How Does Sea Floor Topography Affect Tsunami Wave Height?

Joyce E. Patterson Stark
Albert Einstein Distinguished Educator Fellow
National Oceanic and Atmospheric Administration
Office of Education and Sustainable Development
Herbert Hoover Building Room 6863
14th and Constitution Avenue NW
Washington D.C. 20230
Joyce.Stark@noaa.gov

Inquiry involves teaching that incorporates discovery. It will take longer and the teacher may require more in depth knowledge before doing the activity.

Problem

Students will discover how a V-shaped valley on the sea floor will affect wave height, run-up and inundation distance, then design changes in the sea floor and compare results.

Teacher Preparation

Using guided inquiry, the teacher will demonstrate the how to measure wave height, run-up and inundation. Students should be familiar with experimental design (hypothesis, materials, control, constant, manipulated and responding variables). The manipulated variable will be the V-shaped valley or the student's sea floor designs and the responding variable will be the measurements for wave height, run-up and inundation distance. The students will construct a V-shaped valley and then collect data from their experiment. The V- shaped valley will be narrower as it approaches the shore and wider as it faces the sea. It will be open and not closed at the narrow end. The control will be a sand beach with no materials added to the sea floor. Students should decide what the control will be before starting to experiment. The experiment should be repeated three times and the data averaged. This part of the experiment and the data tables should be submitted to the teacher for approval before beginning the experiment. The next part of the experiment will be open inquiry. The students will modify the sea floor using sand, rocks, and pebbles. They should be collected in advance and kept in buckets or bags for group use. Students will submit their designs and procedures for teacher approval before experimenting.

This inquiry experiment could be used for grades 6-9 with some modifications for the younger students. This activity will take more than one class period. A block of time would be the most effective. Students should work in groups (3-4) but each student must write the experimental design in their journal.

Teacher Background

Wave height - vertical measurement of the wave before it reaches the shore

Run-up - vertical height a wave reaches above a reference sea level as it washes ashore.

Inundation distance- horizontal distance tsunami waves reach landward from the shoreline

Bore – a traveling wave with an abrupt vertical front or wall of water. Under certain conditions the leading edge of a tsunami wave may form a bore as it approaches and runs onshore.

Contours of the sea floor and coastline have a profound influence on the height of waves. In 1993, Okushiri, Japan, the wave run-up on the coast averaged ~15-20 meters (50-65 feet). In one spot, waves pushed into a V-shaped valley open to the sea, concentrating the water in a tighter and tighter space. In the end, water ran up 32 meters (90') above sea level (the height of an 8 story building).
http://www.prh.noaa.gov/itic/tsunami_events/historical/summaries/1993.pdf

When it reaches the coast, the wave can appear as a rapidly rising or falling tide, a series of breaking waves or a bore. This simulation shows what happens when a tsunami encounters land.
http://www.geophys.washington.edu/tsunami/general/physics/runup.html

Additional information about tsunamis can be found at this website:
http://www.pmel.noaa.gov

Inquiry-generating Questions

These are some sample questions to initiate discussion about tsunamis before beginning the experiment.

1. Have you ever walked form a sandy beach into the water? Is it always sandy or does the structure of the sea floor change as you leave the shoreline?

2. What do you think run-up means?

3. What does topography mean? What other word is similar to the ending "graphy"?

4. Do you know what a tsunami is? What causes a tsunami?

5. Ask for ideas about inundation distance.

Title:

Problem:

Hypothesis: I believe ……..

Materials:

Stream or erosion tables or long plastic shoe boxes, sand, rocks, pebbles, modeling clay, water, metric ruler, meter stick crossbar or wooden doweling.

Student Procedures

1. After setting up the stream table (erosion table), construct a beach area using just the sand at one end of the table.

2. Fill the stream table with enough water to cover part of the beach.

3. Place the cross bar or wooden doweling in the water at the opposite end of the beach. Move the bar back and forth or up and down to create waves. Count the number of times the bar was moved (and/ or the distance) to keep this constant for the experiment.

4. Each student should have a job. One can record data in their journal for sharing with other members of the team. One should measure wave height with a metric ruler or meter stick. The ruler can be placed in the water away from the shoreline. Another student can measure run-up on the shore with a metric ruler. Another student can measure inundation distance on the beach.

5. The experiment should be repeated three times and the data averaged. Graph your data.

6. The control consists of no materials added to the sea floor.

7. Construct a V-shaped valley from modeling clay and place it on the sea floor before it reaches the beach. Turn in your experimental design to your teacher for approval.

8. After completing the V-shaped design, modify the sea floor by constructing a design of your own. Turn in your experimental design for approval before beginning to construct.

Results

1. Compare and contrast the data from wave height, run-up and inundation distance from your control, V-shaped valley and your design.

2. Which design would cause more damage onshore?

Conclusion

1. Was your hypothesis accepted or rejected. Explain why.

2. What did you learn?

3. In a summary paragraph, discuss the average data from your experiments.

Application

How will your experiment be able to help people who live on coastal areas prepare for tsunamis?

Assessment

The rough draft of the lab will be written in the journal. A 25 point rubric will be used to evaluate either the rough draft or a final copy for each student or the group.

	Points
Title:	1
Problem:	1
Hypothesis	1
Control	1
Constant	1
Manipulated Variable	1
Responding Variable	1
Procedures: V-shaped Valley Sea Floor Modifications	3
Data Tables (2)	4
Graphs (2)	4
Results	3
Conclusion	3
Application	1
	25

National Science Education Standards

Grades 5-8

Content Standard A	Abilities to do scientific inquiry Understanding scientific inquiry
Content Standard B	Motion and forces Transfer of energy
Content Standard D	Structure of Earth system Earth's history
Content Standard F	Natural hazards Risks and benefits
Content Standard G	Nature of science

Grades 9-12

Content Standard A	Abilities to do scientific inquiry Understanding scientific inquiry
Content Standard B	Motions and forces Conservation of energy and increase in disorder Interactions of energy and matter
Content Standard D	Energy in the Earth's system Origin and evolution of the Earth system
Content Standard E	Natural and human induced hazards