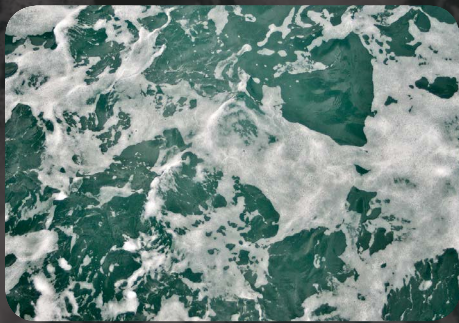


River Buddies

Grade: 6

Subject Areas:
Life Science, Social Science, Chemistry

Skills: **identifying, observing, predicting, classifying, inferring**

Duration: **1-2 hours**

Connections:
ecology, water quality, fisheries, natural resource planning

Vocabulary
reservoirs
indigenous
watershed
monitor
assess
macroinvertebrate
metamorphosis
complete metamorphosis
incomplete
metamorphosis
tolerance
habitat
detritus

Objective:
Students will identify macroinvertebrates and will connect them to the health of a stream as an introduction into biological monitoring.

Materials
- keys to common macroinvertebrates (see attached)
- samples of macroinvertebrates taken from a nearby waterway (nets required)
- large and small plastic tubs
- small plastic spoons and paint brushes
- student handout (see attached)

Standards
Strands: Excellence in Environmental Education Guidelines
Strand 1 —Questioning and Analysis: E) Organizing Information: Learners are able to classify and order data, and to organize and display information in ways that help analysis and interpretation. **G) Developing explanations:** Learners are to synthesize their observations and findings into coherent explanations.
Strand 2 — Env. Processes and Systems: 2.2 The Living Environment: A) Organisms, populations, and communities: Learners understand that biotic communities are made up of plants and animals that are adapted to live in particular environments. **C) Systems and connections:** Learners understand major kinds of interactions among organisms or populations of organisms.
2.4 Environment and Society: Human/environment interactions: Learners understand that human caused changes have consequences for the immediate environment as well as for other places and future times.
Strand 3 - 3.1 Skills for Analyzing and Investigating Environmental Issues: C) Identifying and evaluating alternative solutions and courses of actions: Learners are able to apply identify and develop action strategies for addressing particular issues.

California State Educational Standards:
Earth Science: 2a. Students know water running downhill is the dominant process in shaping the landscape, including California's landscape. **2b.** Students know rivers and streams are dynamic systems that erode, transport sediment, change course, and flood their banks in natural and recurring patterns.
Life Sciences (Ecology) 5c. Students know populations of organisms can be categorized by the functions they serve in an ecosystem. **5e.** Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition**.**

Background

Flowing Waters

Rivers are a major force behind modifying the landscape and linking mountains with the sea. They come in assorted sizes and shapes depending on the amount of rainfall and slope of the surrounding land. Often smaller streams join larger ones, carving branch-like drainage patterns and picking up sediment as they course down slope. Eventually most rivers reach a lake or an ocean where they release the last of their sediment load that is carried with their water.

Rivers and streams benefit the landscape in many ways. As they move, rivers and their adjoining streams carry water, food, and sediments. These transported substances can sometimes travel hundreds of miles from their source. Important gases and nutrients stored in rivers are used by a multitude of living things including algae, mollusks and amphibians. They provide abundant food for animals like otters and turtles and vital habitat for fish and aquatic insects. Rivers are essential sources of fresh water for people and wildlife. Many communities depend on rivers for their main supply of fresh water. In order to store water for long periods of time, rivers are frequently dammed to make **reservoirs**. These can be damaging to fish and other organisms that depend on water. Most stored water is used for agriculture, however reservoirs are used for recreational activities too.

Because rivers are full of life giving resources, a diverse background of cultures have held them sacred for millennia. The Nile and the Ganges are two major examples. Local rivers like the Eel and the Mattole were the central focus for the indigenous tribes that lived along their banks. **Indigenous** refers to the original group living in an area. Here, salmon returned to the rivers to spawn twice a year. Prior to the early 1900's these salmon runs were so productive hundreds of thousands of salmon filled the rivers supplying an seemingly endless supply of food for people and wildlife alike.

Within the King Range National Conservation area (NCA), thirteen streams provide potential habitat for salmon. Many of these streams are located on the western flank of the King Range and flow directly into the Pacific Ocean. Others wind their way through the Mattole river watershed. A **watershed** is the entire drainage of a particular

Local Connection

Friends of the Eel River (FOER)

Friends of the Eel River (FOER) is a nonprofit group dedicated to monitoring and improving the Eel River system. FOER works in a variety of capacities with the overall goal of increasing the flow of the Eel River to historic levels. 90% of the headwaters is diverted to the Potter Valley Hydroelectric Project (PVP), ultimately ending up in the Russian River of Sonoma county. According to FOER, the PVP is an example of antiquated water management and poor urban planning. It blocks one hundred miles of prime breeding habitat for salmon and depletes available water resources downstream.

Today the PVP is owned by PG& E (Pacific Gas and Electric). The project got started in 1906 when Ukiah outgrew its small, dirty coal fired power plant. The city of Ukiah hired M. M. Van Arsdale to build a hydroelectric plant. He did so by tunneling out one mile of a mountain in order to divert water from the mainstem of the Eel River to the Russian River. In 1906, the Cape Horn Dam was built creating the Van Arsdale Reservoir. This reservoir quickly silted up and in 1922, the Scott Dam was erected 12 miles upstream creating Lake Pillsbury. From Lake Pillsbury, water moves through the Van Arsdale tunnel and down a steep gradient through several turbines, generating nine megawatts of electricity daily.

Historically, the Eel River had the third largest run of salmon in California and was a popular location for both recreational and commercial fishing. The collapse of the Eel River salmon population is a key factor to the official listing of chinook and coho salmon as threatened and endangered throughout Northern California. In addition, the construction of the dams killed hundreds if not thousands of "eel" (actually lamprey), the namesake of the Eel River. Noted as the third longest river in California, many miles are designated as wild and scenic. FOER continues to be an advocate for fish and other wildlife and has filed many lawsuits in the hopes that the dams will be dismantled and the PVP will ultimately come to an end.

waterway like a river or stream.

The Mattole watershed has high levels of sediment based on historical land practices and the geology of the area. Anecdotal evidence indicates that salmonids were so numerous they could be speared, snagged or netted in many locations along lower reaches of the river's banks until the early 1970s. Runs of salmon have declined drastically here in recent decades. Much work is being done to support salmon populations including replanting, improving culverts, and fish counts. Monitoring fish by counting them helps to check their progress.

Rivers and streams can be vulnerable to sedimentation, pollution and other hazardous substances because rain and snow wash substances into low lying places. Biological monitoring can be used to **assess** or estimate the quality of a river and its surrounding watershed. Monitoring includes collecting and studying data on water chemistry, physical characteristics and the organisms that live there.

Testing the Water

Biological organisms can be used for assessing the health of a stream because some organisms are more sensitive to pollution than others. The organisms most used for stream monitoring are called macroinvertebrates **Macroinvertebrates** lack an internal skeleton and are large enough to see with the naked eye. Most macroinvertebrates are insect larvae, however others include crustaceans, snails and worms. Crustaceans have an exoskeleton like insects and include little shrimp commonly found called scud. Many insects likes caddis flies, beetles and dragonflies have two stages of life very different from one another. Their immature stage lives in fresh water and has gills. The adult stage usually has wings and lives outside of water. The change from one form to the other is called **metamorphosis**.

Some insects go through a **complete metamorphosis** like flies, beetles and caddis flies. Others go through incomplete metamorphosis. Both forms begin with an egg laid in water. During complete metamorphosis, the egg develops into a larva which gradually transforms into a pupa. Pupae are often incased, like the cocoon of a butterfly or moth. Caddis flies for instance make little cases out of mud, sticks, leaves, shells, and rocks. The pupa undergoes a drastic change as it morphs from an aquatic organism to a terrestrial one. It eventually emerges as an adult. **Incomplete metamorphosis** lacks the pupa stage. Larval forms can have both an early and late form and are sometimes referred to as nymphs. Dragonflies, stoneflies and mayflies are examples of insects that go through incomplete metamorphosis. In general, nymphs look more like their adult counterparts compared to pupae. Winged adults from both types can often be observed along a rivers edge in late spring and summer.

As mentioned earlier, certain species of macroinvertebrates can be described as less tolerant to certain factors, like pollutants, than others. **Tolerance** in this case refers to the relative capacity for an organism to withstand certain unfavorable environmental conditions. Less tolerant species can be used as indicators because if they are abundant, levels of pollution and/or sediment have not reached destructive levels. On the other hand, if only tolerant species are observed, there is a high probability that water quality has been compromised. Analyzing the overall diversity of a stream can therefore be used to assess its health. (see attached list for various types of macroinvertebrates and their associated levels of tolerance)

Healthy Streams

Several factors influence the health of a stream and consequently the organisms that live in it. These factors include temperature, dissolved oxygen, and the presence of chemicals like phosphates and nitrates. **Habitat** or the space a macroinvertebrate occupies, is also important. This habitat includes the rocks and sediments that lie along the bottom of a stream, the plants that live in and around a stream, and the decomposed material or **detritus** that fall into a stream. Decomposed material can include logs, sticks and woody debris all of which provide important places to live.

Activities along a stream can greatly impact environmental factors. For instance, if the vegetation living along a stream, known as riparian habitat, is removed, stream banks can become unstable. Unstable stream banks may lead to increased erosion which increases the amount of sedimentation. Excess sedimentation fills in pockets of air spaces among the rocks reducing oxygen levels. Removing vegetation also increases water temperature and decreases food resources and habitat. Similarly, if cattle or other farm animals are in or near a stream, their droppings lead to excess nitrogen. Excess nitrogen encourages algae and bacterial growth, both of which can reduce oxygen levels available for other organisms. Another source of nitrogen is human sewage, which can come from homes with leaky septic systems or pot farms. Alien or exotic species pose another threat to populations of native organisms by crowding them out or outcompeting them.

Environmental degradation more than likely reduces diversity of any ecosystem. Rivers and streams are particularly vulnerable to factors like pollution because they collect runoff. Many macroinvertebrates are stationary and must survive in the place where they are born. These wonderful and fascinating organisms can be indicators of the health of a waterway and are also important links to aquatic food chains. By learning more about macroinvertebrates, students can not only participate in biological monitoring, but can also begin to make deeper connections to how human activities influence their local waterways.

Activity 1: Identifying General Features of Macroinvertebrates

Preparation
Using a kick net and/or a D-frame net, collect an assortment of macroinvertebrates from a local stream. Once in the classroom, place them in containers so different groups can have access to them for identification purposes. Since you will be the "expert" on keying macroinvertebrates, become familiar with most of the common ones. (see attached key) Rachel may have others.

Materials
- **keys to common macroinvertebrates (see attached)**
- **samples of macroinvertebrates taken from a nearby waterway (nets required)**
- **large and small plastic tubs**
- **small plastic spoons and paint brushes**
- **student handout (see attached)**

Procedure
1. Begin by asking the students to take a minute to come up with how they could monitor the health of a stream if they were a biologist and this was their job. Have the students share their ideas. Summarize their ideas by writing them on the board. Using their examples, begin to ask questions about environmental factors affecting local streams and rivers. An option is to have students take notes.

- *What are some words we could use to describe a healthy stream?*
- *Why is it important to monitor streams?*
- *What types of things indicate a healthy stream versus an unhealthy stream?*
- *What are some things that might lower the water quality of a stream?*
- *Who can give me an example of something that depends on a stream to live? (repeat the last question—ask what else)*
- *For this last question, try and gather examples of different groups of animals and plants. (cottonwoods, willows, algae, river otter, osprey, turtles, clams, fish, and insects).*

2. Together come up with several examples of an aquatic food chain using student responses. A food chain shows the flow of energy from one organism to the next as they are consumed (algae, insect, fish, osprey). Next, ask which organisms can't move very far. For instance, fish can swim away from an area, but a clam has to stay in the same location year after year. Those that stay fixed in one place are found more easily which is one of the reasons why they are used to monitor the health of a stream. Introduce the term macroinvertebrate. Break the word down and have them help give definitions for "macro" (large) and "invertebrate" (no backbone).

3. After reviewing important characteristics used for identification (gills, size, morphology), break the students up into groups of 3-4. In their groups, have the students observe and identify collected samples of macroinvertebrates (see attached key). Tell the students where the water sample is from. They should observe specimens closely by removing them using a spoon or small paint brush. It is important that the macroinvertebrates stay in water the entire time. Some are more delicate than others. If you have a large nymph of a dragonfly or other sensitive species, you may want to set it aside and have students come up to view it separately. Give about 20 minutes for students to identify a few macroinvertebrates or until you see them losing attention. While students are identifying the macroinvertebrates in their water sample, have them sketch a few and label of few of them.

Activity 2: Assessing the Health of a Stream Using Macroinvertebrates

Preparation

Make four or more stations each with a different sample of macroinvertebrates. Some samples should have a wide diversity of organisms including non-tolerant species. Other samples should have a limited amount of organisms with a majority of tolerant species. Number each station clearly. Instead of keying out individual species, students will assess which samples of water indicate a healthy stream versus an unhealthy stream by counting individual types. Directions are on their handout, however, you may need to read these directions out loud first.

Procedure

1. Review with the students how one can use macroinvertebrates to assess and monitor the health of a stream. Give the definitions for the terms: assess and monitor, and write them on the board. Pass out the student worksheet to each student. Students should work in groups, but fill out their own sheet.

2. In groups, have the students fill in their worksheet by identifying and counting different types of macroinvertebrates. Once they are done, have them analyze their results to assess the health of each sample. Review the results together. Make a table on the board or overhead and cluster their results. Rank the samples from highest to lowest water quality based on the diversity of species and their tolerance levels.

- *What factors are necessary for less tolerant species to survive? (cold water, high oxygen content, space, etc.)*
- *What might be some factors that would cause the difference observed in our water samples?*
- *What kinds of activities might increase the temperature of a stream?*
- *What kinds of activities might decrease oxygen levels of a stream?*
- *What can people do to improve the water quality of streams?*

Extensions

- Have students learn how to identify the different species of salmon that live in local streams. A good coloring book is available at: http://library.fws.gov/pubs1pacsalmon_steelcoloring00.pdf
- Encourage local stewardship by having students reinforce river banks, remove exotic species and/or plant trees in their local watershed.
- Relate local geology and rock types to weathering and erosion.
- Invite a member of the community who is part of an indigenous tribe. Have him or her share stories about their culture.
- Set up an obstacle course outside representing the hazards salmon run into as they return to a river to spawn. Include dams, fishermen, improperly placed culverts and other hardships.
- Take a field trip to a local stream and have the students assess its water quality.

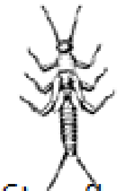
References

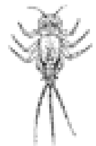
Aquatic macroinvertebrates; KRIS Web, http://www.krisweb.com/aqualife/insect.htm
Biological Stream Monitoring, http://www.iwla.org/index.php?ht=display/ContentDetails/i/1479/pid/1976
King Range National Conservation Area Draft Resource Management Plan and Draft Environmental Impact Statement, U.S. Department of Interior, BLM, Arcata Office, Jan. 2004
Macroinvertebrates, http://www.delawarenaturesociety.org/sw_macro.html
Macroinvertebrate Mayhem , Project Wet Curriculum & Activity Guide, pgs. 322-324, www.projectwet.org, 2011
Rivers and Streams, http://www.nhptv.org/natureworks/nwep7j.htm
The Mattole Watershed, http://www.mattolesalmon.org/index.php/the-mattole-watershed
Virtual Fish Tent: Dams http://eelriver.org/outreach/virtual-fish-tent-dams/, 2011
Watersheds and Salmonid Teaching Resources, http://

REFERENCES continued……...
www.watershedstewards.com/education_rs, 2011

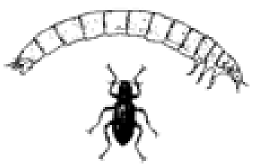
AQUATIC MACROINVERTEBRATE IDENTIFICATION KEY

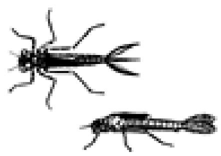
Sensitive to Pollution


Stonefly

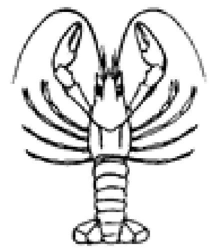

Mayfly

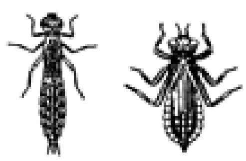
Somewhat Sensitive to Pollution

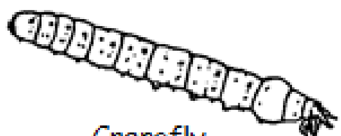

Riffle Beetle
Larvae & Adult

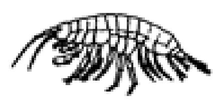

Damselfly


Caddisfly


Crayfish

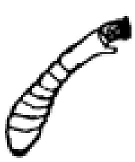

Dragonfly

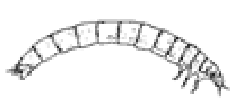

Cranefly

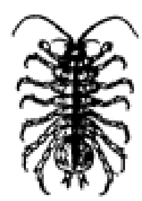

Scud
(swims on side)

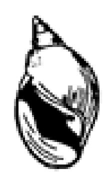
Tolerant to to Pollution


Aquatic
Worms


Blackfly


Midge
(red)


Isopods
(walks on bottom)


Pouch Snail
(left opening)

MACROINVERTEBRATE WATER QUALITY INDICATORS

http://farm5.staticflickr.com/4058/4577656328_69fe4e3942_o.jpg

Stoneflies *(Order Plecoptera)*
All stonefly nymphs have a roach-like body, two tails and two hooks at the end of each leg. The nymphs can reach up to 1 inch in length. They live in fresh water.

Water Quality: **EXCELLENT**

http://farm5.staticflickr.com/4092/5209630331_7ace914f88_b.jpg

Mayflies *(Order Ephemeroptera)*
All mayfly nymphs have a roach-like body, two or three tails and one claw at the end of each leg. Rows of gills can often be seen along the sides of the abdomen. They live in fresh water.

Water Quality: **GOOD**

http://farm7.staticflickr.com/6188/6147877002_5161acc558_b.jpg

Caddisflies *(Order Trichoptera)*
All caddisfly larvae have a maggot-like body, six distinct legs and two hooks at the end of the body. Many camouflage themselves in cases made from pebbles and debris fastened by silk to the underside of rocks. They live in fresh water.

Water Quality: **FAIR**

http://farm4.staticflickr.com/3419/3951349029_a461907fba_o.jpg

True Flies *(Order Diptera)*
All true flies have a maggot-like body and lack distinct legs. They live in fresh water.

Water Quality: **POOR**

For more information on microinvertebrates visit:
http://people.virgina.edu/~sos-iwla/Stream-Study/StreamStudy-HomePage/StreamStudy.html

Date: ____________________ School: ____

Creek/River/Stream Name: ___________________________________ Air Temperature: ____________

Weather Conditions: ☐ Clear ☐ Cloudy ☐ Rainy ☐ Other: ______________________

Water Appearance:

- ☐ Scum
- ☐ Foam
- ☐ Muddy
- ☐ Milky
- ☐ Clear
- ☐ Oily sheen
- ☐ Brownish
- ☐ Algal
- ☐ _______________

Stream Bed Coating:

- ☐ Orange to red
- ☐ Yellowish
- ☐ Black
- ☐ Brown
- ☐ None
- ☐ ________________

Odor:

- ☐ Rotten egg
- ☐ Musky
- ☐ Odd
- ☐ Chemical
- ☐ Metallic
- ☐ Chlorine
- ☐ None
- ☐ ________________

Monitoring Parameters	Results
Temperature	
pH	
Dissolved Oxygen	
Turbidity	
Phosphate	
Nitrate	
Coliform	

Other observations: ______________________________________

____

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Bioindicators: Aquatic Macroinvertebrates	**Scientific Class or Order**	**Pollution Tolerance**	**Numbers Found**
Backswimmers/Striders	Hemiptera	Class 2	
Beetles	Coleoptera	Class 2	
Clams	Pelecypoda	Class 3	
Dragonflies/Damselfly	Odonata	Class 1-2	
Flat worms	Turbellaria	Class 3	
Flies (true)	Diptera	Class 3	
“Flies” (Caddis, Stone, May, Dobson)	Various	Class 1	
☐ Caddisfly	Tricoptera	Class 1	
☐ Stonefly	Plecoptera	Class 1	
☐ Mayfly	Ephemeroptera	Class 1	
☐ Dobsonfly	Megaloptera	Class 1	
Isopods	Isopoda	Class 2-3	
Leeches	Hirudinea	Class 3	
Midges	Diptera	Class 3	
Mussels	Pelecypoda	Class 3	
Segmented worms	Oligochaeta	Class 3	
Snails	Gastropoda	Class 3	
Other			

Pollution Tolerance Categories:

Class 1: Needs clean water Class 2: Needs fairly clean water Class 3: Tolerates polluted water