Tide Gauge Sleuths

Grades
9-12

Overview:

In this lesson, students sleuth out the locations of tide gauges by analyzing marigrams in a tsunami event. Students should have prior understanding of how bathymetry affects wave propagation and have a basic understanding of interpreting marigrams (See 9-12 lessons: "Tsunami Speed," "Wave Behavior," and "Make a Marigram").

Targeted Alaska Grade Level Expectations:

Science

[9] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

[10-11] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating.

[9] SD3.1 The student demonstrates an understanding of cycles influenced by energy from the sun and by Earth's position and motion in our solar system by recognizing the effect of the moon and sun on tides.

Math

[9-10] S&P-1 The student demonstrates an ability to classify and organize data by [designing, collecting L], organizing, displaying, or explaining the classification of data in real-world problems (e.g., science or humanities, peers, community, or careers) using information from tables or graphs that display two sets of data [or with technology L]

[9-10] S&P-3 The student demonstrates an ability to analyze data (comparing, explaining, interpreting, evaluating, making predictions, describing trends; drawing, formulating, or justifying conclusions by using and justifying range and measures of central tendency to determine the best representation of the data for a practical situation.

[9] PS-5 The student demonstrates the ability to apply mathematical skills and processes across the content strands by using real-world contexts such as science, humanities, peers, community, careers, and national issues.

Objectives:

The student will:

- analyze marigrams for tide and tsunami data; and
- compare sets of data to determine the location of tide gauges.

Materials:

- STUDENT WORKSHEET: "Tide Gauge Sleuths"
- VISUAL AIDS: "Marigram A," "Marigram B," "Marigram C," and "Marigram D"
- VISUAL AID: "Kuril November 2006 Time Travel Map"

Whole Picture:

Tide gauge data is one source of information that is analyzed to understand tsunamis and, in general, changes in global sea level. By comparing tide gauge data from several known locations, it is possible to gain a sense of the location of the tsunami-generating event. Likewise, it is possible to determine the location of several tide gauges with a known location of a tsunami-generating event.

Tide gauges measure water level. Mariners use the information gathered from tide gauges to determine when and where to travel. This information is also used for tsunami and storm surge warnings. Long-term tide records are used for marine boundary determinations, tidal predictions, monitoring sea level trends, oceanographic research, and climate research. Changes in water level also affect bridge, breakwater and deep-water channel construction, and landward extent of storm surge flooding.

Tide gauge data are recorded on graphs called marigrams. Marigrams show the range of tidal fluctuation and also if the area experiences diurnal, semi-diurnal, or mixed tides.

- diurnal tides: a single high tide and a single low tide per day
- semidiurnal tides: two distinct high tides and two distinct low tides per day
- mixed tides: are a combination of semidiurnal, and diurnal tidal patterns.

The marigrams used in this lesson show actual data from the tsunami generated by an earthquake with a moment magnitude of 8.3 in the Kuril Islands (46.607°N, 153.230°E). The Kuril Islands are a chain of islands that extend from the southern tip of the Kamchatka Peninsula to the northern tip of Hokkaido, Japan in the northwestern part of the Pacific Ocean. This earthquake occurred at 1114 UTC (Coordinated Universal Time) on Wednesday, 15 November 2006 (day 319 of 2006). Coordinated Universal Time (UTC) is a time standard.

In this lesson, students will have to determine range for the tides shown on the marigrams as well as the range of the tsunami. The range of a set of data is the difference between the highest and lowest values of the set.

Activity Preparation:

If you are using Option B from the Activity Procedure, make enough copies of Part A of the student worksheet to accommodate students.

Activity Procedure:

Choose one of the options below to present this lesson to students.

Option A: Jigsaw

1. Explain students will use clues to determine the location of several tide gauges using tsunami data.
2. To begin the jigsaw teaching method, divide the class into four “expert” groups.
3. Distribute VISUAL AIDS: “Marigram A,” “Marigram B,” “Marigram C” and “Marigram D” and assign one marigram to each group. Each group will work to become the “experts” of the information on the group’s assigned marigram.
4. Distribute STUDENT WORKSHEET: “Tide Gauge Sleuths” and allow time for each expert group to analyze the data and complete Part A of the student worksheet. Explain students will be assessed on the information they teach and learn from their peers.
5. Divide students into “teaching” groups. Teaching groups consist of four people; each one representing one of the four expert groups. Students take turns sharing their expert topic and complete Part B of

the student worksheet together. When students are done with #2 on Part B, distribute VISUAL AID: "Kuril November 2006 Time Travel Map."

6. After all groups have completed the worksheet, discuss student results.

Option B:

1. Explain that students will use clues to determine the location of several tide gauges using tsunami data.
2. Distribute STUDENT WORKSHEET: "Tide Gauge Sleuths" and review the information and extra copies of Part A of the student worksheet. In this option, students may review more than one marigram. Distribute VISUAL AIDS: "Marigram A," "Marigram B," "Marigram C" and "Marigram D" to students for analysis and completion of the worksheet.
3. When students are done with #2 on Part B, distribute VISUAL AID: "Kuril November 2006 Time Travel Map."
4. After all students have completed the worksheet, discuss student results as a class.

Extension Ideas:

- View MULTIMEDIA FILES: "Kuril Tsunami" and "Kuril Tsunami Energy Flux" at www.AKtsunami.org/multimedia lessons for 5-8, Unit 5.
- Explore the locations and bathymetry on Google Earth.

Answers:

Part A:

	Marigrams			
	A	***B***	***C***	***D***
1.	*A*	*B*	*C*	*D*
2.	*20 cm*	*> 126 cm*	*63 cm*	*61 cm*
3.	*Semidiurnal*	*Semidiurnal*	*Mixed*	*Semidiurnal*
4.A.	*319 or 11/15*	*319 or 11/15*	*319 or 11/15*	*320 or 11/16*
4.B.	*20:30*	*19:45*	*14:30*	*9:30*
5.	*9:16*	*8:31*	*3:16*	*22:16*
6.	*120 cm*	*41 cm*	*46 cm*	*83 cm*

Part B:

1.

Marigram	***Estimated Tsunami Arrival Time (Day and time)***	***Tsunami Travel Time***
A	*319 or 11/15, 20:30*	*9:16*
B	*319 or 11/15, 19:45*	*8:31*
C	*319 or 11/15, 14:30*	*3:16*
D	*320 or 11/16, 9:30*	*22:16*

2. *C, B, A, D*

3.

Marigram	***Tide Gauge Location***
A	*Port San Luis, California*
B	*Charleston, Oregon*
C	*Adak, Alaska*
D	*Arica, Chile*

4.

	Location	***Range of tsunami height***
Smallest:	*Charleston, OR*	*41 cm*
	Adak, AK	*46 cm*
	Arica, Chile	*83 cm*
Largest:	*Port San Luis, CA*	*120 cm*

5. *Answers will vary.*

Lesson Information Sources:

National Oceanic and Atmospheric Administration (NOAA). (2005). *Our Restless Tides: A brief explanation of the basic astronomical factors which produce tides and tidal currents*. http://co-ops.nos.noaa.gov/restles1.html

United States Geological Survey (USGS). *Earthquake Hazards Program.* http://earthquake.usgs.gov/

West Coast/Alaska Tsunami Warning Center, NOAA/NWS. *Tsunami of 15 November 2006*. http://wcatwc.arh.noaa.gov/previous.events/11.15.2006/11-15-06.html

Name:_____

Tide Gauge Sleuths

Student Worksheet (page 1 of 4)

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Tide gauge data is one source of information that is analyzed to understand tsunamis. By comparing tide gauge data from several known locations, it is possible to gain a sense of the location of the tsunami-generating event. Likewise, it is possible to determine the location of several tide gauges with a known location of a tsunami-generating event.

Use the information below to sleuth out the location of several mystery tide gauges.

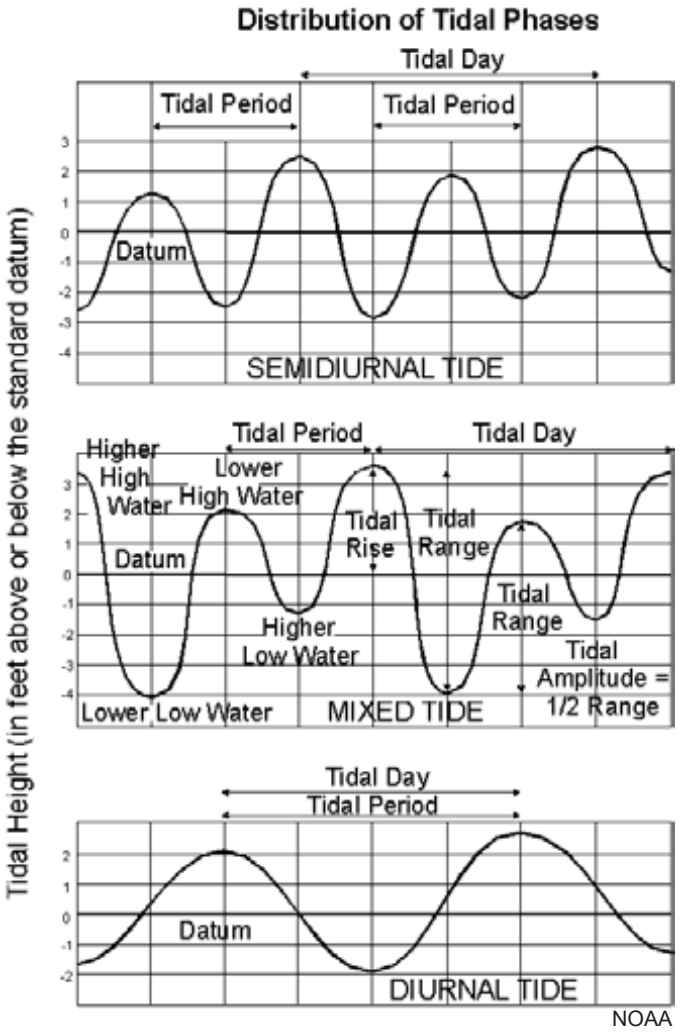
Water Level Data and Tides

Tide gauges measure water level. Mariners use information gathered from tide gauges to determine when and where to travel. This information is also used for tsunami and storm surge warnings. Long-term tide records are used for marine boundary determinations, tidal predictions, monitoring sea level trends, oceanographic research, and climate research. Changes in water level also affect bridge, breakwater and deep-water channel construction.

Tide gauge data are recorded on graphs called marigrams. Marigrams show the range of tidal fluctuation and also if the area experiences diurnal, semi-diurnal, or mixed tides.

- diurnal tides:
  a single high tide and a single low tide per day
- semidiurnal tides:
  two high tides and two low tides per day
- mixed tides:
  a combination of semidiurnal, and diurnal tidal patterns.

Because of the predictable nature of tides, tidal data may be eliminated from marigrams. Once this data is eliminated, water level data reflects waves as a result of wind, storms, harbor resonance, and tsunamis.



NOAA

Name:_____

Tide Gauge Sleuths

Student Worksheet (page 2 of 4)

Grades 9-12

The Tsunami Generator

A great earthquake with a moment magnitude of 8.3 occurred at 1114 UTC (Coordinated Universal Time) on Wednesday, 15 November 2006 (day 319 of 2006) on the Kuril Islands (46.607°N, 153.230°E). The Kuril Islands are a chain of islands that extend from the southern tip of the Kamchatka Peninsula to the northern tip of Hokkaido, Japan in the northwestern part of the Pacific Ocean. Coordinated Universal Time (UTC) is a time standard. In UTC, time is divided into days, hours, minutes and seconds.

Part A:

Analyze a marigram to complete the information below.

1. Which marigram are you analyzing (A, B, C, or D)? _____

2. What is the approximate tidal range represented by this graph?

   (highest tide value – lowest tide value) _____

3. Does this area experience diurnal or semidiurnal tides? _____

4. What is the tsunami's approximate date and time of arrival?

   A. Date: _____

   B. Time: _____

5. Approximately how much time has passed since the earthquake occurred until the tsunami struck this location? _____

6. What is the approximate range of the tsunami height?

   (highest tsunami value – lowest tsunami value) _____

Name:_____

Tide Gauge Sleuths

Student Worksheet (page 3 of 4)

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Part B:

Examine the all four marigrams as a set to complete the information below.

1.

Marigram	Estimated Tsunami Arrival Time (Day and Time)	Tsunami Travel Time
A		
B		
C		
D		

2. Sequence the marigrams in the order that they were struck by the tsunami.

_____ _____ _____ _____

3. Examine the VISUAL AID: "Kuril November 2006 Time Travel Map." Use the information from questions #1 and #2 to identify the communities represented by the tide gauge data.

Marigram	Tide Gauge Location
A	
B	
C	
D	

4. Compare the approximate ranges of tsunami height at each location then list them in order from the smallest range to the largest range.

	Location	Range of tsunami height
Smallest:		
Largest:		

Name:_____

Tide Gauge Sleuths

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5. The same tsunami event affected all communities differently. Describe how bathymetry and the location of the tsunami source may have affected the way in which each location experienced the tsunami.