“Solutions-Oriented Learning” Storyline

MS-Coastal Hazards: Sea Level Rise

Storyline introduction and overview:

Sea level is rising due to climate changes that result from increased emissions of greenhouse gases. In this storyline, students will explore mechanisms of sea level rise and the impacts on Indigenous peoples along with other groups such as urban communities. Natural hazards such as erosion, storm surges, and flooding are intensified by sea level rise. The effects on natural resources, the economies built from those natural resources, and land usage in general can be predicted by utilizing current and historical data.

Coastal Hazards NGSS Learning Progression: The middle school storyline is part of a larger learning progression that includes students mastering standards pre-K to 12th grade. Look at how the middle school performance expectations fit in a continuum of learning for your students.

Placemaking:

How will my favorite water body look if the sea rises? No matter where you are, if you follow your watershed downstream, sooner or later you will arrive at a shoreline.

Anchoring phenomena:

People who live along the Washington coastal and inland shorelines are going to experience change in their lives because of sea level rise.

Washington State shoreline map

Washington State prediction image

Environmental Justice:

Sea Level Rise Threatens Washington’s Coastal and Puget Sound Communities

As the Ocean Encroaches, this Washington State Tribe Is Building Its Next Chapter

Indigenous and other relevant cultural connections:

Since time immemorial Indigenous peoples have been connected to the ocean and the Salish Sea through harvesting food, managing marine land and resources, traveling trade routes, and observing ecosystem changes. The ocean and the Salish Sea have high cultural and sustenance value to Coastal and Puget Sound tribes.

NGSS PEs (progress towards):

MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

MS-ETS1-1 Define criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant principles and potential impacts on people and the natural environment that may limit possible solutions.

“Solutions-Oriented Learning” Storyline

MS-Coastal Hazards: Sea Level Rise

Estimated time required to implement this storyline: 3-4 weeks

NGSS PEs:

MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

MS-ETS1-1 Define criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant principles and potential impacts on people and the natural environment that may limit possible solutions.

Science & Engineering Practice (SEP)	Disciplinary Core Idea (DCI)	Cross Cutting Concept (CCC)
Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings. **Asking Questions and Defining Problems** Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)	**ESS3.B: Natural Hazards** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. **ETS1.A: Defining and Delimiting Engineering Problems** • The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)	**Patterns** • **Graphs, charts, and images can be used to identify patterns in data.** **Influence of Science, Engineering, and Technology on Society and the Natural World** • **The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.** **Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1) • The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-

Materials:

Learning Session	Materials

4- Thermal Expansion	1. 1 disposable plastic water bottle, with a flip-top lid, if available. Small bottles made with thicker, sturdier plastic are preferred. 2. 1 clear plastic straw 3. Food coloring 4. Ruler 5. Cutting tool (see management section) 6. Dark felt-tip pen 7. Thermometer (optional, see management section) 8. Several low-temperature hot-glue guns, putty or other malleable sealants 9. Paper or cloth towels 10. Safety goggles 11. Heat sources (Sun, heat lamps, heat pads, or incandescent bulbs)
8- Mapping Sea Level Rise	1. Beaker (one per group) 2. Pitcher 3. Ice (several cubes per group) 4. Large Potato (1/2 per pair) - Or the clay from earlier activity can be used to make an island 5. Clear plastic tub with flat bottom and clear plastic lid (one per pair) 6. Water soluble marker (one per pair) 7. Centimeter ruler (one per pair) 8. Kitchen knife 9. Water 10. Blue food coloring 11. White paper 12. Scissors 13. Clear tape 14. STUDENT INFORMATION SHEET: "Sea Level Mapping" (Page 4 in http://arcticclimatemodeling.org/lessons/acmp/acmp_912_ClimateChange_MappingSeaLevelRise.pdf 15. STUDENT WORKSHEET: "The Rising Coast" (See last page of lesson)
4- Climate Change and Sea Level Rise	1. 2 identical clear food storage boxes (approximately 6 inches square) per group 2. 8 sticks of classroom modeling clay per group 3. 1 ruler per group 4. 1 tray of ice cubes per group (may need to start storing ice cubes ahead of time) 5. 1 liter of water per group 6. Sea Level Rise Worksheet (1 per student)
9	Per group: One Resilience Measure Checklist - One Climate Events

	Booklet - One medium- or large-sized plastic food storage container. - One smaller plastic container that sits upright, floats, and fits inside the vase. A small condiment container works well. Blue and green food coloring Craft materials for decorating the sides of the large container to represent your city's "coastline" (e.g., crepe paper, glue, and scissors). You can also print out a strip of coastline using Clip Art and tape it onto the side of the container. - About fifteen glass floral beads with flat bottoms. - Two six-sided dice.

Learning Sessions

1.	**Grounding Native Ways of Knowing:**	Estimated time: 50 minutes

To connect to native ways of knowing consider exploring the following ideas in connection with your local tribal nation by researching stories of the past and learn about current work and actions the Tribe is taking to mitigate, adapt to, and find solutions to a changing climate.

- Love Story (video)- The Quinault Tribe has lived in Taholah, Washington, for centuries.

  Now, rising sea levels caused by climate change are forcing couples like Francis and Hazel to leave the town they have loved for decades.

- Read the article *Tribes have up Close Perspective on Climate Change*

To access information on how to reach out and build relationships with local tribes, visit the OSPI Office of Native Education: Partnering with Tribes, and contact your district's tribal liaison/Title VI coordinator.

To learn more about respecting and building upon Indigenous Peoples' Rights visit the Learning in Places website, a project led by Dr. Megan Bang then read Practice Brief #10: Teaching STEM In Ways that Respect and Build Upon Indigenous Peoples' Rights and Practice Brief #11: Implementing Meaningful STEM Education with Indigenous Students & Families published on the University of Washington's STEM Teaching Tools website

Suggested activity for teachers and students: 3-2-1 research process

- Three new learnings about the Tribe most local to you
- Two questions that you still have about the Tribe most local to you
- One action you can commit to begin a partnership with the Tribe most local to you

2.	**Examine phenomena: People's lives in Washington are going to change because of sea level rise**	Estimated time: 50 minutes

MS-Coastal Hazards: Sea Level Rise

	Show Washington State shoreline map and Washington State prediction image Individually students describe their noticings in their notebook of the changes seen in the Bering Sea ice at record low. In small groups students compare their noticings. Show the video Moving to Higher Ground Students read: As the Ocean Encroaches, This Washington State Tribe is Building a Next Chapter .Assign a group of students to each section of the article in order to prepare for a two minute presentation to the class. Using evidence found in section students should explain what the subtitle of the assigned section means in the presentation.

3.	**Pre-Assessment:**	Estimated time: 30 minutes
	MS-Coastal Hazards: Sea Level Rise Pre-Assessment MS-Coastal Hazards: Sea Level Rise Assessment Rubric	

4.	**Guiding question: What is sea level rise? What are the causes of sea level rise?**	Estimated time: Four 50 minute periods

1. Students brainstorm what they think sea level rise is (KWL) by writing and/or drawing their thoughts.
2. Students watch the introductory video: NASA's Earth Minute: Sea Level Rise to prepare them for the next activities.
3. Students engage in a hands-on activity for modeling and data collection related to the properties of thermal expansion: Thermal Expansion Model. At the end of the data collection, students graph their data. This activity can be done outside using radiation from the sun as a source of energy. An optional thermal expansion activity if hands on activity is not available due to distance learning is: Thermal Expansion demonstration video.
4. Students participate in a class discussion: Do sea levels rise when ice melts? Does it matter if the ice is on land or in the ocean? Students then engage in the lab (which spans 4 hours or overnight) Global Climate Change and Sea Level Rise. At the end of the data collection, students graph their data in a bar graph (as shown in the activity). An optional ice displacement activity if hands on activity is not available due to distance learning is: Why Melting Glaciers Matter to the Coasts
5. Students revisit their KWL. With a different color pencil, students respond to the following questions and revise their KWL:
    a. How is thermal expansion and ice melt different from tidal variations and storm surges in sea level rise?

	b. Do rainstorms affect the sea level? c. Does the movement of the continental plates affect sea level rise? d. Does the "Heat Blob" in the Pacific affect sea level rise? (Teachers, choose to use only the questions that are appropriate for your unique group of students)

5.	**Guiding question: How does climate change contribute to sea level rise?**	Estimated time: Two 50 minute periods

1. Students watch The Greenhouse Effect (US EPA) and diagram the natural greenhouse effect and then the enhanced greenhouse effect. An alternate/additional video is Our Climate Our Future video series (specifically chapter 4 - teacher needs to make a free account to view).
2. Students brainstorm consequences of global warming (Use Padlet, write on board, etc.). Expected answers: melting ice, changing sea levels, biodiversity loss, more frequent and extreme weather events, drought, floods, fires, change in the range of disease carrying insects, agricultural shifts, health consequences (heat stroke, asthma, pollen), ocean acidification. Students watch NASA Usual Suspects for climate change video and then revisit their answers.
3. Students engage in the Greenhouse Effect Phet Simulation. In doing so, students will manipulate the level of greenhouse gases and observe the change in temperature. Greenhouse Effect Online Lab Form. After simulation, students respond to the following questions:
    a. How do greenhouse gases affect the climate?
    b. Do all atmospheric gases contribute to the greenhouse effect?
4. To connect climate change and sea level rise, students will use their data from #4 as evidence to answer the following questions using NASA Infographic overview of sea level rise.
    a. What data supports sea level rise found on Infographic?
    b. Explain the Earth's processes influencing sea level rise.
        i. Thermal Expansion
        ii. Melting of ice sheets or glaciers
    c. Describe how sea level rise affects coastal communities.
    d. Why should we care about ice sheets found around northern and southern poles?
    e. How does NASA use technology to measure and provide real time data to monitor climate change?
    f. Explain how NASA can use their technologies to create predictions on current data trends?

Optional activities: Teachers can have students examine temperature and atmospheric CO2 over time graphs. Have them describe the relationship between temperature and CO2 as indicated by the graph. And/or, lead students through one of the many "greenhouse effect labs" available online to view this in a hands-on way.

MS-Coastal Hazards: Sea Level Rise

6.	**Guiding question: How do the natural hazards from sea level rise affect people and their communities?**	Estimated time: 45-60 minutes
	1. Provide students with a note-taking template or have them set up a template in their science notebook. Sea Level Rise Impacts Note Taking Student Worksheet 2. Direct students to Sea Level Rise. Students read the section entitled IMPACT and complete their notes. 3. Students discuss the impacts they noted in small groups. Students can add others' ideas to complete their template. 4. Students watch the video from the first lesson about the impacts on Quinault people. Love Story. Discussion Prompt: How has sea level rise and climate change affected the Quinault?	

7.	**Guiding question: How can we use science to predict increases in natural hazards?**	Estimated time: 75-90 minutes
	5 E lesson modified from Alaska Curriculum. See lesson for details and links. Sea Level Rise Mapping Lesson	

8.	**Guiding question: What are some of the engineering solutions that are being used to solve problems due to current and future sea level rise?**	Estimated time: Three 50-minute periods
	1. Students research a specific location in Washington where sea level rise has become or will become a problem Washington Coastal Hazards Resilience Network and be used as a resource). In their research, students address the following: a. Which individuals or groups need this problem to be solved? b. The needs that must be met by solving the problem. c. Scientific issues that are relevant to the problem. d. Potential societal and environmental impacts of solutions. e. The relative importance of the various issues and components of the process or system 2. Using the 12 solutions noted in Beat the Uncertainty, students look for the scientific principles that are being applied. 3. Students prepare a short (5 minute) visual presentation to share the results of their research with the class.	

9.	**Guiding question: What are the criteria and constraints on those engineering solutions?**	Estimated time: Three 50-minute periods

MS-Coastal Hazards: Sea Level Rise

	1. Students engage in the game Beat the Uncertainty in order to explore the constraints and criteria considered in solving problems due to sea level rise. Students will work in groups of 4-5. a. The first time through the game, debrief about what went well and what did not in terms of playing the game. Students discuss the criteria they were given to play the game (their role as a decision maker, the goal of making their city more resilient, working together to decide how to spend their funds). Students also discuss the constraints of the game (the amount of funds available, the uncertainty of which climate threat will affect their city, etc.) b. The second time through the game, students will choose a different coastal strategy. They will try to improve their "score" from the first time. At the end of the game, students revisit their lists of criteria and constraints and revise or add to it. c. The third time through the game, the students are in new groups and they will choose a strategy that is new to all of them. 2. As a concluding activity, students engage in a class discussion about the importance of identifying as many of the factors as possible affecting a solution in order to insure success.

10.	**Possible next steps/off-ramps/actions:**	
	• To extend the greenhouse gas activity in learning session 5, teachers can choose to talk about photons' role in increasing temperatures	

11.	**Post -Assessment:**	
	MS-Coastal Hazards: Sea Level Rise Post-Assessment MS-Coastal Hazards: Sea Level Rise Assessment Rubric	

MS-Coastal Hazards: Sea Level Rise OER Tracker

Pacific Education Institute would like to acknowledge and thank the writing team for their work. The team included Chad Allen, Karen Lippy, Michelle Townshend, Jody Cook, Julie Tennis and Shelley Stromholt. In you have comments or questions please contact info@pacificeducationinstitute.org

Except where otherwise noted, this work developed by Pacific Education Institute (PEI) for the Washington Office of Superintendent of Public Instruction, is available under a Creative Commons Attribution 4.0 License. All logos and trademarks are the property of their respective owners.