NATURE WORKS EVERYWHERE

As part of Recycle for Nature, PepsiCo Recycling has partnered with The Nature Conservancy and its Nature Works Everywhere program to provide some fun activities to encourage families and children to get outdoors. Nature Works Everywhere gives teachers, students and families everything they need to start exploring and understanding nature around the globe alongside The Nature Conservancy scientists—interactive games, and interactive lesson plans that align to standards and can be customized for each classroom.

*All website links work in Internet Explorer 9 or later, Google Chrome or Firefox browsers

MANAGING SALMON TO SUPPORT HEALTHY FORESTS

For more information about PepsiCo Recycling, visit: www.PepsiCoRecycling.com.
For more resources that support this lesson, download the full lesson plan here.

Essential Question:

How can managing salmon support healthy forests?

Lesson Overview:

Test a simple interactive population model to estimate sustainable salmon harvest.

Learning Objectives:

Evaluation

- Assess the value of salmon in terms of their impact on nutrients and forest health, and the benefits salmon and forests provide to people.

Synthesis

- Predict how change in salmon runs affect nutrient inputs and forest health, and thereby impacts benefits to people.

Analysis

- Interpret the consequences of changing salmon runs on nutrient inputs and forest health, and hence how changes in salmon runs impact benefits to people.

Application

- Demonstrate how the size of salmon runs impact nutrient inputs.

Comprehension

- Explain how salmon runs contribute to the health of forests by contributing nutrient inputs via consumption of salmon by other animals.

Knowledge

- Know that salmon runs contribute to the health of forests and thereby affect people.
- Know that salmon is a popular and healthy food source that benefits people.
- Know that healthy forests filter water and protect watersheds, and provide numerous other benefits to people.

Middle School Next Generation Science Standards

LS1-4: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

High School Next Generation Science Standards

HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

HS-LS2-4: Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

HS-LS2-6: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS-LS2-8: Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

HS-LS4-5: Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

HS-LS4-6: Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*

HS-Ess3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-ESS3-3: Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Vocabulary:

- *Fisheries*: An industry based on fish for food and other products. Fisheries usually focus on a target fish such as salmon.
- *Nutrient Recycling*: Nutrients nourish plants and animals. Organisms combine nutrients using energy into complex molecules that sustain biological processes. Many nutrients are recycled for re-use in a system. Nature recycles many different kinds of materials so that a limited quantity of nutrients can be re-used over and over in different ways.
- *Ecosystem*: Groups of organisms that interact in a shared habitat. All the plants and animals are interconnected by ecological relationships such as predation and competition.

- *Biomass*: The total amount of matter from organisms in a given area. The mass (or weight) of all biological organisms including plants, animals and microbes makes up the total weight in a particular area.
- *Deficiency*: Lack of one or more nutrients essential for growth. When a plant is deficient in a nutrient, it grows more slowly or shows signs such as yellowing leaves.

Background for the Teacher:

In this lesson plan, students address the impact of unsustainable fishing practices, as applied to the case of salmon fisheries in the Pacific Northwest. Salmon runs are an important factor in cycling several nutrients, notably phosphorus and nitrogen. As fish return to rivers during their annual spawning run, they are consumed by predators or die at the end of the spawning run. Their carcasses contribute nutrients that are a significant input for forest plants. Overfishing salmon reduces the forest's capacity for growth and regeneration.

Salmon is a healthy, nutritious food, and salmon fisheries employ numerous people. The forests fertilized by salmon provide products such as lumber, jobs, and ecosystem services such as protecting watersheds by filtering water. Therefore, strong salmon runs benefit people directly and indirectly. For this reason, fisheries managers, conservationists and policy makers want to work together to prevent overfishing.

To emphasize the benefits of a sustainable salmon fishery, students explore the connection between the size of salmon runs and forest health. Students address the question: how can managing salmon support healthy forests? To answer the question, students participate in two activities. First, they work with the teacher to test a simple population model (using Netlogo, software free for educators). The model includes parameters that can be varied independently. The students use the model to estimate a sustainable salmon harvest. The second activity is to simulate variation in nutrient input by comparing growth of plants given inputs of different concentrations of fish-based fertilizer with a control.

CLASSROOM ACTIVITIES:

Using a computer to estimate a sustainable salmon harvest

Materials

Materials for each group of students:

- computer with Internet connection

Engage

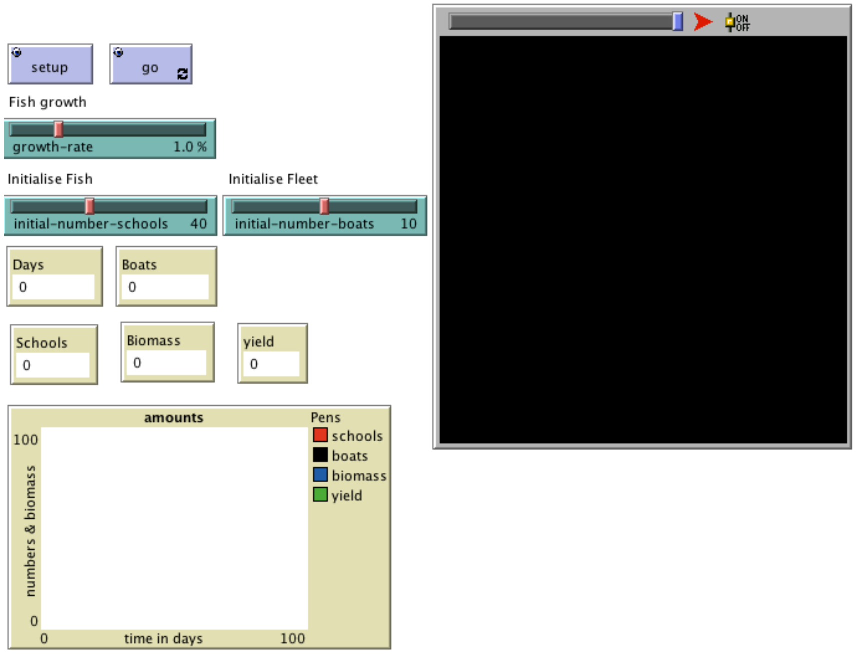
1. Show the *Salmon – Healthy Dinner, Healthy Forests* introductory video (https://vimeo.com/77811134)
2. Ask students: Have you eaten salmon?

3. Describe how salmon is delicious and healthy.
4. Explain that people rely on salmon *fisheries* for jobs.
5. Tell students that salmon runs were a feature of pioneer life, and before that a tradition of Native Americans.
6. Much of our salmon comes from fish farms, but a lot of it is still wild-harvested.
7. Many animals such as bears rely on the annual salmon migration. That is why the forest depends on salmon too.
8. Remind students of the “poop loop.” The poop loop enables *nutrient recycling* via salmon into the forest into plants, enhancing growth of trees and shrubs, upon which many other animals depend. For example, a run of 20 million salmon provides a nutrient input equivalent to the amount of fertilizer needed for 140,000 acres of intensive corn production.
9. The nutrients provided by salmon to the forest represent a key function in the forest-river-salmon *ecosystem*.
10. Show the *Meet the Scientist: Jonathan Hoekstra* video followed by the scientist video that answers the question, “How is it possible that the health of the forest depends on salmon?”

Explore

1. Introduce students to the idea that we can model salmon populations with a fisheries model.
2. Have students work in pairs or small groups.
3. They will use an interactive online application to explore how changing the variables in a fishery impacts fish stocks.
4. Click on the URL to visit the Netlogo website: http://ccl.northwestern.edu/netlogo/models/community/Fishery
5. The link takes you to the page with the Fishery model.
6. Review the information on the page that describes the model and how it works.
7. There are four variables:
    a. number of boats
    b. number of schools of fish
    c. *biomass* (total weight) of fish
    d. daily yield to the fishery
8. These variables are indicated graphically.
9. Students set three initial conditions that determine how these variables change over time.
10. Growth rate (how quickly the population grows)
11. Initial number of schools (the starting population of fish)
12. Initial number of boats (size of the fishing fleet)
13. Set the goal for students: work out which combination of the initial conditions results in the maximum daily yield.
14. Click on the link “Run Fishery in your browser”
15. A new page loads, which looks like this:

Figure 1. Screen shot of fisheries simulation initial set up.



16. Have the students initialize the variables by using the sliders. It's not important which values they use, but encourage them to be systematic. When the variables are set, click "setup" to initiate the model. You will see the fish and boat icons load into the large window.
17. Move the slider on the large window to the left to slow the rate at which the model runs.
18. Click "go" to run or stop the simulation. (Be sure to click "set up" each time to re-initialize the system, i.e., start at Day 0.)
19. Have the students run 5 simulations, each for 10 days.
    Have students record the results of each simulation in a table. (A student record sheet for the simulation is provided as an attachment to this lesson plan).

    Example Table (five days only)

	VARIABLES			RESULTS						
				Yield					Biomass	
Simulation	Growth Rate (%)	Initial Number of Schools	Initial Number of Boats	1	2	3	4	5	Start	End
1										
2										
3										

4										
5										

For example, hold the growth rate and initial number of schools constant while varying the initial number of boats. An example result is shown for five simulations, each of five days:

Example Results (five days only)

	VARIABLES			RESULTS						
				Yield					Biomass	
Simulation	Growth Rate (%)	Initial Number of Schools	Initial Number of Boats	1	2	3	4	5	Start	End
1	1	50	4	1	0	1	1	0	149	155
2	1	50	8	3	0	1	1	0	150	153
3	1	50	12	2	2	2	2	1	144	140
4	1	50	16	3	3	3	4	4	150	143
5	1	50	20	4	4	4	4	1	158	146

20. Encourage students to explore the model. It will help them understand the system if they run the model faster, for longer. Have students look at the graphical data as well as the numbers. Depending on the inputs, they may see cyclical behavior, a collapse, or peak populations of fish. Have students answer the following questions by exploring the model:
    a. What combination of variables caused the fishery to collapse?
    b. What combination of variables resulted in maximizing salmon populations?
    c. What combination of variables resulted in maximum yields?
21. Show the scientist video that answers the question, "What levels of fishing cause the salmon fishery to collapse?"

Explain

1. Have students show how different inputs affect various elements of the system, and explain that using models helps scientists predict how the system will respond as system variables are

changed. Students should explain that salmon populations decline due to overfishing, so the populations become unsustainable.

2. Have students explain that in the example data, 5 days of each simulation scenario, a pattern emerges. Students can discuss the pattern to see that although yields are higher with more initial boats, biomass decreases. When the initial number of boats is fewer, biomass increases.
3. Students should be able to explain that the maximum yields depend on the right combination of initial conditions. For example, if the growth rate is too low, the fish cannot replace their population, and the fishery will decline. Likewise, if the initial number of boats is too high, they will quickly remove all the fish.
4. Have students explain the broader picture in context. They can explain that ecosystems are complex and their parts are interdependent. Humans rely on natural systems for "ecosystem services." We do not exist apart from nature but as part of it. Humans must learn to manage their needs with the needs of natural systems to maintain a balance.
5. Have students explain the role of models, so that students can articulate that models help us predict where the balance is. Students can show that models help resource managers meet the needs of human society and natural systems such as salmon populations and forests.
6. Ensure that students can describe that via the "poop loop," lower salmon biomass results in less nutrient input into the forest during salmon runs. For this reason, fisheries managers must aim for a yield that does not result in a decline in biomass. (Fisheries managers call this concept "Maximum Sustainable Yield.") Show the scientist video that answers, "Will preventing overfishing help maintain healthy forests?"
7. Have students explain that salmon hatcheries are one way that resource managers can boost salmon populations.
8. Students should be able to show that much of the salmon that ends up in stores is not wild caught but is farmed. This source of salmon reduces pressure on wild stocks.