√GEOMATH

Tsunami: Catching the Ultimate Wave!

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Grade Level	6
Duration	1 class period

National Standards

GEOGRAPHY
Element 1: The World in Spatial Terms
1. How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information
Element 5: Environment and Society
15. How physical systems affect human systems.

AZ Standards

MATHEMATICS
The Number System
6.NS.B.3. Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation.
Extension Idea
Expressions and Equations
6.EE.B.6. Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

Arizona Social Science Standards

GEOGRAPHY
The use of geographic representations and tools helps individuals understand their world.
6.G1.1 Use and construct maps, graphs, and other representations to explain relationships between locations of places and regions.
Examining human population and movement helps individuals understand past, present, and future conditions on Earth's surface.
6.G3.1 Analyze how cultural and environmental characteristics affect the distribution and movement of people, goods, and ideas.
6.G3.2 Analyze the influence of location, use of natural resources, catastrophic environmental events, and technological developments on human settlement and migration

Overview

Tsunamis are triggered by earthquakes or underwater landslides and can travel rapidly across even the largest bodies of water. Protecting humans living along the coast requires accurate prediction of the expected arrival of the wave (among other factors). In this lesson, students will determine the length of time for the arrival of a wave from a given point.

Purpose

In this lesson, students will use math and geography skills to determine how long it will take for a tsunami to arrive at a given point on a coast.

Materials

- Tsunami: Catching the Ultimate Wave map
- Atlases
- Student Worksheet
- Ruler

Objective

The students will be able to accurately calculate the length of time between a tsunami-causing event and the arrival of the tsunami at a coastal point

Background Information

Tsunami is the currently accepted term for the oftentimes very destructive ocean waves that were formerly known as "tidal waves." That term was dropped in 1963 because the phenomenon has nothing to do with tides. Tsunami is a Japanese word that translates to harbor wave.

Tsunamis are generated by earthquakes, plate movements, volcanic eruptions, underwater landslides, and even asteroid impacts. Imagine lifting one side of a shallow basin of water several inches. Dropping the basin would be analogous to an earthquake and some of the other events. The resulting wave action would correspond to the reaction of the water in the basin. The speed of a

ARIZONA GEOGRAPHIC ALLIANCE

tsunami depends on the depth of the water, being fastest in deep water and slower in shallow water (such as when passing over shallow areas or when approaching shore). A tsunami in very deep waters may reach 600 miles per hour. The average speed for the Pacific Ocean is thought to be about 440 miles per hour. But to keep calculations simpler we will use a speed of 500 miles per hour in this lesson. This figure is often used in the literature.

As a tsunami approaches shore and slows to an estimated 30 miles an hour, the height of the wave increases rapidly. The size of the waves generated by tsunamis varies with the strength of the event but can range between 5 and 15 meters in height when they reach shore. It's difficult to overestimate the power of a wall of water moving at 30 miles per hour, especially when augmented with debris being swept along with the wave. The pressure on a building can exceed millions of pounds.

The wavelength of a tsunami may reach 100 miles or more. The pressure of a tsunami passing through an area extends all the way to the bottom of the deepest oceans. This is the basis for the tsunami warning systems, which utilize pressure sensors on or near the bottom, to detect passing waves.

The size of the wave out in open ocean may be as little as a few inches or feet over the course of minutes or even hours and ships may not even note its passing.

Coastal areas are always most at risk, but in areas of low topography (such as Florida and many islands), this risk can extend far into the interior. The highest elevation in Florida, for example, is only 105 meters above sea level. One of the dangers of tsunamis is that they are often followed by a second or third wave. Before the first wave and between subsequent waves, the water may withdraw far out to sea, luring people to venture into the exposed shoreline or lulling people into a false sense of security, only to be hit by a second or third wave. Indeed, this sudden withdrawal of water should be used as a serious warning sign of an impending tsunami. A few mega-tsunamis have been postulated that would have generated waves of perhaps 200 meters height or more. One potentially very worrisome event could involve the collapse of the Cumbre Vieja volcano on the western side of the Canary Island of La Palma. One scientist for the USGS has calculated that 100 cubic miles of material could slide into the Atlantic at a speed of up to 200 miles per hour. This could devastate much of the East Coast of the U.S. and Caribbean with waves of 40 feet and up to 300 feet on the nearby coast of Africa. This last appears to have happened 500,000 years ago and is thought by some to be likely in the not so distant geologic future.

In the December 26, 2004 tsunami originating off the island of Sumatra, Indonesia, the tsunami was triggered by a 9.0 scale earthquake as the Indian Plate was subducted (pulled under) the Burma Plate, moving the island of Sumatra an estimated 66 feet and lifting the edge of the overlying Burma Plate by 15 feet.

An interesting fact is that the tsunami generated by the 1883 blast at Krakatoa (in what is now Indonesia) was phenomenally destructive in the immediate area, but propagated all the way across the Indian Ocean, rounded the Cape of Good Hope, and was detected all the way to Atlantic France, albeit in a much reduced height.

Procedures

1. Read the Background Information to the students. Locate some of the tsunami sites mentioned so students can see how many areas are affected by this natural hazard. Relate a few current events involving tsunamis. Some possible websites are:
https://www.livescience.com/topics/tsunamis
https://www.weather.gov
https://www.tsunami.gov/recent_tsunamis/
https://www.theguardian.com/world/2018/dec/24/sunda-strait-tsunami-volcano-indonesia
2. Explain to students that to further their understanding of this natural hazard, they will use their mathematics skills. Distribute the Student Worksheet, rulers, atlases, and Tsunami: Catching the Ultimate Wave map. Review measurement skills and how to use a map scale beforehand. Recommend that they round distance on the map to the nearest 1/4 inch.
3. Model doing the first problem for them. Instruct students to complete the worksheet in groups or as individuals.
4. As a ticket out the door, have students respond to this question. Knowing what you now know about tsunamis, would this discourage you from living near the ocean? If time, have students share their answers.

Assessment

Mathematics and Geography
Students will be assessed using the student worksheet. Students should be able to calculate travel times for tsunamis within a reasonable margin of error with a score of 80% or higher.

Extensions

Research recent and historic tsunami events. These might include the 1883 Krakatoa, the 1946 Hilo (Hawai'i), the 1964 Anchorage, the 1998 New Guinea tsunamis, and the 1700 tsunami along the Pacific Northwest coast.

Research warning systems, current zoning, evacuation and other regulations for tsunami preparedness.

Research innovative architectural techniques for building in tsunami prone areas

Point out that the 500 miles per hour rate given in the lesson is a variable. The time could be more or less. Have students recalculate the travel time with different amounts of miles per hour.

Sources

These sites give some good background information on tsunamis:
http://armageddononline.tripod.com/tsunamis.htm

http://nctr.pmel.noaa.gov/tsunami-forecast.html

http://www.tsunami.org/

http://en.wikipedia.org/wiki/Tsunami