Chapter 4: Aquatic Animals

Goals

Students will understand:

1. A stream or river food web and the importance of having a diversity of aquatic life.
2. What benthic macroinvertebrates are and how to identify organisms to order.
3. How macroinvertebrates and fish can be used to determine water quality.

Background Information

Surface waters provide important habitat for a wide range of life (see Chapter 2 for more information about habitat types). Mammals, reptiles, and amphibians find shelter in the riparian zone and birds search for food in streams, rivers, lakes, ponds, and wetlands. Many different fish, macroinvertebrates, and other organisms use surface waters as their home. The biodiversity of specific types of organisms can be used to give an indication of water quality or surface water health. **Biodiversity**, or biological diversity, is the variety of all forms of life that occur within a region.

This chapter will focus on stream and river biodiversity, emphasizing fish and benthic macroinvertebrates as indicators of water quality. See Chapter 5 for a discussion about aquatic plants and the differences between native, non-native, and invasive.

Aquatic Food Webs

Stream and river life can be divided into seven groups:

- Bacteria
- Algae
- Macrophytes (large plants)
- Protists (amoebas, flagellates, ciliates)
- Microinvertebrates (invertebrates less than 0.02 inch in length, such as rotifers, copepods, and nematodes)
- Macroinvertebrates (invertebrates greater than 0.02 inch in length, such as mayflies, stoneflies, caddisflies, crayfish, worms, clams, and snails)
- Vertebrates (fish, amphibians, reptiles, mammals)

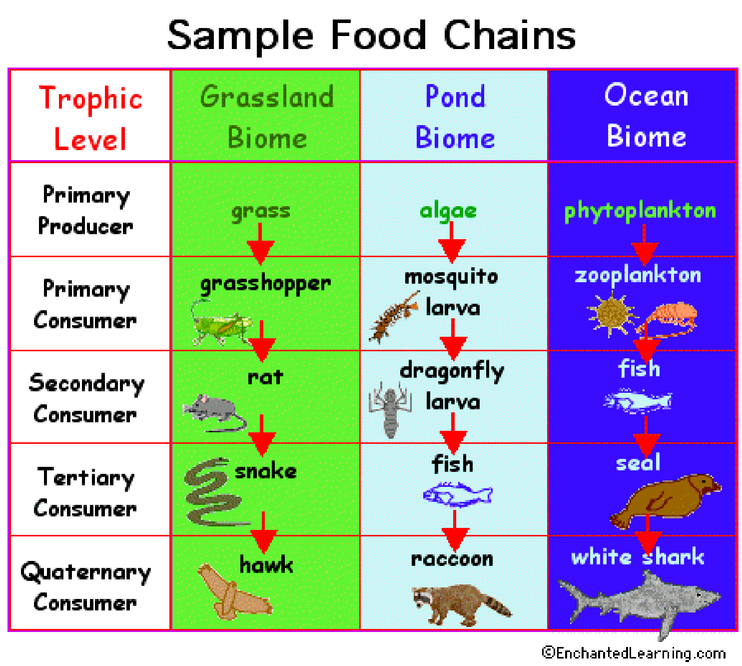

Figure 1. Examples of food chains (http://www.enchantedlearning.com/subjects/foodchain/)

These organisms depend on sunlight, nutrients, and each other in many interrelated food chains. A **food chain** is the transfer of energy from one organism to another as each consumes a lower member and is in turn preyed upon by a higher member (Figure 1). A food chain starts with the primary energy source, usually the sun. The next link in the chain is an organism that can use the primary energy source to make its own food. These organisms are called primary producers. Primary producers are eaten by primary consumers. The primary consumers are eaten by the secondary consumers and so on until the top predator is reached. The arrows in a food chain show the flow of energy, from the sun to a top predator. A network of many food chains is called a **food web**. Figure 2 shows an example of a stream food web. In contrast to food chains, food webs more accurately reflect the complexity of the ecosystem.

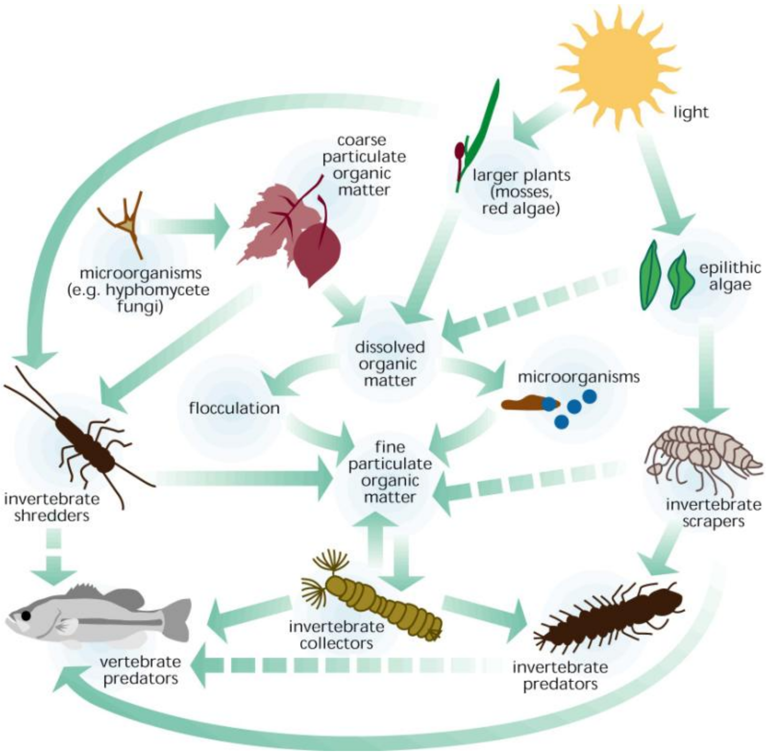

Figure 2. Typical stream food web (http://www.nrcs.usda.gov/technical/stream_restoration/Images/scrhimage/chap2/fig2-33.jpg)

In a stream, leaves and other organic materials that fall into the water provide nutrients for aquatic life. Bacteria, benthic macroinvertebrates, and other microorganisms break down the organic material and facilitate the flow of energy through the food web. Some invertebrates act as shredders by breaking down large leaf litter into smaller pieces. Other invertebrates filter smaller organic material from the water or feed on material deposited on the substrate. These primary consumers break down organic matter (through their feeding activities) and become food for other consumer groups, such as fish or birds. In fact, many fish species rely on benthic macroinvertebrates as a food source.

Fish are ecologically important in stream ecosystems because they are usually the largest vertebrates and often the top predator in aquatic systems. The diversity of fish in a given stream depends on the geographic location, evolutionary history, and such intrinsic factors as physical habitat (current, depth, substrates, riffle/pool ratio, wood snags, and undercut banks), water quality (temperature, dissolved oxygen, suspended solids, nutrients, and toxic chemicals), and biotic interactions (exploitation, predation, and competition). Both benthic macroinvertebrates and fish are used by surface water quality monitoring programs to assess water quality.

Biomonitoring

In addition to testing for specific parameters (e.g. temperature, pH, DO, etc.), biomonitoring is often integrated into surface water quality monitoring programs. **Biomonitoring** uses stream organisms as biological indicators of water quality. The underlying concept is simple: certain types of aquatic organisms occur or thrive only under certain water quality conditions. When conditions change, such as when a stream receives significant non-point source pollution inputs, the abundance and distribution of animals in the stream change as well. Although fish and algae are used in stream biomonitoring programs, benthic macroinvertebrates are the most commonly used organisms. The combined use of benthic macroinvertebrates and traditional stream water quality monitoring provides a more comprehensive evaluation of stream health.

Benthic Macroinvertebrates

The term benthic macroinvertebrate can be broken down into three parts:

- "benthic" – lives on the bottom of the stream or lake, on the substrate
- "macro" – large enough to see with the naked eye
- "invertebrate" – animal without a backbone

Thus, benthic macroinvertebrates are animals without a backbone that are large enough to see without a microscope and live at least part of their life cycle on the bottom of a stream. They inhabit tiny spaces between submerged stones, within organic debris, on logs and aquatic plants, or within fine sediments (silt, clay). Most are insects, but they also include such organisms as clams, snails, mussels, worms, spiders, and crayfish. Except for a small number of insect species that live in the water throughout their life cycle, most benthic macroinvertebrates are the larval and nymph stages of terrestrial insects (described below under "Insect Life Cycles", Figure 3). Adult insects lay their eggs in the water, which hatch into nymphs or larvae, and eventually emerge from the water as mature adults. Some macroinvertebrates live as aquatic organisms for one season, while others stay in their larval or nymph stage for several years before emerging into their adult form.

Macroinvertebrates can quickly tell us things about a river's water quality that chemical testing would otherwise cost tens of thousands of dollars to reveal. Benthic macroinvertebrates are good indicators of water quality because: 1) they are crucial to the food web and make up a majority of the species present in streams, 2) they are affected by the physical, chemical, and biological conditions of the stream and have a range of tolerances to pollution, 3) they are relatively easy to sample and identify, and 4) they have short life cycles and cannot easily escape pollution events. Sampling benthic macroinvertebrates is particularly useful because of their varying degrees of pollution tolerance. Macroinvertebrates can be divided into three tolerance groups: sensitive (intolerant), somewhat sensitive, and tolerant to pollution (Appendix A). Based on the types of macroinvertebrates that are found in a sample, the number found, and their pollution tolerances, an overall assessment of stream health can be determined.

All over the world, benthic macroinvertebrate monitoring is used by government agencies and local communities to manage water resources. Volunteers and school groups can learn how to track the water quality of their river by monitoring benthic macroinvertebrates on a regular basis. If there is a drastic change in benthic macroinvertebrate populations, further water quality analyses can be done to identify the source of the problem and determine potential solutions.

<u>Insect Life Cycles</u>

Many benthic macroinvertebrates are insects in various stages of their life cycle. During their life, insects go through a process called metamorphosis. **Metamorphosis** is the biological process through which a juvenile transforms into a mature adult. Metamorphosis is beneficial to insects because the juvenile does not compete with the adult for the same food resource. For example, a caterpillar (the immature form of a butterfly) feeds on plant leaves while the adult feeds on nectar. Insect life cycles can be divided into two groups: complete and incomplete metamorphosis (Figure 3). In **complete metamorphosis**, insects go through a complete life cycle and all four stages of development: egg, larva, pupa, and adult. In most instances, it is difficult to tell from the juvenile stage what kind of insect it will become as an adult. Because of this mystery, the ancient Latin word "larva" meaning "ghost or mask" was used to name this stage. In other words, the larva is covering up or masking what the insect will look like as an adult. Insects that do not have a pupa stage and do not go through all four stages of development go through the process of **incomplete metamorphosis**. These insects have three stages in their life cycle: egg, nymph, and adult. A “nymph”, from the Greek word meaning “bride”, looks a lot like the adult but is not sexually mature and has no wings or only partially developed wings.

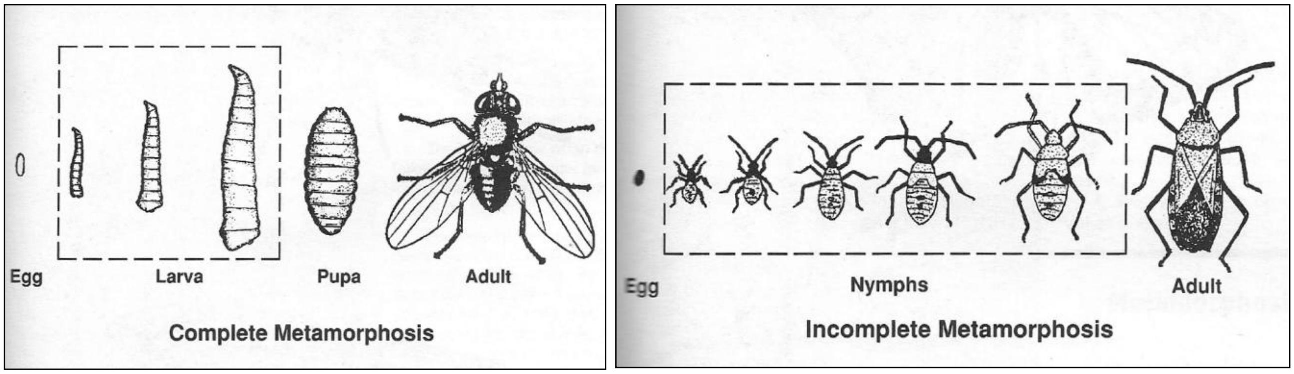

Figure 3. Complete and incomplete metamorphosis insect life cycles (Turpin 1992).

Volunteer Biological Assessment Program (VBAP)

Every fall since 2006, the Green Mountain Conservation Group has been working with NH DES, local schools, and community volunteers to monitor benthic macroinvertebrates in the Ossipee Watershed through the Volunteer Biological Assessment Program (VBAP).

Macroinvertebrate Common Name	**Tolerance Value**
Mayfly nymph	3
Stonefly nymph	1
Caddisfly larvae	4
Dragonfly nymph	3
Damselfly nymph	7
Black fly larvae	7
Midge larvae	6
Most true flies	4
Alderfly	4
Fishfly or Helgrammite	0
Riffle beetle	4
Water penny	4
Beetle and beetle-like	7
Crayfish	6
Snails	7
Aquatic worms	8
Scuds	8
Sowbugs	7
Clams and mussels	7

Figure 4. Common benthic macroinvertebrates and their corresponding pollution tolerance values (NH DES 2003).

VBAP assesses the biological health and integrity of aquatic ecosystems throughout the state. The results of these assessments are used to establish reference locations for "least disturbed" conditions in the state, identifying areas that are biologically impaired, and for prioritizing those areas needing management, restoration, or preservation efforts.

Macroinvertebrates possess a range of tolerances to pollution. Stoneflies and mayflies, for example, are pollution intolerant. In contrast, worms, midges, and fly larvae are pollution tolerant and able to withstand stresses better than more sensitive macroinvertebrates. Each macroinvertebrate has a tolerance value determined by scientists (Figure 4). Macroinvertebrates that have a low tolerance value are sensitive to pollution. Macroinvertebrates with a tolerance value in the middle, are somewhat sensitive to pollution. Finally, those macroinvertebrates with the highest tolerance values are tolerant to pollution. A stream with high water quality would have mostly macroinvertebrates with low tolerance values.

At each VBAP site, a sample of benthic macroinvertebrates is collected (Figure 5). By counting the types of macroinvertebrates found and using their assigned tolerance values, a rough "biotic index" can be calculated and compared to other sites. Based on the biotic index, the stream site is placed in one of three water quality categories: fairly poor, good, or excellent. While the biotic index provides a method for comparing sites, the tolerance values and water quality categories are still under development and may be calibrated to a set of reference sites to more accurately reflect stream health.

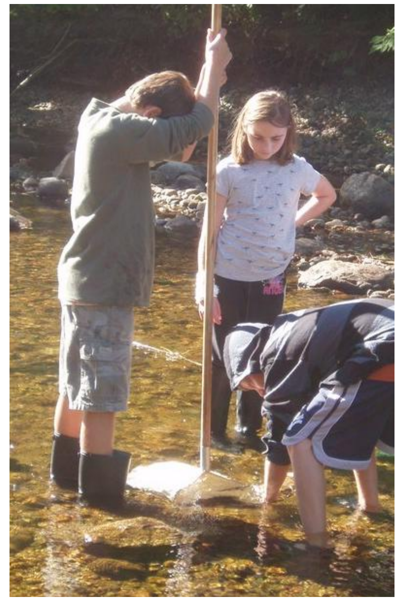

Figure 5. Students collecting a benthic macroinvertebrate sample as a part of VBAP (GMCG).

Fish

In addition to benthic macroinvertebrates, fish are also used in biomonitoring programs in New Hampshire. Fish are used for a variety of reasons. Under natural environmental conditions, fish populations tend to be stable. Similar to macroinvertebrates, some fish species are tolerant to pollution while others can only live in the cleanest, coldest, oxygen-rich waters. Furthermore, fish are also relatively easy to collect and identify to the species level. Most specimens can be sorted and identified in the field by experienced fisheries professionals, and subsequently released unharmed.

In contrast to macroinvertebrates, which have a life span of several weeks to a couple years, fish tend to live much longer and are mobile, which makes them good indicators of long-term (several years) effects and broad habitat conditions. If pollution is present, it will accumulate in the fish tissue and might become evident on the exterior of the fish, such as through tumors and skin lesions.

Fish populations generally include a range of species that represent a variety of trophic levels (omnivores, herbivores, insectivores, planktivores, piscivores). Because fish are higher up in the food chain, they tend to integrate the effects of lower trophic levels. By studying fish populations over time, scientists can get an understanding of the health of everything the fish eat and interact with. Consequently, fish population structure is reflective of integrated environmental health. Healthy fish populations are important for the stream ecosystem and are especially important to fishermen and those who consume fish. Although fish are at the top of the aquatic food web, because humans eat fish they are ultimately the top predator. For that reason, monitoring fish health becomes important for human health.

Eastern Brook Trout

One of the important native fish species in New Hampshire is the Eastern brook trout. As the only trout native to eastern North America, brook trout are prized sport fish for anglers. However, their populations have declined as land use changes have altered their habitat. Like most of New England, New Hampshire endured intensive timber harvest during the period of early European settlement. The resulting deforestation, log drives, and sediment runoff caused the loss of many wild brook trout populations through habitat degradation. While the state has become reforested to a large extent, suburban and urban development, acid deposition from airborne sources, habitat fragmentation resulting from dams and poorly designed road crossings, and sediment from roadways are all major threats to New Hampshire's wild brook trout. It is estimated that less than 9% of historical brook trout habitat remains intact.

Brook trout only survive in the coldest and cleanest streams and therefore are excellent indicators of the health of the watersheds they inhabit. The reason that brook trout serve as such good indicators of aquatic health is that they have very specific water chemistry requirements. Studies have determined that brook trout cannot tolerate sustained water temperatures exceeding 25°C (77°F) and prefer water temperatures less than 20°C (68°F). Brook trout are less tolerant of warmer water temperatures than brown or rainbow trout and require relatively high concentrations of dissolved oxygen in water compared to other fish and even other trout species. Brook trout have evolved to be the most tolerant of the trout species to acidic conditions and adult fish can tolerate pH levels as low as 5.0. Because Eastern brook trout require pristine water to survive, their presence or absence can provide useful information for surface water quality monitoring programs.

Records suggest that brook trout were once far more abundant in New Hampshire than they are today and their popularity among anglers has resulted in a long history of government stocking programs. For over 100 years, New Hampshire Fish and Game has augmented native brook trout populations with fish raised in hatcheries. However, recent efforts have focused on making sure hatchery raised fish are not released into streams or rivers with known wild trout populations. Hopefully, through the Eastern Brook Trout Join Venture (a partnership between local, state, and federal agencies and groups to protect, restore, and enhance aquatic habitat throughout the historic range of the Eastern brook trout) and Trout in the Classroom educational programs, brook trout populations will recover. In 2010, Green Mountain Conservation Group (GMCG), New Hampshire Fish and Game, and local schools in the Ossipee Watershed started this program to raise trout eggs in the classroom. More information and how to get involved in Trout in the Classroom can be found in Activity 3 of this chapter.

Indoor Activities

Activity 1: Macroinvertebrate Mayhem

Permission to print this activity from the Project WET Foundation was limited to the hard copy of the Ossipee Watershed Workbook. This activity can be found on pages 322-327 in the Project WET Curriculum and Activity Guide.

New Hampshire State Science Standards

ESS1 –The Earth and Earth materials, as we know them today, have developed over long periods of time, through constant change processes.

7 – Water

ESS4 – The growth of scientific knowledge in Earth Space Science has been advanced through the development of technology and is used (alone or in combination with other sciences) to identify, understand and solve local and global issues.

3 – Social Issues (Local and Global): Uses of Earth Materials and Environmental Change

LS1 – All living organisms have identifiable structures and characteristics that allow for survival (organisms, populations, and species).

2 – Living Things and Organization

LS2 – Energy flows and matter recycles through an ecosystem.

1 – Environment

LS3 – Groups of organisms show evidence of change over time (e.g. evolution, natural selection, structures, behaviors, and biochemistry).

1 – Change

SPS1 – Scientific Inquiry and Critical Thinking Skills

4 – Representing and Understanding Results of Investigations

Associated Student Workbook Activities

- Name that Macroinvertebrate! (Chapter 4, page 2)
- Magical Metamorphosis (Chapter 4, page 4)
- Macroinvertebrate Drawing (Chapter 4, page 5)

Activity 2: Fish Food Chain

New Hampshire State Science Standards

LS1 – All living organisms have identifiable structures and characteristics that allow for survival (organisms, populations, and species).

1 – Classification
2 – Living Things And Organization

LS2 – Energy flows and matter recycles through an ecosystem.

1 – Environment
2 – Flow of Energy

SPS1 – Scientific Inquiry and Critical Thinking Skills

4 – Representing and Understanding results of investigations

Source: Adapted from "Hazardous Links, Possible Solutions", Project WILD, © Council for Environmental Education 2000
Summary: Students simulate an aquatic food chain.
Objectives: Students will be able to describe what an aquatic food chain is and identify some aquatic species that make common food chains.
Estimated Time: 1 hour
Materials:

- Site area of about 15-20 meters (~49-67 feet) square
- 4 cones or markers for the playing area corners.
- 4-5 liters (~1-1.3 gallons) of popped popcorn representing algae
- Sashes (touch football flags) of three different colors about 20 centimeters (~8 inches) long
- One plastic baggie for each participant (represents stomach)
- Roll of masking tape
- One timer or stopwatch
- Ruler with centimeters
- Data recording materials

Directions:

1. Discuss the term food chain with students and describe an example, such as grasshoppers eat plants like corn, shrews eat grasshoppers, and hawks eat shrews (Figure 1).
2. Have students prepare stomach bags by placing a strip of tape across the bag so the bottom edge of the tape is 4cm (~1.5in) from the bottom of the bag.
3. Designate the playing area with cones at the four corners. Designate the cones as safe areas, such as under a rock or mud where mosquito larvae can hide and trout are safe.
4. Spread popcorn over the area and tell the group it is algae for the mosquito larvae to eat.
5. In a class of 20 students: 15 are mosquito larvae (green); 4 are trout (red); and 1 is a heron (blue). Try to keep the ratio of larvae, trout, and herons the same when adjusting for different class sizes.
6. Hand out a pre-taped baggy and sash to each mosquito larvae. Tell them they must collect the algae (popcorn) for food and place it in their stomachs (baggie).
7. Hand out a pre-taped baggy and sash to each trout. Tell them they must capture (take sash/tag) mosquito larvae for food and add the baggie with its contents to their own.
8. Hand out sashes to the heron(s) and tell him/her to capture (take sash/tag) trout for food and add the baggie with its contents to his/her own.
9. Start the activity by allowing the larvae to collect food (popcorn) in the playing area.

10. At the end of 45 seconds, send the trout in to hunt/capture food (larvae).
11. At the end of an additional 30 seconds send the heron(s) in to hunt/capture food (trout).
12. Stop the activity after an additional 30 seconds.

Analysis:
How many animals survive? To survive a mosquito larva must have filled its stomach (baggie) to the bottom edge of the tape (4cm or ~1.5in); for a trout to survive it must have filled its stomach to the top edge of the tape. A heron must have caught at least two trout to survive. If at least one of each kind of animal survives there is an on-going food chain. Record the results to compare with future rounds with different criteria (see Extension). Return the popcorn to the playing field.

Extension:
The first round of this game usually ends quickly. Replay the game with suggestions that result in a more balanced end result. Change one criterion per each replay. Suggestions:

- Change the numbers of each species.
- Provide safety zone, if not used on first play.
- Let the species out together for one minute, so there is no time for any unmolested feeding.
- Final round spread out caramel corn. Don't let the players know that it signifies some form of pollutant (DDT). Examine how it concentrates at higher consumer levels. Set an upper limit for the survivability of each species that ingests the pollutant.

Follow up:

- Discuss the roles of each of the species. What happens when the numbers of each species change?
- How do energy needs and pollutant levels change at the higher consumer levels?
- Do herons need plants to survive?
- Describe other food chains.

Associated Student Workbook Activities

- Web of Life (Chapter 4, page 3)

Activity 3: Eastern Brook Trout Egg in the Classroom

New Hampshire State Science Standards

LS1 – All living organisms have identifiable structures and characteristics that allow for survival (organisms, populations, and species).
  1 – Classification
  2 – Living Things And Organization

LS2 – Energy flows and matter recycles through an ecosystem.
  1 – Environment
  2 – Flow of Energy

SPS1 – Scientific Inquiry and Critical Thinking Skills
  1 – Making observations and asking questions
  4 – Representing and Understanding results of investigations

SPS2 – Unifying Concepts of Science (including NECAP Science Assessment Targets by Big Idea)
  1 – Nature of Science (NOS)

SBS3 – Personal, Social, and Technological Perspectives
  2 – Environment, Natural Resources, and Conservation

SPS4 – Science Skills for Information, Communication and Media Literacy

3 – Problem Identification, Formulation, and Solution

Source: Judy Tumosa, Watershed Education Specialist, New Hampshire Fish and Game. Trout in the classroom programs in New Hampshire are supported by NH Fish and Game, NH Trout Unlimited Council and local Trout Unlimited chapters.
Summary: The Trout Egg in the Classroom Program is a way to educate students about the importance of maintaining native fish populations, for both ecological and recreational reasons, and provides them with an opportunity to assist with both state-wide and national efforts to increase brook trout populations.
Objectives: Students will learn about native trout, their life cycle, habitat and ecological requirements, and wildlife management strategies.
Estimated Time: Variable. Raising the trout eggs begins in January and ends in May/June when the small fish are released into a state-approved stream or river. Daily student involvement in the process of raising and monitoring the trout eggs and participation in supplemental activities is determined by each teacher.
Materials:
Purchasing materials for the Egg in the Classroom program can be quite costly. An aquarium chiller costs about $700 and the tank and other supplies can be around $200. Partnering with a local chapter of Trout Unlimited or another wildlife group can help raise the funds needed to have this program at your school.

- 20-30 gallon aquarium tank
- Aquarium chiller (available from Glacier Corporation at www.glaciercorp.com)
- Gravel (to cover bottom of tank)
- Tank insulation (to cover outside of tank completely)
- Duct tape
- Air stone
- Water filter
- Thermometer
- Turkey baster
- Trout in the Classroom forms and materials (provided at teacher training and from NH Fish and Game, examples for 2010-2011 can be found on the Workbook CD)

General Schedule:
August/September – NH Fish and Game sends out introduction letter and "Trout in the School Registration Form" to the schools to sign up for the program. All schools need a permit to raise and release the fish so they must go through Judy Tumosa to get their eggs. Schools should be arranging to get their equipment.
September/October – NH Fish and Game processes registration forms and sends them onto the fisheries biologists for approval of the stocking sites, egg numbers, and permit information.
November – NH Fish and Game and partners train new teachers and liaisons in trout life history, restoration program, tank set up and care, and fisheries activities. Typically lasts 4-6 hours, can be moved around the state and can include a tour of a hatchery.
December/January – NH Fish and Game sends out permits for the schools. NH Fish & Game coordinates with the hatcheries to get the eggs to the schools. Schools should set up their tanks at least a week ahead of time to make sure the chillers work.
January/April – Schools are raising their eggs and doing watershed and fish culture activities such as testing their local river and visiting their local hatchery. Schools track the development of trout using the daily temperature units (DTUs).

May – Schools stock the tiny fish, called fry, and fill out “Trout in the Schools Evaluation” and “Fry Stocking” forms.

<u>Additional Information</u>

- The New Hampshire Trout in the Classroom program is coordinated by NH Fish and Game and information about how to get your school involved can be found on this website: http://www.nhtrout.org/outreach-programs/trout-in-the-classroom/.
- The national Trout in the Classroom program website, hosted by Trout Unlimited, provides lesson plans and additional information about how to set up a tank and care for the trout: http://www.troutintheclassroom.org/.
- Project WILD Aquatic activities “Hooks and Ladders”, “Fishy Who’s Who”, and “Fashion a Fish” can be used to support the Trout in the Classroom program.

<u>Associated Student Workbook Activities</u>

- Web of Life (Chapter 4, page 3)
- Trout Life Cycle (Chapter 4, page 7)

Field component/Service project

Volunteer Biological Assessment Program (VBAP) Field Trip and Community Presentation

- Each fall, youth are encouraged to participate in VBAP and should contact Green Mountain Conservation Group before their annual training for new volunteers and teachers in August. Field days occur during two weeks in early to mid-September and sampling takes about 3 hours for each stream site.
- Students volunteer groups assist with the macroinvertebrate collection and sorting while at the stream site, and calculate the water quality score once back in the classroom. The VBAP Data Sheet is located on page 6 in Chapter 4 of the Student Workbook.
- Students who participate in VBAP can analyze their results and put together a presentation for the November Ossipee Watershed School Presentation and Open House for teachers, students, parents, and the community. Examples of 2010 school presentations and a template can be found on the Workbook CD.

Trout in Classroom Field Trips

- There are two potential field trips for schools participating in the Trout Egg in the Classroom program. Students can visit the fish hatchery in January when the trout eggs are picked up or they can take a trip to their local stream or river to release the trout fry in May/June.

Analysis

Graphing

- After the VBAP sampling field day and after students calculate their water quality score, they can create graphs of water quality score over time and across all the sites in the watershed and pie charts of the macroinvertebrate composition of each site. Examples of possible graphs and charts can be found in the 2009 VBAP Report and 2010 school presentation examples found on the Workbook CD, or in VBAP Reports on GMCG’s website: www.gmcg.org.

Mapping

- Map VBAP water quality scores across the Ossipee Watershed using Geographic Information System (GIS) software such as ArcGIS (if available) or Quantum GIS (free software available at www.qgis.org). For GPS coordinates and data, contact GMCG.

Extensions

- Have students select a specific macroinvertebrate that they observed at the stream. Based on what they learned about the insect in class and in the field, have the students write a story about the life of the organism. If possible, the students can do additional research for their stories.
- Investigate insect or fish poems and folklore with students. Have students write their own folk short story or poem. Examples of insect poems and folklore from The Insect Appreciation Digest by F. Tom Turpin can be found on the Workbook CD.
- For younger children, reading the picture book Trout are Made of Trees by April Pulley Sayre before participating in VBAP or the Trout in the Classroom program gives a good overview of stream ecosystems, macroinvertebrates, and trout.
- Another resource for younger students is the Elementary GLOBE Water Book and "The Discoveries at Willow Creek" story (Workbook CD).

Assessment Tools

- Draw an example of a food chain in a stream or river and describe.
- Graph and map data for VBAP Community Presentation
- Student Quiz (Appendix B)

Glossary

Benthic macroinvertebrate: Animal without a backbone that is large enough to see without a microscope and lives at least part of its life cycle on the bottom of a stream.

Biodiversity (biological diversity): The variety of all forms of life that occur within a region.

Biomonitoring: Using stream organisms as biological indicators of water quality.

Carnivore: A meat eater.

Complete metamorphosis: A process where insects go through a complete life cycle and all four stages of development: egg, larva, pupa, and adult.

Consumer: The first part of an ecosystem is the nonliving substance; the second part consists of those organisms that are called "producers", or food makers; the third part of this system is called the "consumer" because it uses the producer for its food; it may in turn be used as food by a secondary consumer.

Food chain: The transfer of energy from one organism to another as each consumes a lower member and is in turn preyed upon by a higher member.

Food web: A network of many food chains that more accurately reflects the complexity of the ecosystem.

Fry: Small young fish that have recently hatched.

Habitat: A place that includes everything that an animal or plant needs to live and grow. It includes food resources and the physical characteristics of the environment, as well as places and materials to build nests, raise young, and keep them safe from predators.

Hatchery: A place where fish eggs are hatched and raised.

Herbivore: A plant eater.

Incomplete metamorphosis: A process where insects do not go through all four stages of development and do not have a pupa stage. These insects have three stages in their life cycle: egg, nymph, and adult.

Indicator (species): Any species that defines a trait or characteristic of the environment.

Insectivore: An insect eater.

Metamorphosis: The biological process through which a juvenile transforms into a mature adult.

Omnivore: An animal that eats both plants and animals.

Piscivore: An animal that eats fish.

Planktivore: An animal that eats plankton.

Predator: An animal that kills and eats other animals.

Prey: Animals that are killed and eaten by other animals.

Primary producer: Organisms that are able to manufacture food from simple organic substances.

Tolerance: The ability to withstand a particular condition; for example, pollution-tolerant indicates the ability to live in polluted waters. An example of a pollution tolerant organism would be a leech because it can tolerate streams that have low dissolved oxygen levels. An example of a pollution intolerant organism would be brook trout because they require clear, oxygen-rich, streams.

Trophic level: The position an organism occupies on the food chain.

Water quality: The physical, chemical, and biological characteristics of water in relationship to a set of standards. Water quality standards are determined to protect drinking water, human contact with water, and the health of ecosystems.

Wildlife management: The application of scientific knowledge and technical skills to protect, preserve, conserve, limit, enhance, or extend the value of wildlife and its habitat.

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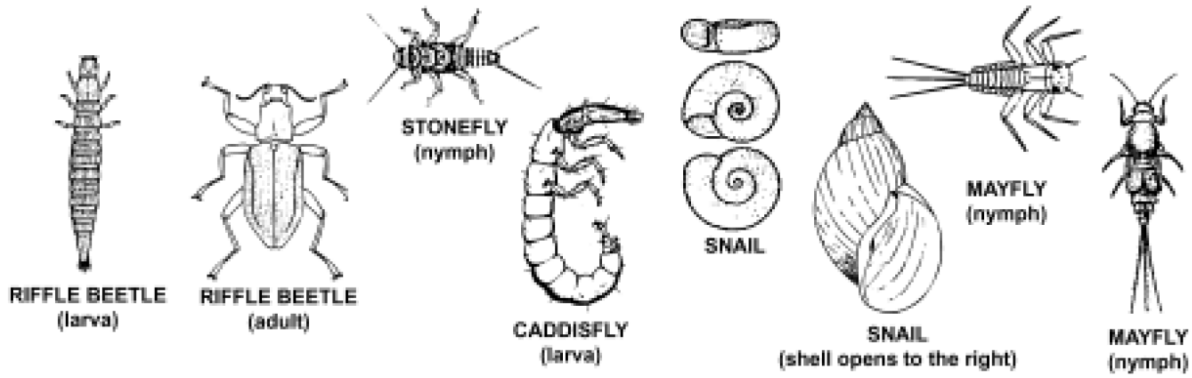
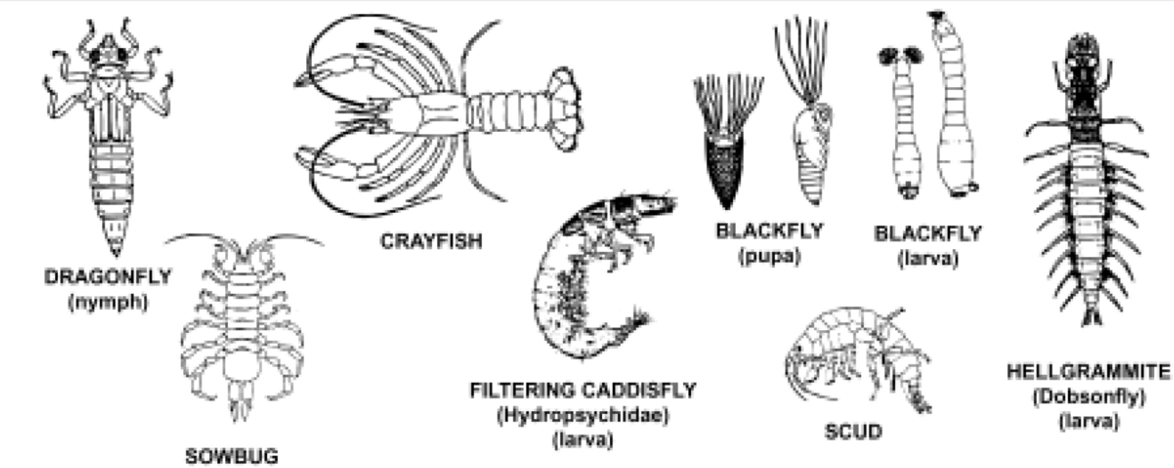
Appendix A: Macroinvertebrate Identification Sheet

MACROINVERTEBRATE GROUPS
Beginner s Protocol PICTURE KEY

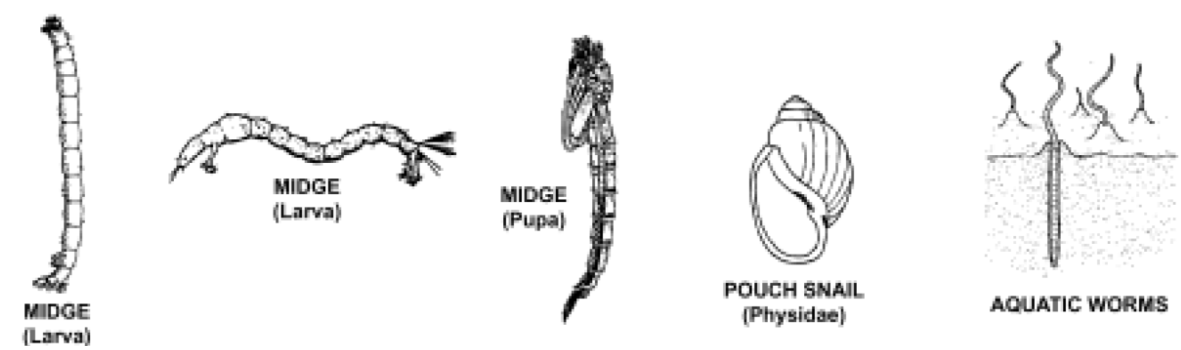
GROUP 1 *These organisms are generally pollution intolerant.*
*Their dominance generally signifies **Excellent-Good Water Quality.***



GROUP 2 *These organisms exist in a **Wide Range** of water quality conditions.*



GROUP 3 *These organisms are generally tolerant of pollution.*
*Their dominance generally signifies **Fair-Poor Water Quality.***



Appendix B: Student Quiz

Chapter 4: Aquatic Animals

Student Quiz

Define the following words.

1. Benthic macroinvertebrate: ____

   ____

   ____

   ____

2. Food web: ____

   ____

   ____

   ____

Fill in the blank.

3. Biomonitoring uses __________________________ as indicators of water quality.
4. Herbivores eat only _____________________.
5. Many food chains make up a _____________________.
6. The three pollution tolerance groups for macroinvertebrates are _____________________,

   _____________________, and _____________________.

Write in the pollution tolerance group for the following macroinvertebrates.
Hint: There are 3 in each group.

7. _____________________ Mayfly nymph
8. _____________________ Aquatic worm
9. _____________________ Caddisfly larvae
10. _____________________ Dragonfly nymph

11. ____________________ Blackfly larvae

12. ____________________ Damselfly nymph

13. ____________________ Midgefly larvae

14. ____________________ Cranefly larvae

15. ____________________ Hellgrammite (Dobsonfly)

<u>Match these drawings of benthic macroinvertebrates with their names in the box.</u>

16. _____

17. _____

18. _____

19. _____

20. _____

21. _____

22. _____

23. _____

A. Mayfly nymph

B. Stonefly nymph

C. Caddisfly larvae

D. Hellgrammite (dobsonfly)

E. Dragonfly nymph

F. Damselfly nymph

G. Blackfly larvae

H. Water penny

True/False

24. _____ Carnivores eat only plants.

25. _____ Most humans are omnivores.

26. _____ Predators are often at the top of the food chain.

27. _____ Having lots of macroinvertebrates that are sensitive to pollution in a stream means that the water quality is good.

28. _____ Having Eastern brook trout in a stream indicates poor water quality.

Draw an example of an aquatic food chain:

Make sure to draw the arrows in the correct direction and include at least four trophic levels.

Chapter 4: Aquatic Animals

Student Quiz Answer Sheet

Define the following words.

1. Benthic macroinvertebrate:

   An animal without a backbone that is large enough to see without a microscope and lives at least part of its life cycle on the bottom of a stream.

2. Food web:

   A network of many food chains that more accurately reflects the complexity of the ecosystem. A food chain is the transfer of energy from one organism to another as each consumes a lower member and is in turn preyed upon by a higher member.

Fill in the blank.

3. Biomonitoring uses __stream organisms__ as indicators of water quality.

4. Herbivores eat only __plants__.

5. Many food chains make up a __food web__.

6. The three pollution tolerance groups for macroinvertebrates are __sensitive__,

   __somewhat sensitive__, and __tolerant__.

Write in the pollution tolerance group for the following macroinvertebrates.
Hint: There are 3 in each group.

7. __Sensitive___________ Mayfly nymph

8. __Tolerant____________ Aquatic worm

9. __Sensitive___________ Caddisfly larvae

10. __Somewhat sensitive_ Dragonfly nymph

11. __Tolerant____________ Blackfly larvae

12. __Somewhat sensitive_ Damselfly nymph

13. __Tolerant___________ Midgefly larvae

14. __Somewhat sensitive_ Cranefly larvae

15. __Sensitive__________ Hellgrammite (Dobsonfly)

Match these drawings of benthic macroinvertebrates with their names in the box.

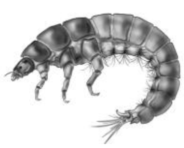
A. Mayfly nymph
B. Stonefly nymph
C. Caddisfly larvae
D. Hellgrammite (dobsonfly)
E. Dragonfly nymph
F. Damselfly nymph
G. Blackfly larvae
H. Water penny

16. __B__

17. __E__

18. __H__

19. __G__



20. __C__

21. __F__

22. __D__

23. __A__

True/False

24. __F__ Carnivores eat only plants.

25. __T__ Most humans are omnivores.

26. __T__ Predators are often at the top of the food chain.

27. __T__ Having lots of macroinvertebrates that are sensitive to pollution in a stream means that the water quality is good.

28. __F__ Having Eastern brook trout in a stream indicates poor water quality.