1. General Lesson Information

Briefly describe the lesson, including major content covered, required knowledge (by the person teaching it), and general activities (this is an overview for volunteers and for classroom teachers):

Lesson Title	**Coastal erosion**
Topics Covered	**Calculating area and volume; effect of waves on coastlines; how seawalls and other natural/human barriers affect/protect coastlines from erosion/inundation**
NGSS connections (link to NGSS website)	**NGSS:** **HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.** **HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.** **MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.** **MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.** **Common Core (math)** **Model and Problem Solve: Formulate, represent and communicate mathematical problems and solutions by using tools such as diagrams, two-way tables, graphs, flowcharts and formulas.** **CCSS.Math.Content.HSG-GMD.A.3** **Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.** **CCSS.Math.Content.HSG-MG.A.2** **Apply concepts of density based on area and volume in modeling situations.**
What will students know at the end of this lesson?	Erosion from wave action moves material along; seawalls, reefs, and shellfish beds provide protection to coastlines by damping the wave action; different coastline and seawall materials respond to wave action in different ways

	Volume of material removed/relocated can be calculated by tracing affected areas
What will students be able to do at the end of this lesson?	Calculate volume of material moved through erosion and connect it to different solutions to this problem
How long will this lesson take?	**4 hours (2 2-hour blocks? Or 4 1-hour blocks?)**
Required prior knowledge	**Students will already have learned some basic ideas about area/volume and transformations; from previous projects (for Maritime High School students), students are aware of oyster beds and how they can protect coastlines (ideally)**
Targeted grade level	**10 (for an integrated math class)**
How does this lesson fit into a larger sequence of content? Is this a standalone activity or part of a sequence?	**Mathematically, this can be part of a larger unit on area and volume of different shapes. For the original purposes of this lesson, students had already learned about oyster aquaculture and reefs as well as shoreline development from a marine construction perspective, providing some context for the activity in the math classroom. For classroom groups without this background, it would be worth spending more time on the hook and initial context.**
What is the ideal site for this lesson/activity (classroom, lab, boat, beach, etc)	**Combination of lab (for the experiment) and classroom (for**
What science/math skills will students use in this activity?	**Conducting a controlled experiment;** **Interpreting data to draw a conclusion** **Mathematical reasoning** **Presenting results to peers**
What type of project could this be linked to?	**Connects with ideas around climate change (waves, tides, weather patterns, sea level); shellfish aquaculture and restoration; marine construction and shoreline development; ,**
What special skills do students need (i.e. coding, pipetting, etc)	**None**
What interdisciplinary connections could there be with this lesson?	**This was already designed as a contextual/interdisciplinary lesson, but there are opportunities to elaborate on the ecology/shellfish management aspect of things.**

How could this lesson be adapted for younger or older students?	**Younger: More of the hands on exploration and coming up with ideas for the experiment, basic math, looking more at images and less at quantitative maps** **Older: More independent experimental design; More quantitative analysis of maps; the mathematical portion of the lesson could be adjusted for a calculus context where students were integrating shapes rather than calculating simple areas/volumes.**

2. Lesson Details

I. CHECKING PRIOR KNOWLEDGE Identify how you will inventory student knowledge ahead of the task, lesson, or activity. (e.g., communication with teacher, previous day's exit tickets shared by teacher, warm-up activity, class discussion, etc.)	**The hook will provide an opportunity for students to share what they already know. Student ideas and commentary shared based on the hook should be recorded in some way so that they can be revisited throughout the lesson.**
II. STUDENT QUESTIONS ADDRESSED How will you identify what questions students have, and incorporate these questions into your lesson?	
III. KEY VOCABULARY Note which terms or academic vocabulary will be essential to this lesson. If you serve English language learners, consider what additional vocabulary might be necessary for them to access the content/skills during the instructional activities.	**Erosion** **Seawall**
IV. FORMATIVE ASSESSMENT How will you gather info on what students are learning during and at the end of the lesson? How will you make sure this information is shared between the lesson presenters and the classroom teacher?	**Teachers will circulate during the experimental phase to gather information from students about what they are thinking.**
V. LESSON PLAN This can be a rough outline, and we can flesh out the details below Possible lesson structure (5E): **ENGAGEMENT** · **Describe how the teacher will capture students' interest.** · **What kind of questions should the students ask themselves after the engagement? (please note that as much as possible the goal is to build on student questions rather than purely teacher questions)**	**Hook: Diagram: "Living Shorelines Support Resilient Communities"** (Based on the diagram) What is a living shoreline? What role do living shorelines play in coastal environments? (For MHS students): What examples of this have we already learned about this year? What are the threats to living shorelines?

EXPLORATION · **Describe what hands-on/minds-on activities students will be doing.** · **List "big idea" conceptual questions the teacher will use to encourage and/or focus students' exploration**	(For MHS students): How do you think marine construction activities (i.e. pier construction) interact with living coastlines?
EXPLANATION · **Student explanations should precede introduction of terms or explanations by the teacher. What questions or techniques will the teacher use to help students connect their exploration to the concept under examination?** · **List higher order thinking questions which teachers will use to solicit *student* explanations and help them to justify their explanations.** **EVALUATION** · **How will students demonstrate that they have achieved the lesson objective?** · **This should be embedded throughout the lesson as well as at the end of the lesson**	**Part 1: Hands on exploration of coastal erosion. Students will use simple lab materials to explore the effect of waves on unprotected shorelines and compare this to different cases of protected shorelines.** UW Curriculum - Coastal Erosion UW_CoastalErosion_Worksheet **Student choice: students will get to choose the type of protected shoreline they would like to experiment with, and design the barrier.** **Students will share their results with their classmates to insure that students get the benefit of learning from each other and different experimental setups** **Differentiation: Different levels of support will be available for the portion of the activity where students are making calculations. For students who move more quickly through the initial experiments and calculations, we will make materials available for students to test more configurations. All students will still get to participate fully in the scientific process and interpretation of results.**
	Part 2: Calculating erosion volumes using math (using previous worksheet) **For each case they tested, students will calculate the area of the sand removed from the "beach" using the different lines they draw on the side of their tubs. They can average the measurement from each side of the tub, and calculate a volume using the width.** **Students can also calculate the relative cost of different types of coastline protection vs. the economic impacts of erosion to get a sense of whether actions like restoring oyster reefs is financially beneficial.** **At the end of this section, students should present to their classmates about what they learned from testing different materials/seawalls**
	Part 3: Mapping coastal erosion (Zach is taking the lead on planning this) **Tools and Resources** Coastal Flood Exposure Mapping Lab

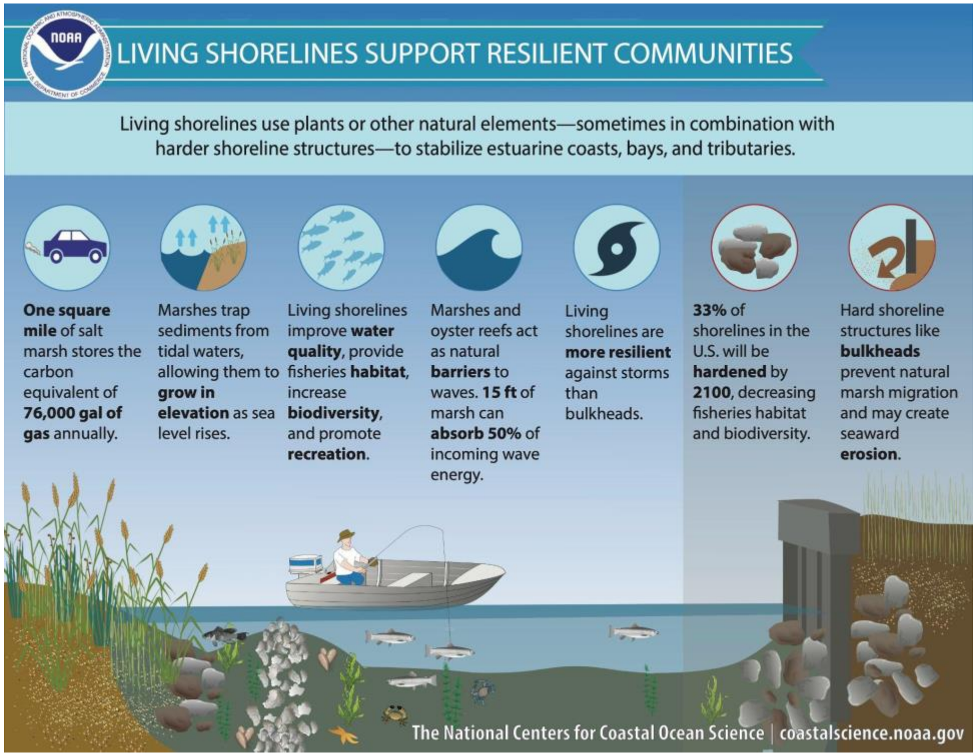
	We can tie back to oysters through the NOAA living shorelines framework and show how mapping/monitoring of coastal erosion and associated sea level rise works in Washington.
	Final task: Use Coastal Flood Exposure map to compare different regions. Using the layers we've explored (Coastal Hazards, Population Density, and Natural Protection), compare the flood risk of two different areas (like Des Moines, WA and Seattle, WA). A. Which area has more coastal hazards? B. Which area has a higher population near flood risk? C. Is there natural protection at both sites? D. Where might you recommend the implementation of a living shoreline or other types of natural protection?
VI. SCAFFOLDS Scaffolds are intended to be temporary supports that are removed when students no longer need them. For written activities, this may include providing recommended vocabulary to incorporate, sentence starters, or a response framework (such as "Claim-Evidence-Reasoning". For analyzing data, this may include prompts for how to start looking at the data and/or a set of increasingly complex questions for students to respond to (starting with very straightforward observations).	**We will probably want to provide some structure for how students present their results to their peers (to make sure that they can compare results between groups), as well as some structure for the final task.** **For the part of the lab activity where students are making calculations, we want to consider multiple levels of support. Some students may be comfortable carrying out calculations from beginning to end without guidance, whereas others may need more step-by-step support.** **The final section has students explore the NOAA Coastal Hazards Map. As it stands, students get to explore different features and layer. However, this could be restructured so that links to specific maps or screenshots are provided (particularly if access to computers is an obstacle) to allow students to do the same sorts of comparisons but with less computer-intensive time.**
VII. REFLECTION How will presenters gather information about the success of the lesson, reflect, and incorporate this into future versions of the lesson?	
IX. TOOLS/RESOURCES Student-facing tools (such as handouts, "Notecatchers", or worksheets), human resources such as experts or community members, teacher tools, equipment (please be as specific as possible to make sure that all resources required for the lesson are available), etc. If special materials are required, please be clear about who is responsible for providing them and/or how schools can acquire them.	**Basic materials for experiment:** - Plastic clip boards (one per group for making waves) - Sand - Before the activity, rinse and soak the sand in water in buckets. Students will then use pre-soaked sand to build the simulations. - Pebbles/rocks - Water

	- Oyster shells - Lego pieces - Large tupperware container (one per group) - Markers dry-erase (one pair of different colors per group) - Colored pencils (one pair of different colors per group) - Ruler (one per group) - Towels For Part 3 (Mapping Coastal Erosion), students will need access to computers to visit data portals.

3. Detailed lesson outline

<u>Hook details:</u>

Diagram: "Living Shorelines Support Resilient Communities"



(Based on the diagram)
What is a living shoreline?
What role do living shorelines play in coastal environments?

(For MHS students): What examples of this have we already learned about this year?

What are the threats to living shorelines?

(For MHS students): How do you think marine construction activities (i.e. pier construction) interact with living coastlines?

<u>Part 1 details:</u>
Overview:

In this activity, students will document shoreline erosion in a hands-on simulation. Students will test and measure how different types of barriers and seawalls change shoreline erosion.

This is adapted from Nature Lab Education Resources: https://www.nature.org/content/dam/tnc/nature/en/documents/nature-lab-lesson-plans/Wheres-The-Beach-TeacherGuide-NL.pdf

Materials:

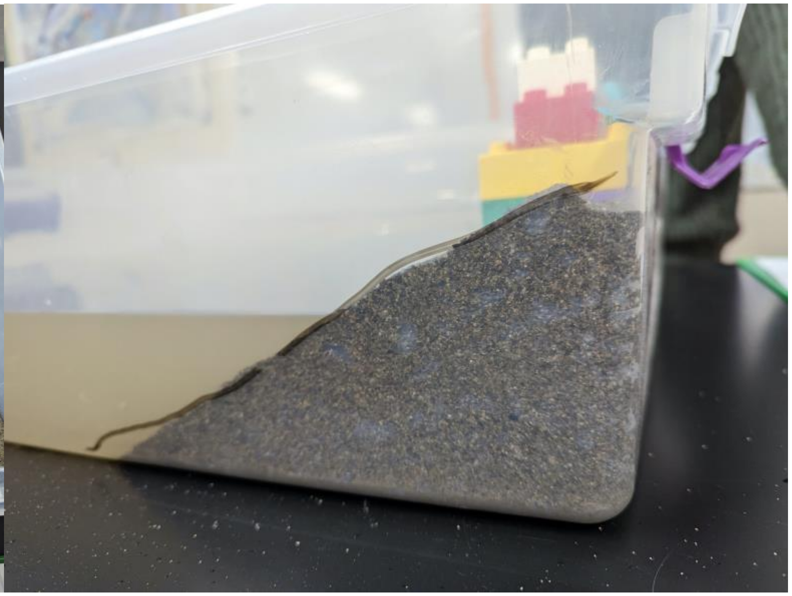
- (6) Plastic clip boards
- Sand
    - Before the activity, rinse and soak the sand in water in buckets. Students will then use pre-soaked sand to build the simulations.
- Pebbles/rocks
- Water
- Oyster shells
- Lego pieces
- (6) Large tupperware container
- (12) Markers dry-erase (6 pairs of different colors)
- (12) Colored pencils (6 pairs of different colors)
- (6) Ruler
- Towels

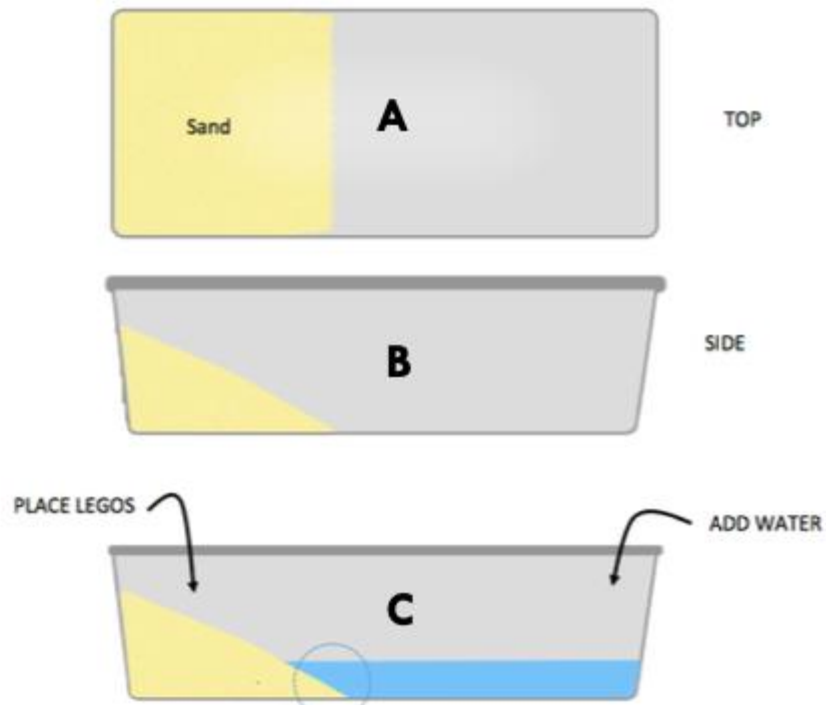
Procedure:

In this activity, there will be 6 groups of students. All students will run a simulation with no seawall. Half of the groups will then test an artificial barrier (rock wall) and a natural barrier (oyster reef). Students will record their observations and then share data between groups to examine which seawall structure best protects the shoreline.

1. **All Groups: Testing with no barrier**
    a. Construct a wave device using the image example below.
    b. Add sand to one end of the tub to come about half way up the side of the tub (see diagram).
    c. Add enough water to cover about ½-¾ the height of the beach.

d. Place Lego pieces to simulate buildings and shoreline structures on the sand.





Prepare wave materials

e. After your wave device and seawall is constructed, prepare materials for generating waves.
f. Mark your container to standardize the distance that you will move the clipboard to generate waves (see image below).
g. At the back of the container, mark a line with a dry-erase marker. Then measure 10 cm towards the beach and mark another line. You will move the paver between these two lines to generate waves.
h. During the simulation, you will move the clipboard from the back to the forward line 10 times to generate waves. Between each forward wave, pick the clipboard out of the water, place at the back line again, and repeat the wave generation. In other words, only move the clipboard forward to make a wave - don't move the clipboard back and forth.

Gather Data

i. Pre-measurements

i. Before generating waves, trace the outline of the sand with one color of dry erase marker
ii. Draw the shape of the sand and measure the length of all sides with the ruler in the worksheet.

j. Trial
   i. Have one person in the group generate waves using the marked lines on the container. Generate 10 waves.
   ii. Record observations while the waves are generated. What happened to the sand? What did you notice about the direction and force of the wave energy?

k. Post-measurements
   i. After the trial is completed, trace the new outline of the sand in a new color on both sides of the container. Draw the outline of the sand over your pre-measurement drawing in a new color. Measure the dimensions of the shapes with the ruler and record.
   ii. Trace the differences in the shapes from pre- and post-measurements.
   iii. Approximate the shape of this area. Is it a triangle? Rectangle?
   iv. Using dimensions in your drawing, estimate the area of sand that was moved during the trial on the worksheet. Calculate the average of measurements from both sides of the container.

2. **Groups 1, 2, & 3: Artificial barrier**
   a. Follow the steps above to reset your wave device to start a new trial.
   b. After the sand and water are set up in the bin, build a seawall using pebbles 3 cm in front of the beach.
   c. Fill mesh socks/pantyhose with rocks, this will form your seawall.
   d. Add the mesh sock with rocks to the container high enough to just touch the surface of the water.
   e. Trace the sand on both sides of the container.
   f. Generate 10 waves as you did in the first trial.
   g. After generating waves, trace the new outline of sand as you did in the last trial.
   h. Calculate the mean area of sand moved as an average of measurements from both sides of the container.

3. **Groups 4, 5, & 6: Natural barrier**
   a. Follow the steps above to reset your wave device to start a new trial.
   b. After the sand and water are set up in the bin, build an oyster reef using oyster shells 3 cm in front of the beach.
   c. Build an oyster reef that is high enough to just touch the surface of the water.
   d. Trace the sand on both sides of the container.
   e. Generate 10 waves as you did in the first trial.
   f. After generating waves, trace the new outline of sand as you did in the last trial.

    g. Calculate the mean area of sand moved as an average of measurements from both sides of the container.
4. Share the data with other groups and follow the discussion questions on the worksheet.

Other Resources
https://coseenow.net/mare/files/2012/04/Who-Moved-the-Beach.pdf
https://coseenow.net/mare/files/2012/04/Modeling-Beach-Erosion.pdf
https://seagrant.soest.hawaii.edu/north-shore-coastal-erosion/
https://www.thetech.org/sites/default/files/ta19_lesson_plan_ela.pdf
https://wacoastalnetwork.com/research-and-tools/slr-case-studies/

Part 2 details:

See lab handout for calculations.

Depending on the existing class culture and larger goals for the activity, sharing results could take a variety of forms, including mixing up groups so students can share their results with a small group of students who performed different experiments, posting all of the results on the boards for students to look at, and engaging in a class discussion about the different methods.

Part 3 details:

Final task details:

4. Outreach Checklist

- Communication with classroom teacher
    - Do you know what the teacher is expecting from this lesson?
    - Do you know what students have already done or will have done by the time this lesson happens?
    - Does the teacher know what you are planning to do?
    - Do you have a plan for gathering feedback from students and the teacher about how the lesson went?

- Materials
    - Do you have all the materials you need for this lesson?
        - If no, who is responsible for getting/providing the materials?
    - Who is responsible for transporting/setting up materials?
- What is your plan for making notes on/modifications to the lesson after you teach it?