

# “Solutions-Oriented Learning” Storyline

## HS-Coastal Hazards: Sea Level Rise

### Storyline introduction and overview:

As the climate is changing, one of the many consequences is sea level rise, which is not a standalone factor, but is closely related to erosion and extreme weather/storm conditions. The majority of coastal houses, recreational parks, and other coastal buildings were built as sturdy but stagnant structures that do not adjust well to the changing elements. Coastal homes have been collapsing into the ocean and restaurants have been destroyed by storm waves. The economic damage has been accumulating. In this storyline, students will explore the reasons behind sea level rise looking at thermal expansion, glacial ice melt, and sea ice melt. Students will examine real scenarios of coastal damage in Washington state and evaluate current city and tribal resilience plans. Finally, students will evaluate the constraints of existing challenges and propose strategies for solving these challenges.

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

<p><b>Placemaking:</b></p> <p>Reflect on where you live? Are you near an ocean? What watershed do you live in? Do you know that some of the rainfall around you leads to a coastline, somewhere! If sea levels were to rise, would you be safe? Teachers, look at your town’s sea level rise plan.</p> <p>Use <a href="#">Learning in Places: For Families</a> scenarios, <a href="#">LE 3.C</a>, or <a href="#">LE 3.D</a>, that are easily adaptable for many geographical areas along the ocean, or waterways affected by rising sea levels, especially in a virtual or hybrid model.</p>	<p><b>Anchoring phenomena:</b></p> <p>Display the before and after photos of Bay Breeze restaurant being destroyed by a king tide in Birch Bay, WA. Lead students in a discussion of the picture and elicit ideas on what could have caused the destruction.</p>	<p><b>Environmental Justice:</b></p> <p>Sea Level Rise Threatens Washington’s Coastal and Puget Sound Communities</p> <p><a href="#">As the Ocean Encroaches, this Washington State Tribe Is Building Its Next Chapter</a></p>
<p><b>Indigenous and other relevant cultural connections:</b></p> <p>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</p>	<p><b>NGSS PEs (progress towards):</b></p> <p>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.</p> <p>HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural and environmental impacts.</p>	

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sustenance value to Coastal and Puget Sound tribes.

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

### NGSS PEs:

Science & Engineering Practice (SEP)	Disciplinary Core Idea (DCI)	Cross Cutting Concept (CCC)
<p><b>Constructing Explanations and Designing Solutions</b></p> <p>Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories.</p> <ul style="list-style-type: none"> <li>Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.</li> <li>Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</li> </ul>	<p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> <li>When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.</li> </ul> <p>ESS3.A: Natural Resources</p> <ul style="list-style-type: none"> <li>Resource availability has guided the development of human society.</li> </ul> <p>ESS3.B: Natural Hazards</p> <ul style="list-style-type: none"> <li>Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.</li> </ul>	<p><b>Cause and Effect</b></p> <ul style="list-style-type: none"> <li>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</li> </ul> <p>-----</p> <p><b>Connections to Engineering, Technology, and Applications of Science</b></p> <p>Influence of Science, Engineering, and Technology on Society and the Natural World</p> <ul style="list-style-type: none"> <li>Modern civilization depends on major technological systems.</li> <li>New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.</li> </ul>

### Materials:

Learning Session	Materials
4	1 disposable plastic water bottle, 1 clear plastic straw, Dark Marking pen, Clay, putty, or malleable sealant, Paper or cloth towels, Heat source (such as incandescent light bulbs, heat lamps, heating pads or the sun), (optional) thermometer, (optional) food coloring, (optional) ruler
4	<a href="#">How Warming Water Causes Sea Level Rise</a> (may have been done in

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	middle school) Two identical, clear plastic containers, Clay, play dough, or small rocks, Tray of ice cubes, Ruler, Cold water, Piece of paper or data sheet, (optional) permanent marker
4	<a href="#">How Melting Ice Causes Sea Level Rise</a> 2 identical plastic containers (6”x6”), Clay (enough to make 1-2” chunks), Ice cubes, cold water, marking pen, ruler

### Learning Sessions

<b>1.</b>	<b>Grounding Native Ways of Knowing:</b>	Estimated time: 50 minutes
<p>Students listen to the 4 minute audio at <a href="#">Native Tribe Takes it Plea to Paris</a> and read the article. Students discuss the different factors that are contributing to the hazards of the sea level rise in this village. Students identify the concerns of the Quinault people. The factors and concerns are posted on a board to be available for reference throughout the rest of the learning sessions.</p> <p>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 learning about current work and actions the Tribe is taking to mitigate, adapt to, and find solutions to a changing climate.</p> <p>To access information on how to reach out and build relationships with local tribes, visit the <a href="#">OSPI Office of Native Education: Partnering with Tribes</a>, and contact your district’s tribal liaison/Title VI coordinator.</p> <p>To learn more about respecting and building upon Indigenous Peoples’ Rights visit the <a href="#">Learning in Places website</a>, a project led by Dr. Megan Bang then read Practice Brief #10: <a href="#">Teaching STEM In Ways that Respect and Build Upon Indigenous Peoples’ Rights</a> and Practice Brief #11: <a href="#">Implementing Meaningful STEM Education with Indigenous Students &amp; Families</a> published on the University of Washington’s <a href="#">STEM Teaching Tools website</a></p> <p>Suggested activity for teachers and students: 3-2-1 research process</p> <ul style="list-style-type: none"> <li>• Three new learnings about the Tribe most local to you</li> <li>• Two questions that you still have about the Tribe most local to you</li> <li>• One action you can commit to begin a partnership with the Tribe most local to you</li> </ul> <p>Below are some examples of regional tribal connections to sea level rise.</p> <ul style="list-style-type: none"> <li>• <a href="#">Quinault Indian Reservation</a>’s plan to relocate with rising sea levels</li> <li>• <a href="#">Makah Tribe’s</a> climate assessment to determine migration</li> <li>• <a href="#">Case Studies: UW Geographical</a> reference for tribal case studies</li> </ul>		

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2.	<b>Examine phenomena:</b>	Estimated time: 30 minutes
<p>Display the before and after photos of Bay Breeze restaurant being destroyed by a king tide in Birch Bay, WA. Elicit ideas on what caused the destruction. Encourage students to think about the factors that caused the actual damage and the changes in the environment that impacted those factors. Use this link to access photos: <a href="#">Watch: Storm surge floods waterfront restaurant in Birch Bay</a></p> <p>Explore the <a href="#">Birch Bay repairs could help beachfront weather big storms</a> that occurred after the storm, this one includes a design for a solution.</p> <p>Find a tribe near your school and see what the projections for sea level rise in the next few decades, by using the <a href="#">Tribal Climate Tool</a>.</p> <p>Note: You should set the parameters as follows: <b>view:</b> using graph, <b>climate-related variable:</b> relative sea level</p>		
3.	<b>Pre-Assessment:</b>	Estimated time: 30 minutes
<p><a href="#">HS-Coastal Hazards: Sea Level Rise Pre-Assessment</a></p> <p><a href="#">HS-Coastal Hazards: Sea Level Rise Rubric</a></p>		
4.	<b>Guiding question: How are sea levels impacted by thermal water expansion, glacial ice, and/or sea ice melting?</b>	Estimated time: Three 50-minute periods
<p>A common misconception is that sea ice and land ice add equal amounts of water to the ocean when melted, but that is not the case. Use the activities below to eradicate any misconceptions.</p> <ol style="list-style-type: none"> <li>1. Students <a href="#">Thermal Expansion of Water: Demonstration and Experimentation</a> (approx. 3 minutes) to prepare for the following lab in #2.</li> <li>2. Students build a model that demonstrates how sea level rise can be caused by increased global temperatures. <a href="#">How Warming Water Causes Sea Level Rise</a> lab.</li> <li>3. Students can extend their learning by observing the physical difference between land ice and sea ice using this activity, <a href="#">Land Ice vs. Sea Ice: Observations &amp; Conclusions</a>.</li> <li>4. Students respond to the questions: How are sea levels impacted by thermal expansion, glacial ice, and sea ice? How is climate change impacting sea levels?</li> </ol>		

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5.	<b>Guiding question: How does sea level rise affect coastal locations?</b>	Estimated time: Two 50-minute periods
<p>1. Students respond to the question: When the sea level rises, what are some possible consequences to those that live near the coast and even those that live away from the coast but near watersheds? Some examples to share after students have generated some possible consequences: <a href="#">Coastal Erosion</a>.</p> <p>2. Students read <a href="#">Tacoma redesigning popular beach using climate change projections</a> (there is also a video in the article). The following tribal stories may also be used as an alternative: <a href="#">Sea Level Rise in the South Salish Sea</a> or <a href="#">Our Future Climate In Samish Traditional Territory</a></p> <p>3. Students respond to the following questions:</p> <ol style="list-style-type: none"> <li>Are any parts of their community threatened by sea level rise and if so, what solutions has the city implemented?</li> <li>How much money did the solution cost?</li> <li>Do you support the solution? Give reason for either supporting or refuting the solution.</li> </ol> <p>4. Students explore the <a href="#">U.S. Climate Resilience Tool Kit</a>. This tool allows students to explore rising sea levels in WA, as well as other areas across the U.S. Students choose different layers on the map, including property, income, landmarks, and ethnicity. For coastal communities that have cliffs, consider doing a virtual beach profile to show how sea level rise will impact the cliffs.</p> <p>If your area is not threatened by sea level rise, make a connection to areas that are impacted. Connections include food sources, transportation, recreation, family connections, etc. A good resource for finding projects like the project noted in #1 is <a href="#">WA Coastal Hazards Resilience Network</a>.</p>		

6.	<b>Guiding question: How have coastline alterations impacted current landscapes?</b>	Estimated time: Two 50-minute periods
<p>1. Students watch <a href="#">Washaway Beach - Fastest Eroding Place</a> (<i>until 1 min</i>), Ask students to think about their nearest coast, populated (waterfronts) and non-populated (beaches/bluffs). Have they noticed any changes in the past years or seasons? Students turn to their elbow partners and peer share:</p> <ul style="list-style-type: none"> <li>What are the constraints the homeowners are facing?</li> <li>What would you do if you were the cranberry farmers?</li> <li>What is the cost to the suggested alternative?</li> </ul> <p>2. Continue the video, <a href="#">Washaway Beach - Fastest Eroding Place</a> (<i>after 1 min</i>), Students turn to their elbow partners and peer share:</p> <ul style="list-style-type: none"> <li>What do you think about the solution to Washaway Beach? Do you</li> </ul>		

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	<p>think it is a long- or short-term solution?</p> <ul style="list-style-type: none"> <li>• What do you think of additions to your own local coastlines?</li> </ul> <p>3. Students explore clam gardens at <a href="#">the Clam Garden Network</a> and how they have been used by Indigenous peoples from Alaska to the PNW. Students evaluate the use of clam gardens noting the criteria and the tradeoffs of this solution to the effects of sea level rise.</p>
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<b>7.</b>	<b>Guiding question: What role do living systems play in providing solutions to coastal erosion problems?</b>	Estimated time: Two 50-minute periods
	<p>P.O.E. format (predict-observe-explain)</p> <p><b>Predict:</b> Either as a class or in pairs, have students talk about what they know about estuaries (what are some benefits). Show students <a href="#">Blue Carbon: A Story from the Snohomish Estuary</a> Then, ask students to predict and share what they think would happen if estuaries were destroyed or removed due to climate change and/or human activities.</p> <p><b>Observe:</b> Now have students watch <a href="#">Coastal Resiliency</a> and have them note observations about natural coastal resilience.</p> <p><b>Explain:</b> Have students answer the guiding question: What role do living systems play in solving sea level rise and coastal erosion problems? (Note to teacher: guide students towards the idea that sometimes you can grow a solution which may be more resilient than one you build. Natural habitats such as estuaries can adapt, change, and be resilient towards the steady sea level rise. Human constructed structures must be constantly updated or adjusted, but natural structures will grow and break down as a natural selection process).</p> <p>Extension activity: Students can be assigned various coastal habitats and research the benefits, adaptation capability, and how humans may have already altered/ damaged such habitats. Coastal habitats include coral reefs, beaches, sand dunes, rock pools and rock platforms, estuaries, and mangroves.</p> <p><b>Estuaries and climate change and coastal erosion:</b></p> <ul style="list-style-type: none"> <li>○ <a href="#">Blue Carbon: A Story from the Snohomish Estuary</a></li> <li>○ <a href="#">Coastal Resiliency</a></li> </ul>	

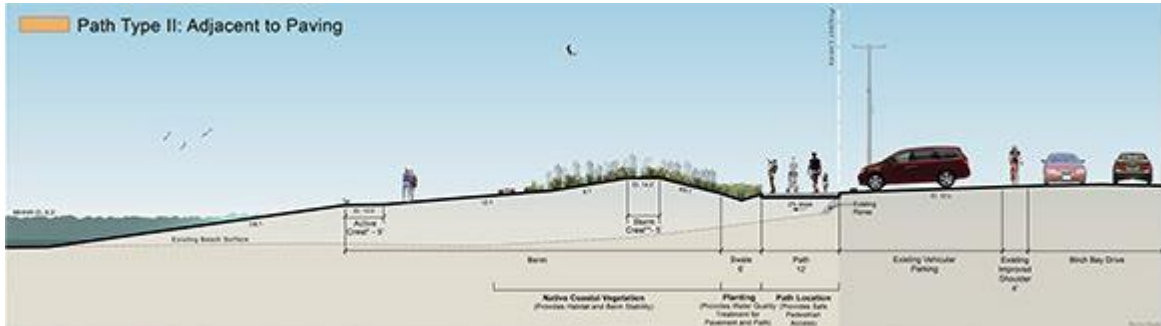
<b>8.</b>	<b>Guiding question: What criteria and constraints need to be considered when proposing solutions to sea level rise?</b>	Estimated time: 50 minutes
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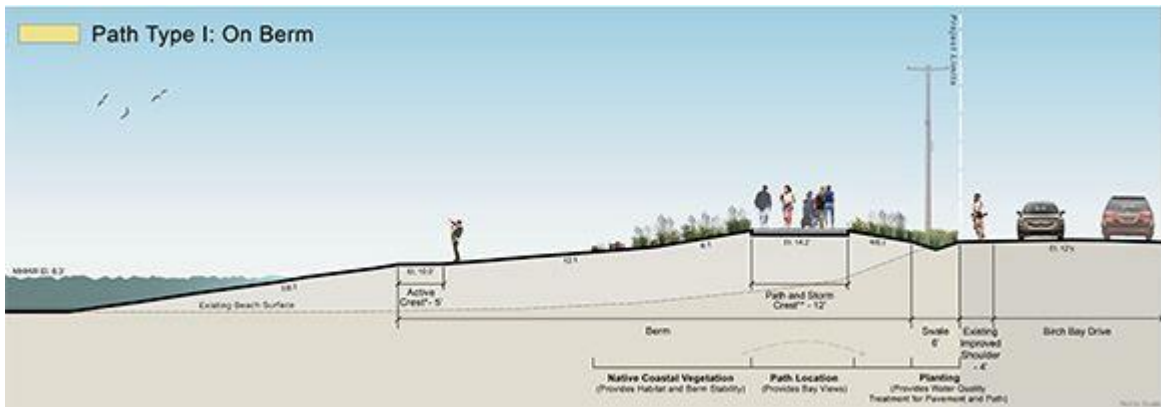
## HS-Coastal Hazards: Sea Level Rise

- Students revisit the Birch Bay king tide that flooded Bay Breeze Restaurant from learning session 2. . Soon after the flood, Whatcom County put a plan in place to avoid future hazards. The [Birch Bay Drive & Pedestrian Facility Project](#) has provided multiple documents to explore, and can be found towards the end of the web-page under ‘Other Project Information’ (specifically, the 2006 Phase I Community Meeting PWA Report) Below are some renderings of the project, before and after completion.

Before



After



- Students complete the [Coastal Erosion: Criteria and Constraints](#) and assign priority to each constraint/criteria.

<p><b>9.</b></p>	<p><b>Guiding question: What is the impact of climate change on coastal communities? What strategies are most effective in adapting to sea level rise?</b></p>	<p>Estimated time: Three- Five 50-minute periods</p>
<ol style="list-style-type: none"> <li>Students Choose and evaluate one of the following plans: <ul style="list-style-type: none"> <li><a href="#">Olympia Sea Level Rise Response Plan</a></li> <li><a href="#">A Coastal Community- Erosion Impact and Response, Ocean Shores</a></li> <li><a href="#">Taholah Village Relocation Master Plan Project</a></li> <li><a href="#">Anacortes, Washington Rebuilds Water Treatment Plant for Climate Change</a></li> <li><a href="#">Squaxin: Sea Level Rise</a></li> <li><a href="#">Preparing for Climate Change, Seattle Office of Sustainability and Environment</a></li> </ul> </li> </ol>		

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	<ul style="list-style-type: none"> <li>● <a href="#">Climate Risk Assessment - City of Tacoma</a></li> <li>● <a href="#">Climate Action and Adaptation Plan, City of Long Beach</a></li> </ul> <ol style="list-style-type: none"> <li>2. Students research how climate change is impacting their chosen community. Students can use the 5 criteria of a vulnerability assessment that was introduced in the pre-assessment in crafting their explanation as well as the science learned in session 4.</li> <li>3. Students then evaluate the strategies for how the community is working to reduce the impact of sea level rise on their coastlines. In their evaluation, students consider cost, safety, reliability, and aesthetics, as well as possible social, cultural and environmental impacts. Students propose their own ideas of strategies that would decrease the impacts of sea level rise on the coastal communities. Points to consider:             <ul style="list-style-type: none"> <li>● Stay and make the location more resilient or relocate.</li> <li>● Decide which of the above constraints are the most important (rank the priority level of the constraints)</li> <li>● If deciding to stay, what method will be used to stabilize shoreline with different materials, building codes, and create cost benefit analysis.</li> <li>● If deciding to relocate, estimate the cost for relocation and to where and why.</li> <li>● Think about possible ways to engage with local communities to research their terrestrial, marine, aquatic, infrastructure, and health vulnerability.</li> </ul> </li> <li>4. Students (in groups or individually) prepare a presentation for the class or a community. The presentation could be an infographic, a PowerPoint, a written plan, etc. Students ask for feedback and revise as needed.</li> </ol>
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<b>10.</b>	<b>Post-Assessment:</b>	Estimated time: 30 minutes
<a href="#">HS-Coastal Hazards: Sea Level Rise Post-Assessment</a> <a href="#">HS-Coastal Hazards: Sea Level Rise Rubric</a>		

<b>11.</b>	<b>Possible next steps/off-ramps/actions/career connections:</b>	
<ul style="list-style-type: none"> <li>● Engineering hands on experience: In groups of 2-3 students, pick a location and analyze the problems presented with living in the said location. Then propose and design possible solutions with concrete reasoning and cost/analysis evaluations. Past designs (successful or not for that specific location) can be used but must be supported with reasons why that design will work for your said location.</li> <li>● Career Connections: <a href="#">The Washington Coastal Hazards Resilience Network</a> membership includes over 70 members and 150 listserv subscribers who are coastal hazards and climate change practitioners from federal, local and state government agencies, tribes, academic institutions, consulting firms and nonprofit organizations.</li> </ul>		



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Students can scroll through the profiles of the members to explore many of the professions that are working on the impact of sea level rise.

- Add an additional Guiding Question: How does sea level affect intertidal communities and/or forests that are impacted by salt intrusion?

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### [HS-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 Madison Crow, Chris Stone, John Hunter, Cheyanne Shere, Julie Tennis and Shelley Stromholt. In you have comments or questions please contact [info@pacificeducationinstitute.org](mailto:info@pacificeducationinstitute.org)

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