Creek Critters: An Introduction to Biological Monitoring

Students learn how benthic macroinvertebrates are collected, identified and categorized to assign a water quality index to a stream. They will also become familiar with some representative species of benthic macroinvertebrates.

Level(s): 6-8

Subject(s): Earth Science, Life Science

Virginia SOLs: 6.5 g; 6.7 a,c,f,g; LS4 a,b,c; LS7 a,b,c,d; LS9 a,b,d; LS10 c; LS11 a,b; LS12 b,d,e;

Objectives:
Students will be able to:

1. List one representative of each of the three groups of tolerant, slightly tolerant and intolerant macroinvertebrate index species.

2. Explain how to collect a sample of benthic macroinvertebrates from a stream.

3. Use an identification guide to identify common benthic macroinvertebrates.

Materials:

- Biological Monitoring Powerpoint Presentation, *Creek Critters: An Introduction to Biological Monitoring*
- *Biological Monitoring Worksheet*
- *Biological Monitoring Field Worksheet*
- *I.D. Guide to Macroinvertebrates*
- Macroinvertebrate Game Cards (one set for each group of 3-4 students)

Estimated Time:
In the Classroom: 45 – 60 minutes

Background Information:
Benthic Macroinvertebrates and Biological Stream Monitoring, p.31.

Preparation:

- Make copies of Macroinvertebrate Game Cards and cut them out to provide one set for each group of 3-4 students. If possible, the cards should be laminated for repeated use.
- Make copies of the handouts: *Biological Monitoring Worksheet*, *Biological Monitoring Field Worksheet*, *I.D. Guide to Macroinvertebrates*.

Activity Procedure:

1. Have students fill in the blanks on the worksheet while you give the Powerpoint presentation and discuss with students the concepts introduced. Each slide indicates the relevant worksheet item in the upper left-hand corner.

2. Start the Powerpoint presentation *Creek Critters: An Introduction to Biological Monitoring*. **Slide #1** has a photograph of a **hellgrammite**, one of the larger (2-3 inches) macroinvertebrates found living on the bottom of local streams.

3. **Slide #2** gives a **definition** of "benthic macroinvertebrate", the creatures we will be capturing and identifying in the method of biological monitoring we will introduce in this unit.

4. **Slide #3** has pictures of some of the species of **macroinvertebrates** we will be working with.

5. **Slide #4** gives an example of each of the three groups of macroinvertebrates that are used in biological monitoring: one that is **intolerant** of pollution, one that is **slightly tolerant** and one that is **tolerant** of pollution.

6. **Slide #5** compares the **larval** and **adult** stages of one macroinvertebrate species. Most benthic macroinvertebrates represent the larval stages of insects.

7. **Slide #6** has a picture of one larvae card and one adult card in the **matching game** the students will be playing to help them become familiar with some macroinvertebrate species. **Slides #7** and **#8** explain the rules. Make sure the students understand the rules. Divide the students into groups of 3 or 4. **Give each group one deck of cards**. You can have the students play the game twice, time permitting.

8. **Slide #9** has a picture of macroinvertebrates on rocks in a stream **riffle**. A riffle is stretch of stream that is covered with cobbles (rocks between the size of a tennis ball up to about the size of a basketball), where the water is stirred up as it passes over and between the rocks. Many macroinvertebrates live on these rocks, and benefit from the dissolved oxygen that the turbulence they produce introduces into the water **Slides #10** and **#11** are photographs of two typical **riffles** in local streams.

9. **Slides #12** and **#13** show monitors using a net to collect macroinvertebrates from a stream. Go over the procedure outlined on the student worksheet. Provide a net and some rocks and have some student volunteers act out the procedure for using the net to collect bugs on a stream bottom.

10. **Slides #15-#17** show how the bugs are identified.

11. Hand out copies of the ***Field Workshee****t* and the ***Macroinvertebrate Identification Guide***. Students can work individually or in pairs to identify each bug on **slide #18** using the *Macroinvertebrate Identification Guide*. They should then use the *Field Worksheet* to find out which **class** the macroinvertebrate is located, and write the name of the bug under that class on the other side of the **Field Worksheet**.

12. **Slide #19** takes the students through the simple calculation required to find the Water Quality Index. **Slide #20** shows the Water Quality Index Chart used to rate the water quality of a stream based on the Water Quality Index.

13. Go over the last two items on the student worksheet in section III.

Assessment Opportunities:
Ask students to do the following:

1. List one representative of each of the three groups of tolerant, slightly tolerant and intolerant macroinvertebrate index species.

2. Explain how to collect a sample of benthic macroinvertebrates from a stream.

3. Use an identification guide to identify common benthic macroinvertebrates.

Extensions:
Follow this activity up with a field experience collecting and identifying macroinvertebrates in a local stream (see *Biological Monitoring* lesson plan).

Benthic Macroinvertebrates and Biological Stream Monitoring

Macroinvertebrates are animals that do not have backbones (*invertebrate*), but are visible to the naked eye (*macro*). A variety of these organisms live on the stream bottom (*benthos*). Many benthic macroinvertebrates are the larval stage of insects, but others are represented by freshwater aquatic worms, snails, clams, and crustaceans (crabs, crayfish, shrimp). In this article we will refer to benthic macroinvertebrates as BMIs.

Because BMIs are relatively sedentary residents of the stream bottom, they are often quite vulnerable to pollution. Fish can often swim away from some pollution problems, but BMIs do not have that option. Alterations to the stream may have a great impact on the abundance and distribution of different macroinvertebrate types.

Some species are intolerant of pollution. Their presence in a stream suggests healthy conditions. Some can tolerate low levels of pollution, while others are quite tolerant of pollution. Taken together, the presence or absence of tolerant and intolerant types can indicate the overall health of a stream. A sample of benthic macroinvertebrates can be taken to gauge the general health of a stream. Methods vary from the quantitative Virginia Save Our Streams protocol to more qualitative simplified methods used to get a rough idea of the water and habitat quality.

Samples of benthic macroinvertebrates are taken in the shallow, rocky areas of streams known as riffles. A net is used to collect organisms dislodged from the rocks and other substrate on the bottom of the stream. The organisms are identified to form a qualitative picture of the quality of the habitat,. The number of individuals of each species can also be counted and percentages calculated to document stream health in a quantitative manner.

Water Pollution

A variety of environmental stressors can impact macroinvertebrate populations. Urban and/or agricultural runoff can produce conditions that some macroinvertebrates cannot tolerate. Runoff washes numerous substances into streams, including **pesticide** and **herbicide** residues, depositions of **oil** and **gas** from cars and small quantities of highly toxic **heavy metals**.

Sewage and **fertilizers** contain nutrients which promote the rapid growth of algae in streams. When algae die in large quantities and decompose, bacteria consume oxygen and make it unavailable to macroinvertebrates and other aquatic species. Atmospheric nitrogen from car exhaust and other sources is also a plant nutrient deposited in streams.

Changes in land use when natural vegetation is removed on construction sites or poorly protected cropland may expose soil to erosion and add **sediment** to the water during storm events. Sedimentation destroys habitats by smothering the rocky areas of the stream where macroinvertebrates live. Sediment can also cloud the water, clogging gills and making food more difficult to find.

Sediment suspended in the water can also raise the water **temperature** when particles absorb heat from the sun. The removal of trees along the banks of a river and alteration of stream **velocity** can both alter normal water temperature patterns in a stream. Most aquatic organisms require a constant temperature within a certain range to remain healthy.

Life Cycles

Many BMIs (especially those of insects), tend to have short life cycles, usually one season or less in length. To assess the effect of a pollutant or flood on this year's population of trout or salmon, we would have to wait as long as four years, depending on the species, to see a decreased number of returning adults. With BMIs, a problem would become apparent in a much shorter time.

Many BMIs represent an immature stage in the life cycle of an insect. Some insects such as flies, beetles and caddisflies go through a complex set of changes known as *complete metamorphosis*, beginning their life as an **egg**, hatching into a **larva**, transforming into a **pupa** (usually non-moving and encased like the cocoon of a butterfly or moth), and eventually emerging as a winged **adult**. Other insects such as dragonflies, stoneflies and mayflies undergo a less complex series of changes called *incomplete metamorphosis*, skipping the pupal stage. The larva of insects which undergo incomplete metamorphosis are sometimes called *nymphs*.

As a larvae grows, it must shed or molt its skin-like exoskeleton. Most aquatic insects spend the greater part of their lives as larvae, and may molt as many as 40 times. Some larvae live a year or more in the water before spending a season or less as an adult. Mayflies, for example, may live only a few hours as an adult. After spending most of their life eating and growing as a larvae, adult insects must quickly find another of the same species, mate and deposit their eggs before they die to begin the cycle anew.

Food Chain

Macroinvertebrates play an important part in the stream food chains as the intermediate link between higher and lower feeding levels. Some macroinvertebrates are **herbivores**, feeding on plants or algae (plants are known as primary producers because of their ability to use photosynthesis to produce their own food). Other BMIs are **carnivores**, feeding on other macroinvertebrates, and even small fish and amphibians. Still others are **detritivores**, feeding on organic material that fall into and is carried into the stream habitat. Macroinvertebrates in all feeding groups play an important role in recycling nutrients in the stream ecosystem.

Feeding Adaptations

BMIs are divided into four groups according to their feeding habits. They have developed a variety of adaptations which maximize the effectiveness of their preferred feeding strategy. **Shredders** posses chewing mouthparts which allow them to feed on large pieces of decaying organic mater, such as leaves and twigs, which fall into the stream from trees and other plants in the riparian zone. Some have strong enough mouth parts to chew dead animal parts and/or living plant material when detritus is in short supply.

Scrapers or **grazers** remove attached algae from rock or wood surfaces in the current. They are found in areas where sunlight is able to reach the stream bottom, because without sunlight, algae cannot grow. Because these conditions often occur in larger, wider streams, many scrapers have developed adaptations for "hanging on" in relatively swift currents. They have flat, streamlined bodies or suction disks.

Collectors depend on fine particles of organic matter. **Filtering collectors** are adapted for capturing these particles from flowing water. Some caddisfly larvae spin nets for this purpose. Black fly larvae attach themselves to the substrate and filter particles using sticky hair-like fans.

Gathering Collectors gather small sediment deposits from stream bottoms and other substrates. Their mouth parts and appendages are designed for such activity, and many are adapted for burrowing into bottom sediments.

Predators consume other macroinvertebrates. They have behavioral and anatomical adaptations for capturing prey. May have extensible mouthparts or raptorial forelegs adapted for grasping prey, and strong opposable mouthparts for biting and chewing. Some predators pierce their prey and such body fluids with tubelike mouthparts. Yum!

Breathing Adapattions

The art of breathing[1] in an aquatic environment depends on extracting **dissolved oxygen** in the water. Some species have soft or membranous areas of the body wall through which oxygen diffuses Many have external **gills** (membranous outgrowths of the body wall) which increase surface area for oxygen uptake. These gills can be platelike, filamentous, tubelike or fleshy.

Some macroinvertebrates constantly **move** part of their bodies to increase available oxygen supply. You can observe the feathery waving motion of the abdominal gills on certain mayfly larva, for example. Some caddisfly larvae, which have no gills, move their abdomens in an undulating motion. Other BMIs posses functional **spiracles**, openings on the outer body wall which lead directly to a network of tubes that distribute oxygen throughout the body. Other aquatic macroinvertebrates with spiracles maintain some bodily contact with the surface of the water via tubelike structures and actually breathe atmospheric oxygen. You can observe mosquito pupae "attached" to the surface of the water breathing in this manner. Some species such as adult water beetles carry their own oxygen supply in a bubble captured at the surface and held by wings or hair-covered body parts which they breathe using s system of spiracles.

[1]When no air is taken into lungs, this is technically called *respiration* rather than *breathing*.

Sources: Adopt a Stream Foundation: *Streamkeeper's Field Guide*
Project Wet: *Macroinvertebrate Mayhem*

Biological Monitoring of Streams

Students collect benthic macroinvertebrates from a local stream. They then identify and categorize the species collected, and use the result to calculate a water quality index for the stream. The activity described in this lesson plan is a simplified version of the Virginia Save Our Streams protocol used by the Virginia Department of Environmental Quality.

Level(s): 6-8

Subject(s): Earth Science, Life Science

Virginia SOLs: 6.5 g; 6.7 a,c,f,g; LS4 a,b,c; LS7 a,b,c,d; LS9 a,b,d; LS10 c; LS11 a,b; LS12 b,d,e; PS1 k;

Objectives:
Students will be able to:

1. Collect a sample of benthic macroinvertebrates from a local stream.

2. Identify the species collected.

3. Calculate a water quality index for the stream based on the collection data.

Materials:
For each student:

- *Biological Monitoring Field Worksheet*
- *I.D. Guide to Macroinvertebrate Index Species*

For each Student Group:

- clipboard
- kick seine
- (optional) outdoor table
- white plastic tablecloth
- several pairs of tweezers
- 2 white plastic ice cube trays
- (optional) magnifying glasses

Estimated Time:
In the Field: 45 – 60 minutes

Background Information:
Benthic Macroinvertebrates and Biological Stream Monitoring, p.31.

Preparation:

- Make copies of the handouts: *Biological Monitoring Field Worksheet, I.D. Guide to Macroinvertebrate Index Species*.
- Have the equipment set up at streamside before the activity begins.
- It is desirable to have one adult to assist/monitor each student group.
- Make sure all students have a change of shoes and socks, and that they have a change of clothes (or are wearing shorts – or trousers that can be rolled up).

Activity Procedure:

1. Explain safety rules: no pushing, splashing or throwing of rocks. Stay out of deeper areas of the stream if there are any.
2. Discuss with students the name of the river and list the path it takes to the Chesapeake Bay (reminding students that they are collecting data about both the local watershed for the stream they are studying and for a part of larger watersheds to which it is connected).
3. Ask the students to observe the river from the bank and give their opinion on whether the water looks dirty or clean. Fill a glass jar with a sample of the water and hold it up. Remind students that even if the water looks clear, some kinds of pollution cannot be seen. That is why they will be collecting the insect larvae that live under rocks in the stream to reach a conclusion regarding the water quality.
4. Students capture a sample of benthic macroinvertebrates in the stream using a net (kick seine). Two students hold the net in place while others stir up the bottom with their hands and feet to dislodge insect larvae and other macroinvertebrates.
5. The sample is then examined on shore. Unroll the nets on the ground (or onto tables if you have them). Macroinvertebrates are removed from the net using fingers or tweezers, placed in ice cube trays and identified with the help of the I.D. Guide.
6. One or two students should record the names of the macroinvertebrates identified, use the Field Worksheet to identify the "class" to which they belong (tolerant of pollution, slightly tolerant of pollution, intolerant of pollution). They should then write the name of each organism on a line under the correct category.
7. When all types of organisms in the sample have been identified, the group should fill in their Field Work Sheets and each student should calculate the water quality index.
8. A good wrap-up activity is to share the specimens collected by each group with the other groups, asking students to identify them and determine whether they are sensitive, moderately sensitive or tolerant of pollution. Based on the water quality index, ask the students whether they think the water in the stream is relatively clean, polluted, or someplace in between.

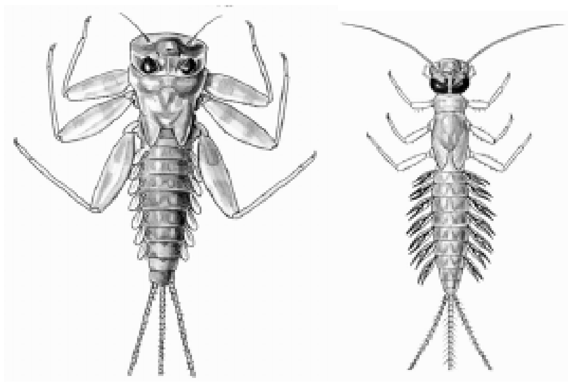
Assessment Opportunities:
Ask students to do the following:

1. List the steps to take in collecting a sample of benthic macroinvertebrates in a stream.
2. List two organisms their group collected during the field activity. Explain whether they are intolerant of pollution, slightly tolerant or tolerant of pollution.
3. Provide students with pictures of 3-5 macroinvertebrates and have them use their I.D. Guide and Field Worksheet to identify the organisms and calculate a water quality index.

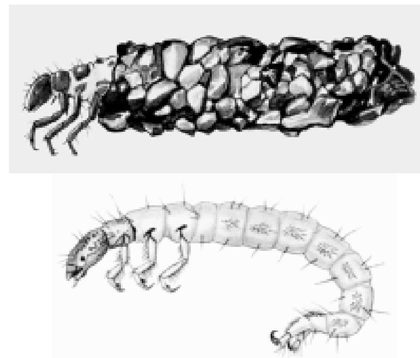
Extensions:
Discuss with the class what land uses occur in the watershed from which they collected their sample. Identify what kinds of pollution each land use could contribute to the stream. Discuss how such pollution can be prevented using such practices as riparian buffers, recycling, and efficient use of fertilizers and other agricultural or lawn care products.

Macroinvertebrate Index Species

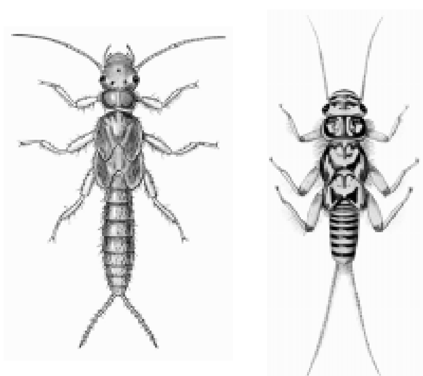
Sensitive to Pollution



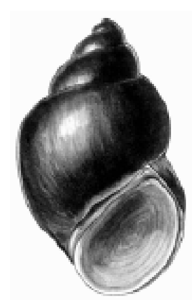
Mayflies
Feathery gills on abdomen. Three tails. One claw on the end of each leg.



Caddisflies
Hooked legs on upper third of body. No gills. May live in a stick, rock or leaf case.



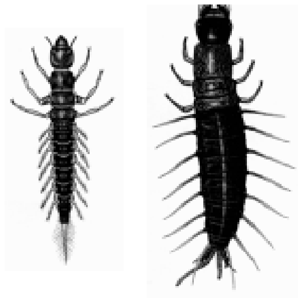
Stoneflies
Two claws on the end of each leg. Two tails. No gills on abdomen (gills on thorax).



Gilled Snail
Right-handed opening.

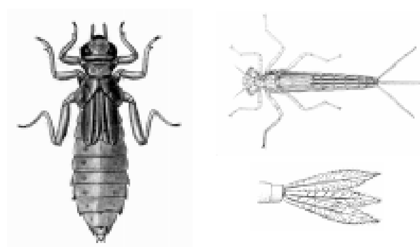
Macroinvertebrate Index Species

Somewhat Sensitive to Pollution



Alderfly & Hellgrammite
Large pinching jaws. 8 pairs of feelers along abdomen. Alderfly has spiky tail and Hellgrammite has two hooks on tail.

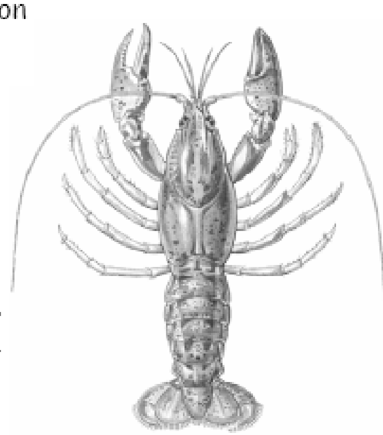
Riffle Beetle & Beetle Larvae
Adult beetle sinks and crawls around under water. Waterpenny is round and flat. Larvae has segmented body with legs at front.



Dragonfly & Damselfly
Both have large eyes and long legs. Dragonfly has large, oval abdomen. Damselfly has 3 broad oar-shaped tails.

Netspinning Caddisfly
Six hooked legs on upper third of body. Gills on abdomen.

Fingernail or Pea Clam
Filter-feeding bivalve. Burrows into soft sediment.



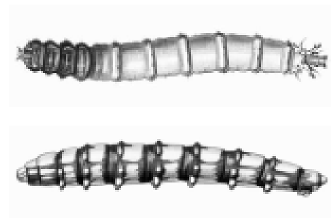
Crayfish
A crustacean which resembles a small lobster, with 8 legs and 2 large claws. Up to 6 inches .

Macroinvertebrate Index Species

Tolerant of Pollution

Midges

Worm-like segmented body with distinct head. Two leg-like projections on each side. Whitish or clear, sometimes red.



Cranefly & Horsefly

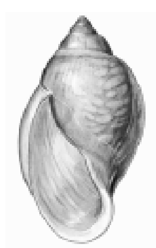
Bodies large, plump and caterpillar -like. No distinct head parts. Tail may have lobes.

Blackfly

End of abdomen wider than head. Sucker on end of abdomen.

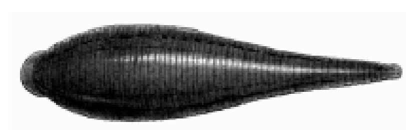
Aquatic Worm

Thin, worm-like body. Often pink or red.



Lunged Snail

Left-handed opening.



Leech

Segmented body with suction cups on both ends. Swims through water with undulating movement

Field Worksheet: Calculating an Index of Water Quality

Write the names of all the animals your group found. Use the *Macroinvertebrate Identification Guide* to figure out what each animal is called. Write each animal's name in the class it belongs to - Class 1, Class 2 or Class 3 - using the lists below. Perform the calculations and add up the numbers to get your Water Quality Index.

Class 1 – Sensitive to Pollution

mayfly larva	caddisly larva	gilled snail
stonefly larva	case maker caddisfly	

Class 2 – Somewhat Sensitive to Pollution

"water penny"	hellgrammite	crayfish
riffle beetle	alderfly larva	fingernail or pea clam
riffle beetle larva	dragonfly larva	damselfly larva
netspinning caddisfly		

Class 3 – Tolerant of Pollution

blackfly larva	cranefly larvae	midge
lunged snail	aquatic worm	leech
horsefly larva		

Water Quality Index
Excellent = 23 and above
Good = 17 – 22
Fair = 11-16
Poor = 10 or below

Class 1 (Pollution intolerant – they need clean water!)

____________________ ________________________

____________________ ________________________

____________________ ________________________

Total number of TYPES found: ____ X 3 = __

Class 2 (Can live with some pollution.)

____________________ ________________________

____________________ ________________________

____________________ ________________________

Total number of TYPES found: ____ X 2 = __

Class 3 (Don't mind living in polluted water.)

____________________ ________________________

____________________ ________________________

____________________ ________________________

Total number of TYPES found: ____ X 1 = __

GRAND TOTAL = _____

Stream Survey

A field exercise in which students survey a stream, collecting data and reaching conclusions about the health of the stream.

Level(s): 6-8

Subject(s): Life Science, Earth Science, Mathematics

Virginia SOLs: 6.5 g; 6.7 a,c,f,g; 6.9 a,c; LS.4 a,b,c; LS.10 b; LS.11 a; LS.12 b,d,e; PS1 b,k; PS.10 a; Math 6.10

Objectives:

1. Students will be able to perform observations and measurements of a stream in order to fill out a visual stream assessment field worksheet.

2. Students will be able to briefly explain the significance of each parameter recorded on the worksheet.

Materials:

- PowerPoint Presentation: *Stream Survey* (photos of examples)

For every student

- *Stream Survey Field Worksheet*
- *Stream Survey Student Handout*

For each student group

- Clipboard
- Stopwatch
- Yardstick
- Tape measure
- Kite string
- Wooden stakes
- Orange, rubber ducky or equivalent floating object
- 3 sets of waders or rubber boots (optional)
- Map of the site (optional)

Estimated Time:

In the classroom: 45-50 minutes
In the field: 90 minutes

Preparation:

1. A stream must be located which is accessible and less than 2 feet deep.

2. Parents or other adult volunteers will be required to help supervise student groups in the field.

3. Designate by means of signs the areas on the stream where the following activities will take place:
   - 4 locations where in-stream depth, width and velocity measurements can be taken.
   - beginning and end of stream walk (at least 100 yards in length)

Activity Procedure:

In the classroom

1. Hand out copies of the *Stream Survey Field Worksheet* and *Stream Survey Handout*.

2. Give the PowerPoint presentation *Stream Survey Procedure*. Have the students follow along with their field worksheets. You might want to let the students work in pairs to answer the questions.

3. Divide the students into 4 groups for the field exercise. Have each group designate a recorder to record the data collected.

4. Make sure the students understand that they will need to bring a change of clothing and an extra pair of shoes that can get wet, as well as shorts or long pants that can be rolled up.

In the field

1. Assign adults to supervise each student group.

2. Begin the exercise with the stream walk, during which students make observations and record them for items #6-14 on the *Field Worksheet.*

3. End the exercise with the four groups taking in-stream measurements and recording observations for items #1-5 on the *Field Worksheet*.

Back in the classroom

1. Have each group report their findings along with their conclusions regarding the health of the stream based on the data collected. Encourage students to hypothesize the source or cause of any potential problems reported, such as stream bank erosion, strong smells or large amounts of sediment on the bottom of the stream.

Assessment Opportunities:

1. Have students give brief explanations of observations required to assess the health of a stream.
2. Have students explain the significance of various parameters included in the stream survey.

Extension:

1. Combine or follow up this activity with biological and chemical monitoring of the same stream.

2. Have students write a report recording their observations and reaching conclusions regarding the health of the stream based on the data.

3. Have students draw conclusions regarding effects of land use observed with various stream conditions.

Additional Reference Material:

Tom Murdoch and Martha Cheo. 2001. *Streamkeeper's Field Guide*. The Adopt-A-Stream-Foundation, Everett, WA.

Stream Survey

A stream survey records observations of factors that are related to the quality of the stream habitat and the health of the stream. The data collected can be used to study changes in the stream over time that may be due to changes in the surrounding land use. You will need to wade into the stream for some of the observations. Make sure you have appropriate shoes and clothing (and a change of clothes!)

Substrate and In-Stream Features

1. **Stream Bottom**: the materials on the bottom of the stream. The type of stream bottom determines what kind of creatures can live there. If all rocks or gravel are covered with silt, sand or mud, many stream organisms cannot survive.

   - **silt/clay/mud -** small sticky particles
   - **sand gritty, -** particles up to ladybug size
   - **gravel -** stones up to tennis ball size
   - **cobbles -** rocks up to basketball size
   - **boulders -** rocks up to the size of a car
   - **bedrock -** slabs bigger than a car

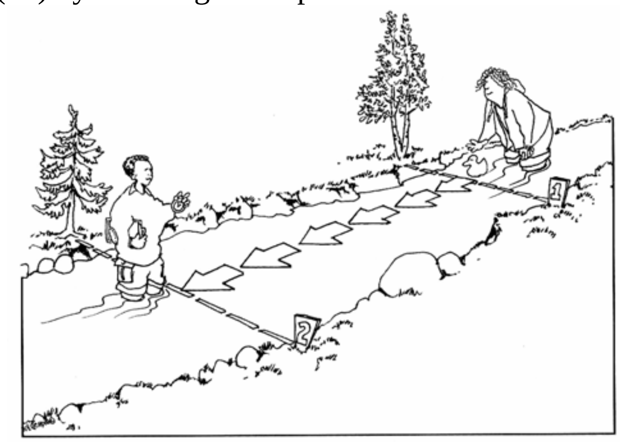
2. **Water Odor**: If you smell something, it might be an indication of pollution.

Odorless	A good sign
Sewage	Might be of human origin
Chlorine	Might be from sewage treatment plant (or swimming pool)
Fishy	Might be excessive algal growth, or dead fish
Rotten Eggs	Possible sewage pollution (presence of hydrogen sulfide gas)

3. **Average Depth of stream**: Stretch a string across the stream. Use the stream ruler to take depth measurements at one-quarter, one-half and three quarters the distance across. Take measurements and divide by 4 (divide by 4 instead of 3 to take account for the 0 depths that occur at each shore).

4. **Average Width of the stream channel**: Estimate the average channel width by measuring at three places. Average the results.

5. **Stream velocity**: Directly affects the health, variety, and abundance of aquatic communities. Can be affected by dams, channelization, terrain, runoff and other factors.
    - Stretch a piece of string across two places in the stream 10 feet apart along a straight stretch.
    - One person releases an orange from the upstream line. A second person with a stopwatch or a second-hand on their watch records when the orange passes under the downstream line. Repeat 3 times and average the times. Divide distance (10) by time to get feet per second.



courtesy *Streamkeeper's Field Guide*

6. **In-Stream Logs and Woody Debris** (not twigs and leaves) in the stream: this can slow or divert water to create fish habitat.

7. **In-stream Organic Matter**: Smaller-scale matter such as leaves and twigs that serves as a food source to aquatic organisms.

8. **Water Appearance**: May indicate a pollution problem.

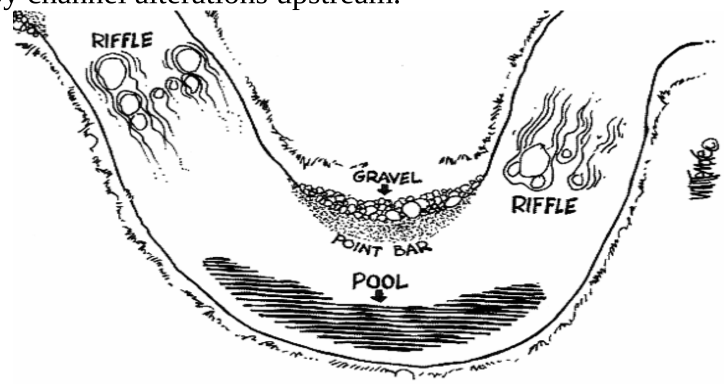
Clear	Colorless, transparent
Milky	Cloudy white or gray, not transparent
Foamy	Might be natural or due to pollutants
Turbid	Cloudy brown due to suspended silt or organic matter
Dark Brown	Possible indicator of release of acids due to decaying plants
Oily sheen	Multicolored reflection
Reddish	Might be acid drainage (from a mine)
Green	Might indicate algae growth due to excessive nutrients

9. **Channel Shape**: Check the appropriate box for your stream. You can find the answer by looking at the data already collected for average width and average depth.

narrow (<6ft) & **deep** (>3ft.)	**wide** (>6ft.) & **deep** (>3ft.)
narrow (<6ft.) & **shallow** (<3ft.)	**wide** (>6ft.) & **shallow** (<3ft.)

10. **(Man-made) Channel Alteration**: Straightening a stream channel, or introducing obstructions, interferes with the stream velocity and affects the channel upstream and downstream, causing more erosion and instability. People change river channels when they build bridges or install culverts. They also use riprap and concrete to prevent erosion, and straighten channels for "convenience".

Islands, point bars and sedimentation are caused by erosion and are sometimes caused by channel alterations upstream.



courtesy *Streamkeeper's Field Guide*

Riparian and Bank Structure

11. **Streambank Stability**: Healthy streams have stable banks with a gradual slope (<30°). Erosion undercuts streambanks and causes them to collapse. Look for streambanks that are:

vertical	collapsed	have a steep slope (>30°)
undercut	eroded	

12. **Streambank Cover**: A healthy stream is protected by the vegetation that grows on both sides of the stream. Trees, shrubs, groundcover and other natural vegetation filter and take in pollutants. Plants also prevent erosion by covering the soil and holding it in place with roots. Plants also provide habitat for wildlife.

13. **Stream Shading** (overhead canopy): How much of the stream is shaded by vegetation such as trees, bushes and tall grasses. It keeps the water cool in summer.

14. **Adjacent Land Use**: The way the land on each side of a steam is being used has a great impact on the health of the stream, as well as aquatic and terrestrial life. Adjacent land uses can affect sedimentation and erosion, pollutant runoff and other impacts to the health of the stream. Consider the differences in the impact of such land use as crops, livestock, residential, and urban. When the land is covered with impervious surfaces such as roads, parking lots and buildings, there is more runoff after rains (which can cause bank erosion) and more pollution is washed into the water by runoff.

Stream Survey Field Worksheet

Student Name: ____________________________ Date: ________________

Stream Name: ____________________ Watershed: _________________

Today's Weather: Cloudy ☐ Clear ☐ Fog ☐ Rain/Snow ☐

Weather in past 24 hours: Cloudy ☐ Clear ☐ Fog ☐ Rain/Snow ☐

Substrate and In-Stream Features

1. Stream Bottom (substrate)

☐ silt/clay/mud (very fine) ☐ cobble (2-10 in. diam.)

☐ sand (gritty, ladybug size) ☐ boulder (> 10 in. diam.)

☐ gravel (0.1 – 2 in. diam.) ☐ bedrock (big slabs > car)

2. Water Odor

☐ odorless ☐ sewage ☐ chlorine ☐ fishy ☐ rotten eggs

☐ other ______________________________

3. Depth ______ ft ______ ft _______ ft Average _______

4. Width of Stream Channel

_____ ft _____ ft _____ ft _____ ft Average _______

5. Stream Velocity (on a 10-foot section)

_____ sec _____ sec _____ sec Average _______

Divide into 10 = ________ ft/sec (For example: 10 ft divided by 5.0 sec = 2.0 ft/sec)

---

6. In-Stream logs and woody debris (not twigs and leaves)

☐ none ☐ a little (<50%) ☐ a lot (>50%)

7. In-Stream Organic Matter (leaves, twigs, smaller plant debris)

☐ none ☐ a little (<50%) ☐ a lot (>50%)

8. Water Appearance

☐ clear ☐ milky ☐ foamy ☐ turbid ☐ dark brown

☐ reddish ☐ green ☐ oily sheen ☐ other ____________

Channel Features

9. Channel Shape

☐ narrow (<6 ft) & deep (>3 ft) ☐ wide (>6 ft) & deep (>3 ft)

☐ narrow (<6 ft) & shallow (<3 ft) ☐ wide(>6 ft) & shallow(<3 ft)

10. (Man-made) Channel Alteration

Bridges, rip-rap, concrete reinforcement, culvert or straightening?

☐ None ☐ a little (<50%) ☐ a lot (>50%)

Islands, point bars, sedimentation? ☐ none ☐ moderate ☐ heavy

Riparian and Bank Structure

11. Streambank Stability (Bank A is on right, looking downstream)

	none	a little (<50%)	a lot (>50%)
Vertical, undercut	☐	☐	☐
Steep slope (>30°)	☐	☐	☐
Gradual slope (<30°)	☐	☐	☐
Banks collapsed	☐	☐	☐

12. Streambank Vegetative Cover

☐ evergreens ☐ hardwoods ☐ bushes, shrubs ☐ tall grass, ferns

☐ lawn, short grass ☐ boulders ☐ gravel, cobbles, sand

☐ bare soil ☐ pavement, man-made structure

13. Stream Shading (by trees next to stream)

☐ none ☐ a little (<50%) ☐ a lot (>50%)

14. Adjacent Land Use

☐ forestry ☐ field/pasture ☐ farming ☐ residential

☐ commercial ☐ industrial ☐ other____________________

Terrarium

Students construct terrariums and observe the water cycle inside them. May be used as an introduction to the water cycle, or a review and reinforcement of the topic.

Level(s): 6-7

Subject(s): Life Science, Earth Science

Virginia SOLs: 6.5 b,f,g; 6.7 a; 6.9 a; LS4 a,c; LS7 a,b,c; LS10 a,b

Objectives:
Students will be able to:
1. Explain the steps in the water cycle.
2. Explain the meaning of "closed system"

Materials:
In addition to the materials below, you will need an area in which you can keep the terrariums once they are constructed, with a source of light.
For each student group:
- 2-liter plastic bottle
- 4 cups of potting soil
- small plants that grow well in moist environments (mosses and plants found on the forest floor)
- 1 cup gravel
- 5 cups of water
- scissors
- plastic wrap
- rubber bands or masking tape
- student handouts

Estimated Time: 50 minutes

Preparation:
Have materials ready at stations for use by each group of students.

Activity Procedure:
1. Explain that one definition of the term "closed system" is a system that functions in isolation without any input of matter from the outside (another definition excludes input of energy as well). The terrarium they will be constructing is an example of this kind of closed system (it will require the input of energy from the outside in the form of light and heat). Ask the students if they can think of a much larger example of such a closed system that is naturally occurring [*Answer*: the Earth].

2. Divide the class into groups of 3 or 4 students and assign them to a set of materials.

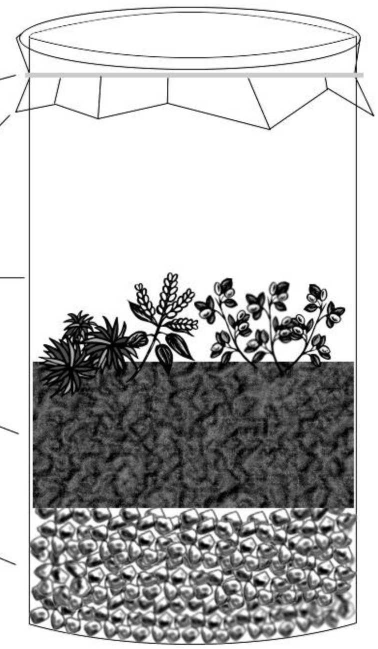
3. Have the students cut the top of their 2-liter bottle using scissors.

4. Have the students cover the bottom of the bottle with gravel, and place the soil on top.

5. Have the students plant the plants and gently water them with all the water.

6. Finally, have the students cover the terrarium with a piece of plastic wrap and seal it with rubber bands or masking tape.

7. Have the students place the terrariums on a window will where they can get sunlight, or under a source of light. Ask the students to observe the terrariums carefully in the coming days, noting the path of the water through the water cycle, taking notes on any changes they observe. The period of observation can be as short as a week, or as long as the school year.



8. Ask the students to make predictions regarding what they might observe over the course of days, weeks, and/or months.

9. After a week, ask students to explain what their terrarium observations so far have to say about water in our environment [*Answer*: water is never created or destroyed, but is continually obtained, used and recycled in nature – and by humans] Have them compare their predictions and their observations.

10. Discuss the water cycle with the class (you can hand out copies of the USGS diagram *The Water Cycle*). Which parts of the water cycle were observed in the terrariums the students constructed? [*Answer*: *evaporation*, *transpiration*, *condensation*, *precipitation* and *infiltration*.]

Assessment Opportunities:
1. List end explain the steps in the water cycle.
2. Explain the meaning of the term "closed system".

Extensions:
1. Make a terrarium on a larger scale using a 5-gallon bottled water bottle or an aquarium.
2. Discuss what the closed system would need for an animal to survive within it.

3. Have students design on paper a larger and more complex closed system in which humans could survive for a year or longer. (read about Columbia University's Arizona Biosphere 2 experiment at www.accessexcellence.org/LC/ST/st4bg.html)

Additional Reference Material:
On the Natural Resources Conservation Service web site:
www.wcc.nrcs.usda.gov/factpub/aib326.html

On the USGS web site:
ga.water.usgs.gov/edu/watercycle.html

from **Water Source Book,** pp. 1-9 to 1-13.


The Water Cycle
USGS
science for a changing world
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Sublimation
Precipitation
Evapotranspiration
Evaporation
Snowmelt runoff to streams
Surface runoff
Streamflow
Evaporation
Infiltration
Spring
Freshwater storage
Water storage in oceans
Ground-water discharge
Ground-water storage
U S Department of the Interior
U.S. Geological Survey
Illustration by John M. Evans, USGS
http://ga.water.usgs.gov/edu/watercycle.html

Hot and Cold

Students observe the effect of temperature on the rate of respiration of a goldfish and relate this to the effect of temperature on other creatures living in streams and other bodies of water.

Level(s): 6-8

Subject(s): Life Science

Virginia SOLs: 6.7 g; LS4 b,c; LS10 b,c; LS11 a; LS12 b,d,e; PS1 b,g,h,k,m; PS7 a

Objectives:
Students will be able to
1. Accurately measure and record the temperature of water in a container in both Farenheit and Celsius.
2. Observe and record the rate of respiration of a goldfish.
3. Plot data for the respiration rate of goldfish vs temperature as temperature changes.

Materials:
- Large jar
- Goldfish
- Ice cubes
- Watch
- Thermometer (with both °C and °F)

Estimated Time: 40-50 minutes

Preparation: set up materials for use

Activity Procedure:
1. Discuss how plants and animals (including humans) adapt to different temperatures (for colder temperatures: deciduous plants lose their leaves and become dormant, mammals increase activity, reptiles decrease activity. Birds fluff up feathers fur, mammals grow longer fur, hibernate, put on more clothing).

2. Observe the goldfish. How can the goldfish's rate of respiration be observed?

3. Take the temperature in both °C and °F.

3. Count the number of times the gill covers open in one minute and record it on a chart of Temperature on the X Axis vs Rate of Respiration on the Y Axis. Make sure each student charts the data in their notebooks.

4. Add one cube of ice. Wait four minutes and repeat the procedure in #2 and #3. Continue for several more cube additions.

5. Discuss what happened to the goldfish's rate of respiration. Discuss the significance of the line on your chart. Discuss the reason for the change. Do human's respond the same way to colder temperatures? What does this suggest about the effect of water temperature on creatures living in water?

Note: Before returning the goldfish to a larger aquarium, the temperature in the jar should be allowed to slowly return to the temperature of the aquarium. A sudden change in temperature can be harmful to the fish.

Assessment Opportunities:

1. Have students explain how the rate of respiration of a fish changes with a change in water temperature.

2. Give students some hypothetical data in the form of a list of temperature vs openings of a goldfish's gill covers and have them graph the data.

Extensions:

1. Have students do research on the preferred temperatures for various fish and other aquatic creatures.

2. Investigate the relationship between temperature and such factors as dissolved oxygen, turbidity, algae blooms and tree canopy.

from **Two H's and an O, A Teaching Resource Packet on Water Education**, pp. 26-27.

Balance in an Aquatic Community

Students will learn about the roles of producers, consumers (herbivorous , carnivorous , and omnivorous) and decomposers in maintaining a balanced aquatic community.

Level(s): 7

Subject(s): Life Science

Virginia SOLs: LS4 a,b,c; LS7 c,d; LS9 a,b; LS10 b

Objectives:
Students will be able to:
1. Explain the roles of producers, consumers and decomposers in maintaining a balanced community.
2. Explain the meaning of the terms *herbivore*, *carnivore* and *omnivore*.
3. Give three examples each of locally occurring producers and consumers.

Materials:
- Copies of guidebooks to native flora and fauna (or internet sites)
- Pictures of animals and plants (internet, nature magazines, clip art). You could also give students an assignment to bring in pictures of native microorganisms, plants, insects, birds and animals to represent producers, consumers and decomposers in local streams.
- "gear" handout

Estimated Time: 50 minutes

Preparation:
1. Collect information about local plants and animals (including macroinvertebrates). A local nature center, wildlife biologist, cooperative extension agent or local soil and water conservation district are possible sources of this information.

2. Make 4 copies of the blank "gear" for each student group.

Activity Procedure:
1. Explain the roles of producers (algae and other plants provide food for consumers), consumers (control animal and plant populations), and decomposers (recycle producer and consumer nutrients for producers to use).

2. Discuss the difference between herbivores, carnivores and omnivores. Compare the teeth and other adaptions of each type of consumer.

3. See what examples students can provide of local plants and animals (including insects and birds) that play a role in the aquatic ecosystem. Do not forget such creatures as the raccoons and herons that prey on aquatic animal animals, and ducks that eat aquatic vegetation.

4. Divide the class into groups of 3-4 students. Give each group 4 copies of the blank gear. Ask them to choose one of the major groups of aquatic organisms (producers, herbivore consumers, carnivore consumers and decomposers) for each gear and illustrate or paste pictures of examples of each group onto the gear. Also ask the students to arrange the gears in a configuration or *system* that will represent the connections and interactions between the different groups in the aquatic ecosystem.

5. Observe the students as they lay out the gears in a linear or circular pattern. The first group to correctly assemble the gears could then present their balanced community to the class. Ask them to identify the source of energy that keeps the gears in motion (sunlight) and to explain the interactions between each of the gears.

6. *A Balanced Community* can be made into a transparency to focus discussion on balance in aquatic ecosystems.

7. Give each group time to reconfigure their system of gears. You may want to display the results in the classroom.

Assessment Opportunities:

1. Ask students to identify the four major groups in an aquatic ecosystem (producers herbivorous consumers, carnivorous consumers and decomposers)

2. Ask student to identify the roles of each of the four major groups.

3. Ask students to explain the differences among herbivores, carnivores and omnivores. Have them identify adaptions of each groups.

4. Have student provide examples of native plants and animals.

Extensions:

1. Take a walk near a local stream or pond and see what examples of the four groups they can identify. Samples of pond water or detritus on a stream bottom could be returned to the classroom for examination under a microscope.

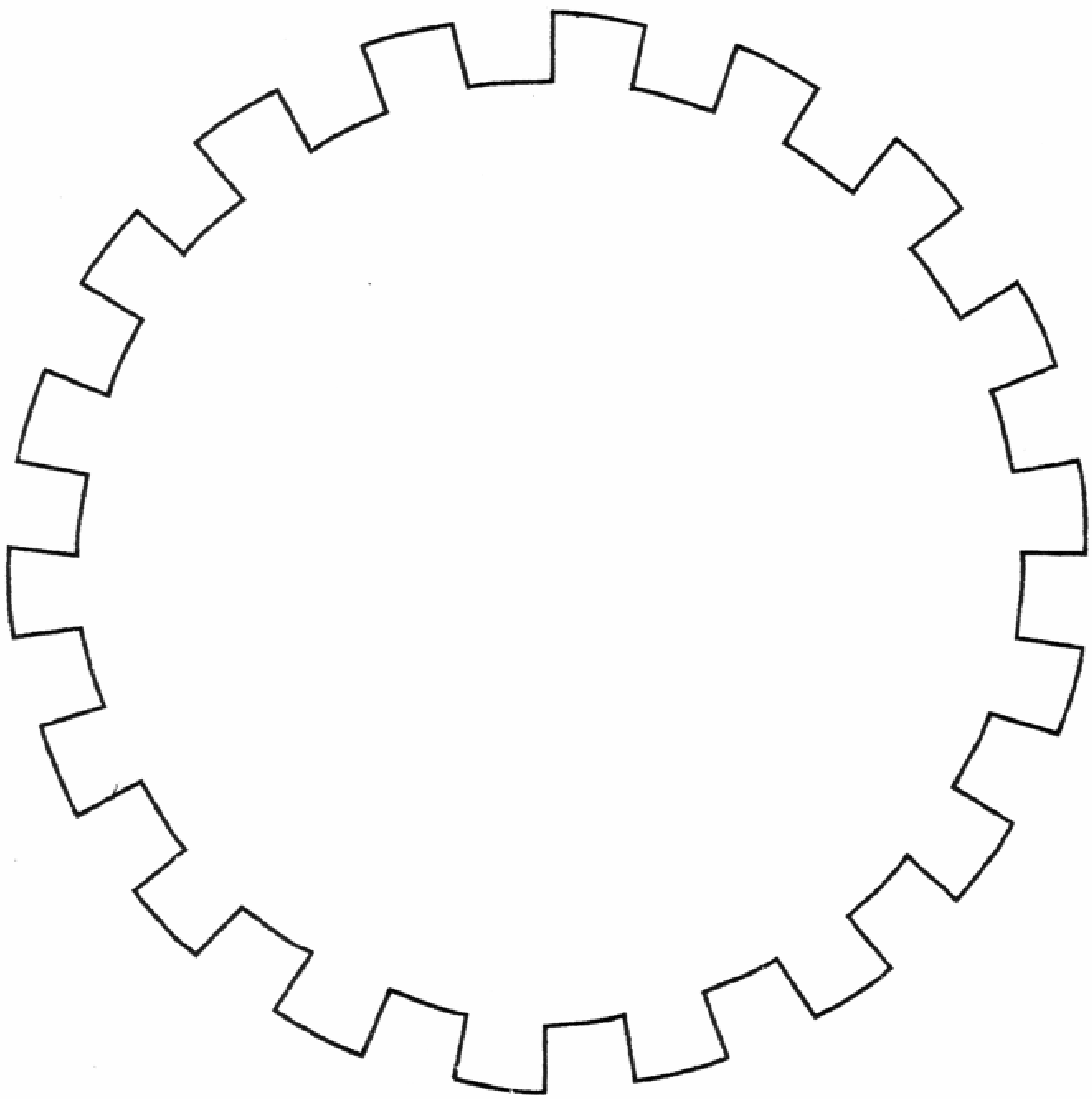
2. Discuss the effect of exotic invasive species on the balance of an ecosystem. Have the students do research on such species as *ailanthus* (tree of heaven), *multiflora* rose, English Ivy, honeysuckle, kudzu, Autumn Olive, zebra mussels, hemlock wooly adelgids, tiger mosquitoes, and starlings.

3. Discuss/investigate the effect of pollution by nutrients (nitrates and phosphates) from fertilizers, animal waste and sewage on a balanced aquatic ecosystem when they cause algae blooms.

Adapted from **The No Waste Anthology**, pp. 38-41.

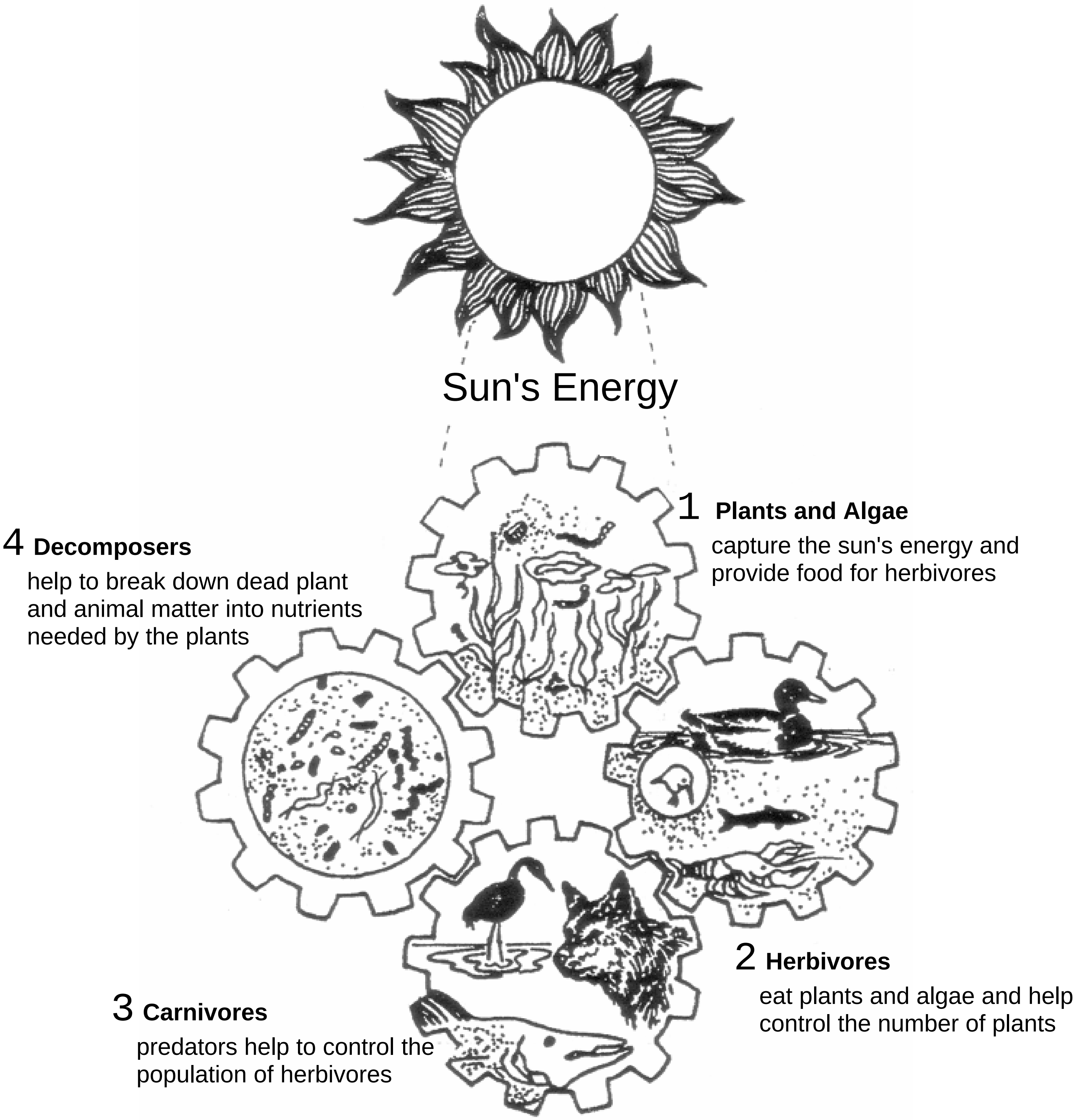
Balance in the Aquatic Community

Members of the aquatic community interact like the gears of a finely tuned machine. Each group of organisms is interrelated with the others. Label each of the 4 gears with a category of aquatic plants or animals and fill in the gears with the names ad/or illustrations of organisms living in local waterways.



A Balanced Aquatic Community

Design by Jim McEvoy. Reprinted with permission of Wisconsin Department of Natural Resources



Chesapeake Bay Habitats

Students use a binary key to classify Chesapeake Bay habitats pictured on cards.

Level(s): 6-7

Subject(s): Geography, Life Science

Virginia SOLs: 6.7 a,c,d,e; LS4 b; LS7 c; LS9 a,b,e; LS10 b

Objectives:
Students will be able to:
1. Use a binary key to for classification and identification.
2. List 3 Chesapeake Bay habitats and describe them.

Materials:
For each student group
- One set of Chesapeake Bay Habitat Cards

For each student
- 1 copy of the key to Habitats of the Chesapeake Bay

Estimated Time: 45-50 minutes

Preparation:
Cut out the Chesapeake Bay Habitat Cards. If you plan to use the cards more than once, you may wish to have them laminated.

Activity Procedure:
1. Discuss the importance of habitat. See if students can identify how the habitat for animals such as deer, groundhogs, squirrels, and geese might differ. Explain that identifying and classifying different habitats is an important factor in the study of an ecosystem.

2. Divide the students into groups. Hand out one set of Habitat Cards to each group. Hand out keys to Chesapeake Bay Habitat to all students.

3. Have the students read each card carefully and then use the key to identify the habitat, starting with the first two choices on the left side of the key.

4. Go over their results as a class when the groups have finished.

Assessment Opportunities:

1. Find a simple key for identifying the leaves of trees or types of bottom-dwelling stream macroinvertebrates and have students identify a picture of a leaf or benthic macroinvertebrate.

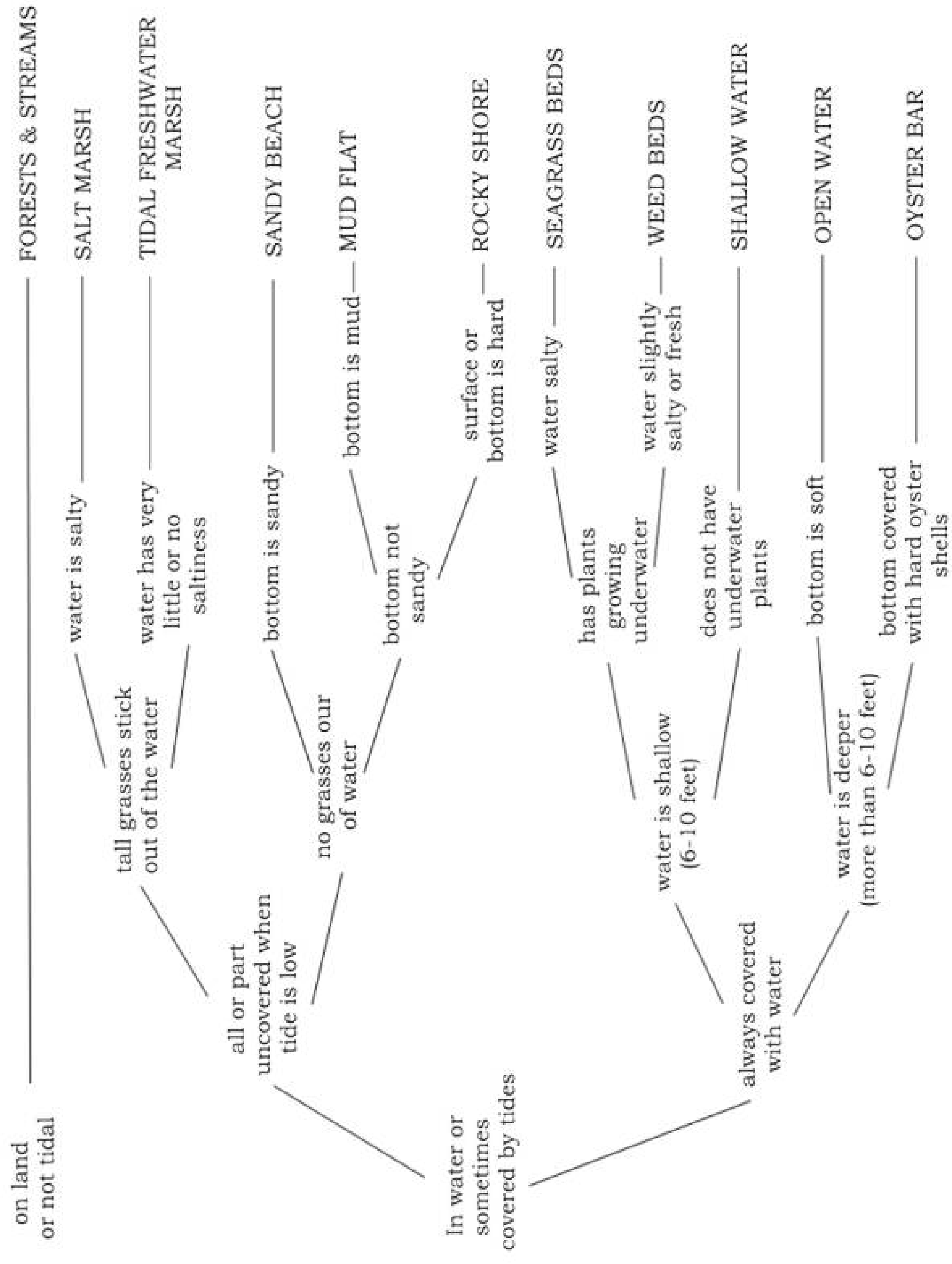
2. Have students list and describe 3 Chesapeake Bay habitats.

Extensions:
Have students go to the web site listed below and collect information about what kind of animals might live in each habitat.

Additional Reference Material: www.chesapeakebay.net/habitats.htm

from **The Changing Chesapeake: An Introduction to the Natural History and Cultural History, Revise**d, pp 18-22

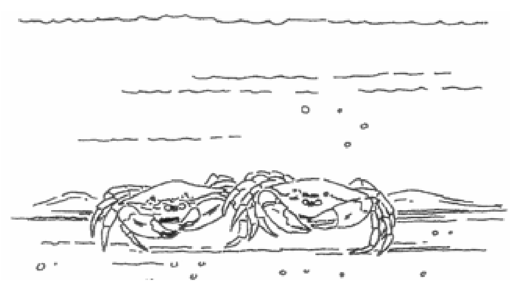
Key to the Habitats of the Chesapeake Bay



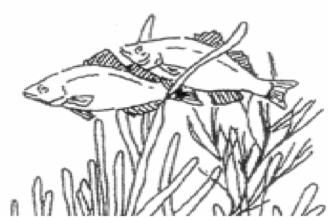
Chesapeake Bay Habitats

1. Where rocks are in shallow water along the shore, they may be uncovered by the tide. Manmade structures like piers also have animals and plants that need hard surfaces as places to attach. Where the water is salty, some seaweeds grow.

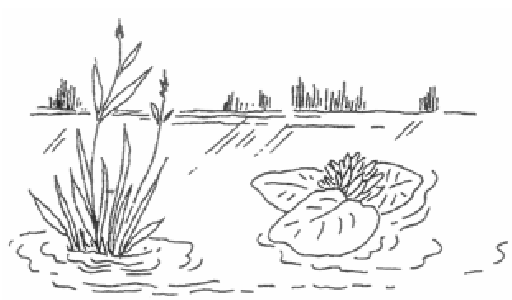
2. Things living in shallow water are not uncovered by the tides, but must be able to stand heat and cold, wind and waves (which make the water muddy), and even ice in winter. But small fish are safer here from the bigger fish that eat them, and there is lots of food. There may be marshes and grass beds nearby which are places to hide if needed.



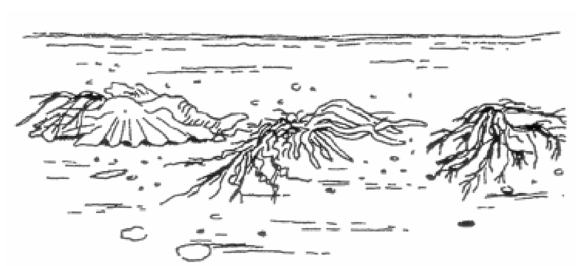
3. In the lower part of the Bay where the water is saltier, two kinds of plants may grow under the shallow water. They can only live where it is shallow because they are rooted on the bottom and need light to make food. The plants are eaten by many animals and many more find a safe place to live among them. These plants protect the shore and reduce the muddiness of the water by slowing the waves.



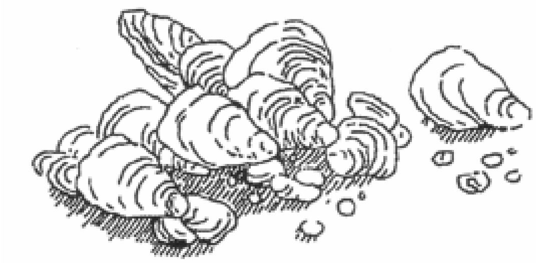
4. Tall grasses grow up out of the water. Even though the water has little or no salt, the tides push up the Bay or rivers far enough to cause the water level to change here. Other plants like pond lilies also grow here. The plants provide food for many kinds of invertebrates and fish which also hide among their stems.



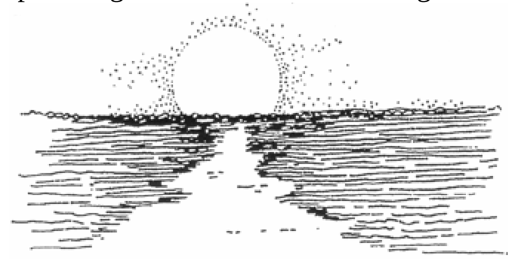
5. Fine bits of dirt make mud when they settle out of the water. Where the muddy bottom is very shallow, it is uncovered at low tide. While this area may not look like home to many animals, there are lots of creatures living down in the mud. Watch for shorebirds searching in the mud for some of them.



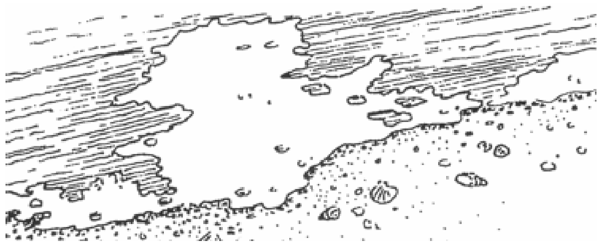
6. In some places where the saltiness is right and there are dead oyster shells, oysters and many other animals live. The water is deep enough to protect the animals from being uncovered by the tides or disturbed by hard waves.



7. In deep water little light reaches the bottom. Since plants need light, they do not grow here. The water is filled with tiny, drifting algae which use the sunlight near the surface to make food. The bottom is covered with mud which has settled from the water. In this open space large schools of fish swim together.

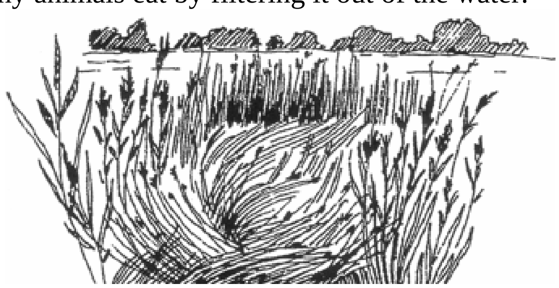


8. The waves during storms push the grains of sand in ever-changing patterns. During low tide the animals that live among the sand grains feel the summer heat or the winter cold. Shorebirds search along the water's edge for these animals and for bits of food that wash in from the Bay.



9. In shallow water where there is good light and the water has little salt, underwater plants sometimes grow. Some of these plants are valuable as food for many kinds of waterfowl such as ducks, geese, and swans. All make places for little fish and other animals to live and feed. These plants also slow water movement and protect the shore from waves.

10. Along the shore where the water is salty, tall grasses grow out of the water. Tides move in and out, but some places are flooded only during storms and very high tides. These tough plants break down in the water to form little bits of food called detritus which many animals eat by filtering it out of the water.



11. Trees cover the land. Water runs among the tress. Sometimes the trees grow where there is very slowly flowing fresh water around them.