



Overview:

In this lesson, students briefly examine the use of acoustics for data collection then use Microsoft Excel to analyze tide gauge data. Basic knowledge of Microsoft Excel is recommended.

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:

- explore the use of acoustic waves for collecting data; and
- create and interpret a marigram.

Materials:

- Computer with Internet access and Microsoft Excel
- STUDENT WORKSHEET: "Make a Marigram"
- VISUAL AID: "Yup'ik Acoustics for Data Collection"
- VISUAL AID: "Next Generation Water Level Measuring System"
- VISUAL AID: "Earlier Tide Gauges"

Whole Picture:

Acoustic (sound) waves are used for measuring many things. Yup'ik hunters are known to have used paddles to detect the proximity of seals and storms by dipping the paddle into the water and holding the handle up to the hunter's ear. The paddle acts as a hydrophone, an underwater microphone, de-

tecting sound waves. Acoustic waves travel faster in water than in air so a storm could be warned of in advance by listening to the paddle. Yup'ik elder Frank Andrew recalled:

If they dipped their paddle in the water, they could hear *qalrilriit* [male bearded seals giving their mating calls] through that handle. Sound is very loud in the water. And when bowing our heads down into the kayak, one can hear those *qalrilriit*. (Fienup-Riordan, 2007, p.107)

Today, acoustic waves have many uses, including more efficient and accurate means of measuring water levels. Earlier forms of tide gauges consisted of a tide house, often along a pier, that contains a stilling tube that extends below the water surface. (View the visual aids as a reference.) A stilling tube calms the surface of the water within it to get a more accurate sense of water level. The tide house also contains an analog-to-digital recorder (ADR) that records water level at timed intervals by determining the length of a wire that extends down the stilling tube to a float on the water surface. Measurement from nearby tide staffs, permanently fixed measuring devices that act as a vertical reference, are compared to measurements gathered by the ADR. Geodetic benchmarks are also placed on land nearby as another comparison and to determine the amount of land movement (uplift or subsidence) in relation to water level.

New tide gauges, also called Next Generation Water Level Measuring System (NGWLMS), are more accurate than the older model of tide gauge and require less maintenance. New tide gauges measure water level by sending a pulse of acoustic energy down a sounding tube, and calculate the travel time of the sound wave transmitting and reflecting off the surface of the water. A pressure sensor on a tide staff serves as backup for data collection. In Alaska, many tide gauges sample the water level every 15 seconds or every minute. This data is accessed by satellite transmission or by telephone connection. These new tide gauges can support sensors to detect other environmental parameters such as wind speed, direction and gust, water current speed and direction, air and water temperature, barometric pressure, water conductivity, dew point, rainfall and solar radiation.

The tide gauge data used in this lesson has been filtered from the original data to list samples approximately every ten minutes to accommodate graphing in Microsoft Excel.

Activity Procedure:

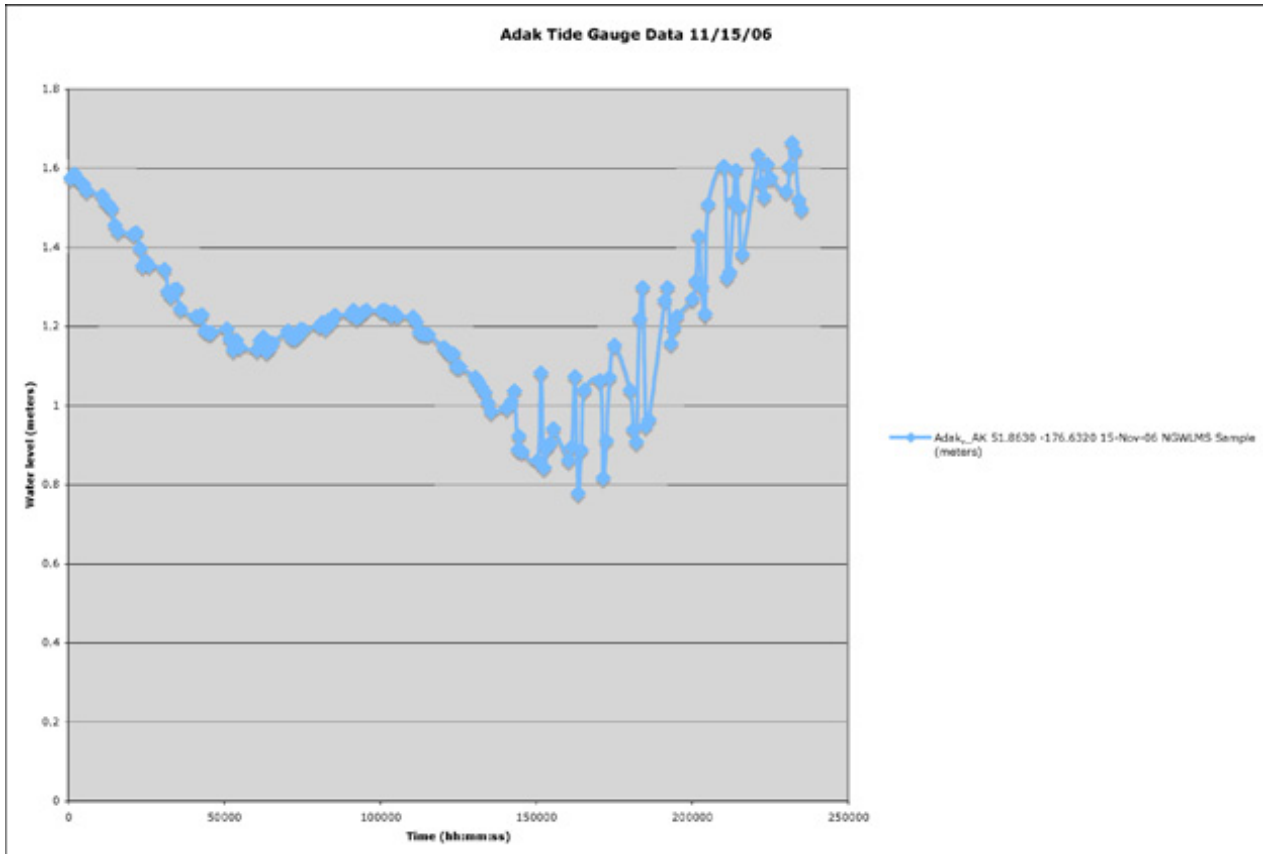
1. Display VISUAL AID: “Yup'ik Acoustics for Data Collection” and VISUAL AID: “Next Generation Water Level Measuring System” and explain that these two visual aids share something in common. Ask students what they think is similar between the visual aids.
2. Display VISUAL AID: “Yup'ik Acoustics for Data Collection” and explain that they both use acoustic waves to collect data. Use the information from *Whole Picture* and the three visual aids to describe the use of acoustics in Yup'ik seal hunting and the evolution of the tide gauge.
3. Distribute STUDENT WORKSHEET: “Make a Marigram.” Review the information presented on the worksheet.

When students are finished, discuss student responses as a class.

Answers:

1. *November 15, 2006*
2. *10 minutes*
3. *00:07:59*
4. *23:49:58*
5. *13:53:59, At this point the water level transitions from a smooth receding pattern of the tide to an increasing water level.*
6. *positive*
7. *14 waves*

8. 1.643 meters time: 23:29:59
9. 0.779 meters time: 16:33:59
10. 0.864 meters
11. The wave with the greatest period began at 19:30:00 and continued until 20:40:00. The period for this wave was one hour and ten minutes.
12. The wave with the greatest amplitude began at 18:19:59 with an initial water level of 0.908 meters. It rose 0.391 meters to a maximum height of 1.299 meters.
13. d. There is not enough data shown to answer this question.
- 14.



Lesson Information Sources:

Fienup-Riordan, A. (2007). *The way we genuinely live = Yuungnaqpiallerput : masterworks of Yup'ik science and survival*. Seattle: University of Washington Press.

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>

National Oceanic and Atmospheric Administration. *Tides & Currents: About water levels, tides and currents*. <http://tidesandcurrents.noaa.gov/about2.html>

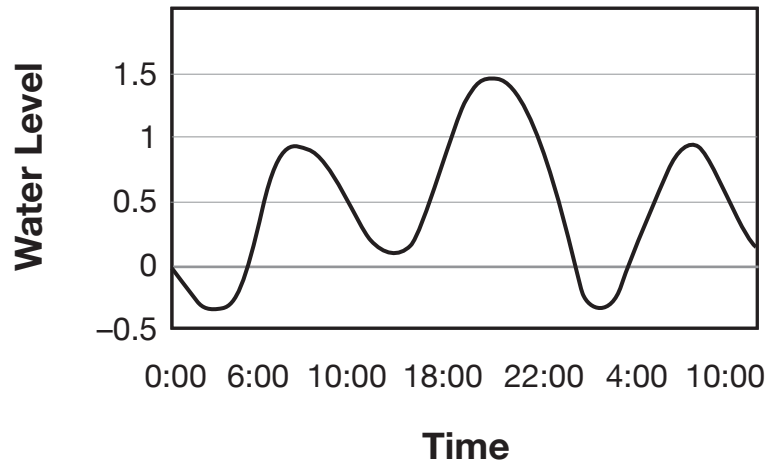
Name: _____



Make a Marigram

Student Worksheet (page 1 of 3)

Tide gauges can collect enormous amounts of data. Rather than analyzing a large list of numbers, graphs help scientists quickly evaluate large sets of data. Graphic displays of water level data are called marigrams. Because of their predictable nature, water levels affected by the tide are easily identifiable on a marigram. Tsunamis produce water level fluctuations that interrupt the smoother pattern of the tide. The diagram below shows the smooth fluctuations in water level due to the tides.



Access the set of data at the following URL:

<http://www.aktsunami.com/lessons/9-12/unit7/adaktidegauge.html>

This data was gathered at a tide gauge near Adak, Alaska on November 15, 2006. Water sample data is measured in meters. The time is recorded such that the last two digits are seconds, the third and fourth digits from the right are minutes, and the fifth and sixth digit from the right are hours (hh:mm:ss).

Examples:

sample time: 759 = 7 minutes and 59 seconds (00:07:59)

sample time: 80400 = 8 hours and 4 minutes (08:04:00)

This data is also recorded on a 24-hour clock (military time).

sample time: 194959 = 19 hours, 49 minutes and 59 seconds (19:49:59) = 7:49:59 pm

Name: _____

Make a Marigram

Student Worksheet (page 2 of 3)



- STEP 1. Copy and paste data from the website described above to a new spreadsheet in Microsoft Excel.
- STEP 2. Click on "View" and select "Normal."
- STEP 3. Highlight both columns of data.
- STEP 4. Click on the chart icon, or click on "Insert," "Chart." Select the chart type: XY (Scatter). Select the chart sub-type: "Scatter with data points connected by smoothed lines."
- STEP 5. Follow the steps on the Chart Wizard and be sure to include an appropriate "Chart Title" for the chart and title for "Value (X) axis" and (Value (Y) axis."
- STEP 6. For Step 4, of 4 on the Chart Wizard, keep the default as object in Sheet 1, and click "Finish."

Data Analysis:

Use the list of data and the graph to answer the following questions. Roll the mouse over the data points to get X, Y coordinates as necessary.

- 1. What is the date this data was recorded? _____
- 2. About how often was data recorded? _____
- 3. First time data was recorded (hours: minutes: seconds): _____
- 4. Last time data was recorded (hours: minutes: seconds): _____
- 5. What time would you say the tsunami struck the tide gauge? _____
Why? _____

- 6. Did the first wave arrive as a positive wave (rising water level) or as a negative wave (receding water level)? _____
- 7. How many tsunami waves are recorded on this data set? _____

Name: _____

Grades

9-12

Make a Marigram

Student Worksheet (page 3 of 3)



8. What is the highest recorded water level: _____ time: _____

9. What is the lowest recorded water level: _____ time: _____

10. What is the range of water level fluctuation? _____

11. Describe the wave with the greatest period (start time, end time, and period). The period of a wave refers to the time it takes for one wavelength (one crest + one trough) to pass a given point.

12. Describe the positive tsunami wave with the greatest amplitude (start time, end time, period, and amplitude).

13. When does the tsunami end? Circle the correct answer.

- a. 22:10:00
- b. 23:19:57
- c. 23:49:58
- d. There is not enough data shown to answer this question.

14. Print out the chart and attach it to this worksheet.