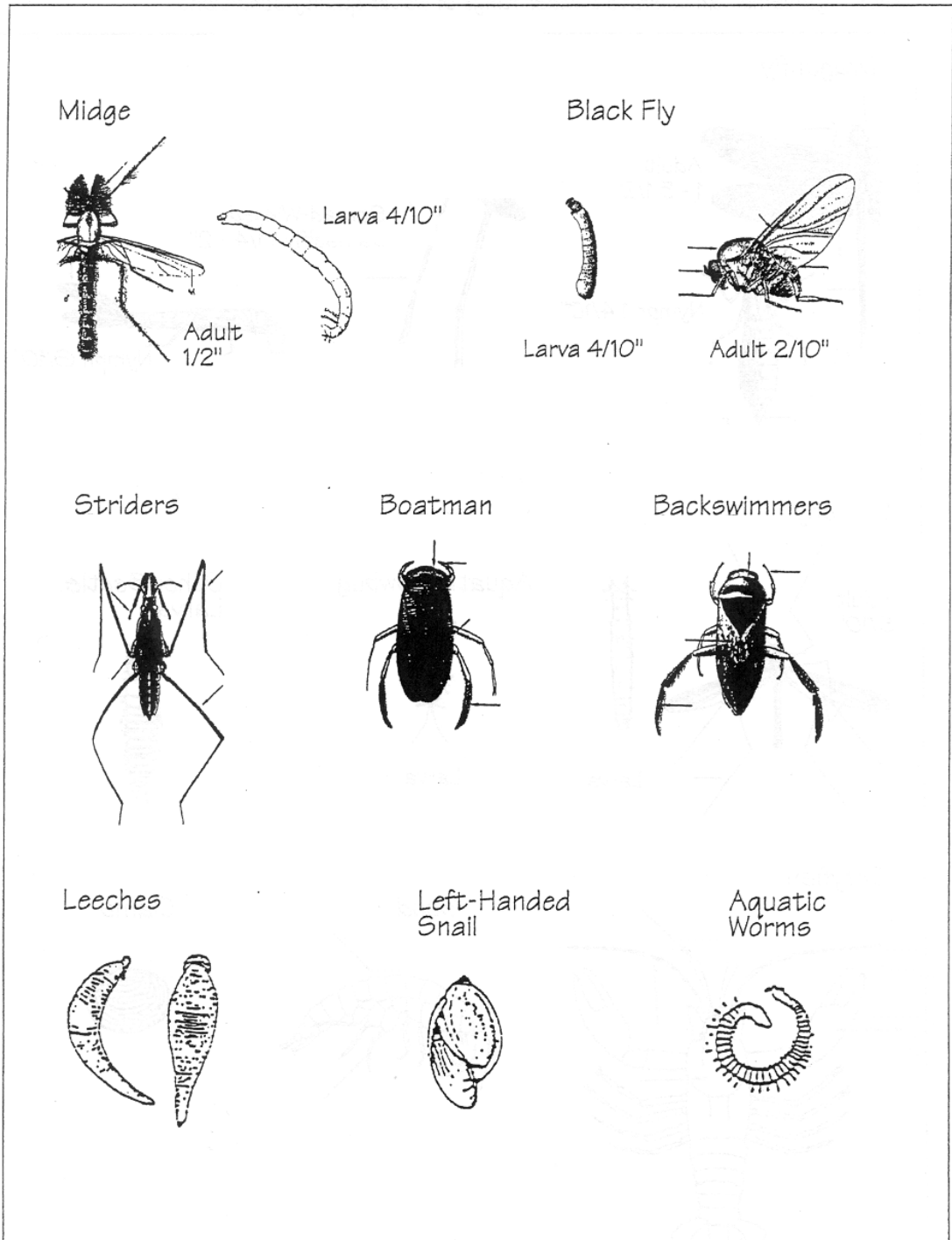
Group 2: Somewhat Tolerant

These organisms can tolerate a wider range of water quality conditions.





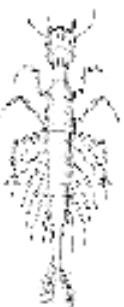







Group 3: Tolerant






These organisms are generally tolerant of pollution. Their dominance suggests poor water quality.








QUICK REFERENCE GUIDE TO AQUATIC INVERTEBRATES

Name	Distinguishing Characteristics	Where Found	How Oxygen is Obtained	Food Gathering	Things To Look For
Stonefly Nymph 	2 tails, 2 sets wing pads, (wing pads not always noticeable)	Cold running water	Through body surface; some small gills; does "pushups" to increase oxygen flow	Predator or herbivore	Streamlined body for crawling on rocks; requires high oxygen levels
Mayfly Nymph 	3 tails (sometimes 2); 1 set wing pads.	Cool or cold running water	Through gills along abdomen; may wave gills in water to increase oxygen flow	Herbivore or scavenger	Requires high to medium oxygen levels
Caddisfly Larva 	Most species build cases or nets soft body, some free living	Cool or cold running water; ponds	Through body surface; some finger-like gills	Filter feeder, herbivore, predator	Builds cases of heavy material (rocks) to avoid being swept away by fast-flowing streams; uses grass and plants to make cases as well
Water Penny Larva 	Round, flat, segmented, disk-like body	Cold running water	Usually through gills on underside	Herbivore—grazes on algae	Flattened body resists pull of current
Predaceous Diving Beetle Larva 	Up to 6 cm long; robust jaws	Most still and moving water habitats	Through body surface	Voracious predator	Special channels in jaws to suck body fluids of prey

Name	Distinguishing Characteristics	Where Found	How Oxygen is Obtained	Food Gathering	Things To Look For
Whirligig Beetle 	Black; congregates in schools	Surface of quiet water	From atmosphere	Predator or scavenger	Has two pairs of eyes to see above and below water's surface; has type of "radar" to locate object in water; secretes white odorous substance to deter predators
Black Fly Larva 	Small body; small hooks at end of abdomen attach to rocks	Cold running water	Through body surface; small gills	Filter feeder	Anchors to rocks with silk; only needs medium to high oxygen levels
Dragonfly Nymph 	Stout body; arm-like grabbing mouthpart	Cool still water	Dissolved oxygen, through gills in internal body chamber	Active predator	Clings to vegetation or hides in clumps of dead leaves or sediment
Damselfly Nymph 	3 leaf-like gills at end; arm-like grabbing mouthpart	Cool still water	Through gills at end of abdomen	Active predator	Clings to vegetation or hides in clumps of dead leaves or sediment
Hellgrammite (Dobsonfly, Alderfly or fishfly Larva) 	Up to 9 cm. Long	Cool or cold, slow to fast moving water	Through gills along side of abdomen; some fish flies have breathing tubes	Active predator	Can swallow prey without chewing

Name	Distinguishing Characteristics	Where Found	How Oxygen is Obtained	Food Gathering	Things to Look For
Water Strider Adult 	Skates on water's surface	Ponds or still pools of stream	From atmosphere	Active predator	Can stay on water's surface because feet have small surface area and are water repellent
Water Boatman Adult 	Long swimming hairs on legs	Ponds or still pools of stream	From atmosphere, by carrying air bubble from water's surface on body	Omnivore, herbivore, or scavenger	Has swimming hairs on legs that act as oars
Backswimmer Adult 	Light-colored underside; swims on back	Ponds or still pools of streams	From atmosphere, by carrying air bubble from water's surface on body	Predator	Swim on back, sleek body shape
Cranefly Larva 	Cylindrical body; often has lobes at hind end, may have small soft legs	Bottoms of streams and ponds in sediment and algae	From atmosphere through spiracles (openings) at hind end	Active predator, herbivore, or omnivore	Species that eat woody decaying matter have gut bacteria to digest cellulose
Mosquito Larva 	Small body; floats at surface	Cool to warm still water	From atmosphere through breathing tube, on hind end as a larva and front end as pupa	Scavenger —feeds on micro-organisms	Swims or dives when disturbed

Name	Distinguishing Characteristics	Where Found	How Oxygen is Obtained	Food Gathering	Things to Look For
Aquatic Sowbug 	Flattened body, top to bottom; 7 pairs legs	Shallow freshwater, among rocks and dead leaves	Through body surface on legs	Scavenger—eats decaying matter---or omnivore	Male clasps female under it during mating; female then sheds half of exoskeleton, which becomes case into which fertilized eggs are placed
Crayfish 	5 pairs of legs, first pair often robust; looks like small lobster	Under rocks or in burrows in shallow freshwater	Through gills under body	Scavenger or omnivore	Crawls backwards when disturbed; males display some courtship behavior to reduce female aggressiveness
Scud 	Flattened body, side to side swims on side	Bottom of lakes, streams or ponds, or streams	Through gills under body	Scavenger or omnivore	Male carries female on its back during mating; female then sheds half of exoskeleton, which becomes case into which fertilized eggs are placed
Midge Larva 	Small thin body with a hard head and small legs on the hind end	Most still and moving water habitats	Through body surface, small gills	Predator, herbivore, or omnivore	Extremely common; sometimes red because they have hemoglobin in their blood to help transport oxygen; wiggle actively
Rat-Tailed Maggot Larva 	Cylindrical body; tail-like breathing tube	Cool to warm water with low oxygen levels	From atmosphere through breathing tube	Scavenger—eats decaying matter and sewage	Can survive low oxygen levels fatal to most invertebrates



Share your field data quickly and easily using StreamWebs. Find out what the macroinvertebrates you found say about your stream, keep track of your photopoints, graph water quality data, upload a video, and much more.

www.streamwebs.org

Name: _____

School: _____ Teacher: _____

Date: _____ Time: _____ Weather: _____

Stream/Site Name: _____ Time spent sorting/identifying: _____







of people sorting/identifying: _____ Riffle Pool

Directions:








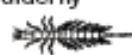

1. Record the number of each type of organism found in the # found column of each section.
2. Then circle the number in the score column (3, 2, or 1) if any of that organism was found.
3. Complete the equation at the bottom by adding up the circled numbers from each score column.

SENSITIVITY TO POLLUTION


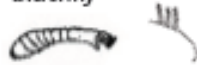




Sensitive / Intolerant

	# found	score
caddisfly 		3
mayfly 		3
riffle beetle 		3
stonefly 		3
water penny 		3
dobsonfly 		3
Sensitive TOTAL =		

Somewhat Sensitive

	# found	score
clam/mussel 		2
crane fly 		2
crayfish 		2
damselfly 		2
dragonfly 		2
scud 		2
fishfly 		2
alderfly 		2
mite 		2
Somewhat Sensitive TOTAL =		

Tolerant

	# found	score
aquatic worm 		1
blackfly 		1
leech 		1
midge 		1
snail 		1
mosquito larva 		1
Tolerant TOTAL =		

<input type="text"/>	Sensitive total
+	<input type="text"/>
	Somewhat sensitive total
+	<input type="text"/>
	Tolerant total
=	<input type="text"/>
	Water Quality Rating
<input type="checkbox"/>	Excellent (>22)
<input type="checkbox"/>	Good (17-22)
<input type="checkbox"/>	Fair (11-16)
<input type="checkbox"/>	Poor (<11)

Adapted from: Environmental Services
City of Portland