Waves: The Arms of the Sea

ABSTRACT

Students work with models to explore ocean waves. They identify several different environmental actions that cause ocean waves including wind, underwater earthquakes and glacier melt. Students recognize the importance of waves in colonizing the Hawaiian Islands and the role waves play in shaping coastlines of the islands.

BACKGROUND INFORMATION FOR TEACHERS

Waves are an important feature of our island home. We relax by the sound of their rhythmic crashing, we surf and play in their breaks, and they help to produce and move the sand that cushions our coastlines. Small or large, they can be mesmerizing to watch. Although not often addressed in Earth system science curricula, ocean waves offer an engaging opportunity for students to examine how the hydrosphere, atmosphere, geosphere, and biosphere interact.

Ocean waves we come to expect on a normal trip to the beach are caused by wind, or changes in the atmosphere. The hydrosphere and atmosphere are interacting. These surface waves caused by wind, move in a circular motion and do not propel objects forward. The frequency and size of these waves are directly affected by the strength and speed of the wind. However, large tsunami waves are created by interaction between the geosphere and hydrosphere (e.g. underwater earthquakes or landslides). These giants are not your typical boogie boarding waves. These waves cause a surging rise in total sea level that is dangerous and destructive. The Ocean Explorer website by National Oceanic and Atmospheric Administration (NOAA) helps us to understand more about the origin of ocean waves:

Waves shape the Hawaiian Islands. As established in the previous lesson, “Hitchin a Ride to Paradise”, waves played a role in colonizing the islands with new life. The biosphere and hydrosphere are interacting again. The erosion of the islands by waves can be acutely observed by comparing pictures of the older islands with newer islands. Again, the hydrosphere and geosphere are interacting. As soon as the islands rose above sea level, the shoreline was hit by waves. Captivating, powerful, and ever-changing, ocean waves help us to examine the relationship between the ocean and other systems here on Earth.
Scientists, surfers, fishermen, and many islanders are curious about waves. They are often interested in observing and understanding more about how waves as they impact them. How do waves respond to and cause changes in the geosphere, biosphere, and atmosphere? Larger, higher frequency waves may indicate a storm surge offshore, or small, low frequency waves may indicate calm atmospheric conditions. Similarly, the size of wave breaks on shore help us to understand erosion. Measuring waves, especially moving ocean waves, is challenging. Even if we can’t measure the exact height or length of a wave, we can make a reasonable judgement of its frequency. The frequency of a wave is determined by how many waves pass a point within a given time. The more energy used to create a wave and the closer the waves are to the source, the higher they will be in frequency. What’s more, exploring wave frequency equips our students with experiences that will aid them in future studies of sound and light, both of which travel through the world in waves.

**PLANNING**

**Essential Questions**
- How do waves impact me?
- What do waves tell us about what is happening on Earth?
- How do waves affect our island home?

**Instructional Objectives**

Students will:
- Use simulation to explore how waves helped life to reach the islands and how waves erode coastlines.
- Identify the features of Earth’s spheres that interact to cause waves.
- Describe the relationship between how waves shape the coastline and how this affects life on the island.
- Construct explanations based upon recorded observations of experiments and group discussions.

**Key Vocabulary**
- Tsunami
- Erosion
- Glacier
- Bow waves

**INSTRUCTION**

**Materials**

For the overall lesson:
- Class set of “The Wonder of Waves” student worksheets
- Science notebook
- One set of “Discussion Questions”
- Poster paper
- Post-its
- PowerPoint presentation, “Waves: The Arms of the Sea” (link below in “Resources”)
To explore colonization of the islands, each group of four to five students will need:

- One paint tray filled with water
- Sand for each tray
- Timer
- Two to three natural objects (leaves, sticks, feathers, seeds, etc.) to float on the surface of the water in each pan
- Large chunks of ice for each tray
- Four to five small drinking straws (coffee straws work best)

**Preparation**

Gather materials:
- Set-up water trays and wave exploration materials for each small group of students.
- Print and cut out discussion questions

**Resources**

**NASA:**

**Other:**
- PowerPoint presentation, “Waves, the Arms of the Sea”

---

**ENGAGE**

1. Ignite prior knowledge and review the previous lesson in this unit by asking students to name the three ways plant and animal life first arrived to the Hawaiian Islands: Wings, Waves and Wind. Make three columns on the board, one for each dispersal mechanism. Students share names of native plants and animals and explain how they arrived using one of these three mechanisms. Then, ask students to identify which of the three W’s is part of the hydrosphere.

2. Pose the following question for students to discuss in a Think-Pair-Share format:

   - *Where do you see waves?*
   - *Are the waves at all of the beaches you visit the same?*
   - *Why are some waves bigger than others?*
   - *Do we need waves?*
   - *How are waves created?*
   - *How could we find out more?*

---

**EXPLORE**

Students now experiment with waves in a small group blowing through straws onto a tray of water. Students can observe first, then discuss, and draw pictures in their science notebooks. They should also answer the questions on the “The Wonder of Waves” worksheet included at the end of this lesson.

1. Experiment with making waves with your straw. Do not submerge the straw in the water. Stay just above it. How do the waves change as you change the strength of your breath? What type of breathing works best?
2. Float natural objects such as feathers, seeds, or bark in the water at one end of the tray. Without moving the straw, aim towards the water and blow into the straw creating waves in the tray. Record observations and ideas:
   - What happens to the object?
   - How does it move?

3. What do students think about this? Connect this to the formation of the Hawaiian Islands.

4. Pile up sand at the shallow end of the paint tray and continue to explore how waves created by wind, cause erosion to the shore line. Create waves with the straws at the deep end of the tray.
   - What happens to the sand?
   Record observations in words and pictures in science notebooks.

5. Create waves by shaking the table, what in nature would this be like? Start by shaking the table once very gently. Then, shake the table five times, forcefully.
   - What sorts of problems do students run into with these waves?
   - Are they easy or difficult to control?
   - Record observations and new questions.
   - How are these waves different from the waves created with the straws?
   - How do students know?
   - How do these waves affect the sand?

6. Drop a large chunk of ice into the tray. Record observations. What would this be like in nature? Share this video from the Today Show about glacier melt contributing to sea level rise: http://www.today.com/video/today/52148284#52148284. It contains info about how NASA scientists are researching glacier melt as well as footage of glaciers dropping chunks of ice into the ocean.

1. Assign each group of students one of the explorations listed above to demonstrate and explain to the class. Listed below are important connection and follow-up questions for each demonstration. Give the teams the follow up question for the demonstration ahead of time and ask them to prepare an answer to share with the class. These follow-up questions are printed in an easy to cut-out and distribute format at the end of this lesson:
   - What in nature do the straws represent?
   - What causes ocean waves by moving the air just above the surface of the water?
   - Did waves really help objects to arrive to the Hawaiian islands?
   - What kind of waves were the most helpful to seeds and logs that floated to the islands?
   - What does this exploration tell us about how waves affect the sand on our beaches?
   - How are waves caused by earthquakes different from waves caused by wind?
   - When and why would large chunks of ice drop into the ocean?
   - How are the waves caused by ice chunks different from waves caused by earthquakes or wind?
   - Would waves in Hawai‘i ever be affected by ice dropping into the ocean? Why or why not?
EXTEND

1. Gather students and show the pictures of both the Kohala coastline and Nā Pali coastline side by side. Pose the questions:

   - How do the mountains on Kauaʻi look different from the mountains on Hawaiʻi?
   - Why do you think they look different?
   - How do waves affect the coast of our island?
   - What else, besides waves, affects the coastline?
   - How do you think the Kohala mountains will look in the future?
   - What other ways do waves affect our island home?

2. Discuss different pictures of waves with the PowerPoint presentation, “Waves: The Arms of the Sea.”

3. Create a class poster. At the top write the question, How do waves affect the Hawaiian Islands? Provide each student with a post-it note and ask them to contribute an idea to the class poster.

   Sample ideas may include:

   - Waves erode the sand and rocks along the shore.
   - Waves help seeds and life to reach the islands.
   - Waves move sand.
   - Waves provide recreation such as surfing and boogie boarding.
   - Waves make it fun to go to the beach because ___________.

4. Share the bow wave video from the NASA Wavelength Digital Library, Here. There. Everywhere. Introduce students to bow waves which are created as objects move. Students can use their experiences with making waves in this new context:

   - Besides at the beach or in bodies of water, where can we see waves?
   - How does studying ocean waves help us to understand more about Earth and our solar system?
   - What other questions do you have about waves?

EVALUATE

Students compose an acrostic poem to share what they have learned about waves. Students create a rough draft using the format provided at the end of this lesson. After corrections, they may wish to create an artistic rendering of the poem. They can decorate by drawing waves or use photographs of waves from magazines.

Example:

Wind creates waves on the surface of the ocean.
A seed or log could be pushed to shore by waves.
Very large waves can be created by underwater earthquakes, these are called tsunamis.
Erosion of the rocks on our shores is caused, in part, by waves.

© Bishop Museum, 2015.
Sand is carried to the beaches by waves.

**ASSESSMENT OPTIONS**

**Formative Assessment**
- Students generate an idea on a post-it note to contribute to the class poster about how waves affect the Hawaiian Islands. Student worksheets and science notebook entries are an ongoing formative assessment adventure in the classroom.

**Summative Assessment**
- Student participation in the final discussion and composition of an acrostic poem to express what they’ve learned about waves may be used to capture their conclusions and understandings.

**CULTURE CONNECTION**

*Image courtesy of W. Drake.*

*Traditional Hawaiian Surfing*

*He ‘e nalu* is the Hawaiian word for surfing. Early Hawaiian people are thought to be the pioneers of today’s modern day surfing. They viewed surfing as an art and perhaps a spiritual activity, not just a recreation or sport. The boards they used were large and heavy and made from trees. Invite students to share surfing experiences with a partner. Which beaches are best for surfing? Which beaches are not good for surfing? Why? What features of the beach affect the waves? Students can draw a favorite beach and the type of waves they have seen there.

Engage students in discussion by asking the following questions:

- How is modern day surfing different or similar from early, traditional surfing?
- Is surfing important to our island home, why or why not?
- How does the source and frequency of waves affect surfing?

**DIFFERENTIATION**

**Emerging Learners**
- Students may be challenged to connect each part of the “Explore” model with nature. To help students, label each part of the model. The straws can be labeled as strong wind and light wind respectively. Place mini palm trees, or shell pieces on the beach, add a few drops of blue food coloring to the water, and submerge coral pieces to help students visualize the ocean on small scale.

**Advanced Learners**
- Challenge students to extend the exploration further:
  - How does adding oil to the water affect the movement of waves or how does the movement of the waves affect the oil in the water?
  - Does the oil change the way the waves affect the sand?
  - Why would scientists want to understand how oil travels in water?

**English Language Learners**
- Frontload the lesson by helping students to understand all key vocabulary. Each student should find or draw pictures to represent each word and add these to his/her science notebook. Students can also write a sentence for each vocabulary word.

**EXTENSIONS**

To further explore wave action with your students, gather 10-12 students around a bed sheet in a large field or gym. The bedsheets represent the surface of the ocean. The students pick up the bed sheet and grip it tightly it at waist height. Two to three students at a time go under the sheet to represent coral and ocean life beneath the ocean’s surface. Guide the students through the following visualizations and simulations (if possible, take videos of the students’ to watch and discuss later):

- Demonstrate the surface of the ocean when it is calm.
- Demonstrate the surface of the ocean during a storm.
- Demonstrate the surface of the ocean after an underwater earthquake. (Remember: the sea level rises, so students should raise their hands up higher.)
- If we place a ball on the sheet when it is calm, what happens?
- If we place a ball on the sheet when it is wavy, what happens?
- How does one, big ball respond to waves differently from many small balls at once? What does this tell us about objects arriving at the Hawaiian Islands?

All the students move to one side of the bed sheet and sit down. Now the open end of the bed sheet represents the coast. As students remain seated, repeat the exploration of how one ball responds to the waves compared to many waves. Ask the students:
Was there any change?
What does this tell us about objects arriving on the islands?

With all the students still on one side of the sheet, stack cardboard boxes on the opposite side of the bedsheet. The boxes represent a mountain cliff. Ask the students to create waves that will reach the boxes. The waves knock the boxes over. This demonstrates how erosion occurs on the coast. Introduce and discuss the term erosion. When you return to the classroom, add this word and a student definition to the science notebooks. Ask your class:

How, if at all, were the students who represented the coral/fish affected by the wave action on the surface?

Materials needed for this activity:
- 1 flat, king-size sheet for each group of 10-12 students
- 1 Rubber, recess ball for each bedsheet
- 7 smaller balls, tennis or golf ball size, for each group

Additionally, you can invite students to ponder how waves are measured. Introduce the term “frequency” and work with a student volunteer and a jump rope to model high and low frequency waves for the rest of the class. Project the graphic below to help students understand. Students can explore making waves with loose clothing such as a t-shirt, they can also draw and take notes about what they see.

Students discuss the difference between high frequency and low frequency waves and add these words to science notebooks. For further understanding, distribute a jump rope, to each pair of students. Students practice creating high frequency waves and low frequency waves with their rope and respond to the following questions in their science notebooks:

What do you notice about the waves in the jump rope when you and your partner move the rope quickly?
● How about when you move it slowly?
● What might cause high frequency waves at the beach?
● How about low frequency?

STANDARDS

Next Generation Science Standards
Crosscutting Concepts:
● Patterns - In grades 3-5, students identify similarities and differences in order to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and to use these patterns to make predictions.
● Systems and System Models - In grades 3-5, students understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions.
● Energy and Matter - In grades 3-5, students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change.

Science and Engineering Practices:
● Develop and use models
● Planning and carrying out investigations
● Constructing explanations
● Obtain, evaluate, and communicate information

Disciplinary Core Idea:
● ESS2.A Earth Materials and Systems - Earth’s major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth’s surface materials and processes.

Common Core
● W.3.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

Hawaii Content & Performance Standards III
● SC.3.1.1 Pose a question and develop a hypothesis based on observations
● SC.3.1.2 Safely collect and analyze data to answer a question

General Learner Outcomes
● Self-Directed Learner
● Community Contributor
● Quality Producer
● Effective Communicator
● Complex Thinker

© Bishop Museum, 2015.
NOAA Ocean Explorers video called Ocean Waves:  
http://oceanexplorer.noaa.gov/edu/learning/player/lesson09.html

My Life With the Wave book on DVD from Reading Rainbow:  
http://shopgpn.com/mylifewiththewave.aspx

REFERENCES


http://hte.cfa.harvard.edu/waves.html

Drake, William (Photographer). (circa 1913). Le Passage de Brisants a Hawaii [Photograph]. Retrieved on April 12, 2015, from:  
http://commons.wikimedia.org/wiki/File:Le_Passage_des_Brisants_à_Hawaiî,c._1913.jpg


http://commons.wikimedia.org/wiki/File:Na_pali.jpg

Hawaiian Encyclopedia : The History of Surfing. (n.d.). Retrieved April 13, 2015, from:  
http://www.hawaiianencyclopedia.com/the-history-of-surfing.asp


Ocean Waves. (n.d.). Retrieved February 19, 2015, from:  
http://oceanexplorer.noaa.gov/edu/learning/player/lesson09.html

The Case of the Shaky Quake. (n.d.). Retrieved February 16, 2015, from:  

Waves are caused by energy passing through the water, causing the water to move in a circular motion.  
# The Wonder of Waves

<table>
<thead>
<tr>
<th>Experiment with making waves with the straw.</th>
<th>How do the waves change as you change the strength of your breath?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>How do the waves change as you increase or decrease the straw’s distance from the water?</td>
</tr>
<tr>
<td></td>
<td>Try blowing on the water without the straw. What happens?</td>
</tr>
<tr>
<td></td>
<td>Additional observations:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Float natural objects such as feathers, seeds, or bark in the water at one end of the tray. <strong>Without moving the straw to follow the object,</strong> create waves in the tray with the straw. Record your observations of how the object moves.</th>
<th>Name of object I floated: ________________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Does it move forward when you create waves?</td>
</tr>
<tr>
<td></td>
<td>Yes    No</td>
</tr>
<tr>
<td></td>
<td>Remember: Don’t follow the object with the straw!</td>
</tr>
</tbody>
</table>

| Pile sand at the shallow end of the tray like it is a sandy beach. Use straws to create waves from the deep end of the tray. | What happens to the sand at the end of the tray? |
| Shake the table firmly five times in a row to create tsunami waves. Describe the waves you see. | Do the waves splash water outside of the tray? Yes No  
How many seconds do the waves last? Use a timer. Press start when the waves begin and stop when the water is still again.  
What happens to the sand when you shake the table and create waves? |
| Drop a large chunk of ice into the tray and time how long the waves last. Start the timer as soon as you see waves and stop it when the water is still again. Describe the waves you see. | Do the waves splash water outside of the tray? Yes No  
How many seconds did the waves last?  
What happened to the sand when you dropped the ice? |
Teacher Resource: Discussion Question Cards

Print, cut-out and distribute to each team before they present their assigned demonstration with the tray. These will be used in the Explain section of the lesson.

1. What do the straws represent in the natural world? What causes ocean waves by moving the air just above the surface of the water?

2. Do waves really help objects to arrive to the Hawaiian islands? What kind of waves were the most helpful to seeds and logs that floated to the islands?

3. What does this exploration tell us about how waves affect the sand on our beaches?

4. How are waves caused by earthquakes different from waves caused by wind?

5. When and why would large chunks of ice drop into the ocean? How are the waves caused by ice chunks different from waves caused by earthquakes or wind? Could waves in Hawai‘i be affected by ice dropping into the ocean? Why or why not?
Teacher Resource: Coastal Photographs
Print in color or project side by side for students to examine.

Nā Pali Coast, Kauaʻi

![Image of Na Pali Coast](image1)

Image courtesy of Eivind.

Kohala Mountains, Hawaiʻi (Big Island)

![Image of Kohala Mountains](image2)

Image courtesy of P. Hirst.
Wave Poetry

Write an acrostic poem to show what you learned about waves. Be sure to use the vocabulary words from the word bank provided. How many of these words can you include?

The more, the better.

costline | erosion | shore | earthquake
---|---|---|---
bow waves | sand | wind | tsunami
island | glacier | Hawai`i | surface

W ____________________________
A ____________________________
V ____________________________
E ____________________________
S ____________________________