PACIFIC EDUCATION INSTITUTE

"Solutions-Oriented Learning" Storyline

High School Wetlands: Blue Carbon and Rising Seas

Storyline introduction and overview:
Students will engage in learning about the function and benefits of coastal wetlands and their role in adapting and mitigating rising carbon levels and sea level rise. Spatial and interactive planning tools will support students in collaboratively designing solutions to enhance coastal wetlands.

NGSS Learning Progression for this Storyline:
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.

Placemaking:	**Anchoring phenomena:**	**Drawdown:**
Show: What Is An Estuary? Now You Know! Students locate and research a local estuary or saltmarsh. Use Google Earth or Maps Satellite & Street View. WDOE Modeled Wetlands Inventory shows classifications of wetlands. Research Resources: Google Earth Google Maps 2016 Modeled Wetlands Inventory- Washington Department of Ecology Map of Washington Wetlands	Coastal wetlands bury carbon at rates 10x greater than forest and capture carbon at rates 2-4x greater than forests on a per area basis.	Drawdown: Coastal Wetland Restoration Agriculture, development, and natural disasters have degraded many coastal wetlands. Restoring mangrove forests, salt marshes, and seagrass beds to health revives carbon sequestration.
Indigenous and other relevant cultural connections: Billy Frank Jr. story of the Nisqually Delta Nisqually Story: Water from the Mountain (Nisqually) Where the Salmon Run: The Life and Legacy of Billy Frank, Jr.	**NGSS Pes (progress towards):** **HS-ESS3-4** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. (Evidence statements) **HS-LS2-5.** Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. (Evidence Statements) **HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range	

	of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. (Evidence Statements)

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

NGSS PEs:

HS-ESS3-4 Earth and Human Activity

HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. (Evidence statements)

HS-LS2-5 Ecosystems: Interactions, Energy, and Dynamics

HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. (Evidence Statements)

HS-ETS1-3 Engineering Design

HS-ETS1 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. (Evidence Statements)

Science & Engineering Practice (SEP)	Disciplinary Core Idea (DCI)	Cross Cutting Concept (CCC)
Constructing Explanations and Designing Solutions 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 knowledge, principles, and theories. Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**For HS-ESS3-4** **ESS3.C: Human Impacts on Earth Systems** Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. **ETS1.B: Developing Possible Solutions** 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. *(secondary)*	**Stability and Change** Feedback (negative or positive) can stabilize or destabilize a system. **Influence of Science, Engineering, and Technology on Society and the Natural World** Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

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Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show how relationships among variables between systems and their components in the natural and designed worlds. Develop a model based on evidence to illustrate the relationships between systems or components of a system.	For HS-LS2-5. **LS2.B: Cycles of Matter and Energy** Transfer in Ecosystems Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. **PS3.D: Energy in Chemical Processes** The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary)	**Systems and System Models** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
Constructing Explanations and Designing Solutions 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. Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	For HS-ETS1 **ETS1.B: Developing Possible Solutions** 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.	**Influence of Science, Engineering, and Technology on Society and the Natural World** 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.

Materials

Learning Session	Materials
6	*For each group of 3-5 students:* ● Scale ● Sieve ● Cheesecloth ● Sphagnum moss ● Sod ● Sand ● Gravel
7	*Extended Learning Option- Wetlands Soil* ● 3 or more soil samples from various areas and depths in a wetland (Likely locations for wetlands include the edges of ponds and streams, low lying topography that is often wet

	and muddy, drainage ditches that are frequently full of water, or sites with obvious wetland vegetation—e.g., cattails and reeds. ● Several packs of 64 Crayola® crayons ● Poster board or manila folders
7	*Extended Learning Opportunity- Measuring Decomposition* ● Soil samples from wetlands (~100 g [~ 1/2-1 cup] for each titration, depending on moisture content) ● Drying oven or microwave ● Metric balance with 0.1 g accuracy ● Beakers ● Spoon or scoop for handling soil ● Distilled water ● Gloves and goggles ● (optional) Incubator (You can build an incubator using a light or heating pad in a box.) ● (optional) Magnetic stirring plate and bar *For collecting samples:* ● Lid to a wide-mouthed container ● Knife ● Garden trowel and spatula ● Plastic wrap ● Marker ● Air-tight container *For each soil sample:* ● 1 shallow, wide, airtight container (approximately 25 cm x 25 cm) ● Beaker to hold NaOH (needs to fit inside the airtight container with air space above) ● 20 mL 1M NaOH (sodium hydroxide) ● 10 or 20 mL pipette ● 20 mL 1M HCl (hydrocloric acid) ● 2 mL 1M SrCl2 (strontium chloride) ● Phenolphthalein ● 20-50 mL buret or “Poor Man’s Buret” *Note:* For every 5 soil samples, you will need to create a “blank,” which will require an additional airtight container and beaker with NaOH.

	Note: The activity “Wetland Soil” also requires soil samples. Consider collecting samples for both activities concurrently.

Learning Sessions

1.	**Grounding Native Ways of Knowing**	Estimated time: 30-60 minutes
	Coastal wetlands are critical sources of food for Indigenous people and have been since time immemorial, “When the tide is out, the table is set.” The depth of this relationship and the threats of climate change are revealed in these activities. Introduce this to students with this video Coastal Tribes Facing Climate Change Why Do the Foods We Eat Matter? provides perspectives from Native American community members, images, objects, and other sources to help students and teachers understand the efforts of Native Nations of the Pacific Northwest to protect and sustain salmon, water, and homelands. Select portions of the online lesson for students to complete. Suggested portions include Food is More Than Just What You Eat, Why is Salmon Important to Native People and Nations of the Pacific Northwest?, What Actions are Native Nations Taking to Restore Salmon and Strengthen Cultures? Also consider having students read Puget Sound Estuary Restoration Case Study and discuss the questions. This case is explored further in Learning Session 8. Extended learning opportunities on this topic might also identifying local tribal boundaries at Native-Land.ca | Our home on native land Read and listen to Nisqually Food Sovereignty: Sustainable Decolonization and Restoration 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 .	

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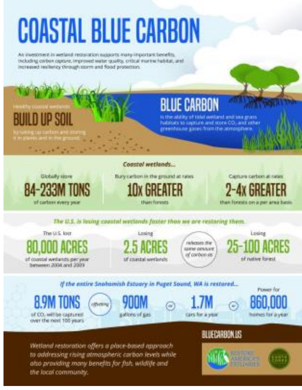
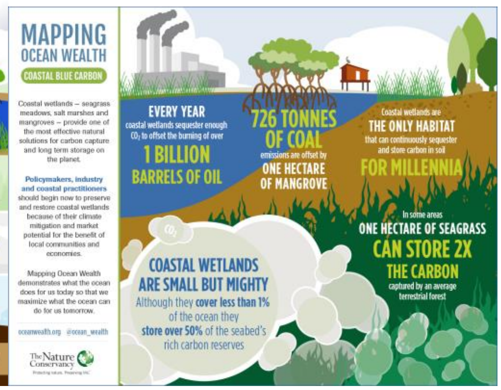
2.	**Examine Phenomena**	Estimated time: 30 minutes

Provide infographics, either on screen or in print. In groups, have students analyze one of the infographics, completing using the HO2.1 Infographic Protocol. Discuss learnings and responses as a class.





Infographics:
Coastal Blue Carbon & Mapping Ocean Wealth

3.	**Pre Assessment**	Estimated time: 30 minutes

Pre Assessment:.
Wetlands: Blue Carbon and Rising Seas Pre-Assessment

Rubric:
Wetlands: Blue Carbon and Rising Seas Change Rubric

4.	**Guiding questions:** **What is a wetland? What are the types of wetlands?**	Estimated time: 60-90 minutes
	In this learning session, students will learn about wetlands, including the different types of wetlands. They will view a video, annotate an article, and complete a WebQuest. Show introductory video: What are Wetlands? Next, have students annotate Washington Wetlands article, focusing on what is a wetland and why they are important. Students then complete a webquest comparing each wetland type: Tidal Marsh, Non-Tidal Marsh, Swamp, Bog. This can be done individually, in groups or as a jigsaw activity. EPA Wetlands Classification website. If computer access is an issue, here is a print option: EPA Types of Wetlands Options to extend learning about wetlands types: Find out where and what type of wetland are near you using the National Wetlands Mapper. Visit a wetland for outdoor learning. See *Explore a Wetland Field Study* on page 35 in *Our Wetlands, Our World* Secrets of Saltmarshes is a video about how salt marshes function. This will help students understand why carbon builds up in salt marshes.	

5.	**Guiding questions:** **What are the benefits of wetlands? What has happened to wetlands?**	Estimated time: 60 minutes
	In this learning session, students will learn about the benefits of wetlands and what has caused their decline. They will view a video, read online information from the US Environmental Protection Agency and analyze images of human impacts on wetlands. Begin by showing video Why Wetlands are Nature's Super-Systems | WWT	

	Then, have students read either about wetland values and functions online at Why are Wetlands Important? | Wetlands Protection and Restoration or if a print option is needed, a short EPA article Functions & Values of Wetlands Finally, students explore human impacts on local wetlands using aerial images., See *Changes Over Time* on pages 70-74 in *Our Wetlands, Our World* for activity guidelines. Use River History and Photographs — DRCC to replace Newport Bay images and timeline.

6.	**Guiding questions:** **How can coastal wetlands mitigate sea level rise?**	Estimated time:3 to 5 60 minute class periods
	Students will engage with the National Oceanic and Atmospheric Administration’s data to understand the effects of sea level rise by viewing a video, engage in an interactive sea level rise data activity and reading. Students will also conduct a classroom investigation exploring how wetlands absorb water. Students start by engaging with Sea Level Rise - NOS Education This NOAA video explains sea level rise and how data is collected. Teacher support materials are included. Next students interact with Investigating Sea Level | NOAA Data in the Classroom This activity uses a series of interactive web maps, apps, and high resolution images to help students learn about sea level using real data from NOAA. Teacher support materials are also included. Students connect how coastal wetlands provide and adaptation for sea level rise by reading and summarizing Understand - Conserving Coastal Wetlands for Sea Level Rise Adaptation | Digital Coast Finally, to explore how coastal wetlands protect low lying areas from sea level rise, have students engage in a classroom investigation of how various materials absorb water. Topic B Water, Water Everywhere: Activity 1 Flooding and the “Giant Sponge” Effect (page 7) guides students through an investigation of how various materials absorb water.	

	There are many additional resources for students to extend their learning: • Understand - Conserving Coastal Wetlands for Sea Level Rise Adaptation | Digital Coast has additional information outlining the entire NOAA process of Conserving Coastal Wetlands for Sea Level Rise Adaptation. • Washington State’s Sea Level Rise predictions can be explored at Sea Level Rise in Washington State – A 2018 Assessment | Climate Impacts Group • NASA has lesson on the coastal consequences of sea level rise at My NASA Data

7.	**Guiding question:** **How do wetlands sequester carbon?**	Estimated time: 60-90 minutes
	In this learning session, students will learn about blue carbon by reading a short article and viewing a video, then engaging in an interactive carbon cycling activity. Excellent background information on how wetlands and their soils sequester carbon can be found here Wetland and Hydric Soils Introduce blue carbon by having students read Blue Carbon and watch Blue Carbon – A Story from the Snohomish Estuary Next, students explore the carbon cycle, including the main processes or flows that move carbon between reservoirs on Earth. They first do a Quick Write and share ideas with a partner to access their prior knowledge and learn more about carbon flows and reservoirs by sorting carbon cards and viewing a video. Students then make a sketch from an image of the local estuarine/harbor ecosystem, labeling all the carbon reservoirs and flows. Modify the activity by having students add highlights demonstrating where photosynthesis is trapping carbon and where respiration is releasing carbon to meet **HS LS 2.5 Cycling of Matter Standard**. MARE Carbon Reservoirs and Global Carbon Cycle Activity Overview Activity write-up Teacher Directions Activity Powerpoint slides Activity handouts (Carbon Cards) Extend this learning by: • Taking students outdoors to study Wetland Soil, pages 43-50. • Calculating the amount of carbon in soils by Measuring Decomposition, Pages 51-64. • Another video What is Blue Carbon?	

	• Online article Fact file: Saltmarshes and mudflats • Blog Salt Marshes: Working Hard Without Pay - WMAP Blog - State of Delaware

8.	**Guiding question:** **How can coast wetlands be restored to accommodate both sea level rise and sequester carbon? How do we make these decisions collaboratively?**	Estimated time: 4 to 5 60 minute class periods
	In this learning session, students will watch a video, engage with an online animation, and study an example of a local restoration. To conclude, the students use a mapping tool and takeoff analysis to inform a proposed action plan for land use actions that will preserve or expand a local or important Washington state coastal wetlands. Show introductory video Ecosystem Services Next, students will engage in the interactive NOAA: Green Infrastructure Protective Services Animation Students will learn about how the Skokomish tribe and other partners worked together to restore their river's estuary. Engage students by showing video Skokomish Estuary Then students read Skokomish Estuary Restoration | Puget Sound Innovation Stories and/or Restoring the Skokomish River and/or Puget Sound Estuary Restoration Case Study | Teacher Resource Finish by showing video highlighting partnerships. Coming Back: Restoring the Skokomish Watershed Finally groups of students will work together to plan for land use that will preserve or expand a local or important Washington state coastal wetlands. To start, students will choose a coastal wetlands area using the Coastal Flood Exposure Mapper After exploring options, students propose land use actions that will preserve or expand the wetland. Using the process outlined in Wetland Tradeoffs Page 131-137 Our Wetlands, Our World, students analyze their proposed actions and develop a final proposal. Additional resources to extend learning: Other restoration stories Estuaries Rivers and Tides: Restoring the Nisqually Estuary	

	Coastal Wetland Restoration

9.	**Possible next steps/off-ramps/actions:**	
	Design and take action to conserve coastal wetlands. Check out Our Wetlands, Our World **Taking Action** lesson on pgs.113-115 or design your own project using Pacific Education Institutes' FieldDesign Engineering Design for Field-Based Applications 6-12. Ideas for specific actions can be found at *At Home with Wetlands: A Landowner's Guide*. Make career connections and explore how Washington State Department of Ecology supports the management and protection of wetlands, including rating systems, delineation and mitigation. WDOE Wetlands Expand into the arts. Check out the Burke Museum's Drawing Wild Washington and Salish Seas Wetland Art and Poetry.	

10	**Post Assessment**	Estimated time: 30 minutes
	Wetlands: Blue Carbon and Rising Seas Post Assessment **Wetlands: Blue Carbon and Rising Seas Rubric**	

OER Tracker -HS Wetlands: Blue Carbon and Rising Seas

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