Bio-indicators: Healthy Ecoystems

Grade: 5

Subject Areas:
Life Science, Social Science, Mathematics

Skills: modeling, describing, calculating, predicting, interpreting, graphing

Duration: 1- 2 hours

Connections:
biodiversity, pollution, human activities, natural resource planning, estimation,

Vocabulary

ecosystem

limiting factors

assess

non-point source pollution

range of tolerance

population

biodiversity

bio-indicator

invertebrates

macroinvertebrates

Objective:

Students will be introduced to factors that potentially influence an ecosystem. Using a realistic simulation, they will determine if population numbers infer a healthy ecosystem.

Materials

- brown bags (one per group)
- permanent markers (one per group)
- fava beans or goldfish crackers (for salmon)
- lima beans or dried raisins (for bats)
- lined paper for note taking
- calculators and graph paper
- list of nonpoint pollution sources (optional)

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.
F) Working with models and simulations: Learners understand many of the uses and limitations of models.
Environmental Process and Systems: Strand 2.2 — The Living Environment: C) Systems and Connections: Learners understand major kinds of interactions among organisms or populations of organisms.
Strand 2.4 — Environment and Society: A) Human/environment interaction: Learners understand that human caused changes have consequences for the immediate environment as well as for other places and future times.

California State Educational Standards:

Life Sciences 2a: Students know many multicellular organisms have specialized structures to support the transport of materials.
Earth Sciences 3d: Students know the amount of fresh water located in rivers, lakes, underground sources, and glaciers is limited and that its availability can be extended by recycling and decreasing the use of water.
Investigation and Experimentation (I and E) 6g: Students will record data by using graphic representations (including charts, graphs, and label diagrams) and make inferences based on those data.
I and E 6f: Students will draw conclusions from scientific evidence and indicate whether further information is needed to support a specific conclusion.

Background

Test of Health

The health of an ecosystem can be assessed in many different ways. An **ecosystem** consists of all living and non-living components of a defined area. Some non-living components in an ecosystem can include nutrients like nitrogen, phosphorous and carbon which are constantly used and recycled.

Simply speaking there are four basic needs for life: food, space, shelter and water. These needs become more defined as one studies a particular organism. Plants for instance, take in carbon dioxide and give off oxygen during photosynthesis. They need light and a source of nitrogen to form their food. Those things responsible for limiting the population of a species are referred to as **limiting factors**. Limiting factors can be a host of things from the amount of energy available in a system to the pH of the soil.

Certain organisms are more sensitive to change than others. People have known this fact for years to the point of using certain animals to **assess** the safety of an area. In coal mines, a canary was put in a cage and taken down into the mine shaft. When the canary died, miners knew levels of toxic gas had exceeded safe limits.

Organisms are considered to have a **range of tolerance** for various conditions within their habitat. In the Eel River near the King Range National Conservation Area (NCA), salmon are in direct competition with a non-native species, the Northern Pike Minnow. The pike minnow has a greater range of tolerance for water temperature. It can live in warm water whereas salmon need cold, well oxygenated water. Because, cold water holds more oxygen, most salmon die with temperatures greater than 24 degrees Celsius (75 degrees Fahrenheit). As pools dry up in the warm months of summer, more Northern Pike Minnows survive while salmon die because their range of tolerance for temperature is greater. Streams with more salmon, show optimal oxygen levels capable for supporting a greater variety of organisms.

Threats to Life

Today, with ever growing human population, many stresses are put on wildlife. Humans compete directly for food, water, and space. Many of our forests, rivers and lakes are being polluted by excess nutrients and other non-point sources of pollution. **Non-point source pollution** is difficult to pin point to a specific location. In addition, water is diverted away from streams for agriculture and household use. Forests are cut down for wood pulp and lumber. This leaves less land and water for the wildlife that depends on it.

It is not always easy to assess the health of an ecosystem. Typically an initial survey is performed which gives a baseline to compare to. Numbers of species are calculated by a variety of methods. A **population** is a group of organisms that can interbreed. Once baseline population numbers have been determined, future data collection from the same area can be compared to see how the numbers have changed. Finding optimal levels is a challenging task.

Seeking Diversity

It stands to reason that the greater number of species an area can support, the richer the ecosystem is. For years, scientists have connected biodiversity with the health and stability of an ecosystem. One definition of biodiversity is the total number of different species in a given area. Recent studies suggest that among other reasons, three things are most responsible for the decline in biodiversity: 1) exploitation of resources 2) habitat loss and 3) invasion of introduced species . Worldwide, the loss of biodiversity is one of the greatest threats to our environment.

The existence of certain species used to assess the health of an ecosystem is called a **bio-indicator**. By assessing the number and health of salmon in a stream, they can be used as a bio-indicator for the overall health of the stream. If the population of a certain salmon species is high, then the conditions necessary for supporting the population are favorable. The fatter the fish, the more healthy it is. If fish are nice and healthy, one can infer that food is plentiful. For food to be available, the water quality has to be within with certain acceptable ranges. Like salmon, most animals are mobile.

A common method used to accurately count a mobile population is called the mark and recapture method. In this method, individuals are captured and marked. Later, animals are captured again in the same place again. If only marked animals are captured, this indicates a low population level. In other words, the population is so slow, the same animals are being caught. If very few marked animals are caught, this indicates a high population. A formula is used to come up with specific numbers (see activity). Salmon are good indicators of the health of a watershed because they live for several years, are easy to identify in the field, and differ in their range of tolerance for types of pollution.

One of the most popular bio-indicators used for assessing water quality is to identify and count different types of macroinvertebrates. **Invertebrates** are animals without a backbone and salmon love them. Small aquatic animals are referred to as **macroinvertebrates** because they can be easily seen. They include animals like worms, nymphs, clams, fly larva and water beetles. Macroinvertebrates tend to be more numerous and easier to catch than salmon. Certain ones are intolerant of pollution like mayfly nymphs and caddis flies. Catching and counting macroinvertebrates is a great thing to do with students along a river or stream during a field trip.

If a scientist wants to assess the health of a land or terrestrial ecosystem, a good bio-indicator to use in many places is bats. Bats are winged mammals that live in a variety of habitats. Many populations are affected by a variety of stressors including climate change, water quality, disease, and habitat fragmentation. These sensitivities make them good bio-indicators. If an ecosystem has a healthy population of bats, for instance, one could infer that it can support a lot of insects. Bats literally eat thousands of insects every night. In one hour, a little brown bat, which is commonly found in the King Range NCA, can eat over 600 mosquitoes.

In other places, like the tropical rainforest, bats are even more important because they disperse seeds. Many tropical bats eat fruit. After they digest the fruit, they spread the seeds throughout the forest through their droppings. In agricultural areas, bats eat lots of pests especially moths. They help farmers by controlling pests which decreases the need for pesticides. In forests, they eat many bugs that could otherwise harm trees. Many desert plants are only pollinated by bats, such as the saguaro cactus and some species of bananas. Some bats are more tolerant of change than others. The little brown bat can live in modified habitats like cities where there are many disturbances, whereas the Townsend's big-eared bat is less tolerant to disturbances, for instance.

Humans are often misinformed about bats. People tend to fear bats and associate them with things that are dark and sinister. Today, we know that bats help eat millions of harmful insects. They reduce disease by eating mosquitoes and other pathogens. Having a greater understanding and appreciation of bats is one of the reasons why they have been selected for use in this lesson.

Salmon and bats are only two species used as bio-indicators. There are several more. Interrelationships between plants, invertebrates, mammals and fish are a good reminder that there are many interconnected components to ever ecosystem. By attempting to understand interactions between species, we can more accurately assess the health and stability of an ecosystem.

Local Connection

Watershed Conservation Stewards

The Americorp's Watershed Conservation Stewards (WCS) strives to conserve, restore, and enhance anadromous watersheds for future generations by linking education with sound high quality science practices. The local chapter provides a range of services including restoration and educational outreach. In Humboldt county, several high quality programs can be brought directly to your classroom for free.

One extensive program called "Real Science: Watershed and Salmonid Education Program (WSP)" is presented over a course of six classroom visits. It is heavily aligned with California State Science Standards. Students learn about watersheds, the salmon cycle, and important salmon habitats. Single visits can also be arranged.

Another option is to join in the fun during Creek Days, an outdoor environmental education fair. Creek Days is co-coordinated effort between Eel River Watershed Improvement Group (ERWIG) and WSP. Students spend approximately four hours outside learning about the world of rivers and forests through investigation and exploration. Watersheds emphasized in the past include Bull Creek, the Van Duzen, and the South Fork of the Eel.

For more information contact the WSP office in Fortuna at:
(707) 725-8601 **or go to** *www.watershedstewards.org*

Activity: Mark and Recapture

Preparation

4 bags will represent salmon populations and 4 bags will represent bat populations. The number of bags can be changed depending on the size of the class. For salmon make 2 bags of 75 fava beans, and 2 bags of 150 fava beans. Repeat the same proportions for bat populations. Label the bags for salmon, S1, S2, S3, and S4. Label the bags for bats B1, B2, B3, and B4. Be sure to record how many are in each bag on a separate piece of paper. You may want to mix the bags up so bag 1 doesn't have the fewest samples and bag 4 with the most samples and so on. Modify # after trials

Materials

- brown bags (one per group)
- permanent markers (one per group)
- fava beans or goldfish crackers (for salmon)
- lima beans or dried raisins (for bats)
- lined paper for note taking
- calculators and graph paper
- list of nonpoint pollution sources (optional)

Procedure

1. In this exercise, students will pretend to capture animals, tag them, and then release them back into the wild. They will then recapture some and compare how many are tagged to how many are untagged. If more than 1/3 or so of the recaptured animals are "tagged" then the population is relatively small. Actual population numbers are calculated using a formula. Calculators will probably be needed for this.

2. Begin by defining the terms, ecosystem, limiting factor, population, range of tolerance, and bio-indicator. It is optional to have the students take notes. Ask the students questions about local ecosystems. Include discussion about different ways people can assess the health of an ecosystem, and possible causes for low population numbers in a given ecosystem. Remind students of the 4 basic needs organisms have to survive. Write key ideas down for display.

- *What kinds of things are a part of an ecosystem? (living and non-living)*
- *What are some different types of local ecosystems?*
- *What types of things can affect the health of an ecosystem?*
- *Do you think certain species have different needs? In a river, what needs do fish have?*
- *What does a large population of fat healthy fish tell a fisheries biologist?*
- *Do you think different fish have different needs? Do you think different fish have different tolerances?*
- *(Comparing a stream ecosystem with a forest ecosystem) What needs do bats have?*
- *What similar needs does a bat and a fish have?*
- *What are some clues we can use to determine if there is a healthy bat population? (hopefully they can understand that the size of population is related to health)*
- *What do bats mostly eat?*
- *What kinds of activities will reduce the amount of bats in an area? (reduction in food, space, etc.)*
- *How can bats be beneficial to humans?*
- *Should humans be afraid of bats?*
- *What changes in an environment are human caused?*
- *Is it important to monitor and assess ecosystems?*

3. Explain to the students that they will determine the health of an ecosystem by determining the size of a population. Populations of salmon will be used as a for assessing a stream ecosystem and populations of bats will be used for assessing a forest ecosystem. In this exercise, salmon and bats are bio-indicators. The assumption is, that the higher the population of salmon and bats the healthier the ecosystem is.

4. Break the entire class in half. Half of the class will be forest biologists and the other half fisheries biologists. Each half will be divided further into 4 groups. There should be 3-4 students per group; partners are fine too. Each group should get a labeled paper bag and a permanent marker. Don't allow them to look into their bag until the very end.

5. First they need to capture animals and mark them (beans). Have them pull out 25 samples (organisms) one at a time and clearly mark them with a pen. After "tagging" them, they need to record this number in the correct column on their worksheet (see attached worksheet). Secondly, they need to put all marked pieces back into their bag and shake it well. Next, they set out "traps" and catch animals again (recapture some). Have them pull out 25 samples again from their bag without looking. Have them tally in the marked (R or un-marked C columns). After they are through, they need to add how many total marked and unmarked samples they have and record it on their sheet. They need to repeat the entire second part (recapturing) and record it under trial 2.

6. Mark and Recapture Method (see worksheet): The total population number is estimated by the following formula:

Where: R = # recaptured and marked
C = # recaptured unmarked
M = # originally captured and marked
N = estimated population number

Note: This equation has been simplified by manipulating the formal equation used (M/N = R/C).

After getting their individual data, using calculators have them estimate their population using the given formula (see worksheet). Remind students that in algebra letters are called variables. Letters are used because the numbers change. They need to insert the proper values for each variable. While students are marking and capturing their "animals", make a chart on the board or overhead where students can entire their final results. Once all groups have calculated their population sizes, have a representative from each group enter their data on the chart. Next, have them count the actual populations in their bag and compare them to their estimates. Discuss the results.

Ideally, the students will graph the entire data set using a bar graph. They may need help getting their graph set up. The X axis should be labeled "sample" (S1, B2, etc.) and the Y axis should be labeled "population" (N). This may be an activity that the classroom teacher has the students perform the next day since it is time consuming.

- *Based on results, which populations are the healthiest and why?*
- *Were estimated populations accurate?*
- *What errors may have occurred in this activity?*
- *How could you make this activity more accurate?*
- *How could a scientists get more accurate population numbers?*
- *What are some strengths and weaknesses of using population numbers to assess the health of an ecosystem? (For instance, invasive plants may be high in numbers, but this is not a good indicator of a healthy ecosystem).*

Extensions

- Make bat houses. See instructions at: www.batcon.org (Bat Conservation International).
- Research the types of bats that live in the local area and have students write a paper.
- Collect, observe, and identify different bugs.
- Erect an obstacle course as a means of modeling the path salmon take to return home to spawn.
- Have a local fisherman or fisheries biologist bring in a salmon and talk about fish stories.
- Investigate different sources of water pollution and solutions. A good source for kids is: www.oceans-idecleanwaterprogram.org
- Make a classroom biodiversity mural or display comparing different regions of the world

References

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Biological Indicators of Watershed Health, EPA, Freshwater Fish Identification and Their Use as Bioindicators, http://www.epa.gov/bioiweb1/, 2010
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Jones, Gareth (et.al), Carpe nocturm, The Importance of Bats as Bioindicators, Open Access, http://www.int-res.com/articles/esr2009/8/n008p093.pdf, 2009
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Name: ______________________________ **Date:** ______________

Mark and Recapture

Estimating populations

1. The larger the population, the ______________ marked individuals will be found. (fewer/more)

2. The smaller the population, the ______________ marked individuals will be found. (fewer/more)

During this simulation I am a ______________________ biologist.

I will be estimating the population of ________________ .

Trial 1

Number marked (M) (during first capture) ____________

Number re-captured ____________

- With marks (R) ____________
- Without marks (C) ____________

Estimated Population (N) (perform calculations ____________

Actual Population in my bag ____________

Trial 2

Number marked (M) (during first capture) ____________

Number re-captured ____________

- With marks (R) ____________
- Without marks (C) ____________

Estimated Population (N) (perform calculations ____________

Actual Population in my bag ____________

To estimate a population: FORMULA: **M/N** = **R/C**

Where: **R** = # recaptured that are marked
C = # recaptured unmarked
M = # originally captured and marked
N = estimated population

Solve: **N** = (**MC**) / **R**

To find population (N): (25 times un marked(C)) divided marked (R)

Show Work: