SIA Junior: Creek Canaries

Revised 7/09

Recommended for:
6^{th} – 8^{th} Grade

Alaska Science Performance Standards (Grade Level Expectations)
[6-8]SA1.1, [6]SA3.1, [8]SA3.1, [6]SC2.1, [6]SC2.2
For more details on standards correlation, see *Correlation Justification* at the end of this document.

Nutshell
Students will learn that salmon require a high-quality habitat to survive, how macroinvertebrates can be used as an indicator of habitat quality, and how the micro-habitats along a stream can be influenced by our activities. They will use a dichotomous key to identify macroinvertebrates, then determine a possible collection site for their sample based on the macroinvertebrates "collected" from a hypothetical stream and some information about the stream.

Concepts
- Salmon require a high-quality habitat to survive.
- Human activities can influence habitat quality.
- Macroinvertebrates can be used as an indicator of habitat quality.

Objectives
Students will be able to:
- Use a dichotomous key to identify common macroinvertebrates.
- Determine the micro-habitat quality of a hypothetical stream based on macroinvertebrates "collected" there.
- Infer where on a hypothetical stream a micro-habitat might exist based on a sampling of macroinvertebrates, and infer whether or not that portion of the stream would make a good salmon habitat.
- Explain how human activities can influence habitats.

Materials
- Video projector for PowerPoint presentation
- Macroinvertebrate dichotomous keys (one for each team of 4 students)
- Macroinvertebrate ID cards (one per team)
- "Collected" macroinvertebrates in collection device (see *Material Preparation* at end of outline)
- White sorting trays (one per team)
- Sorting sheets (one per team)
- Student Datasheets (one per student)

Lesson Outline

10 min. Introduction
10 min. Dichotomous Key Activity
20 min. Stream Health Index Activity
10 min. Closing Discussion

Background

In the early days of coal mining (and actually well into the 20th century), canaries were brought into mines to be used as indicators of the mine's air quality. Because canaries are more sensitive than humans to the presence of dangerous gases in the air (such as methane and carbon monoxide), their discomfort or death indicated that the air was not safe to breath. This would alert the miners to don safety gear or evacuate the mine. Although this practice no longer exists, it stands as an example of how animals have differing sensitivities to environmental factors.

In streams and ponds, the presence or absence of certain organisms, called indicator species, reveals much about water quality. These creatures make up a biotic index (number of living organisms found in an ecosystem). The absence or presence of these organisms is an indicator of water quality.

Water with numerous aquatic species is usually a healthy environment, whereas water with just a few different species usually indicates conditions that are less than healthy. The word healthy is used to indicate an environment supportive of life. Pollution generally reduces the quality of the environment and, in turn, the diversity of life forms. In some cases, the actual biomass will increase because of pollution, but the diversity inevitably goes down.
from Water Canaries, Project WILD Aquatic K-12 Curriculum and Activity Guide, Council for Environmental Education 2004

Advantages to using Macroinvertebrates as a stream-health indicator:

- Macroinvertebrates have limited mobility and therefore are good assessors of site specific impacts (mobility, however, may be affected by storm flows and drift).
- Aquatic insects have relatively short life spans and respond quickly to stress. Therefore, they provide good short-term monitoring results.
- Macroinvertebrates are relatively easy to identify, sampling is reasonably easy and does not affect the resident biota. It is relatively easy to identify degraded systems through casual observations.
- Macroinvertebrates are usually abundant in most small streams where few fish are present.
- Citizen volunteers can quickly learn insects to family level, more comprehensive training is required for other metrics.

Disadvantages to using Macroinvertebrates as a stream-health indicator:

- Some regional modifications of metrics are required to ensure that data is representative of ecoregion.
- Seasonal changes in species composition and populations requires strict adherence to consistent sampling frequency.
- Data collected after major flow events is likely not to be representative of normal conditions due to habitat disruptions.

- The relative health of a selected reference condition can skew the results of the system being evaluated.
- Species identification may be time consuming and complex.
- Sensitive macroinvertebrate species seem to decline significantly at relatively low watershed imperviousness (≤15%) and therefore are less effective as predictive tools for more densely urbanized areas. Watershed imperviousness refers to the portion of the watershed surface that is impervious to water absorption (e.g., covered with cement/asphalt or buildings) and therefore contributes to runoff.
- Paired sampling sites must have comparable habitat to produce valid results. Macroinvertebrate prevalence may be as much a function of habitat type as quality.

from Environmental Indicator Profile Sheet, Center for Watershed Protection, obtained from the Stormwater Manager's Resource Center (www.stormwatercenter.net)

Salmon prefer cool, clean water (between 5ºC and 9ºC is best). A healthy salmon stream runs over a gravel bottom containing a mix of rock sizes. Water flowing over riffles picks up oxygen and washes away silt.

Young salmon are very sensitive to pollutants. Household chemicals, such as bleach, oil or paint, can be fatal. Unless diverted, runoff from roads can carry hazardous pollutants into a stream.

Salmon fry catch tiny insects that float past them. As they grow, the fry can also catch larger insects and caterpillars that fall into the stream or lake, as well as mayflies and stoneflies that land on the water to lay their eggs.
Salmonids in the Classroom: Intermediate, Fisheries and Oceans Canada

The Lesson

Introduction

Discuss concept of some animals being able to live where other animals can't (click to show Slide 2). Click to show trout and ask what type of water it lives in (*fresh*); click again to show the fur seal and ask what type of water it lives in (*salt*). So if we see certain animals in an area, we can learn something about that area: seeing trout swimming around probably means the water in the area is fresh. (Click to show Slide 3) What might it mean if we *don't* see certain animals where we would expect to find them, such as not seeing bald eagles by rivers during salmon season? (Click to have eagle disappear) (*There might be something wrong with the river that is keeping the salmon out, and that in turn is keeping the eagles away.*)

Ask what might be wrong with the river that might keep salmon out (*pollution, water too shallow/warm*). (Click to show Slide 4) Ask what conditions might be important for salmon to live and reproduce (*cool, clean water; gravel bottoms; riffles to mix in oxygen; hiding places (logs, roots, undercut banks); shade from trees; plenty of food*). (Click to show conditions) (Click to show Slide 5) In the streams and creeks that run through Anchorage, what might we (the people who live here) be doing to make the streams unhealthy for salmon? Get responses from kids (*littering, chemicals (oil, soap from washing cars) going down the storm drains that lead directly to creeks, putting too much fertilizer on our lawns, using insecticides, cutting brush* *or mowing too close to the creeks, walking on stream banks and causing erosion, blocking streams with brush or rocks, allowing dog poop to get into the creeks, construction near stream*), then click to show actions.

There are many things to consider when measuring the health of a stream (Click to show Slide 6 and considerations). (Click to Show Slide 7) We could use an *indicator species*. Using something living to determine the health of the local environment is common, and the organism being observed is called a *sentinel* or *indicator species*. Indicator species have been used for many years, and not just to determine how healthy something in nature is. (Click) Ask if they have heard about Mine Canaries (relate story found in *Background* section above) (Click)

So, looking for salmon in a creek could be a way of learning about the condition of the creek, but there are some problems with using salmon as an indicator species for a stream. They are: seasonal (only present for a short time each year); hard to observe since they scare easily and hide; observing them may harm them; since they're at the top of the food chain, problems noticed may have been ongoing for a long time; we depend on them, so we want an earlier indicator. We need a better indicator species, preferably several of them, that will tell us how healthy a creek is most of the year. (Click) Instead of Mine Canaries, we need Creek Canaries! The indicator species should be very sensitive to water quality, and (since we're interested in salmon) (Click) maybe something that salmon eat would be useful. What do salmon eat as they're growing up in streams? (Click) *Macroinvertebrates!* The Creek Canaries that scientists use are called macroinvertebrates. This program is about the indicator species scientists use to get an idea of how healthy a stream is, which in turn allows them to make decisions that will help what they're really interested in: the salmon.

(Click to show Slide 8) If students don't know what a macroinvertebrate is, ask what you should do if you come across a big word you don't know the definition of (*break it apart into smaller words*) (Click to show "macro" and "invertebrate") Define *macroinvertebrate*: (Click) macro=large (enough to be seen without a microscope), (Click) invertebrate=without a backbone. (Click) The term macroinvertebrates traditionally refers to aquatic invertebrates including insects, crustaceans, molluscs, and worms found in river channels, ponds, lakes, wetlands or oceans.

(click to show Slide 9) Scientists use macroinvertebrates as "Creek Canaries," looking for (Click) the *number* (abundance) and *variety* (richness) of macroinvertebrates found in a stream to give an indication of the stream's health.

(Click to show Slide 10) What might cause these measures to be low? (Click) Both measures are affected by poor water quality not allowing many individuals to survive there.

(Click) Abundance is also affected by low food availability (not enough food to support a large population), or lots of predators keeping the macroinvertebrate population low.

(Click) Low richness is also affected by location on the stream (when near the headwaters of a stream, for example, there haven't been opportunities for a lot of macroinvertebrates to lay eggs, and parts of the stream with fast flows will favor those macroinvertebrates that can "hang on" better), the type of bottom material (some macroinvertebrates will favor a stream bottom they can burrow into, others will like pebbles, while others will prefer larger rocks), low availability of specific foods that a species needs, and predators in the area that might feast more on one type of macroinvertebrate than another.

(Click) As we mentioned earlier, we might have an impact on these factors!

(Click to show Slide 11) Let's look at some example streams. (Click) Macroinvertebrate samples from each of these streams contained 100 individual macroinvertebrates. Ask what that tells us about the abundance measure. (Click) It's the same for all.

(Click) Looking further into our data, we see the types of macroinvertebrates that showed up in our samples. Ask what that tells us about the richness measure. (Click) Streams B and C are considered healthier since 5 types of invertebrates were found in their samples compared to only the 2 types found in Stream A

(Click) Looking at the rest of our data, we see the numbers of each type that showed up in our samples. This can also give us an idea about the health of the stream. (Click) Stream B is considered the healthiest since the types of invertebrates found there are more evenly represented than the types of invertebrates found in Stream C.

High richness and abundance of sensitive species are generally considered by scientists to indicate a healthy stream. (Click) Since some macroinvertebrates are more "Creek Canary-ish" than others (i.e., some are more sensitive to poor water quality and others are more tolerant of poor water quality), so we need to start by learning how to identify macroinvertebrates we might collect.

Dichotomous Key Activity
Break the kids up into groups of four (ideally, the teacher will have known of this requirement in advance and will have identified the groups before the presentation). Distribute a dichotomous key to each group. (Click to show Slide 12) Lead the kids through identification of the sample macroinvertebrate, having them select the correct choices using the dichotomous key (Slides 13 – 17).

Distribute a different macroinvertebrate card to each group and have them use the key to identify the critter on the card. After each group has identified their macroinvertebrate, show Slide 18. This shows the pictures and names of all the macroinvertebrates the kids will come across during the next activity. Note that there will be more pictures on the slide than cards the groups used.

Stream Quality Activity
Briefly discuss how macroinvertebrates are sampled.

(Click to show Slide 19) It takes a lot of equipment to collect macroinvertebrate samples, but most of it's easy to come by or can be done without: D-net (so named because of the shape of the opening) is essential and used to funnel the critters into the collection tube; collection tube goes at the back of the D-net net to collect the critters; optional boots to keep your feet dry (and warm); optional gloves to keep your hands and arms dry (and warm); white tray to dump the collecting tube into; magnifying glass to see what you've collected; tweezers to transfer the critters; white ice cube trays for sorting the critters.

One person holds the D-net with attached collection tube in the stream with the flat side down and the opening pointing upstream. Someone else stirs up the stream bottom in front of the net, picking up any rocks and rubbing them. An area about 18" in front of the net and 1½" into the stream bottom is disturbed for about 3 minutes. This is repeated in four other areas in the location being sampled.

The collection container is then dumped into a white tray, the magnifying glass is used to locate and enlarge the critters, and the tweezers are used to transfer the critters to a sorting tray after they've been identified.

Make sure they understand that for macroinvertebrate sampling to be useful, it must follow some specific procedures. While this is just a classroom simulation, their teacher can learn how to take them out to sample macroinvertebrates in a real stream.

If fewer than eight teams will be formed, distribute collection containers in this order: F, G, H, A, B, D, C, and E.

They are now going to process a sample of macroinvertebrates and make some decisions based on their sample. (Click to show Slide 20) To each group distribute a sorting sheet, a white tray, and a collection container. Have them slowly pour the contents of the collection container into the white tray and separate the macroinvertebrates to the proper locations on the sorting sheet, using the images on the sorting sheet and the macroinvertebrate slide to identify the macroinvertebrates. Wait until all groups have their macroinvertebrates sorted, helping those groups that need it.

It is recommended that the trays with the "substrate" be collected at this time to remove temptation from the students.

Sample A	Sample B	Sample C	Sample D
5 Caddisflies 5 Stoneflies 5 Black flies 5 Crane flies 5 Aquatic mites 40 Aquatic worms 5 Midges 5 Snails, pouch	5 Black flies 10 Crane flies 5 Aquatic mites 30 Aquatic worms 10 Midges	10 Caddisflies 30 Mayflies 15 Stoneflies 5 Black flies 40 Crane flies 60 Aquatic mites 10 Aquatic worms 60 Midges	80 Caddisflies 600 Mayflies 150 Stoneflies 20 Planaria 10 Black flies 10 Crane flies 70 Aquatic mites 20 Aquatic worms 80 Midges
Richness: 8 Abundance: 75 Index: 14 (F)	Richness: 5 Abundance: 60 Index: 7 (P)	Richness: 8 Abundance: 230 Index: 16 (F)	Richness: 9 Abundance: 1040 Index: 19 (G)

Sample E	Sample F	Sample G	Sample H
5 Caddisflies 5 Mayflies 5 Aquatic worms 600 Midges	80 Caddisflies 100 Mayflies 180 Stoneflies 10 Planaria 10 Snails, gilled 10 Clams 20 Crane flies 30 Aquatic mites 180 Aquatic worms 60 Midges 10 Snails, pouch	15 Caddisflies 20 Mayflies 10 Stoneflies 5 Black flies	150 Caddisflies 220 Mayflies 50 Stoneflies 190 Black flies 10 Clams 50 Crane flies 70 Aquatic mites 160 Midges 10 Snails, pouch
Richness: 4 Abundance: 615 Index: 8 (P)	Richness: 11 Abundance: 690 Index: 23 (E)	Richness: 4 Abundance: 50 Index: 11 (F)	Richness: 9 Abundance: 910 Index: 18 (G)

When all groups have completed the sorting activity, distribute the Student Data Sheets. Walk through filling out the Macroinvertebrate Data Sheet with the students, clicking through Slides 21-228).

Data Table

1. (Click) Identify the macroinvertebrates in the sample and sort them onto the sorting sheet. Remind them to use the images on the sorting sheet, not the dichotomous key.
2. (Click) For each macroinvertebrate in the sample, enter a ✓ in the ✓ if found column. Suggest that one student read off the names of the critters while the others check their boxes.
3. (Click) Find the Richness of each macroinvertebrate category (Sensitive, Somewhat Sensitive, and Tolerant) by counting the number of ✓s you made for that category.
4. (Click) Find the Total Richness by adding the three Richness values above.

5. (Click) Find the Index Value for each category by multiplying the Richness value by the indicated number. Suggest the students split this task among the members rather than have each student find each value.
6. (Click) Find the Total Index Value by adding the three Index Values above. Check the box for the Index Rating that matches your Total Index Value.
7. (Click) Enter how many of each invertebrate you found in your sample in the Count column. For example, if you have a mayfly marked with "25x," then enter "25" in the Mayflies' Count column. Again, suggest that one student read the numbers off the critter cards while the others record the counts. *It is recommended that the small critter cards be counted and collected after their counts have been noted on the data sheet to minimize the chance of the markers being lost.*
8. (Click) Find the Abundance of each category by totaling the values in the Count column. Suggest the students split this task among the members rather than have each student find each total.
9. (Click) Find the Total Abundance by adding the three Abundance values above.

(Click) When the students have completed the Macroinvertebrate Data Sheet, have them use the map on the back page, their results, and the class discussion to infer where their sample might have been collected. Make sure they keep in mind the different sensitivities of the critters in their collections. Have them mark a possible collection location on the map.

After students have made their inferences, have them identify to you where they think their site was (if the map is being projected on a white board or other markable surface, indicate the students' site locations on the projected map). **Have each team explain whether or not, based on the macroinvertebrates present, the stream is likely to be healthy enough to be a good salmon habitat.** *This part of the discussion is the key to connecting the concepts of macroinvertebrates as creek canaries and salmon needing high-quality habitats to survive.* If time allows, have each team briefly describe their sample to the class and explain why they selected the site they selected.

Click to clear the instructions, click again to show Slide 30 with possible collection sites.

Rationale for locations:

G — Although the indications are that the stream is of poor quality, all the macroinvertebrates are of the type that require high-quality conditions. Most likely this sample was taken far up the stream where it hasn't had the chance to become populated by more macroinvertebrates yet. Probably a good site for redds.

F — Indications are that this is a very healthy part of the stream with an excellent Index Rating and high abundance. There's been time for the stream to become populated by a variety of macroinvertebrates of all sorts, but it doesn't look like people have impacted the area yet. Probably very healthy for salmon fry.

D/H — Indications are that this section of the stream is good, but not great. There's pretty high abundance, but not the variety of macroinvertebrates we'd expect in better parts of the stream. Likely human impact has played a major role. Probably acceptable for salmon fry.

A/C The richness is definitely starting to decline, as is the abundance. This indicates that the water quality has probably degraded quite a bit. Probably a marginal salmon habitat.

B/E The very low richness and focus on the macroinvertebrates that can tolerate poor water quality indicates that this section of the stream has been severely impacted. Probably a poor salmon habitat.

(Click to show closing slide)

Closing Discussion
We can learn a lot about a creek from the indicator species in it, the Creek Canaries. Knowing a little about what the creek passes, we can even make predictions about what macroinvertebrates we might find at certain locations along the creek and predictions about whether or not the stream would be a good salmon habitat.

We've talked about how our activities affect the stream, possibly making it difficult for macroinvertebrates to live in the stream. Ask students what this means about other life in the stream, especially salmon (*if the macroinvertebrates can't live there because of pollution, the salmon probably won't be able to live there either; if the poor water quality itself doesn't kill the fry, thy would die without macroinvertebrates for food*).

Ask for ideas on what they or their families could do to improve stream quality as it runs past their house, playground, school, or city (*keep vegetation in place near streams, don't walk in or along the edges of streams, don't poor stuff down storm drains*).

Ask if this is something they should care about, and if so, why (*examples*). If they're interested in this kind of work (investigating life in the streams around us), they might consider looking into working for the Alaska Department of Fish & Game, the state Department of Environmental Conservation, the Fish and Wildlife Service, or one of the universities.

Optional Activities
Discuss the warning signs of pollution. Give students the "clues" (cloudy or muddy water, algal blooms, surface sheen, etc.) and have them discuss in their teams what might have caused that condition. Call on different groups to give their solutions.

Type of Land Use	Warning Signs of Pollution
Forests	Cloudy or muddy water may be signs of sedimentation from logging, road building or clear cutting trees and vegetation.
Agricultural	Algal blooms are normally associated with the misuse or overuse of fertilizers and manure runoff from pastures, feedlots or compost piles.

Urban	Surface sheen, low pH levels and the absence of pollution intolerant macroinvertebrates may indicate urban runoff such as metals, salts, chemicals and oils.
Industries	Stream discoloration, odors, low pH levels, excessive algal growth and the absence of pollution intolerant macroinvertebrates and fish may indication the deposit of unnatural materials by industry.
Sewage Treatment Plants and Septic Systems	Excessive algal growth is an indication of the release of organic matter. An absence or a decrease in macroinvertebrate levels may indicate high levels of chlorine in the water.
Sanitary Landfills	Rusty streaks and signs of runoff from landfills may be indicated by excessive algal growth and the absence of pollution-intolerant macroinvertebrates.
Construction	Cloudy or muddy water may be signs of sedimentation which may occur around construction sites if proper barrier structures are not in place.
Residential	Algal blooms, the absence of aquatic life and a colored sheen on the water may indicate the dumping of automobile oil, poor fertilizing practices and defective septic systems.

From www.ncsu.edu/sciencejunction/depot/experiments/water/lessons/pollution.html

Research Ties
TBA

Supply Sources
Magnifying glasses: Student 4x magnifier (www.acornaturalists.com, item T-3180) (67¢ ea, 30 @ 53¢ ea)
Forceps: Dissecting forceps (www.ctvalleybio.com, item D 2380) ($1.20 ea, 10 @ $1.00 ea); Frey also has several options, but no images of items

Material Preparation
The "collected" macroinvertebrates are made by printing two copies of *Macroinvertebrate Collections.doc* onto full-sheet label paper. Stick one of the sheets to stiff cardboard, such as that used as backing to pads of paper. After cutting out the individual ovals (inside the dotted lines), stick the back of the cardboard-mounted piece to the sticky side of the corresponding image from the other piece of label-paper. It works well to trim the second image piece into a rectangle just outside the oval lines, then center the cardboard-mounted piece on the sticky side of the second image piece. Trim the double-sided macroinvertebrate piece to remove any remaining oval lines.

The macroinvertebrate tubes are made from standard $2^3/_8$" PVC according to the drawings found in *Macroinvertebrate Collector Model.jpg*. A rectangle of screen is glued with contact cement to the inside of the tubes to cover the holes. Note: this is much easier to do if it is done before the bottom screen is attached because a large dowel can be used to push the screen against the inside of the tube. The screen at the top and bottom is held by the PVC cement used to attach the end pieces to the tube and cap. Drill the hole through the cap and upper end of the collection tube simultaneously, and drill it large enough (~$^{5}/_{16}$")to allow VERY easy insertion of the bolt. The upper end of the tube will need to be sanded to allow the cap to slip on easily. A funnel resembling that found on a D-net can be made of nylon net, reinforced at the seams and at the ends with bias tape, and attached to the cap using a hose clamp.

Resources

Check out the macroinvertebrate resources in T:\Education\Programs - Student\Program Outlines\SIAJ-Macro Monitors

Websites:

Biological Indicators of Watershed Health: www.epa.gov/bioindicators/html/benthosclean.html
Field Guide to Freshwater Invertebrates: www.seanet.com/~leska/Online/Guide.html
Biological Stream Quality Assessment: www.water.ky.gov/homepage_repository/streamql.htm
Macroinvertebrate Identification: www.bgsd.k12.wa.us/hml/jr_cam/macros/macro_id-htm/slide_01.htm
Macroinvertebrate Teaching Resources: www.bgsd.k12.wa.us/hml/jr_cam/macros/resources.html#sorting
SOS Stream Study: people.virginia.edu/~sos-iwla/Stream-Study/StreamStudyHomePage/StreamStudy.HTML
Stream life: www.landcare.org.nz/SHMAK/manual/9streamlife.html

SIA Jr: Creek Canaries Standards Correlation

Understand the process of science by

[6-8]SA1.1 – asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

Will look at how macroinvertebrates are used as indicators of stream/habitat quality. Will identify macroinvertebrates and classify them as sensitive, somewhat sensitive, or tolerant. Will determine a Stream Health Index, generalize about the health of the hypothetical habitat based on the invertebrates found there, and, shown a map of the hypothetical stream, infer from which part the stream their sample came.

Understand that interactions with the environment provide an opportunity for understanding scientific concepts by

[6]SA3.1 – gathering data to build a knowledge base that contributes to the development of questions about the local environment.

[8]SA3.1 – conducting research to learn how the local environment is used by a variety of competing interests.

Will look at how macroinvertebrates are used as indicators of stream quality and how human activities can affect the stream quality, especially as habitat for salmon. The competing interests discussed are human activity and salmon habitat.

Understand the structure, function, behavior, development, life cycles, and diversity of living organisms by

[6]SC2.1 – using a dichotomous key to classify animals and plants into groups using external or internal features.

[6]SC2.2 – identifying basic behaviors (e.g., migration, communication, hibernation) used by organisms to meet the requirements of life.

Will use a dichotomous key to identify macroinvertebrates. Will discuss the how macroinvertebrates survive in a fast-moving stream.