Bring Salmon Back Up the River

"Coho Spawning on the Salmon River" by Bureau of Land Management Oregon and Washington is licensed under CC BY 2.0.

Math Content:
- Algebra

Possible Content Standards:
- HSF-IF.C: Analyze functions using different representations
- HSF-LE.A: Write a function defined by an expression in different but equivalent forms to reveal and explain the properties of the function
- HSF-BF.A: Write a function that describes a relationship between two quantities
- HSF-LE.A: Construct and compare linear, quadratic, and exponential models and solve problems

Mathematical Practices Focus:
- SMP1 - Make sense of problems and persevere in solving them.
- SMP3 - Construct viable arguments and critique the reasoning of others.
- SMP4 - Model with mathematics.

Overview

The purpose of this 3 ACT task is to provide students with an opportunity to problem-solve based on a real-world situation (Claims 2 and 4). Due to the nature of the task, there are a variety of mathematical approaches students can take to successfully complete the task, however, the mathematical approach presented in Act 3 of the task addresses CCSS.MATH.CONTENT.HSF-LE.B.5 (Interpret the parameters in a linear or exponential function in terms of context). This performance task is intended for students with prior knowledge of geometric sequences or graphs of exponential growth, table and graph creation, and pattern recognition. It is important to note that the data presented in this task is being thought of as having a consistent growth rate for student modeling, and this should be considered by students when deciding on their problem-solving approach.

The task is modeled after the task 3 ACT Fill 'Er Up by Graham Fletcher. In the task, students are presented a scenario faced by Washington State fisheries: determining the future salmon populations of rivers. Students must make a determination of how well repopulation will progress. Students must then decide what information is important and determine the necessary resources for finding the solution and are given time as a group to complete their work. The task concludes by having students examine the information provided in Act 3 to see if it answers their questions.

Possible *Since Time Immemorial: Tribal Sovereignty in Washington State* Connections and/or Extensions

- Native Knowledge 360° – PNW Inquiries – Grades 9-12
  - Why Do the Foods We Eat Matter?
    - Standard Connections
  - The Fish Wars: What Kinds of Action Can Lead to Justice?
    - Standard Connections

Content Focus:
- HS Algebra

Possible Content Standards:
- HSF-IF.C: Analyze functions using different representations
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Mathematical Practices Focus:
- SMP1 - Make sense of problems and persevere in solving them.
- SMP3 - Construct viable arguments and critique the reasoning of others.
- SMP4 - Model with mathematics.

Smarter-Balanced Assessment (SBA) Targets Addressed:
- Claim 2 Target A: Apply mathematics to solve problems arising in everyday life, society, and the workplace.
- Claim 2 Target D: Identify important quantities in a practical situation and map their relationship (e.g., using diagrams, two-way tables, graphs, flow charts, or formulas).
- Claim 4 Target D: Interpret results in the context of a situation.

Overview of task with specified standard addressed

The mathematical approach presented in Act 3 of the task addresses CCSS.MATH.CONTENT.HSF-IF.C.7.E (Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude), CCSS.MATH.CONTENT.HSF-IF.C.8.B (Use the properties of exponents to interpret expressions for exponential functions), CCSS.MATH.CONTENT.HSF-BF.A.1.A (Determine an explicit expression, a recursive process, or steps for calculation from a context), CCSS.MATH.CONTENT.HSF-LE.A.1.C (Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another), and CCSS.MATH.CONTENT.HSF-LE.B.5 (Interpret the parameters in a linear or exponential function in terms of context).

Note that there is a strong possible extension with Washington State mandated Since Time Immemorial: Tribal Sovereignty in Washington State standards. Since tribal communities have relied on salmon and salmon fishing to sustain their communities and there is a deep history with how overfishing, dams, and pollution have affected tribal traditions, consider utilizing this opportunity to integrate Since Time Immemorial resources into your class.

Learning Goal Statement

- Students will solve a range of complex well-posed problems in applied mathematics (SMP1)
- Students will solve a complex problem by making productive use of knowledge and problem-solving strategies (SMP2)
- Students will analyze complex, real-world scenarios (SMP4)

Success Criteria

- I can apply concepts to solve a problem about salmon population growth to make predictions.
- I can build a function that models a relationship between two quantities.
- I can make predictions and justify them mathematically.

Step By Step:

1. Materials

- Recording sheet, scratch paper, whiteboards, whiteboard markers, calculators, graph paper, and math journal (if applicable) for each group
- Technology to show videos/PowerPoint
- Technology for students to use an online graphing program or graphing calculators
- Student worksheet or notebooks
- Manipulatives (optional)

2. Pre-Planning

- Students will be identifying and solving their own student-generated problems based on the context provided by a hypothetical scenario, and information about salmon population growth.
- Additional information is available to students as they come up with questions through the PowerPoint slides. You may choose to keep it in the PowerPoint format, print each question/answer on cards, or some other method. It is recommended that you do not reveal the questions/answers unless students are asking. You can also choose to reveal the answers to specific groups as requested or to the entire class.
- This lesson will include a productive discussion that will open opportunities for multiple possible questions and math concepts. Students may need scaffolded support or routines for productive discussions.
- Prepare access to materials such as scratch paper, math manipulatives, and other materials as you see fit for use as needed throughout the task.

3. Act 1: Introduction

- Display the “Learning Goals and Success Criteria” slide from Bringing Salmon Back. Have a volunteer read the learning goals aloud. Use the Think-Pair-Share strategy to have students respond to the prompt: “What connections or questions come to mind in relation to these learning goals?”
- Repeat the activity with the success criteria.
- Display “Career Profile: Cole Baldino” OR read PEI’s Career Profile Card for “Cole Baldino.” <<https://pacificeducationinstitute.org/wp-content/uploads/2020/04/Salmon-Habitat-Restoration-Manager-Cole-Baldino-Career-Profile.pdf>>
- Ask students to Think-Pair-Share to answer the following questions: “What does Cole Baldino do?” “Why are salmon important?” Elicit student ideas.
    - *Talk to students about the following: Salmon are important to the health of our rivers. If salmon are in the rivers, it is cool and not polluted. Salmon helps plants grow near rivers and feed many animals, including people. Without salmon, the ecosystem of rivers and land near rivers struggles.*
- Display the slide, “What do you notice about this data?” Ask students to make observations about the graph. Ask students what they wonder about the data represented here.
    - *Look for students to describe trends or patterns they are noticing. Talk to students about the decreasing salmon population.*
- Display the slide, “What do you notice about this image?” Ask students to make observations about the chart. Ask students what type of salmon Baldino might be most concerned about. Ask students what they wonder about the salmon population.
    - *Talk to students about the Chinook Salmon. While the fall Snake River Chinook salmon are doing great, the spring and summer Chinook salmon are in crisis.*

- Display "The Scenario" slide. Ask students, "What math questions can we ask using the information from the previous slides?" Record student ideas in a public place.
- Display the "Salmon Basics" slide and revise the student-generated questions list.
- Allow time for students to come to a consensus about one question generated from the group ideas. You may want each group to explore their own question, or you could have a consensus question for the entire class. Instruct students to analyze the question generated to determine what information is needed in order to answer the generated questions.
- Display "The hatchery wants the salmon population to recover" slide. Instruct students to record their final question on their **Group Recording Sheet**.
    - Consensus Question: What is your prediction for how long it will take for the 700 Chinook salmon to return to the release spot independently to spawn? How can the growth be modeled so more predictions can be made? Be prepared to explain your reasoning.
- Have groups share questions with the class and discuss as whole group ideas about what information is needed to answer the group's chosen question. Make connections to groups who have posed similar questions.
- Display the slide titled "Nature is Not Predictable." Reinforce that in scientific research, restrictions are necessary to make mathematical models. Students are welcome to answer these questions but are encouraged to pursue their own generated questions as long as the questions stay connected to the facts provided.
    - What strategies can you use to model the data?
    - How many salmon will return each year?
    - What losses of salmon life are important to consider?
    - Are there any restrictions you need to consider to create a model?
    - How do you justify any restrictions you make?
    - How often are salmon totals taken?
    - What variables are districting to model the situation?
    - Can you describe the pattern of salmon growth using math vocabulary?
- Prompt students to generate predictions for answers to the questions and post the responses in a place visible to the class. Estimations can be qualitative or quantitative.

4. Act 2: Conflict

- Display the "What might help you answer this question?" slide. Ask students, "Do you have everything you need to solve your problem?" Give students time to create a list of materials they will need or questions they have.
    - Take a moment to brainstorm algebraic problem-solving strategies as a class. A general list is included in the **Information Card**. The goal is to prepare students to access the problem.
    - Pass out the information cards to each group. Show how the **Information Card** provides the information from the scenario as well as reminders of algebraic problem-solving strategies.
- Let students know that you have answers to commonly asked questions in the slide deck.
    - Teacher note: How to give students the additional information is completely up to you. You could have the information printed on cards, you could reveal the answers ONLY when students ask the question, you could give students access to the slides…Think about the strategies you are trying to help your students learn. By giving them the opportunity to ask their own questions, you are helping students experience the process of mathematical problem solving.
- *Optional* Display the slide, "Remember to talk about your ideas!" to provide all students with discussion starters to use while working.
- Students can use the **Group Recording Sheet**, math notebooks, graph paper, whiteboard, Desmos, graphing calculators, scientific calculators, or manipulatives to organize and make sense of the data.

- Instruct student groups to record their thinking and math work on the **Group Recording Sheet** with other materials as needed. Inform students that this work will be collected as evidence of learning. Consider using technology such as Flip or PDF creators to record student explanations.
- Monitor students and ask questions to promote thinking. Avoid giving students answers.
  - How are you going to model all options? What benefit would only looking at 2 fish returning a year give you? What would only looking at 2 fish returning a year not tell you? What modeling strategies have you tried? What prevented you from making progress?
  - *Teacher move: "What types of questions might scientists ask?"*
    1. *How many years would it take to reach 700 returning salmon if only 2 salmon returned each year? If 5 returned each year?*
    2. *If some years more salmon return to spawn than others, what would an average number of salmon returning from a clutch of eggs look like? How would you choose that number?*
- As students are working, be sure to ask questions about their thinking. Take note of different strategies students are using. Use those notes to create new questions for other groups who are struggling to guide learning or groups using different strategies to help build connections across methodologies.
  - Look for students who do not connect the data points. They are showing an understanding of discrete data collection (the salmon population measurements are not continuous).
- Choose at least three (3) students or groups to share their strategies with the class during Act 3. Make sure the strategies demonstrate math learning that aligns with learning goals.
  - *Teacher moves: select students and student groups that represent a transition from concrete to abstract representations to help all students build that same understanding. For example, students who drew pictures to figure out the totals each year are using a very concrete model. Students who drew graphs are less concrete. Students who generated equations are using abstract modeling.*
- When students or student groups agree on an answer, instruct groups to answer their questions on their group recording sheets.
- Remind students of access to sentence frames on the **Information Card** for complete responses.
- Students can work with a partner to answer the questions using sentence stems.

5. Act 3: Resolution

- Allow at least three (3) students to share their groups' answers with a complete description of how they completed the task. Remind students of access to discussion frames for complete responses.
  - Teacher moves: pay attention to the solutions created by student groups. Select groups to present their solutions to the class and sequence the groups so they present from most concrete ("least sophisticated") to most abstract ("most sophisticated") solution methods. For example, students who drew pictures to figure out the totals each year are using a very concrete model. Students who drew graphs are less concrete. Students who generated equations are using abstract modeling.
- Ask questions that allow students to make connections between the different answer statements to the learning goal. "How were the approaches similar/different?" "Were the restriction choices appropriate for the lesson? How does that model what scientists have to do in the field?" "How would the previous groups' work look using the new groups' model?"
- Display the first "Resolution(s)" slide. This slide provides a formula and table for the slowest and fastest growth rates of the salmon population. It also provides a graph of all growth rates of the salmon population.
  - Student responses may differ from what is provided. For example, a student may take the average population growth rate of 3.5 to calculate the salmon population. Students can verify their predictions result in a number of years between the graph of 3 and 4 salmon returning each year.

- If students had similar questions, have students work together to determine possible reasons for any differences between the answers. If a group's questions were different, have students determine strategies for how the presented solution could have been used to support students in finding the answer to the problem.
- Have students reflect on which answer(s) would be most useful for a scientist.
    - *Talk about how knowing a range of the lowest and highest possible number of years to reach a spawning return of 700 salmon based on the lowest and highest growth rates is realistic.*
- Ask students to rate their learning of the learning goals 0-10, with a score of "0" representing that you made no connections to the learning goals, and "10" representing that you could teach this content.
- Have students record what they learned on their worksheet and turn it in.

Additional Information (from the slide deck):

1. **Question: How will the salmon know where to return? How many eggs do they lay in a year?**
   Answer(s):
    - A salmon will spawn only 1 time.
    - The journey to spawn is so difficult that only a few salmon make it every year.
    - Salmon lay 4,000 to 10,000 eggs (clutch) a year.
    - Each year only 2-5 salmon from a single clutch will return to spawn on their own. It is almost spawning season.

2. **Question: How will the salmon know where to return?**
   Answer(s):
    - The hatchery and school can add more salmon each year. The salmon added won't have a clutch of eggs for 2-4 years.
    - The hatchery and schools can contribute salmon from 1 clutch of eggs per year.

3. ***Question: What causes less salmon to return in a year?**
   Answer(s):
    - Dirty rivers, dams, loss of forests, and overfishing can hurt the salmon from being able to return.
    - This video gives a glimpse into the effect of dams and overfishing (~4 mins).

    Video: Tribal Fishing Tradition Runs Deep by EarthFix Media <<https://youtu.be/yEKF8e0ndRU>>

4. **Question: Is there something that can help more Salmon return each year?**
   Answer(s):
    - Salmon need clean, clear water, a variety of hiding spots in the water to lay their eggs, and a connected path to other bodies of water.
    - This video shows how trees actually make an area better for salmon to lay eggs in (~6 mins).

    Video: Southern Resident Killer Whales Conservation by One Tree Planted (start at 5:43) <<https://youtu.be/E7aZQ6o9-T4?t=343>>

5. **Question: Will the number of salmon that return be the same each year?**
   Answer(s):
    - No. Scientists often estimate the number of salmon that return each year using an average or by giving a range.

6. **Question: What would the total number of salmon look like if only 2 returned from each clutch to spawn each year? 3? 4? 5?**
   Answer(s):
    - 2 salmon return to spawn from each clutch each year after the first year: 2, 4, 8

- 3 salmon return to spawn from each clutch each year after the first year: 2, 6, 18
- 4 salmon return to spawn from each clutch each year after the first year: 2, 8, 32
- 5 salmon return to spawn from each clutch each year after the first year; 2, 10, 50

7. Why are salmon important to have in Washington Rivers?

Answers(s):

- They help build resilient fisheries.
- They expand recreational opportunities.
- They support communities.
- This video shows how salmon bring a better life to Eastern Washington.

Video: Salmon Bring a Better Life to Eastern Washington from NOAA Fisheries (~6 mins). <<https://videos.fisheries.noaa.gov/detail/videos/fish/video/2397257442001/salmon-bring-a-better-life-to-eastern-washington?autoStart=true>>

Resolution(s)

This graph compares all possible growth rates given the 2 starting spring/summer Chinook salmon.

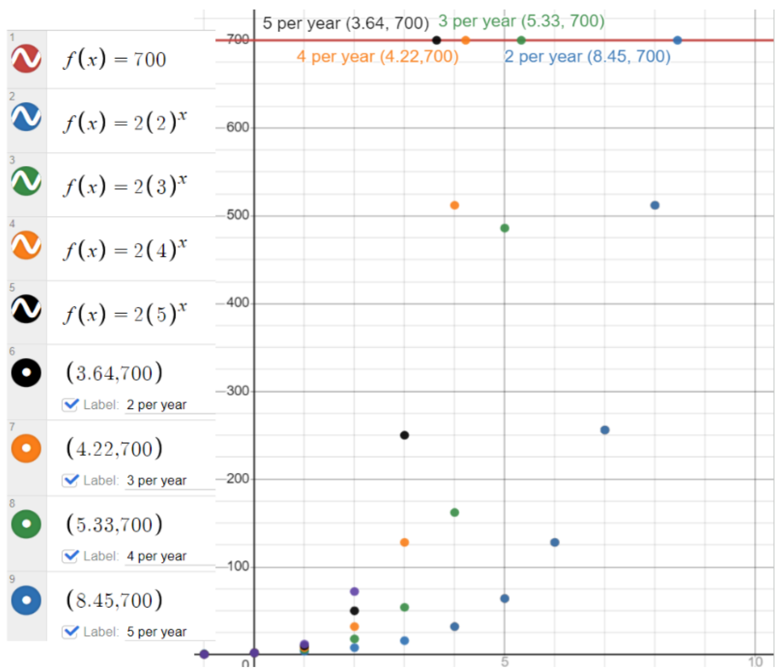
The general exponential growth formula is $f(x) = a\,(b)^x$

a: the starting number of salmon (2)

b: the number of salmon returning each year (assuming it is constant)

x: the number of years since the first fish returned.

The points are not connected because it is a discrete function, not continuous! Data is only measured once a year. We model with an exponential curve.



6. Extensions (optional)

- There are optional math extension activities presented in the slide deck on slides 25-31.

* Question #3 (above) lends itself to integration with the Since Time Immemorial: Tribal Sovereignty in Washington State standards. Several resources are available through the OSPI webpage. The following are suggested for use:

Native Knowledge 360° – PNW Inquiries – Grades 9-12

- Why Do the Foods We Eat Matter?
  - Standard Connections
- The Fish Wars: What Kinds of Action Can Lead to Justice?
  - Standard Connections

Accessibility Strategies Used

- Scratch paper or white boards: Students can use blank paper to record thinking, complete calculations, create diagrams, etc.
- Manipulatives: Students can use any math manipulatives to support their problem-solving.
- Small group collaborative work: Students work with peers to process their thinking, supporting each other. Intentional grouping may offer additional accessibility, though it is not necessary to complete the task.
- Video and infographic information.

Things to Consider

- The lesson can take different turns depending on the questions generated. Use this as an opportunity to reteach or extend different math concepts.
- There is an opportunity for differentiation with the intentional grouping of students by skill level, however, this is not essential for students to meet the learning targets.
- The lesson can be split into two days where students create and find solutions to their questions on the first day and share their responses and discuss solutions on the second day.
- This task can be used as a math classroom tool in several ways:
    - as a formative assessment pre- or post-instruction;
    - as an opportunity to practice new skills;
    - as practice for state tests;
    - to help make connections to math in the world outside the classroom.

Formative Assessment Process

- Clarify learning targets throughout the lesson. This is specifically done at the beginning and end but is helpful at any point to further students' learning.
- Evidence of student learning is found in multiple areas of the lesson. The Group Recording Sheet and individual responses are concrete options. Teacher observations, student questions, and student discussions provide additional evidence of students meeting learning targets.
- Use observations of student thinking and other evidence as an opportunity for purposeful discussions around the math concepts. These can be opportunities to reteach or extend the learning of math concepts.
- Feedback based on evidence of student learning should be provided to students throughout the lesson. This can happen as the teacher circulates the room, during the class discussion, or on group or individual response sheets.

Strategies Used

- 3 ACT Task
    - This is a whole-group task made up of 3 parts: Act 1 is an engaging situation that piques students' curiosity, Act 2 is where students seek information and work towards a solution, Act 3 finishes the task by discussing solutions and tying the work back to the learning targets.
- Think-Pair-Share
    - With this strategy, students are given the opportunity to examine a prompt as an individual, then with a partner or small group, and finally share and listen to responses among the whole class.
- Notice/Wonder
    - This strategy allows students to unpack a problem or prompt before beginning to solve the problem or respond to the prompt. The purpose is to create a common experience and provide

access for all students in an environment where students share their thoughts freely because there is no expectation to find the answer.

- Find out more about the Notice and Wonder strategy on the OER Commons: https://www.oercommons.org/courseware/lesson/79074/overview?section=1

Extensions and Connections learned from teacher implementation

- The challenge in the task is to apply what students know to a rich, in-context problem. While the mathematics they may use to solve the problem addresses earlier standards, the modeling of the problem brings up the complexity and difficulty for students, especially since there is not a single right answer.
- **Lesson Extension Option: Determining Maintainability**
  - Act 1: Hundreds of thousands of salmon use to run the rivers of Washington each year. 700 salmon returning a year is not a sign of sustainability. How long will it take to reach 500,000 salmon returning each year?
  - Act 2: Each clutch of eggs will result in 2 to 5 salmon returning to spawn. We know the salmon project started with 2 salmon returning to spawn on their own. Assume that no more fish will be introduced from the hatchery after the population reaches 700 independent returning.
    - Exponential growth: $f(x) = a\,(b)^x$
  - Act 3: Assuming nothing bad happens to affect the salmon population growth, the salmon will be at 500,000 returning to spawn in 8 to 18 years.
    - This activity allows for the option of students exploring predictions with tables and graphs as well as using Desmos to explore logarithmic functions (which are inverse relations to exponential functions).

Extension Activity: Determining Maintainability Act 3

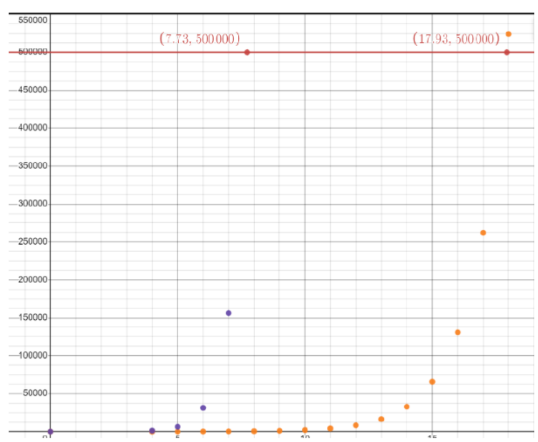
<u>Minimum growth rate:</u> 18 years

$b(x) = 2(2)^x$
$500{,}000 = 2(2)^x$
$17.93 = x$

<u>Maximum growth rate:</u> 8 years

$b(x) = 2(5)^x$
$500{,}000 = 2(5)^x$
$7.73 = x$

x	$b(x)$	$p(x)$
0	2	2
4	32	1250
5	64	6250
6	128	31250
7	256	156250
8	512	781250
9	1024	3.90625×10^6
10	2048	1.953125×10^7
11	4096	9.765625×10^7
12	8192	4.882813×10^8
13	16384	2.441406×10^9
14	32768	1.220703×10^{10}
15	65536	6.103516×10^{10}
16	131072	3.051758×10^{11}
17	262144	1.525879×10^{12}
18	524288	7.629395×10^{12}



- **Lesson Extension Option: Determining Population Rate**
  - Act 1: In the late 1800s, the Yakima River Basin saw salmon runs between 500,000 and 1 million each year. 100 years later, Coho, Sockeye and Summer Chinook salmon were gone. The Yakama Nation fought hard to bring salmon back. In 2009 the Yakama Nation introduced spring/summer Chinook salmon to the Yakima River Basin.
  - Act 2: How fast did the salmon repopulate? Assume that 2 salmon returned to spawn the first year. What was the growth rate if 50,000 Summer Chinook salmon returned in 2014?

- Act 3: Population rate formula: $\left(\frac{50000}{2}\right)^{\frac{1}{2014-2009}} = 7.578582.$
  - Why is this so much higher than the average? A lot of people worked together to remove barriers for the salmon including the removal of dams, planting trees along rivers, cleaning up rivers, and creating new paths for younger salmon to travel.

Samples of Student Work

Coming soon.

Formative Assessment Rubric

Rubric Component	Point Scale			Student Score and Rationale
	3	2	1	
I can make a claim and justify it with mathematics for a prediction about salmon population growth.	Uses models, symbols, and/or technology to represent and explain the solution. The group can explain the appropriateness of the model and any restrictions used as related to the scenario.	Uses models, symbols, and/or technology to represent and explain the solution. The group cannot explain the appropriateness of the model or the restrictions used as related to the scenario.	The prediction is not clearly described or the mathematics are missing or do not support the claim.	
I can build a function that models a relationship between two quantities.	Creates accurate functions or models that are used to find solutions. Uses the model to explain the relationship between quantities and interpret the meaning and can explain why other models were not included.	Creates accurate functions or models that are used to find solutions. Can use the model to explain the relationship between quantities and interpret meaning OR can explain why other models were not included.	Unable to create a function and/or correctly model function to show the relationship between two quantities OR only an individual can explain the relationship between quantities.	
I can collaborate with others to model the population growth of salmon.	Respectful of others' ideas; actively include all members of the group; use talk moves and conversation strategies. Contributes to the solution process	Respectful of others' ideas; but doesn't actively include all members of the group; or doesn't use talk moves and conversation strategies.	Disrespectful of others' ideas or actively discouraging group members from participating.	
Extension Problem: Students apply algebra concepts to solve a problem.	Can explain the process used to solve for the input variable and reasons for restrictions given the situation.	Can model or solve the problem but cannot explain the reason for restrictions or cannot explain the process used.	Cannot model or solve the problem.	

Presentation Materials - PowerPoint Slides

Bringing Salmon Back

3 ACT Math Task
Algebra

1

Learning Goals

- Students will solve a range of complex well-posed problems in applied mathematics (SMP1)
- Students will solve a complex problem by making productive use of knowledge and problem-solving strategies (SMP2)
- Students will analyze complex, real-world scenarios (SMP4)

Success Criteria

- I can apply concepts to solve a problem about salmon population growth to make predictions.
- I can build a function that models a relationship between two quantities.
- I can make predictions and justify them mathematically.

2

Career Profile: Cole Baldino

Salmon Habitat Restoration Manager
A typical day of work is usually split between the field and office. We walk a stream, take samples, and perform assessments to get a baseline understanding of the watershed conditions. Then we plan and prepare for restoration projects. This includes preparing designs, fundraising, and permitting.

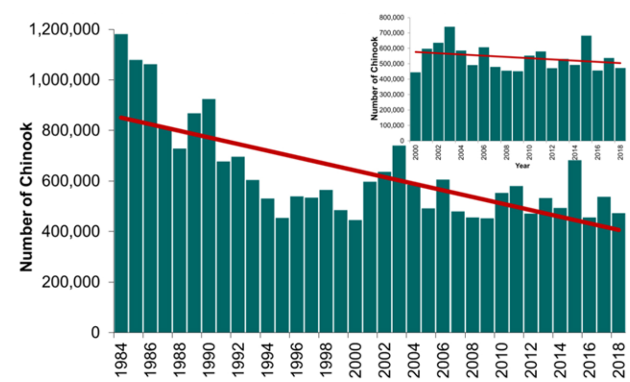
Learn more about Baldino and his work with the Pacific Education Institute Career Profile Card.

3

What do you notice about this data?

What do you wonder?

Scientists use charts like this to find patterns in data.



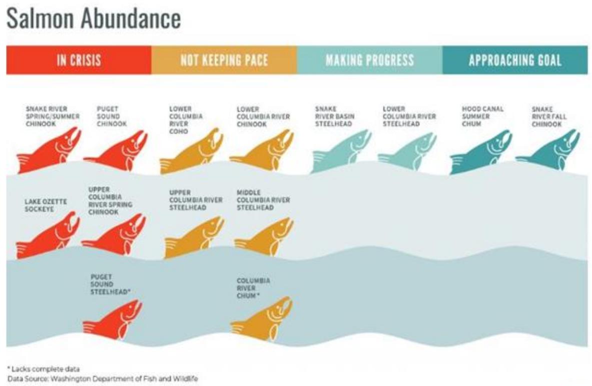
*Abundance is the number of Chinook caught and the number of chinook returning to Salish Sea rivers

Data source: Pacific Salmon Commission, 2019

4

What do you notice about this image?

What do you wonder?



A graphic organizer like this helps display information quickly, making it easier to determine how effective a strategy is and where a strategy is not working well.

5

The Scenario:

A fish hatchery is trying to bring Chinook salmon back to the Snake River in the spring/summer. They have been releasing salmon for several years now at the same spot.

The first salmon to return to the release spot on the river arrived today. There were 2 spring/summer Chinook Salmon.

6

Salmon Basics

There need to be at least 700 salmon returning on their own to know that the rehabilitation efforts are working.

Without counting each individual fish, how could scientists know they are on the right track to salmon recovery?

7

8

Nature is not predictable

There are a lot of unknowns when it comes to making predictions about the salmon population.

As you work through your solution consider:

- ★ What strategies can you use to model the data?
- ★ How many salmon will return each year?
- ★ What losses of salmon life are important to consider?
- ★ Are there any restrictions you need to consider to create a model?
- ★ How do you justify any restrictions you make?
- ★ How often are salmon totals taken?
- ★ What variables are districting to model the situation?
- ★ Can you describe the pattern of salmon growth using math vocabulary?

9

What might help you answer this question?

- Important numbers?
- Formulas?
- Paper?
- Other resources?

BRAINSTORM!

What algebraic problem-solving strategies do you know?

10

Remember to talk about your ideas!

- This reminds me of ____ from class.
- I think ___ because ____.
- I learned that ____.
- I agree because ___.
- We know ___ because ____.
- Since ____, then we can calculate ___.
- I respectfully disagree because ____.
- I can see connections between _____ and _____ because ____.
- So what I think ____ is saying is that ___. Is that correct ____?

11

What other information do you need?

How many times will a Salmon spawn? How many eggs do they lay?	How will the salmon know where to return?	What causes less salmon to return in a year?	Is there something that would make more salmon return in a year?
Will it always be the same number of salmon that return each year?	What would the total number of salmon look like if only 2 spawned each year? 3? 4? 5?	Why are salmon important to have in Washington Rivers?	Click on the question to collect additional information.

12

How will the salmon know where to return?
How many eggs do they lay in a year?

A salmon will spawn only 1 time. The journey to spawn is so difficult that only a few salmon make it every year.

Salmon lay 4,000 to 10,000 eggs (clutch) a year.

Each year only 2-5 salmon from a single clutch will return to spawn on their own. It is almost spawning season.

13

How will the salmon know where to return?

The hatchery and school can add more salmon each year. The salmon added won't have a clutch of eggs for 2-4 years.

The hatchery and schools can contribute salmon from 1 clutch of eggs per year.

14

What causes less salmon to return in a year?

Dirty rivers, dams, loss of forests, and overfishing can hurt the salmon from being able to return.

This video gives a glimpse into the effect that dams and overfishing have had on traditional tribal fishing.

15

Is there something that can help more Salmon return each year?

Salmon need clean, clear water, a variety of hiding spots in the water to lay their eggs, and a connected path to the other bodies of water.

This video shows how trees actually make an area better for salmon to lay eggs in.

16

Will the number of salmon that return be the same each year?

No. Scientists often estimate the number of salmon that return each year using an average or by giving a range.

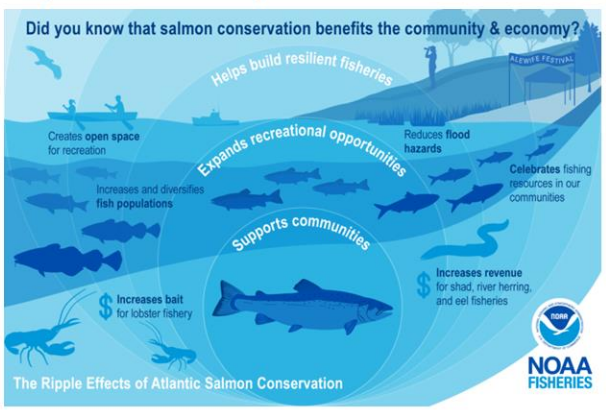
17

What would the total number of salmon look like if only 2 returned to spawn each year after the first year? 3? 4? 5?

Number of fish returning each year	2	3	4	5
Year 1	2	2	2	2
Year 2	4	6	8	10
Year 3	8	27	32	50

18

Why are salmon important to have in Washington Rivers?



Salmon are a keystone species!

Salmon Bring a Better Life to Eastern Washington (video)

19

Resolution(s)

This graph compares all possible growth rates given the 2 starting spring/summer Chinook salmon.

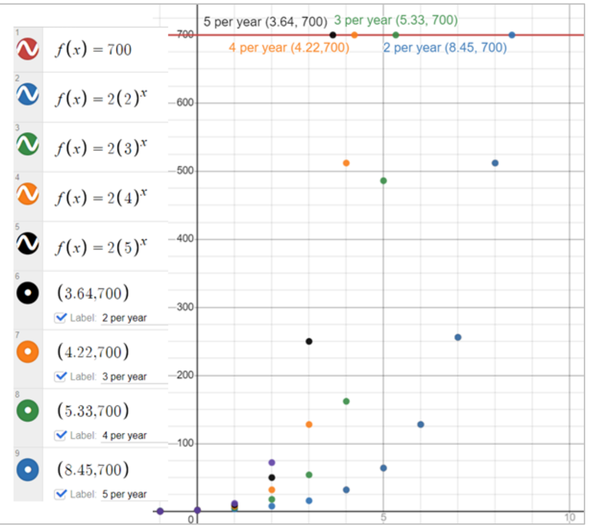
The general exponential growth formula is f(x) = a (b)^x

a: the starting number of salmon (2)

b: the number of salmon returning each year (assuming it is constant)

x: the number of years since the first fish returned.

The points are not connected because it is a discrete function, not continuous! Data is only measured once a year. We model with an exponential curve.



20

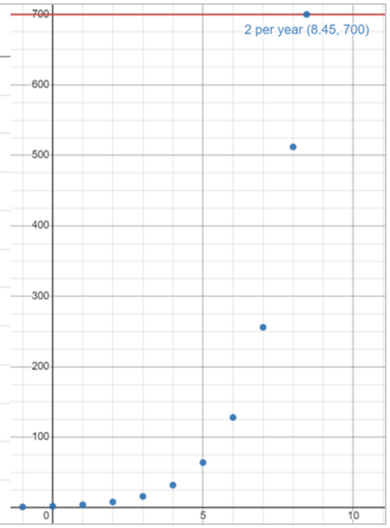
Resolution

Assuming 2 return each year, it will take 9 years to see 700 salmon return independently.

$f(x) = 2(2)^x$
$700 = 2(2)^x$
8.45 years = x

This estimate could be justified as taking into account the longest period of time in case anything goes wrong.

x	$f(x)$
−2	0.5
−1	1
0	2
1	4
2	8
3	16
4	32
5	64
6	128
7	256
8	512
9	1024



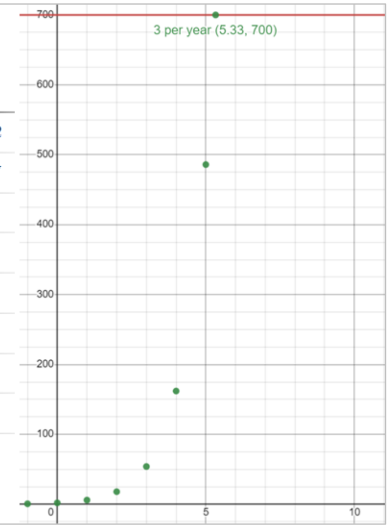
21

Resolution

Assuming 3 return each year, it will take 6 years to see 700 salmon return independently.

$f(x) = 2(3)^x$
$700 = 2(3)^x$
5.33 years = x

x	$g(x)$
−2	0.22222222
−1	0.66666667
0	2
1	6
2	18
3	54
4	162
5	486
6	1458



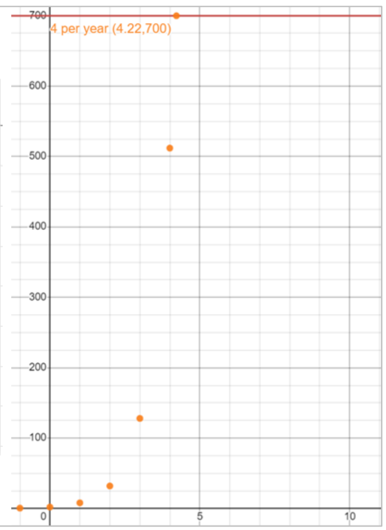
22

Resolution

Assuming 4 return each year, it will take 5 years to see 700 salmon return independently.

$f(x) = 2(4)^x$
$700 = 2(4)^x$
4.22 years = x

x	$h(x)$
−2	0.125
−1	0.5
0	2
1	8
2	32
3	128
4	512
5	2048



23

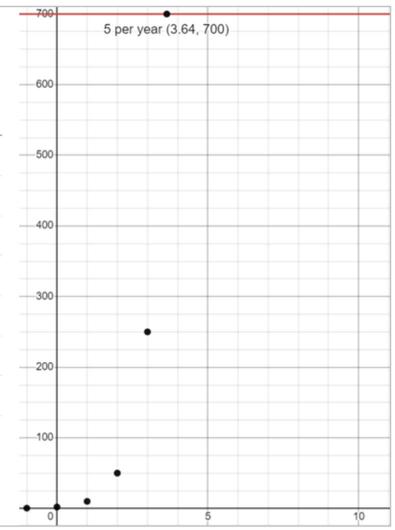
Resolution

Assuming 5 return each year, it will take 5 years to see 700 salmon return independently.

$f(x) = 2(5)^x$
$700 = 2(5)^x$
3.64 years = x

This scenario can be justified as the fastest the salmon will reach 700 returning independently. Might include support for continued hatchery & school help.

x	$i(x)$
−2	0.08
−1	0.4
0	2
1	10
2	50
3	250
4	1250



24

Extension Activity: Determining Maintainability Act 1

How long will it take to reach 500,000 salmon returning each year?

Hundreds of thousands of salmon use to run the rivers of Washington each year.

700 salmon returning a year is not a sign of sustainability.

25

Extension Activity: Determining Maintainability Act 2

How long will it take to reach 500,000 salmon returning each year?

Exponential growth: $f(x) = a (b)^x$

Each clutch of eggs will result in 2 to 5 salmon returning to spawn.

We know the salmon project started with 2 salmon returning on their own to spawn.

Assume that no more fish will be introduced from the hatchery or after the population reaches 700 independently returning.

26

Extension Activity: Determining Maintainability Act 3

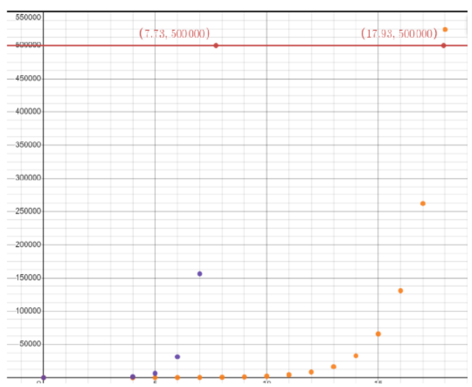
Minimum growth rate: 18 years

$b(x) = 2(2)^x$
$500{,}000 = 2(2)^x$
$17.93 = x$

Maximum growth rate: 8 years

$b(x) = 2(5)^x$
$500{,}000 = 2(5)^x$
$7.73 = x$

x	$b(x)$	$p(x)$
0	2	2
4	32	1250
5	64	6250
6	128	31250
7	256	156250
8	512	781250
9	1024	3.90625×10^6
10	2048	1.953125×10^7
11	4096	9.765625×10^7
12	8192	4.882813×10^8
13	16384	2.441406×10^9
14	32768	1.220703×10^{10}
15	65536	6.103516×10^{10}
16	131072	3.051758×10^{11}
17	262144	1.525879×10^{12}
18	524288	7.629395×10^{12}



27

Extension Activity: Determining Population Rate Act 1

In the late 1800s, the Yakima River Basin saw salmon runs between 500,000 and 1 million each year.

100 years later, Coho, Sockeye, and summer Chinook salmon were gone.

The Yakama Nation fought hard to bring salmon back.

In 2009 the Yakama Nation introduced spring/summer Chinook salmon to the Yakima River Basin.

(https://ybfwrb.org/wp-content/uploads/2020/07/YBFWRB-2018-Press-Kit.pdf)

28

Extension Activity: Determining Population Rate Act 2

How fast did the salmon repopulate?

Assume that 2 salmon returned to spawn the first year.

What was the growth rate if 50,000 Summer Chinook salmon returned in 2014?

29

Extension Activity: Determining Population Rate Act 3

Population rate formula:

$$\left(\frac{50\,000}{2}\right)^{\frac{1}{2014-2009}} = 7.57858283255$$

Why is this so much higher than average?

A lot of people worked together to remove barriers for the salmon including

- The removal of dams
- Planting trees along rivers
- Cleaning up rivers
- Creating new paths for younger salmon to travel.

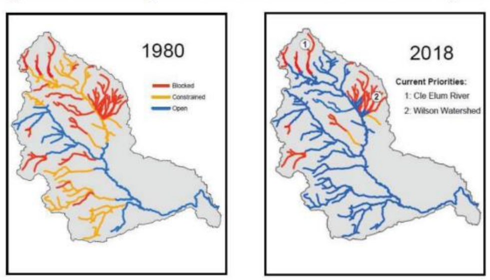
30

Extension Activity: Determining Population Rate Act 3

Check out some of the details from the Yakima Basin Fish and Wildlife Recovery Board.

You can also visit their website.

Progress Removing Barriers to Adult Steelhead Migration



YAKIMA BASIN FISH AND WILDLIFE RECOVERY BOARD

31

Group Recording Sheet (One per student)

Name: ___________________________ Group: ____________________ Date: _______________

Notice	Wonder

1. Group Question

2. Prediction
   a. How many salmon will spawn each year? _______

   Reasoning:

   b. If the rate of change is constant, how many salmon will there be in year 6?

   Show work:

   c. What strategies can you try to model the situation?

3. Materials List:

4. Solution Thinking:

5. Final Answer:

6. Self Reflection:

Information Card (One Per Group)

Scenario:

The hatchery needs to know how long it should take for 700 salmon to return on their own to spawn.

What is your prediction for how long it will take for 700 Chinook Salmon to return to the release spot independently to respawn?

How can the growth be modeled so more predictions can be made?

Be prepared to explain your reasoning.

Algebraic problem-solving strategies:

- ➔ Make a list or table
- ➔ Draw a picture
- ➔ Construct a graph
- ➔ Write an equation
- ➔ Act it out
- ➔ Use logical reasoning
- ➔ Solve part of the problem
- ➔ Work backwards
- ➔ Make a list

Online tools to support thinking:

- www.desmos.com/graphing
- www.geogebra.com

Sentence stems for discussion:

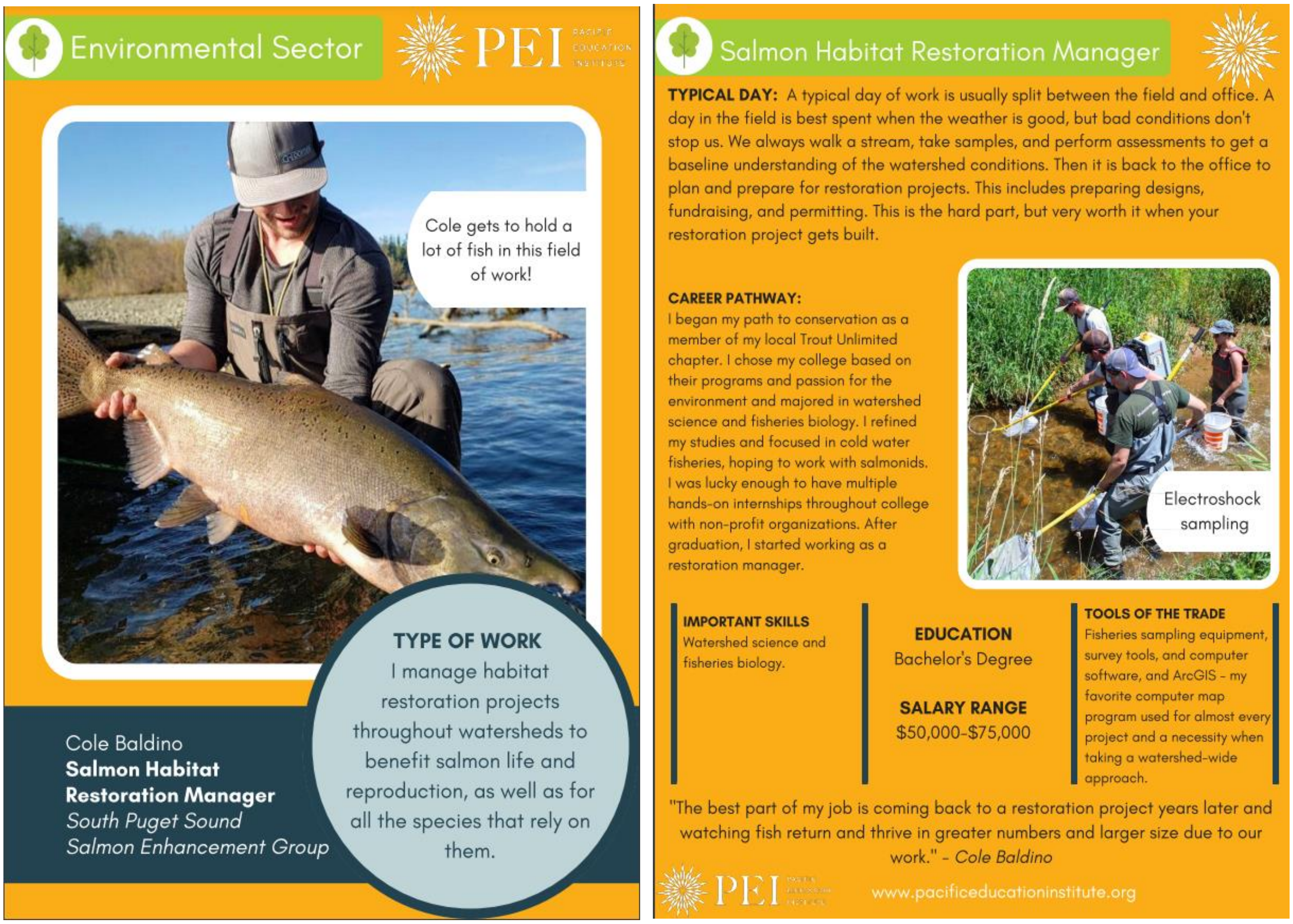
Remember to talk about your ideas!

- This reminds me of ____ from class.
- I think ___ because ____.
- I learned that ____.
- I agree because ___.
- We know ___ because ____.
- Since ____, then we can calculate ___.
- I respectfully disagree because ____.
- I can see connections between _____ and _____ because ____.
- So what I think ____ is saying is that ___. Is that correct ____?

Additional Resources

Career Connections

Cole Baldino's career connection card can be found on the PEI website at https://pacificeducationinstitute.org/wp-content/uploads/2020/04/Salmon-Habitat-Restoration-Manager-Cole-Baldino-Career-Profile.pdf



Community Resources Connections

Students may be unfamiliar with fish hatcheries and repopulation efforts. This collection of resources could help make the scenario more accessible or expand upon the scenario for greater depth.

- Alaska Department of Fish and Game - Salmon in the Classroom: https://www.adfg.alaska.gov/static/education/educators/curricula/pdfs/salmon_in_the_classroom_complete_curriculum.pdf
- Estuary and Salmon Rehabilitation Video (Puget Sound): https://wdfw.wa.gov/species-habitats/habitat-recovery/puget-sound/esrp
- Lower Snake River, ID - Fish Habitat and Dams- The Aerial Perspective: https://www.youtube.com/watch?v=8Qje5lRA-kA
- Salmon in the Classroom: https://wasalmonintheschools.org/partners/
- Story Maps - Washington State Salmon: https://storymaps.arcgis.com/stories/f5e9829466a34cb793fb7be7abe49ed2

Works Cited and Authentic Data

- NOAA Fisheries: https://www.fisheries.noaa.gov/species/chinook-salmon
- NOAA Fisheries - Salmon Bring Better Life to Eastern Washington: https://videos.fisheries.noaa.gov/detail/videos/fish/video/2397257442001/salmon-bring-a-better-life-to-eastern-washington?autoStart=true
- Salmon and the Yakama Nation Video: https://www.youtube.com/watch?v=yEKF8e0ndRU
- Southern Resident Killer Whales Conservation: https://www.youtube.com/watch?v=E7aZQ6o9-T4&t=338s
- Washington Department of Fish and Wildlife: https://wdfw.wa.gov/species-habitats/habitat-recovery/puget-sound/esrp
- Yakima Basin Fish and Wildlife Recovery Board: https://ybfwrb.org/recovery-planning/