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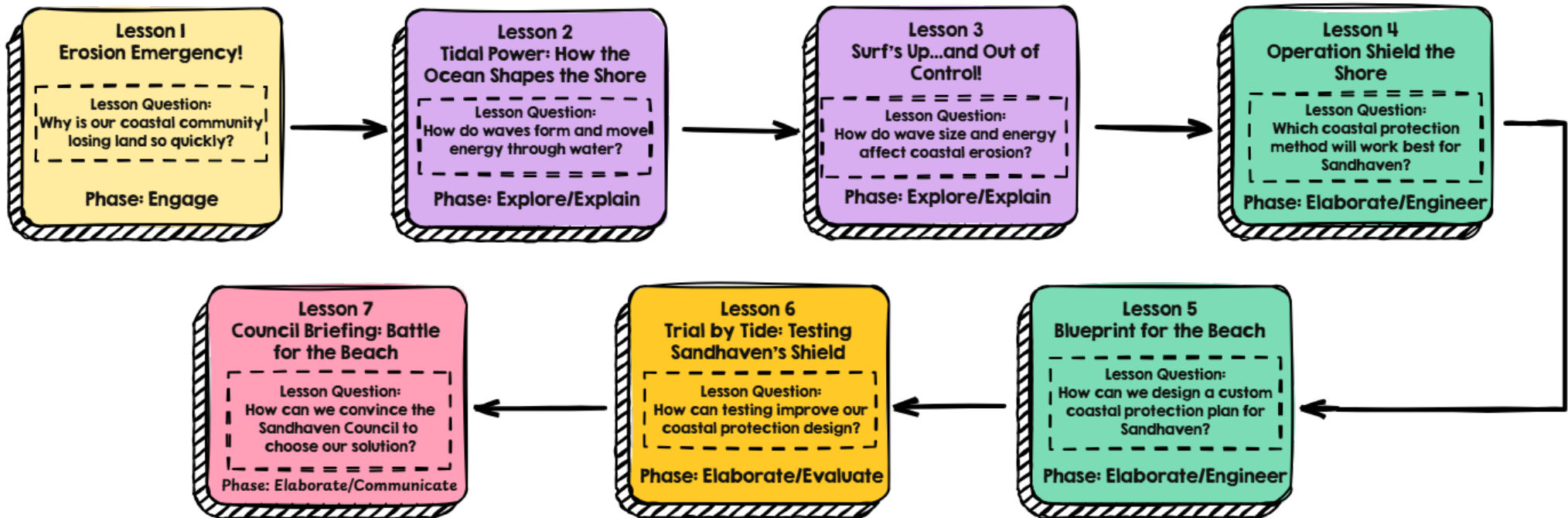
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## Battle for the Beach: Operation Shore Shield At-a-Glance

<b>Unit Essential Question:</b> How can we use our understanding of waves and coastal processes to protect a community from erosion?			
<b>Mission Length</b>	7 Lessons (~50 min each)	<b>Mission Deliverable:</b>	Present a custom coastal protection plan to the Sandhaven Town Council
<b>Mission Format:</b>	7 lessons: Phenomenon-driven, problem-based learning	<b>Core Skills:</b>	Data analysis, engineering design, CER writing, collaborative problem-solving
<b>Mission Audience:</b>	Middle School Science (Grades 6–8) Can be adapted to HS	<b>Assessment Types:</b>	Data tables, models, CER explanations, engineering proposals, and presentations
<b>NGSS Standards:</b> MS-ESS2-4, MS-ESS2-6, MS-PS4-1, MS-PS4-2, MS-ETS1-1, MS-ETS1-2			









# Lesson I - Erosion Emergency!

**Lesson Question:** Why is our coastal community losing land so quickly?

**Phase:** Introduction/Engage

**Student Facing**

**Teacher Facing**

Phenomenon / Problem	Setup & Timing
 <p><i>Image: University of California, Irvine (2023)</i></p> <p>Residents of the fictional town of Sandhaven report that the shoreline has moved back several meters over the past year, damaging homes, roads, and wildlife habitats.</p>	<ul style="list-style-type: none"> <li>• Display before/after coastline images or short video (5 min)</li> </ul>  <p><i>Video: Behind the News — Coastal Erosion</i></p> <ul style="list-style-type: none"> <li>• Whole-class See/Think/Wonder discussion (10–15 min)</li> <li>• Begin Driving Question Board with student ideas/questions (10 min)</li> </ul>
How Students Will Engage	Materials
<ul style="list-style-type: none"> <li> Watch: Time-lapse of coastal erosion during storms</li> <li> Discuss: 'What do you notice? What do you wonder?'</li> <li> Record: Add questions to the Driving Question Board about erosion causes and prevention.</li> <li> Brainstorm: How waves might be involved in the problem.</li> </ul>	<ul style="list-style-type: none"> <li>• Before/after coastline images or video clips</li> <li>• Chart paper or digital DQB tool</li> <li>• Markers or sticky notes for student contributions</li> <li>• <a href="#">Example Padlet DBQ Board</a></li> </ul>



## What We Do & Figure Out

We examine real-world examples of erosion in coastal communities. We figure out:

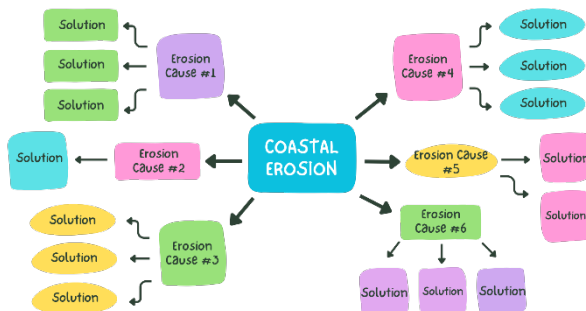
- Waves can carry sand away from the shoreline, causing it to recede.
  - Storms and high-energy waves speed up erosion.
- This problem affects people, property, and ecosystems.
- We need to understand waves to protect our coast.

## Differentiation

- Provide vocabulary cards for key terms (erosion, shoreline, habitat)
- Allow students to draw their 'notice/wonder' responses
- Pair English or struggling learners with peer buddies for discussion

## How We Represent It

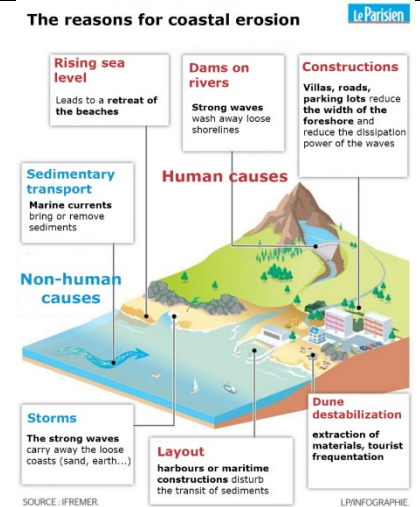
- Driving Question Board entries
- Class brainstorm map linking erosion causes to potential solutions



## Misconceptions to Watch For

- Thinking erosion only happens during storms (it can occur gradually)
- Believing erosion is only a natural process and cannot be influenced by human activity

Photo: Searial Cleaners – Coastal erosion (n.d.)



## Navigation to Next Lesson

We now know that erosion is linked to waves, but we need to understand wave behavior to figure out how to protect the coast.

## Assessment Opportunities

- Listen for student ideas that connect waves to erosion
- Review DQB for accuracy and variety of questions



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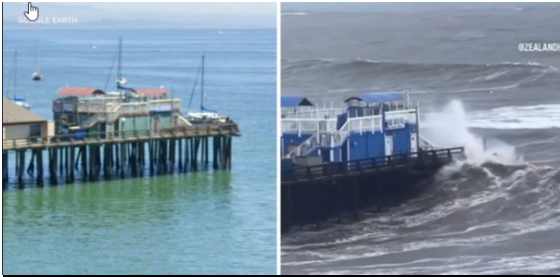




## Lesson 2 - Tidal Power: How the Ocean Shapes the Shore

**Lesson Question:** How can we describe and measure ocean waves?

**Phase:** Explore/Explain

### Student Facing

### Teacher Facing

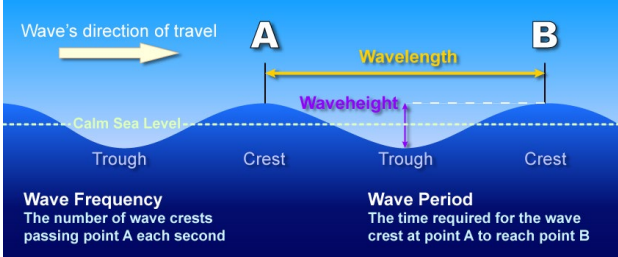
Phenomenon / Problem	Setup & Timing
 <p>Video still: ABC7 News – Santa Cruz flooding causes storm damage, impacts Capitola Pier (2023)</p> <p>To protect Sandhaven, we need to understand the size, speed, and energy of the waves hitting the shore.</p>	<ul style="list-style-type: none"> <li>• Show types of waves video (3–5 min) <ul style="list-style-type: none"> <li>○ <a href="#">How Do Ocean Waves Work?</a></li> <li>○ <a href="#">Types of Waves: Constructive &amp; Destructive</a></li> <li>○ <a href="#">All About Swash and Backwash</a></li> </ul> </li> <li>• Discuss: “What might make one wave more destructive than another?” (10 min)</li> <li>• Introduce wave properties and vocabulary (10 min)</li> <li>• Begin hands-on wave measurement class activity (20–25 min)</li> </ul>
How Students Will Engage	Materials
<ul style="list-style-type: none"> <li> Hands-on: Use a ripple tank or a classroom wave tank to generate waves</li> <li> Measure: Amplitude, wavelength, frequency, and speed</li> <li> Discuss: How might these properties affect erosion? <ul style="list-style-type: none"> <li> Record: Data in a shared class table</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Rulers, timers, and markers for measurement</li> <li>• Data recording sheets or a digital spreadsheet</li> <li>• Paddle or board to generate waves</li> <li>• Cork or floating object to visualize wave movement</li> <li>• Large container for wave tank (ex, fish tank)</li> <li>• Projector or screen for wave property diagrams/videos</li> </ul>



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What We Do & Figure Out	Differentiation
<p>We investigate how to accurately describe and measure waves.</p> <p>We figure out:</p> <ul style="list-style-type: none"> <li>Waves have measurable properties: amplitude, wavelength, frequency, and speed.</li> <li>Larger amplitude and higher frequency waves usually carry more energy.</li> <li>The energy in waves can explain why some cause more erosion than others.</li> </ul> <p>This builds on Lesson 1, where we saw erosion linked to wave action.</p>	<ul style="list-style-type: none"> <li>Provide labeled <a href="#">wave diagrams</a> for visual learners</li> </ul>  <p><i>Image courtesy of NOAA/NWS JetStream – Online Weather School.</i></p> <ul style="list-style-type: none"> <li>Offer sentence starters for explaining wave properties</li> <li>Pair students strategically for measurement tasks</li> <li>Allow use of <a href="#">digital wave simulations</a> for students who struggle with manual measurement</li> </ul>
How We Represent It	Misconceptions to Watch For
<ul style="list-style-type: none"> <li>Data tables of wave measurements</li> <li>Graphs comparing amplitude, frequency, and speed</li> <li>Annotated diagrams of wave parts</li> </ul>	<ul style="list-style-type: none"> <li>Confusing wave speed with water movement</li> <li>Thinking all large waves carry the same energy regardless of frequency</li> </ul>
↓ Navigation to Next Lesson	Assessment Opportunities
<p>We now know how to measure and describe waves. Next, we will explore how waves transfer their energy to the shore and structures.</p>	<ul style="list-style-type: none"> <li>Check the accuracy of measurements in data tables</li> <li>Listen for correct use of wave vocabulary during discussion</li> <li>Review graphs for correct labeling and scaling</li> </ul>




## Lesson 3 - Surf's Up... and Out of Control!

**Lesson Question:** How do wave size and energy affect coastal erosion?

**Phase:** Explore / Explain

### Student Facing

### Teacher Facing

Phenomenon / Problem	Setup & Timing
 <p><i>Photo: Ping Wang, University of South Florida, showing Pinellas County beaches before and after Hurricane Idalia (2023)</i></p> <p>After a powerful storm, Sandhaven's beach seems to "disappear" overnight. Locals report huge waves crashing over the pier and flooding streets. Students are shown before/after shoreline images or a short time-lapse clip.</p>	<ul style="list-style-type: none"> <li>• Show before/after <a href="#">images</a> or <a href="#">time-lapse footage</a> of a local or famous beach impacted by a major storm (ex, Hurricane Idalia) (5 min)</li> <li>• Facilitate a See-Think-Wonder discussion on differences between storm-day and calm-day waves. (10 min)</li> <li>• Introduce the guiding question: How does wave size change the amount of erosion? (5 min)</li> </ul>
How Students Will Engage	Materials
<ul style="list-style-type: none"> <li>📄 Watch: Storm vs. calm-day wave footage</li> <li>💬 Discuss: What's different about these waves? How might size/energy affect erosion?</li> <li>🔬 Investigate: Model waves with a wave tank or a simulation to compare calm vs. storm conditions</li> <li>📊 Record: Note wave height/frequency and visible erosion effects</li> </ul>	<ul style="list-style-type: none"> <li>• Storm wave footage or before/after photos (Ping Wang, USF/WFLA)</li> <li>• Wave tank setup (tray of sand, water, board for wave-making) or <a href="#">PhET Wave on a String</a> simulation</li> <li>• Rulers, stopwatches, markers</li> <li>• Data recording sheets or lab notebooks</li> </ul>



<b>What We Do &amp; Figure Out</b>	<b>Differentiation</b>
<ul style="list-style-type: none"> <li>• Bigger waves carry more energy and move more sand</li> <li>• Higher frequency (more waves per time) can speed up erosion</li> <li>• Storms increase wave energy, leading to faster shoreline change</li> </ul>	<ul style="list-style-type: none"> <li>• Provide diagram labels for wave height, wavelength, and frequency.</li> <li>• Offer simplified data tables for students who need scaffolding.               <ul style="list-style-type: none"> <li>○ See example</li> </ul> </li> <li>• Allow alternative evidence recording methods (drawings, photos, captions).</li> <li>• Pair ELL students with a peer for discussion before sharing with the class.</li> </ul>
<b>How We Represent It</b>	<b>Misconceptions to Watch For</b>
<ul style="list-style-type: none"> <li>• Side-by-side charts/diagrams of calm vs. storm erosion</li> <li>• Annotated wave sketches showing height, wavelength, and frequency</li> <li>• New questions added to the Driving Question Board</li> </ul>	<ul style="list-style-type: none"> <li>• Thinking only wave height matters for erosion; frequency and duration are also key.</li> <li>• Believing erosion only occurs during storms, it can happen gradually.</li> </ul>
<b>↓ Navigation to Next Lesson</b>	<b>Assessment Opportunities</b>
<p>Now that we know how wave energy affects erosion, we'll evaluate real protection options for Sandhaven in the next lesson.</p>	<ul style="list-style-type: none"> <li>• Review data tables for correct measurements and terminology.</li> <li>• Listen for students connecting wave size and energy to erosion during group discussions.</li> <li>• Exit ticket prompt: Explain how wave size and frequency affect erosion rates.</li> </ul>




## Lesson 4 - Operation Shield the Shore

**Lesson Question:** Which coastal protection method will work best for Sandhaven?

**Phase:** Elaborate / Engineer

### Student Facing

### Teacher Facing

Phenomenon / Problem	Setup & Timing
 <p><i>Photo courtesy of EZ Doze It, from Seawalls.</i></p> <p>The Sandhaven town council is reviewing three designs to slow erosion: a seawall, a breakwater, and a dune restoration plan. Each has a price tag, potential benefits, and environmental trade-offs. Residents are divided over which to choose.</p>	<ul style="list-style-type: none"> <li>• Display before/after photos of towns using seawalls, breakwaters, and dune restoration. (5 min) <ul style="list-style-type: none"> <li>◦ <a href="#">Dune Doctors</a></li> </ul> </li> <li>• Give a brief, neutral overview of each method without stating a “best” choice.</li> <li>• Facilitate Think–Pair–Share on possible benefits and drawbacks. (10 min)</li> <li>• Introduce guiding question: Which method will work best for Sandhaven? (5 min)</li> </ul>
How Students Will Engage	Materials
<ul style="list-style-type: none"> <li>🔍 <b>Examine:</b> Photos, diagrams, and short videos showing each method in action.</li> <li>💬 <b>Discuss:</b> Pros and cons for people, property, and ecosystems.</li> <li>📊 <b>Analyze:</b> Compare cost, durability, and environmental impact of each method.</li> <li>✂️ <b>Decide:</b> Recommend one option for Sandhaven and justify the choice.</li> </ul>	<ul style="list-style-type: none"> <li>• Photos, diagrams, and short video clips for each method</li> <li>• Fact sheets or slide deck with cost, lifespan, maintenance, and <a href="#">environmental impact</a></li> <li>• Student comparison chart template</li> <li>• Sticky notes or color-coded markers for pros/cons</li> </ul>



<b>What We Do &amp; Figure Out</b>	<b>Differentiation</b>
<ul style="list-style-type: none"> <li>Coastal protection methods work in different ways and have different trade-offs.</li> <li>Choosing a method requires balancing human needs, costs, and environmental effects.               <ul style="list-style-type: none"> <li>Engineering solutions must be matched to local conditions to be effective.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Provide pre-filled quantitative data (cost, lifespan) so focus stays on qualitative analysis.</li> <li>Use visual icons for categories (💰 cost, 🌿 environment, 🏠 property) to support ELLs and visual learners.</li> <li>Give sentence starters for written justification: “I recommend ___ because...”</li> <li>Allow oral explanations or group presentations instead of only written work.</li> </ul>
<b>How We Represent It</b>	<b>Misconceptions to Watch For</b>
<ul style="list-style-type: none"> <li>Comparison chart of seawall, breakwater, and dune restoration.</li> <li>Annotated diagrams showing how each method affects waves and erosion.</li> <li>Updated Driving Question Board with new solution-focused questions.</li> </ul>	<ul style="list-style-type: none"> <li>Thinking one method is universally best for all locations.</li> <li>Believing “bigger” structures are always more effective.</li> <li>Overlooking that environmental impacts can be positive, not just negative.</li> </ul>
<b>Navigation to Next Lesson</b>	<b>Assessment Opportunities</b>
<p>Now that we’ve evaluated protection options, we’ll combine our wave knowledge and design skills to create our own custom erosion solution for Sandhaven.</p>	<ul style="list-style-type: none"> <li>Review comparison charts for evidence-based pros and cons.</li> <li>Listen for correct use of wave, erosion, and engineering vocabulary.</li> <li>Collect or observe short justifications explaining their chosen method and reasoning.</li> </ul>



# Teacher Guide - Tidal Power: How the Ocean Shapes the Shore

## Goal

Help students observe, record, and interpret the measurable properties of waves so they can connect those properties to wave energy and the potential for coastal erosion.

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## Materials

- Wave tank with water
  - Paddle or board for generating waves
  - Ruler/tape measure taped to the inside of the tank for amplitude/wavelength
  - Stopwatch for frequency measurements
  - Cork or another floating object in the water to help visualize the movement of the waves
  - Project data table on board for class to fill in together
  - Student activity sheets
  - CER checklist poster or anchor page for each student for reference
- 

## Procedure

1. Introduce each wave property (see list below) and point them out on a diagram or short video.
    - a. examples: [diagram](#) or [short video](#)
  2. Generate Trial 1 waves at low amplitude and frequency; have students measure.
  3. Repeat for Trials 2 and 3 with different amplitude/frequency combinations.
  4. Record data in the projected table as students call out measurements.
  5. Work together as a class to calculate the wave speed for each wave and discuss the results in groups, then as a class.
    - a. Wave speed = wavelength x frequency
- 



## Wave Properties Vocabulary

- **Amplitude:** height from rest to crest
- **Wavelength:** distance between crests
- **Frequency:** waves per second (Hz)
- **Wave Speed:** how fast the wave travels (speed = wavelength × frequency)
- **Crest:** highest point of a wave
- **Trough:** lowest point of a wave

## Engagement Tips

- Assign specific measurement calls to student volunteers (e.g., ‘frequency counter,’ ‘amplitude spotter’).
- Keep wave types clearly different for each trial to help students see the pattern.
- Ask prediction questions before each trial

## Assessment Tips

- Listen for correct use of terms in student observations.
- Check that students can identify the relationship between amplitude/frequency and energy.

## Sample Class Data Table

Trial	Amplitude (cm)	Wavelength (cm)	Frequency (Hz)	Speed (cm/s)	Observations
1	4 cm	20 cm	0.5 Hz	10 cm/s	Small, slow waves
2	6 cm	25 cm	0.7 Hz	17.5 cm/s	Medium waves, moderate/medium speed
3	8 cm	24 cm	0.9 Hz	21.6 cm/s	Large, fast waves, with the highest energy



## Group/Class Discussion Questions

- Which trial's waves looked the most powerful? What did you notice?
  - How did amplitude change between trials? How did frequency change?
  - Which wave property seemed to have the biggest effect on wave speed?
  - How could these wave properties affect erosion in Sandhaven?
  - Do you think larger waves always cause more erosion? Why or why not?
- 

## Sample Response: Claim-Evidence-Reasoning (CER)

**Essential Question:** How did the wave properties in each trial affect the amount of energy carried to the shore?

### **Claim:**

The wave properties in each trial changed the amount of energy carried to the shore, with Trial 3 carrying the most energy.

### **Evidence:**

In Trial 1, the waves had a small amplitude and low frequency, so the wave speed was slow. In Trial 2, both the amplitude and frequency increased, which increased the wave speed. In Trial 3, the amplitude was 8 cm, and the frequency was 0.9 Hz, resulting in the fastest wave speed of 21.6 cm/s. Trial 3 had higher measurements than Trials 1 and 2.

### **Reasoning:**

As amplitude increases, waves move more water up and down, which increases energy. As frequency increases, more waves reach the shore each second, adding more energy. Because each trial had different wave properties, each trial carried a different amount of energy to the shore. Trial 3 had the highest amplitude and frequency, so it carried the most energy and could cause the most erosion in Sandhaven.

## Feedback Notes

This CER is strong because:

The **claim** directly answers the question in one sentence. The **evidence** includes precise measurements from the data table (amplitude, frequency, speed). The **reasoning** explains the science behind the evidence and links it to erosion in Sandhaven. Finally, the wave vocabulary is used correctly and in context.



 **Teacher Tip:** 

Use this as a model to show students exactly what a complete CER should look like. Highlight the transition from evidence to reasoning. For comparison purposes, it would also be helpful to include an incomplete CER response and correct it together as a class, allowing them to practice improving CER responses.

 **Partial Response: CER For Feedback Practice** **Claim:**

The third trial had the most energy because the waves were bigger.

**Evidence:**

The waves looked taller in Trial 3.

**Reasoning:**

Bigger waves mean more erosion.

 **Feedback Notes** 

The student gave a reasonable claim, but the evidence is too vague (no measurements). Their reasoning is incomplete; they should explain how amplitude and frequency together affect energy and connect it clearly to erosion.

---

 **What Questions Do You Still Have? - Example Student DBQ Entries** 

Here are some examples of questions a student might have at the end of the lesson to add to the class DBQ:

- If bigger and faster waves cause more erosion, how can coastal towns slow them down before they reach the shore?
- Do waves in deeper water have the same energy as waves near the shore?
- What causes some waves to be taller than others?
- Do animals or plants in the ocean affect the size or speed of waves?
- How does the wind change the shape and speed of waves?
- Can we build something that changes wave speed without hurting the beach?



# How to Write Effective CER STATEMENTS

## CLAIM



Your claim is your answer to a question.

**Check that your CLAIM...**

- Clearly answers the question in one sentence.
- Uses precise, topic-specific vocabulary.
- Avoids starting with "I think" or "I believe."
- Is specific and testable.

## EVIDENCE



Facts, data, observations that support your claim

**Check that your EVIDENCE...**

- Includes 2-3 strong pieces of evidence from the data, text, lab, or observations.
- Makes sure evidence directly supports your claim.
- Uses numbers, facts, or examples, not opinions.

## REASONING



Explains why the evidence supports the claim using science concepts.

**Check that your REASONING..**

- Explains why the evidence supports the claim.
- Makes sure evidence directly supports your claim.
- Uses numbers, facts, or examples, not opinions.



## THE ULTIMATE CER TEST

Read your CER statement like a stranger. Pretend you've never seen the question before. Would your CER still make sense? If not, revise until it does.



# CER SENTENCE STARTERS

Here are some helpful phrases you can use to begin each part of your Claim, Evidence, and Reasoning statements. They give you a starting point so you can focus on your ideas instead of struggling with how to begin. Use them to guide your writing, make your answers clear, and connect your thinking to scientific concepts. As you grow more confident, try the **LEVEL UP** options to make your explanations even stronger.

## CLAIM:

Your answer to the question

The data shows that...

The best explanation is...

The evidence supports the idea that...

Based on the results, I conclude...

## LEVEL UP:

A logical interpretation of the findings is that...

## EVIDENCE:

Facts, data, or observations that support your claim

According to the data...

From the investigation, I observed that...

The results in Table \_\_\_ show that...

One piece of evidence is...

The experiment demonstrated that...

## LEVEL UP:

The quantitative data indicates that...

## REASONING

Explains why the evidence supports the claim using science concepts

This evidence is important because...

This supports the claim since...

This happens because...

According to the science concept of \_\_\_ ...

The data connects to the claim because...

This pattern supports the conclusion that...

## LEVEL UP:

Applying the principle of \_\_\_\_\_, the evidence demonstrates that...



### Wave Size and Erosion Data Table

Trial	Wave Type (circle one)	Wave Height (cm)	Wavelength (cm)	Frequency (waves/min)	Energy Level (Circle One)	Observed Erosion Effect
1	Calm Moderate Storm				Low Medium High	
2	Calm Moderate Storm				Low Medium High	
3	Calm Moderate Storm				Low Medium High	

### Wave Size and Erosion Data Table (Scaffolded)

Trial	Wave Type (circle one)	Wave Height (cm) Measure with ruler	Wavelength (cm) Measure with ruler	Frequency (waves/min) Measure with a stopwatch	Energy Level (Circle One)	Observed Erosion Effect (Choose or Write Your Own)
1	Calm Moderate Storm	cm	cm	waves/min	Low Medium High	No change / Small movement / Large movement / -----
2	Calm Moderate Storm	cm	cm	waves/min	Low Medium High	No change / Small movement / Large movement / -----
3	Calm Moderate Storm	cm	cm	waves/min	Low Medium High	No change / Small movement / Large movement / -----



# Operation Shield the Shore

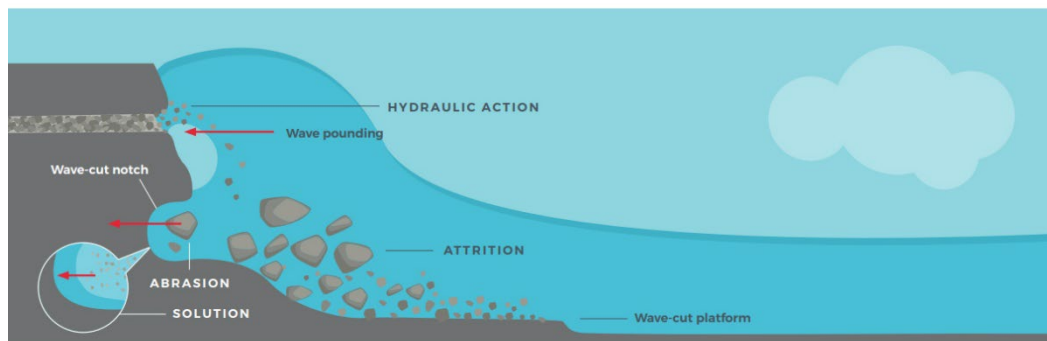
## Goal

Today, we will compare three coastal protection methods – seawalls, breakwaters, and dune restoration – to decide which will best protect Sandhaven’s shoreline. You will weigh the cost, lifespan, and environmental impacts of each option and recommend the best solution to the Sandhaven Council.

## Coastal Erosion Vocabulary

- Hydraulic Action: Waves crash onto the beach and push water and air into gaps between sand and rocks. The pressure loosens and moves material.
- Abrasion: Sand, pebbles, and shells carried by waves scrape and grind the beach surface, wearing it away.
- Attrition: Pebbles, shells, and rocks roll and smash into each other in the surf, breaking into smaller, smoother pieces.
- Solution: Seawater acids dissolve certain types of rock, like chalk or limestone.

## COASTAL EROSION



## Activity Instructions

1. Review the fact sheets on seawalls, breakwaters, and dune restoration.
2. Fill in the Coastal Protection Comparison Chart with pros/cons, cost, lifespan, and environmental impacts.
3. Discuss in your group: Which method would you choose for Sandhaven? Why?
4. Use your completed chart and notes to write a CER explaining your choice.



 **Group/Class Discussion Questions** 

- Which method seems best for protecting property?
  - Which method has the least environmental impact?
  - Which method gives the best long-term value for Sandhaven?
  - Could combining methods be better than using only one? Why or why not?
- 

 **Claim-Evidence-Reasoning (CER)** 

**Essential Question:** Which coastal protection method will work best for Sandhaven?

**Claim:**

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**Evidence:**

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**Reasoning:**

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 **What Questions Do You Still Have?** 

Write at least one question you're still wondering about:








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## **Coastal Protection Comparison Chart**

Method	<b>Cost</b> 	<b>Lifespan (Years)</b> 	<b>Maintenance</b> 	<b>Wave Impact</b> 	<b>Environmental Impact</b> 	<b>Benefits</b> 	<b>Drawbacks</b> 
Seawall							
Breakwater							
Dune Restoration							



## Coastal Protection Comparison Chart

**Note:** Some of this table is filled out for you, while others contain an *italicized* question to help you focus your attention.

Method	Cost 	Lifespan (Years) 	Maintenance 	Wave Impact 	Environmental Impact 	Benefits 	Drawbacks 
Seawall	High upfront cost	<i>How many years can it last before it needs major repairs?</i>	<i>What type of upkeep is needed after major storms?</i>	Reflects waves back to sea	<i>Does it affect erosion in front of or nearby?</i>	<i>What is its biggest advantage for property?</i>	<i>What is one major downside?</i>
Breakwater	Medium cost	<i>How long does it typically last?</i>	<i>What type of upkeep is needed?</i>	<i>Does it reduce wave energy before shore?</i>	Can change sediment patterns	<i>What's a benefit for harbors or beaches?</i>	<i>What negative effect might happen down the coast?</i>
Dune Restoration	Low cost	<i>How long will it last without replanting?</i>	Requires replanting	Absorbs wave energy naturally	<i>How does it help wildlife or ecosystems?</i>	<i>What's one aesthetic or ecological benefit?</i>	<i>Why does it need frequent upkeep?</i>

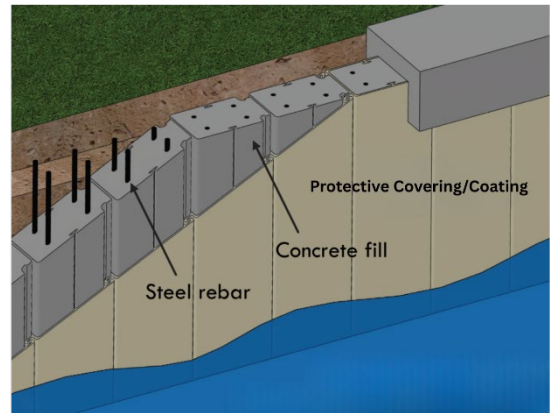


# Fact Sheet - Seawalls

Seawalls are tall, solid structures built along the shoreline to protect land and property from powerful waves. They are usually made of concrete, stone, steel, or other strong materials. Some seawalls are vertical, while others are sloped to reduce the force of the waves.



*Photo courtesy of David Hubbard via Nexus Media News.*



*Photo courtesy of Truline Coastal Engineering from Engineering Solutions*

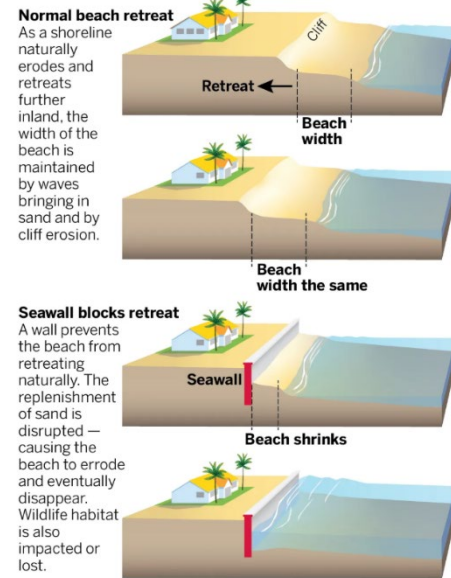
Their main purpose is to stop waves from reaching the land by blocking and reflecting wave energy back into the ocean. Seawalls are one of the strongest and most effective forms of coastal protection, but they are also one of the most expensive to build. Construction can cost millions of dollars, especially along long sections of coast. A well-built seawall can last 40 to 50 years with regular maintenance.

However, storms and constant wave action can cause cracks, holes, or damage over time, requiring repairs. Seawalls block and reflect wave energy, which protects the land behind them, but this can cause erosion right in front of the wall, a process called *scouring*. They can also disrupt natural sand movement and may increase erosion in nearby unprotected areas. While seawalls provide strong, immediate defense for property, they can be costly and sometimes worsen erosion on neighboring beaches.

*Photo courtesy of California Coastal Commission.*

### SEAWALLS CAN THREATEN BEACHES

Manmade seawalls are seen as protection from the ocean, but they can decrease or destroy beaches. Here's how:



Source: Calif. Coastal Commission PAI/BAY AREA NEWS GROUP



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## Fact Sheet - Breakwaters

Breakwaters are barriers built offshore to reduce wave energy before it reaches the beach. They can be constructed from large rocks, concrete blocks, or other heavy materials and are usually placed parallel to or at an angle from the shore.



**Shore-Connected Breakwater**



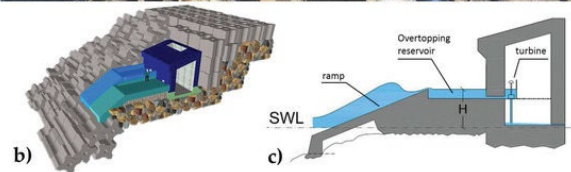
**Offshore Breakwater**



**Rubble Mound Breakwater**

*Photo courtesy of Science ABC – Breakwater example. From How Do Breakwaters Protect the Shoreline?*

By breaking up wave energy early, breakwaters create calmer water between the barrier and the coast. This quieter area can protect beaches, harbors, and coastal buildings from wave damage. Breakwaters have a medium cost, less expensive than seawalls but more costly than dune restoration, because they still require heavy materials and significant construction work, especially if built far from shore. Their lifespan is usually around 20 to 30 years before major repairs are needed. Maintenance involves monitoring for rocks or blocks that have shifted due to storms or strong waves, and replacing or reinforcing sections as needed. Breakwaters reduce wave energy and can even help sand build up on the protected side, but they may change currents and sand movement. This can sometimes cause erosion further down the coast or alter the shape of nearby beaches. In recent years, new breakwater models have been developed that not only protect the shore but also capture the energy of incoming waves and convert it into electricity, offering a potential source of clean, renewable power for coastal communities. Photo courtesy of MDPI (Sustainability, 2016). While they can be very effective in protecting certain areas, breakwaters must be carefully designed to avoid harming marine habitats or creating new erosion problems elsewhere.

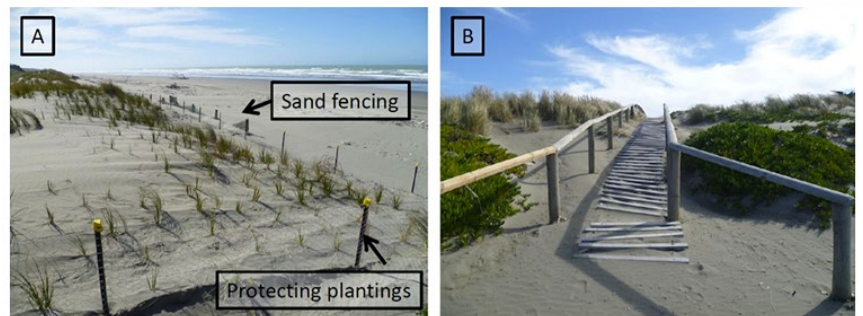


# Fact Sheet - Dune Restoration

Dune restoration focuses on building up or repairing sand dunes along the coast so they can serve as a natural barrier against waves and flooding. This process may include moving sand into place, planting dune grasses, and installing fencing to trap more sand.



*Photo courtesy of Dune Doctors*



*Photos by Emma Kelland, via Wikimedia Commons. Found on Penn State Earth 107 course website.*

Healthy dunes help absorb wave energy and reduce flooding in inland areas during storms. Dune restoration is generally the least expensive method of coastal protection, but the lower upfront cost comes with a trade-off: it requires frequent upkeep. Without



*Photo courtesy of U.S. Geological Survey - Dunes Before and After Hurricane Matthew (Public Domain)*

maintenance, dunes can erode in just 5 to 10 years, especially after major storms. With consistent care, including replanting grasses and repairing damaged sections, dunes can last much longer. Fences or walkways may be needed to prevent people from walking on the plants that stabilize the sand.

Dunes not only provide protection but also create habitats for birds, insects, and other wildlife. They help preserve the natural beauty of the coast, which benefits tourism. However, dunes offer less protection during very large storms than hard structures like seawalls, and they require frequent maintenance to remain effective.



## Photo and Media Credits

### Lesson 1 – Coastal Community in Peril

- Behind the News – *Coastal Erosion* [Video]. <https://youtu.be/rdvFWD2llwA>
- NOAA – Anatomy of a Wave diagram. From NOAA Jetstream.
- NOAA – Coastal erosion image.
- Searial Cleaners – Coastal erosion image. From *Coastal Erosion* webpage. <https://searial-cleaners.com/coastal-erosion/>
- University of California, Irvine – Before/after coastline images. From *California's Beaches Are Eroding – Here's How to Save Them* (2023). <https://engineering.uci.edu/news/2023/6/californias-beaches-are-eroding-heres-how-save-them>

### Lesson 2 – Tidal Power: How the Ocean Shapes the Shore

- ABC7 News – *Santa Cruz flooding causes storm damage, impacts Capitola Pier* (2023) [Video still]. <https://youtu.be/f4Q-3GwfqRI>
- CNN – *Hurricane Florence causes storm surge and coastal flooding* (2018) [Video]. [https://youtu.be/0\\_ICCvIMXfE](https://youtu.be/0_ICCvIMXfE)
- Nat Geo – *Big wave surfers take on monster swells at Jaws* (2016) [Video]. [https://youtu.be/\\_LRc6k-clzE](https://youtu.be/_LRc6k-clzE)
- NOAA – *Anatomy of a Wave* diagram. From NOAA Jetstream. <https://www.noaa.gov/jetstream/ocean/waves/jetstream-max-anatomy-of-wave>
- Peekaboo Kidz – *Waves – The Dr Binocs Show | Educational Videos For Kids* (2018) [Video]. <https://youtu.be/neZMypLU3Nw>
- PhET Interactive Simulations – *Wave on a String* simulation. University of Colorado Boulder. <https://phet.colorado.edu/en/simulation/wave-on-a-string>



### Lesson 3 – Wild Waves: Battle at the Shore

- FOX 35 Orlando – *Huge Waves in California During Storm* (2023) [Video]. [https://youtube.com/shorts/8zOmac47KVc?si=FDmtn6YjaWfSwR\\_h](https://youtube.com/shorts/8zOmac47KVc?si=FDmtn6YjaWfSwR_h)
- PhET Interactive Simulations – *Wave on a String* simulation. University of Colorado Boulder. <https://phet.colorado.edu/en/simulation/wave-on-a-string>
- Ping Wang / University of South Florida – Pinellas County beaches before and after Hurricane Idalia. Via *WFLA News Channel 8*. <https://www.wfla.com/news/pinellas-county/photos-pinellas-county-beaches-before-and-after-hurricane-idalia/>

### Lesson 4 – Shield the Shore

- California Coastal Commission – Coastal protection image. Via *Surfing Waves Forum*. <https://surfing-waves.com/forum/viewtopic.php?f=6&t=41947>
- David Hubbard – Seawall at Arroyo Quemado Beach, California. Via *Nexus Media News*. <https://nexusmedianews.com/sea-walls-california-erosion/>
- Dune Doctors – Still image taken from video on *Dune Doctors* website. <https://dunedoctors.com/>
- Emma Kelland / Wikimedia Commons – *Spencer Park* and *Spencer Park 2*. CC BY-SA 3.0. Found on Penn State *Earth 107: Coastal Processes, Hazards, and Society* course website. <https://www.e-education.psu.edu/earth107/node/1072>
- EZ Doze It – Seawall example. From *Seawalls* webpage. <https://ezdozeit.com/seawalls/>
- MDPI – Coastal protection image. From *Sustainability* (2016). <https://doi.org/10.3390/su8121226>
- NOAA Habitat Blueprint – *Living Shorelines* webpage. <https://www.habitatblueprint.noaa.gov/living-shorelines/>
- NST Travel Group / BBC Bitesize – Coastal processes diagram. <https://www.nstgroup.co.uk>

