SHRINKING SALMON LESSON PLAN

Part 1: The Shrinking Salmon Problem

1. Tell students that in this activity they will consider how human activity can cause evolutionary changes in a particular species, such as salmon, which can in turn affect humans.
2. Have students read the section "Chinook Salmon." Review the salmon life cycle in Figure 2 so that students understand that salmon spend part of their life in the ocean and part of their life in freshwater rivers and streams.
3. Introduce the "Shrinking Salmon Phenomenon." Help students interpret the graphs in Figure 3. Students should see that
   a. Average body size (length) has declined over time.
   b. Average age of salmon in freshwater systems has declined, with some fluctuations.
   c. Average age of salmon in the ocean has declined.
4. Have students read about the consequences of this phenomenon below the figure. Students should realize that smaller salmon have consequences for biodiversity and people.
5. Review the Driving Question for the activity: What is the solution to the "shrinking salmon" problem?
6. Have students read the "Scientific Findings" about possible causes for this phenomenon. These findings are based on real-world data on Chinook salmon gathered by scientists and fisheries managers. Students should be able to summarize the following:
   a. In the ocean, the variables scientists have identified as being important are
      i. Ocean temperature
      ii. Level of competition from invasive species of fish and fish that have escaped from aquaculture pens.
   b. In the streams and rivers, the variables scientists that scientists have identified as being important are
      i. Water quality (which is impacted by pollution from nearby towns)
      ii. Water level (which is impacted by human development in wetland areas).
7. In the Procedure and Analysis section, for Step 1, check for student understanding. A sample student response follows:

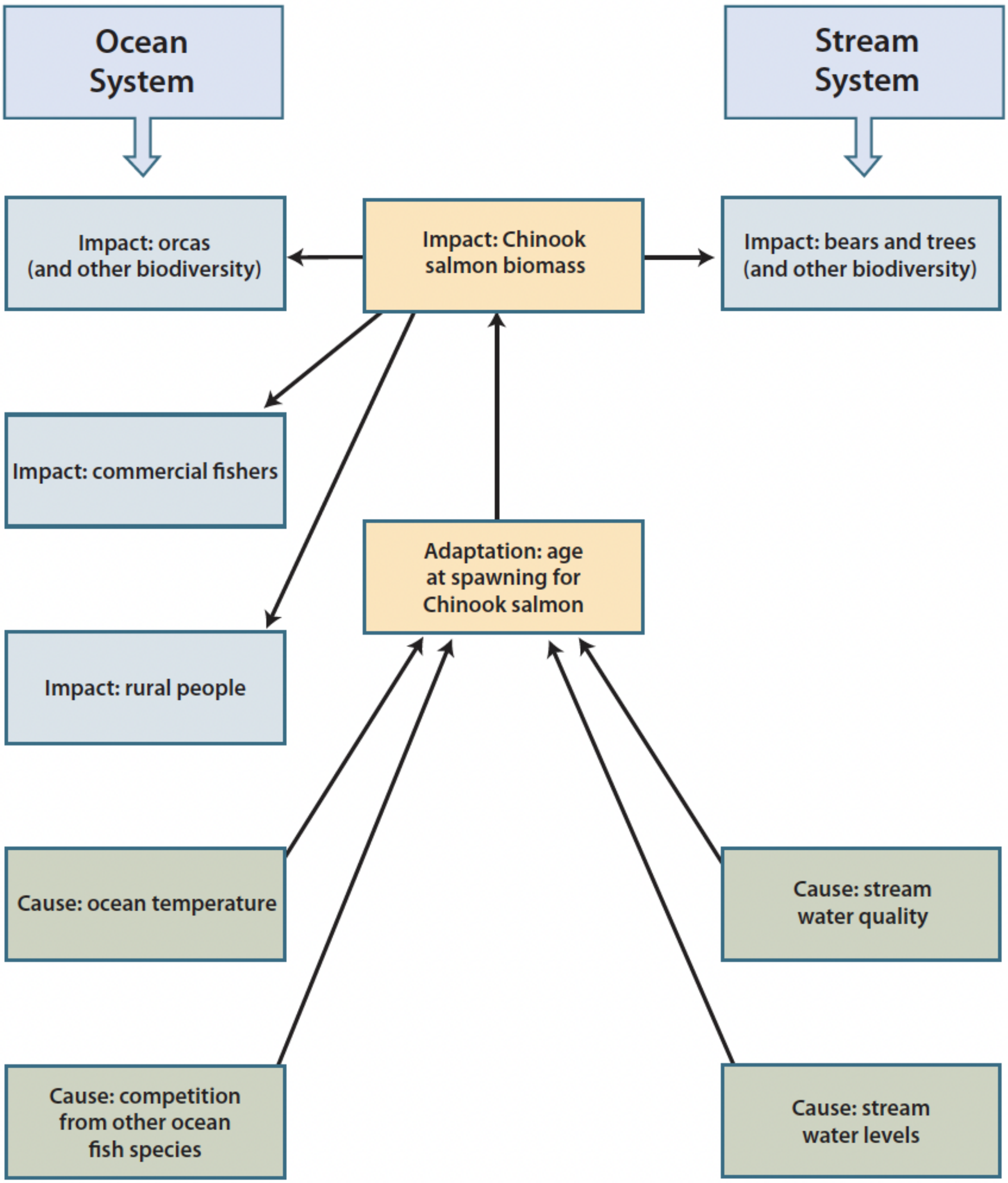
   Typically, the bigger, older salmon survive to return to their upstream breeding grounds. However, with selective pressures, like warming oceans, competition, and commercial fishing, fewer larger salmon are surviving to breed. Younger, smaller salmon are instead returning to the streams to breed. This leads to more smaller salmon and fewer larger salmon being bred, resulting in evolutionary adaptation (salmon are breeding at a younger age) in response to natural selection (fewer larger salmon are surviving). Salmon that had the trait to return to spawn at younger ages started surviving and reproducing at a greater rate than salmon who had the trait to remain at sea. They *passed on this trait to their offspring, so more and more salmon in the population return to spawn at a younger age.*

8. Support students as needed in developing a system model in Step 2. Have students share their models and facilitate a discussion to come to a consensus model. A sample system model is found at the end of this lesson plan.
9. Have students answer the questions in Step 3 individually, and then facilitate a class discussion around their ideas for solving the shrinking salmon problem

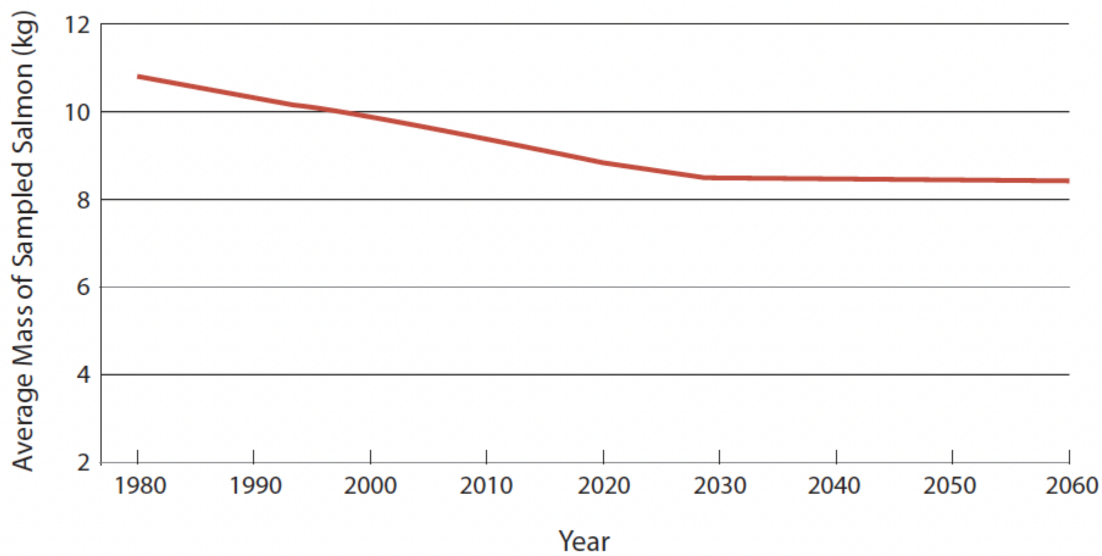
Part 2: Solving the Problem

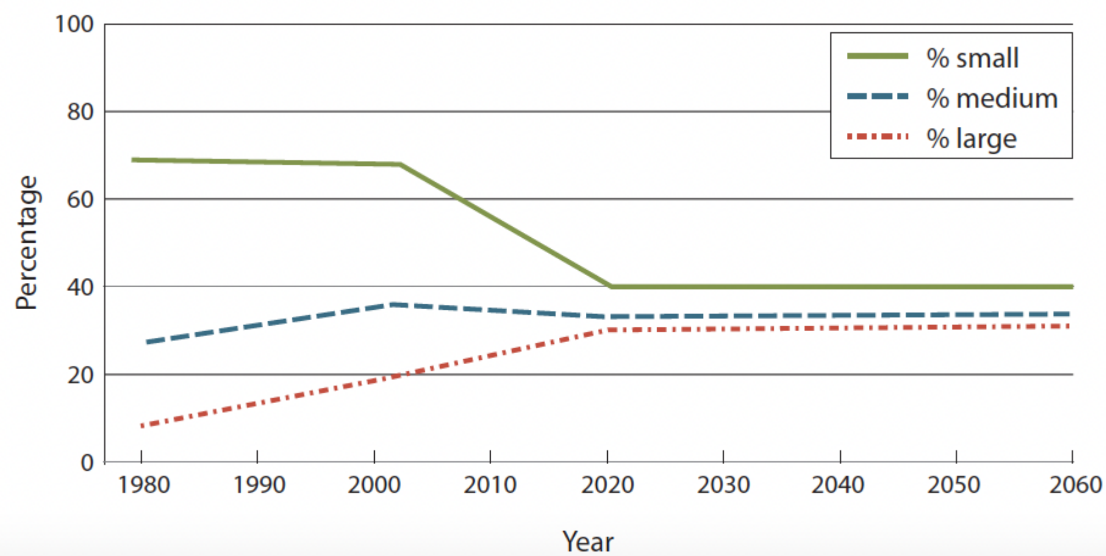
1. Tell students they will use a computer simulation to better understand the complex problem of shrinking salmon and to weigh and consider possible solutions. Discuss the four environmental variables that students will examine to determine their effect on salmon body size: 1) ocean warming, 2) competition in the ocean, 3) stream water quality, and 4) stream water depth.
2. Display "Getting Started with the Salmon Simulation," to orient students to the simulation before they begin exploring it. Help the class read and interpret the graphs.
3. Have students work through Part A of the simulation in pairs. Encourage students to change one variable at a time, recording their results in Part A of the Data Collection Sheet. Let students know they should reset the simulation each time. They will collect data on i) the total biomass of 1,000 randomly sampled salmon, and ii) size class distribution for the 1,000 randomly sampled salmon
4. Have a class discussion on students' findings from Part A. Students may be surprised that stream water quality had no effect in this part of the simulation. This finding will be further explored in Part B.
5. Direct students to Part B of the simulation, where they examine the entire salmon population and consider an additional environmental variable: *population size*. Encourage students to change one variable at a time and record their results in Part B of the Data Collection Sheet.
6. Have students answer the questions in Step 4 individually, and then facilitate a class discussion. Students should realize that in Part A, stream water quality does not affect evolution of body size in salmon, but it does have an ecological effect—reduced population size.
7. Direct students to Part C, where they will propose solutions to the shrinking salmon problem. Encourage students to work through solutions one at a time at first, changing the percentage improvement for each environmental variable. They should record their results in Part C of the Data Collection Sheet.
8. Encourage students to begin combining solutions to develop their best solution.
9. Have students respond to Step 5 individually. Then facilitate a class discussion around the feasibility and cost of different solutions. An optional Extension to this activity would be for students to explore some of these strategies currently being used or proposed.

Chinook Salmon System Model



GETTING STARTED WITH THE SALMON SIMULATION





CT-S Framework (From Alan, Hurt, and Greenwald, LHS)

<table>
<tr><td colspan="2" rowspan="3">CT-S</td><td colspan="3">Cognitive Processes</td></tr>
<tr><td>Reflective Use</td><td>Design</td><td>Evaluation</td></tr>
<tr><td colspan="3">of a computational tool for</td></tr>
<tr><td rowspan="4">Science Activity</td><td>Data Collection</td><td></td><td></td><td></td></tr>
<tr><td>Data Processing</td><td></td><td></td><td></td></tr>
<tr><td>Modeling</td><td></td><td></td><td></td></tr>
<tr><td>Problem-Solving</td><td></td><td></td><td></td></tr>
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Examples:

Reflective Use with **Data Collection**:
How can I use the time-lapse photography feature on my phone to collect data on how fast my plants grow?

Design with **Data Processing**:
I have images that show the sun's height above the horizon from every day of the year from a given location taken at solar noon, what would I need software to do to help me find patterns related to seasonal changes?

Evaluation with Modeling
Which aspects of this digital model accurately reflect natural selection, and which do not?