ACTIVITY: Seismic Waves, Tsunami Waves and Ocean Currents
Grade Level: K-2

Purpose: To introduce young children to the concepts of units, become familiar with the geography of the Northern Pacific basin, and learn about waves and currents. Students will develop an understanding of length (distance), time, and speed. They will estimate speeds of various common activities such as walking, driving in a car and flying and compare these speeds to that of seismic waves, tsunami waves and ocean currents through the story of Kamome.

Time: two 50-minute sessions

Educational Standards:
ESS1-1, ESS2-1, PS2-1, R1.2.1, W.8, SS4.2, SS2.2
See Additional Resources for Teachers – California Educational Standards for Kamome – under the Resource Menu for standard definitions.

Materials:
Classroom copy of the Kamome book
Colored pencils or crayons
Globe or map, which includes Japan, California, Pacific Ocean
Waves and Currents worksheet.pdf, print a copy for each student
Tsunami debris examples.pdf, to display on computer projection screen
Slinky (optional for extended activity)
Go to Activity Menu to download Pacific Map

Procedure:
1. Read the Kamome story out loud, slowly. Ask students to listen for information in the story with details of how long, fast or far the earthquake, tsunami and Kamome traveled.

2. Record details of what students heard about the earthquake, tsunami and travel of Kamome on a wall chart or white board labeled with the sections (example below):

Earthquake	Tsunami	Kamome's Journey
shook and shook in Japan	came after the EQ	lasted a long time
	swept Kamome out to sea	didn't go in a line
	really big in Japan	
	travelled to America	
	made the people sad	

3. Using a globe or map, point out the locations where Kamome came from and where the boat landed: Rikuzentakata, Japan and Crescent City, California. Give students copies of the ***Waves and Currents worksheet.pdf*** and point out the locations of the Pacific Ocean, Japan and California. Have them color the Pacific Ocean in one color and Japan and California in second color. Tell students to draw a line from Rikuzentaka to Crescent City.

4. Estimate with class the distance between the two cities (approximately 5,000 miles). Tell the students to write 5000 miles on the line below the map.

Discussion: Ask the students what '5000 miles' means. If they have difficulty with the concept of distance, ask them what sort of a number is it. The clue is "miles" - that puts the number in a particular category. If we just wrote down 5000, would they know what it meant? Units are important – it tells you what type of thing we are talking about.

Give students examples of distances. Ask if any of them have driven to a San Francisco or another city in their state. Compare this to the distance between Japan and California.

5. This activity introduces speed. Speed involves both distance and time. Ask students how we measure time. They will probably mention minutes, hours and years. Tell them that the Kamome story uses all three of these ways of measuring time.

Talk about how fast things travel. Make a list on the board:

Slug or snail: .03 miles per hour
Walking: 2 miles per hour
Jogging: 5 miles per hour
Fastest shark: 25 miles per hour
Driving on the highway: 60 miles per hour
Jet airplane: 450 miles per hour
Speed of sound: 750 miles per hour
Fastest jet plane: 2000 miles per hour
Fastest rocket launch: 47,000 miles per hour

6. Discuss with students, "what do we know about the earthquake" from the story? (The ground shook, and shook and shook). Tell students that the earthquake on March 11, 2011 began under the ocean floor off the Pacific coast of Japan. The earthquake waves were felt in Japan very soon after the earthquake started, and the earthquake also sent seismic waves in all directions. Although people in Northern California did not feel the earthquake, the seismic waves were recorded on seismographs there. It only took 12 minutes for seismic waves to travel from Japan to California. Have them write 12 minutes on the worksheet on the line for earthquake time.

Ask the students how fast seismic waves are compared to the list you made of how fast things go. Do they think the seismic waves are faster than a car or a jet plane? Help them estimate the speed of the seismic waves (12 minutes = .2 hour; 5000 miles/.2hours = 25,000 miles per hour). Write down this information under the Earthquake column and ask students to write about how fast the seismic waves were traveling (almost as fast as a rocket).

7. Discuss with students what they know about the tsunami from the story and list them under the Tsunami heading. Things they should note: the tsunami arrived in Japan after the earthquake, it pulled many things including Kamome into the ocean, it traveled across the Pacific ocean to Crescent City where it was smaller but still caused some damage.

8. Introducing tsunamis:
(a) Go to: https://www.ducksters.com/science/earth_science/tsunamis.php for a simplified explanation of how tsunamis are formed. The section discussing What Can Cause a Tsunami uses an example of a person sitting in a bathtub of water and moving forward. There is also a diagram on this page that illustrates tsunami development.

(b) Play the IRIS video to demonstrate how a tsunami is generated by the movement of the sea floor (stop video at 1 min, 40 sec). Note: We suggest you mute the volume because the verbal explanation is for higher grade levels.
https://www.iris.edu/hq/inclass/animation/subduction_zone_tsunamis_generated_by_megathrust_earthquakes

Video overview: Earthquake faults can cause the ocean floor to move up or down, causing a series of waves to travel outward like ripples when a rock is dropped into a pond. Tsunami waves arrived quickly along the coastline of Japan nearest to where the earthquake happened. The tsunami also moved out in all directions across the Pacific Ocean.

9. Ask the students to point out Japan and Northern California on the Worksheet. Tell them you are going to play a model of how the tsunami travelled from Japan to California. Scientists used computers to illustrate how quickly the tsunami moved.

Play the NOAA Tsunami Forecast Modeling video. https://www.youtube.com/watch?v=jH3-hQjTGDQ
Stop the video when it hits northern California. Ask students what movement they saw in the video. (Waves moving across the ocean) Explain to students this is a model based on the actual 2011 tsunami event, and that scientists can forecast where and how fast the tsunami will travel. There is a time counter on the video. Read the time that the tsunami reached California (about 9 and a half hours). Have the students to write this down on the Worksheet on the tsunami time line.

Ask the students how fast the tsunami waves are compared to the list you made of how fast things go. Do they think the tsunami waves are faster than a car or a jet plane? Help them estimate the speed of the tsunami (9.5 hours; 5000 miles/9.5 hours ~ 530 miles per hour). Write down this information under the Earthquake column. Look at your list of how fast things go. They should notice that the tsunami is much faster than a car and much slow than the speed of the seismic waves. It is very close to the speed of a Jet airplane. Have the students write the speed (530 mph) or 'jet air plane' on the line for tsunami speed.

9. Ask students what the story tells them about the trip that Kamome made across the ocean and write down their observations under the Kamome's Journey heading. They should note it took a very long time. Years went by. Look at the dates on the map at the beginning of the book and figure out how long it took Kamome to travel across the ocean (2 years and 27 days). Write this on the white board and on the Worksheet.

Ask the students how fast they think Kamome traveled compared to the list you made of how fast things move. Help them estimate Kamome's speed (757 days = 18168 hours; 5000 miles/18168 = .275 miles per hour) and write it on their worksheet. This is even slower than walking speed. But it is faster than a slug! Write this on your white board summary. It might look something like this:

Earthquake	Tsunami	Kamome's Journey
shook and shook in Japan	came after the EQ swept Kamome out to sea really big in Japan travelled to America made the people sad	lasted a long time didn't go in a line
Really fast - almost as fast as a rocket launch	About as fast as a jet airplane	Really slow - we could walk faster
12 minutes	9 and a 1/2 hours	more than 2 years

Ask the students if they know why Kamome moved across the Pacific. They might suggest wind, and they are right. Winds generally blow towards the east in the Pacific. But that isn't the main reason. There are giant ocean currents that slowly cause the Northern Pacific Ocean to rotate like a clock. These currents were the main reason that Kamome traveled from Japan to California.

These currents caused many items that the Japan tsunami pulled into the water to travel across the Pacific. These items are called tsunami debris. There were floats from harbors, many boats and even a dock. Show the ***Tsunami debris examples.pdf*** on your computer display screen. It shows some of the Japan tsunami debris that landed on North America or on islands in the Pacific. Some of these items are very surprising – a child's soccer ball, a large part of a dock and a motorcycle. The motorcycle only made it across the ocean because it was stored in a plastic case. Tsunami debris started landing in Alaska and Canada about one year after the earthquake. It reached a peak about 18 months after the tsunami and by early 2018, tsunami debris sightings appeared to be over.

Extension:

1. Measure and calculate how fast students crawl, walk and run. Use a tape measure to mark 100 feet on the playground. Get a stopwatch and time how long it takes students to crawl, walk, and run this distance. Help them convert the data to miles per hour by setting up a simple chart with time and speed. (100 feet = .019 miles; time in seconds = .00028 time in hours. If it took the student 30 seconds to travel 100 feet, it would convert to .019/(30*.0028) or a little over 2 miles per hour).

2. Demonstrate the movement of seismic waves with a slinky in the classroom. You will need a table or floor space to do this.

(a) Model the slinky movements as shown in the short (21 second) video that illustrates the: https://www.youtube.com/watch?v=BxtiKodKq_E This is a short video (21 seconds) illustrating the difference between P and S waves. If you don't have a slinky, show the video. Ask students what they saw, show the video again and ask them to look for differences in how the slinky moves.

This video https://www.youtube.com/watch?v=BxtiKodKq_E is from Cambridge Volcano Seismology. *Background for the teacher - When an earthquake happens energy spreads outwards in all directions in waves, like a ripple spreading across the surface of a pond when you drop a rock in the water. This video shows the two types of seismic waves (P waves and S waves) that can travel through the deep part of the earth.*

(b) If you have a large slinky, demonstrate P and S waves for your class with two people, one at either end of the table or floor on which the slinky is placed. The P waves can be shown by giving the slinky a push (compression) and watching the movement from one end of the slinky to the other. The S waves can be shown by moving your end of the slinky from side to side, quickly, and watching the waves move from one end of the slinky to the other.

For teachers to watch ahead of time – For a more detailed and fully explained (5 min) video using a slinky generating P and S waves, go to:
https://www.iris.edu/hq/inclass/video/seismic_slinky_modeling_p_and_s_waves_in_the_classroom

(c) Ask the students to contrast the movement of P and S waves in a slinky orally or in a drawing.

3. Have students physically model and demonstrate a P wave to demonstrate how waves move.

(a) Play IRIS video "Modeling Seismic Waves;
https://www.iris.edu/hq/inclass/video/human_wave_modeling_seismic_waves_in_the_classroom
(stop video at 1 min, 25 sec)

(b) Direct students to model the wave as done in the video. After the activity ask the following questions:

Describe how the wave "moved"? (each person moved a little and caused the person next to them to move a little)

Was the person at the beginning of the wave moved to the end? (obviously "no")

Do you think the water in the tsunami surges that arrived in Crescent City traveled all the way from Japan? (No - Tsunami waves are slower than seismic waves, but the wave motion happens in the same way – the earthquake moved the ocean water in Japan. That movement caused the water particles next to the fault area to move, and so on all the way across the Pacific.)

Are the currents that moved Kamome to California waves? (No. One bit of water is not pushing the next bit of water. The ocean water is really moving. Kamome was just like a particle in the water and traveled all the way across the ocean.)

This Activity was modified from *The Extraordinary Voyage of Kamome: Earth science through a true story* CSTA 2017 Workshop developed by Cynthia Pridmore, California Geological Survey

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