# Thinking Inside the Box

Student Activity Sheet (Elementary)

Name _____ Date _____ Class _____

The Mission:
The box before you represents an unexplored section of the deep seafloor. Naval records show that the submarine U.S.S. Bathy sunk somewhere in this area during World War II. You will be using sound to "see" the features of the seafloor in hopes of finding the U.S.S. Bathy and mapping this area. Oceanographers at sea, use sonar equipment, which sends out sound waves that reflect off seafloor features and return to the ship. If you know the time it takes for the pulse of sound to travel to the bottom and back and the speed at which the sound signal travels through water, you can figure out the distance the sound wave has traveled **(Distance = Speed ÷ Time)**. The speed of sound in water changes depending on the temperature and salinity of the water. However, on average, sound travels through water at a speedy 1500 meters per second. That's more than 3000 miles per hour! Sound only travels about 700 miles per hour in air.
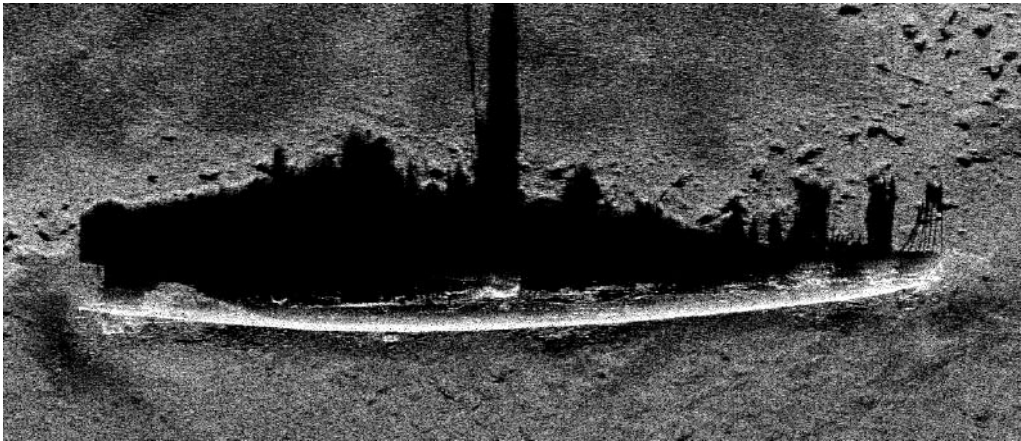
A side scan sonar picture of the U.S. Navy Submarine S5 that sank off the coast of Delaware in 1920
(Courtesy of Klein Associates, Inc.)

Materials:
Copy paper box containing a representative section of the seafloor
Calibrated timing dowel
Data tables

Procedure:

You will use the dowel as an instrument to measure the time it takes for a sound pulse sent from a ship to travel to and from the seafloor. Gently insert the dowel into each grid hole until it hits bottom. Record the "time" from the dowel. This time represents the time it takes for the sound pulse to travel to and from the seafloor.

Trial 1

- Tables 1 and 2 below show the grid system on the top of the 15-hole box lid. The first table is to be used for trial 1 where you will collect times at only the specified coordinates. The coordinate system is similar to the game Battleship. Systematically go through the grid filling in the corresponding times in the empty boxes of Table 1 (Time).

- Once you have collected all your times, use Table 3 (Depth Conversions) to figure out the depth of the seafloor for each time. Enter the depths into Table 2 (Depth). For example if the timing dowel reads 4 seconds then the seafloor is 3000 meters deep at that point.

Trial 1, Table 1: Time (s)

	A	C	E	G	I
2					
4					
6					

Trial 1, Table 2: Depth (m)

	A	C	E	G	I
2					
4					
6					

Table 3: Depth Conversions

Time (seconds)	Depth (meters)
6.0	4500
5.3	4000
4.7	3500
4.0	3000
3.3	2500
2.7	2000
2.0	1500
1.3	1000
0.7	500

Questions:
1. Have you found the submarine? If so list the coordinates where you found it.

2. If you haven't found it, what could you do (besides opening the box) to find it?

Trial 2
- For Trial 2 flip open the 15-hole lid. You will see below it a lid with 60 holes. Follow the same procedure as you did for Trial 1.

Trial 2, Table 4   Time (s)

	A	B	C	D	E	F	G	H	I	J
1										
2										
3										
4										
5										
6										

- Use Depth Conversion Table 3 to convert Table 4 times into distances and enter them into Table 5.

Trial 2, Table 5   Depth (m)

	A	B	C	D	E	F	G	H	I	J
1										
2										
3										
4										
5										
6										

Mapping: You've collected plenty of data, now brainstorm ways by which you could make a map of your 3-dimentional seafloor and present it on a 2-dimensional sheet of paper. Use only the Trial 2 data to make your map.

The following two methods are suggestions for how you can convert your Table 5 data into a map that will help you visualize the features of your ocean floor. Method 1 is a low-tech method using crayons or color pencils while Method 2 requires computers with the program Excel.

Method 1
Materials:
Crayons or color pencils, 1 each of black, dark blue, light blue, green, yellow, orange, red, and pink.
Seafloor Mapping Sheet

Procedure:
Systematically move across each row of your Trial 2 depth data and for each depth look on the depth color table below to find the corresponding color. Color the appropriate square that color on the Seafloor Mapping Sheet. For example, if square A2 is 2500 meters deep then color section A2 green on the Seafloor Mapping Sheet.

Depth Color Table

Depth (meters)	Color Code
4500	Black
4000	Purple
3500	Dark Blue
3000	Light Blue
2500	Green
2000	Yellow
1500	Orange
1000	Red
500	Pink
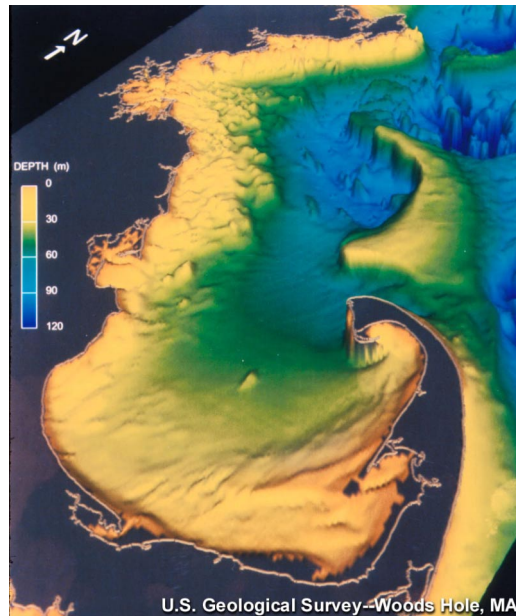
Once it is completed you should have a simplified view of the your ocean floor similar but less detailed than the map of Cape Cod Bay & Stellwagen Bank above.

Method 2
Materials:

Completed Trial 2 Depth data
Computer with the program Excel

Procedure:
The computer program Excel has the capability to make a 3- dimensional surface map from data such as the data collected in Trail 2.
1. Click on Excel to open the program.
2. Enter all the depth data into the corresponding boxes on the Excel table.
3. Once you have entered all the data, highlight all your data by clicking in box A1 and dragging to J6 so that all of your data is highlighted.
4. Go up to the tool bar and click on "chart".
5. Scroll down to "surface" and click on the view you prefer.
6. Fill in a chart title and label the x, y and z-axes. The z-axis is the depth.
7. To rotate the graph to get a better view of it go up to the tool bar and click on "chart".
8. Scroll down to "3-D view" and play with the elevation and perspective until your seafloor is easy to see.
9. To be consistent with standard oceanographic graphs you will need to reverse the order of numbering on the depth axis. Generally the top of the graph is sea level and depth increases as you go down. To change that on the depth axis move the cursor over to the depth axis and right click. Scroll down to "format axis". Click on the "scale" tab. Check the box that reads, "values in reverse order".
10. To get more definition in your depth scale, change the major unit to 300 (or whatever works for you). These changes are made in the same "format axis", "scale" section as above.
11. Once you are satisfied with your graph, you can print it out. (See an example of a 3-plot below.)
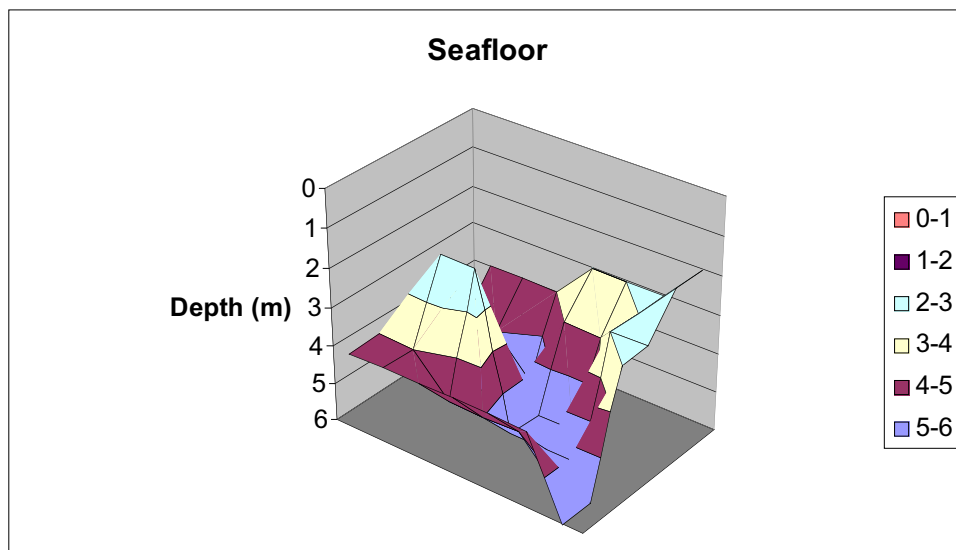
Questions:

3. Compare the seafloor to the floor in the classroom. What is different and what is the same?

4. Now have you found the submarine? If so list the coordinates where you found it.

5. What other features have you found? For example have you found any mountains or trenches? Make a sketch where are they located?

6. Compare the differences between the 15-hole picture and the 60-hole picture.

7. Below is an area of seafloor that you want to map. You are the captain of the ship. What will be the best way to cover every square without passing over any square twice? Draw arrows to mark your path.
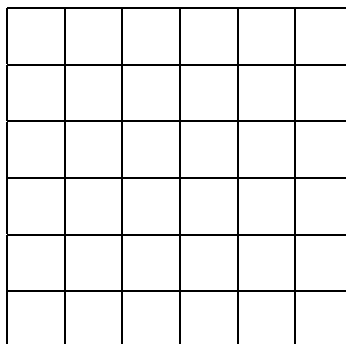
Teacher Strategy

Grade Level: Elementary & Lower Middle School (3-7)

Time Required: 3 Days of 45 minute classes

Standards Addressed:

New Standards Elementary

Applied Learning
Information Tools and Techniques - A3a, A3b

Mathematics
Geometry and Measurement Concepts - M2a, M2b, M2c, M2g, M2I, M2k
Statistics and Probability Concepts - M4a, M4b, M4c

Science
Physical Science Concepts - S1b
Earth and Space Science Concepts - S3a
Scientific tools and Technologies - S6a, S6b,
Scientific Communication - S7a

New Standards Middle School

Applied Learning
Information Tools and Techniques - A3a, A3b

Mathematics
Geometry and Measurement Concepts - M2a, M2b, M2c, M2g, M2I, M2k
Function and Algebra Concepts - M3b, M3c,
Statistics and Probability Concepts - M4a, M4b, M4c

Science
Physical Science Concepts - S1b
Earth and Space Science Concepts - S3a
Scientific Connections and Applications - S4
Scientific tools and Technologies - S6a, S6b, S6c
Scientific Communication - S7a

Science Literacy for ALL Students
Rhode Island Science Framework

Technology and Science Grade 3-5
(Benchmark 2 of 4)
(Benchmark 3 of 4)

Motion Grade 6-8
(Benchmark 4of 5)

Objectives:

1. Students will develop an understanding of how sonar is used and how it works.
2. Students will develop an understanding that sound travels faster through water compared to air.
3. Students will develop an understanding that it takes a longer time for sound to come back to you the farther away the object is you are bouncing the sound off.
4. Students will demonstrate that you can use sound to show what you can not see.
5. Students will demonstrate the collection of data in an organized fashion using grids and data tables correctly.
6. Students will use the data collected to create and build 2 and 3 dimensional maps and graphs by hand with grid paper and by computer with Excel.
7. Students will gain an understanding that the more sound pulses used, the more data collected, the more detailed and clearer the finished product will be.
8. Students will demonstrate the use of the equation speed = distance ÷ time or the correct use of a conversion table.

Background Information:

The ocean is relatively opaque to light and radio waves, but transparent to sound. Sound is the only energy that will travel a large distance at sea. The speed of sound in water varies depending on the temperature, salinity, and pressure of the water. The speed of sound increases with increased salinity, increased temperature, and increased pressure. The speed of sound ranges from 1440 m/s in cold fresh water to 1540 m/s for tropical waters. The average speed is1500 meters per second.

Sonar (Sound navigation and ranging) was developed in the early 20th century and used to detect submarines in World War I. Sonar systems can be active or passive. Passive systems only receive sound. A submarine uses passive sonar to hear without being heard. Active sonar systems send and receive sound. They send out a sound pulse, which hits a surface, and bounces back creating a picture in sound of the surfaces it hits. Refer to Discovery of Sound in the Sea, "What is sonar?" (https://dosits.org/animals/effects-of-sound/anthropogenic-sources/sonar/)

Side scan sonar is used to look at the detail of the ocean floor. Side scan sonar instruments are towed behind ships and often called towfish or tow vehicles. The instrument sends out a sonar signal in pulses at right angles to the direction the ship is moving (so it is "looking" sideways and down). The sonar signal is concentrated in a narrow band on both sides of the tow vehicle. Today's side scan sonar systems generate sound pulses at a frequency around 100kHz. Typical uses of side scan sonar include: looking for objects on the seafloor (sunken ships, pipelines, downed aircraft, lost cargo), detailed mapping of the seafloor, investigation of seafloor properties (grain size, etc) and looking at special features on the seafloor like underwater volcanoes.

Refer to Discovery of Sound in the Sea, "How do we find objects on the bottom of the ocean?" (https://dosits.org/people-and-sound/navigation/how-is-sound-used-to-find-objects-on-the-ocean-bottom/)

Instructional Strategies:

Optional Introductory Activity: *The following activity is optional and can be done to introduce the students to some important concepts.*

Have students lay on the floor in a long hallway with one ear to the floor. Have a teacher or student with clicking heals or shoes walk down the hallway toward the group of students on the floor. (Be sure to have the students on the floor face away from the person walking down the hall.) Ask the students to raise their hands as soon as they hear the person coming. Have one or more students mark down the time. (A stop watch or counting 1 one thousand 2 one thousand could be used.)

Next have students stand in the hallway in the same place with their backs to the person walking down the hall toward them. Ask the students to raise their hand as soon as they hear the person coming. Have one or more students mark down the time.
1. Which way did you hear the person coming down the hall sooner, with your ear to the floor, or standing with your back to the person?
2. Does sound travel faster through air or the solid floor?
3. Does sound travel faster through air or water?
4. (https://dosits.org/science/movement/how-fast-does-sound-travel/) Sound is a pressure wave that travels through different media differently. In general, the denser the medium, the faster the wave travels. Sound travels at about 340 meters per second in air and about 1500 meters per second in seawater.

Optional Opening Demonstration: *The following demonstration is optional and can be done to introduce the students to some important concepts.*

- Throw a ball against a wall and catch it from a close distance. Tell the students that you are always throwing the ball at the same speed. Now back up and throw the ball from farther away.
    1. What do you note about what happens with the ball as I step back away from the wall?
- Continue to bounce the ball off the wall from different distances until the students get the idea that it takes a longer time for the ball to return to you the farther you are from the wall. Explain that sonar works in a similar fashion.
    (Refer to https://dosits.org/animals/effects-of-sound/anthropogenic-sources/sonar/)

Preparation:

1. Assemble enough Seafloor Boxes for your class. Download Seafloor Box Instructions from the Sounds in the Sea web site, (https://dosits.org/resources/resource-categories/classroom-activities/#insidethebox)

2. Be sure to include the Seafloor mapping- student worksheet with the Student Activity packet.

Assessing Prior Knowledge:

Begin the class with a group discussion or short writing activity. Ask/Give the students the following questions:
1. How do scientists find out what the bottom of the seafloor looks like or find sunken ships or planes?
2. Here in front of you we have a model of the seafloor but it is inside this covered copy paper box. Why is the box covered? How is this like the seafloor?
3. What other sense could we use to find out what the seafloor or any thing else looks like if we could not see it?
4. How do some animals tell what is in front of them if they can not see it? (Refer to Discovery of Sound in the Sea, "How do Animals use sound to navigate?" https://dosits.org/animals/use-of-sound/marine-mammal-navigation/)
5. List tools that researchers and scientists use to see the seafloor. (Refer to Discovery of Sound in the Sea, People and Sound in the Sea, https://dosits.org/people-and-sound/examine-the-earth/map-the-sea-floor/)
6. How could we use this wooden dowel to see or find out what is in the bottom of our copy paper box without opening the box.
7. What research tool would the wooden dowel represent?

Procedural Tips:

- Note that the times given in Table 3: Depth Conversions are based on the time it takes for the sound signal to reach the seafloor and then return to the surface (round-trip). The depths represent the distance from the surface to the seafloor.
- The following is sample data that may be helpful when the students are conducting this activity. It also may be useful for when you are constructing the Seafloor Box.

Sample Data:

Trial 2, Time (s)

	A	B	C	D	E	F	G	H	I	J
1	3.3	2.0	1.3	2.0	2.7	3.3	3.3	3.3	3.3	3.3
2	2.7	1.3	0.7	1.3	4.0	4.7	4.7	4.7	4.7	4.7
3	2.7	2.7	1.3	4.7	4.7	4.7	4.7	4.7	4.7	4.7
4	3.3	3.3	4.7	4.7	6.0	6.0	6.0	6.0	6.0	6.0
5	4.7	4.7	4.7	6.0	6.0	4.0	4.0	3.6	4.0	4.0
6	4.7	6.0	6.0	6.0	4.0	4.0	4.0	3.6	4.0	4.0

Trial 2,   Depth (m)

	A	B	C	D	E	F	G	H	I	J
1	2500	1500	1000	1500	2000	2500	2500	2500	2500	2500
2	2000	1000	500	1000	3000	3500	3500	3500	3500	3500
3	2000	2000	1000	3500	3500	3500	3500	3500	3500	3500
4	2500	2500	3500	3500	4500	4500	4500	4500	4500	4500
5	3500	3500	3500	4500	4500	3000	3000	2700	3000	3000
6	3500	4500	4500	4500	3000	3000	3000	2700	3000	3000

Samples of Surface Maps Using the Data from the Activity and Graphing With Excel
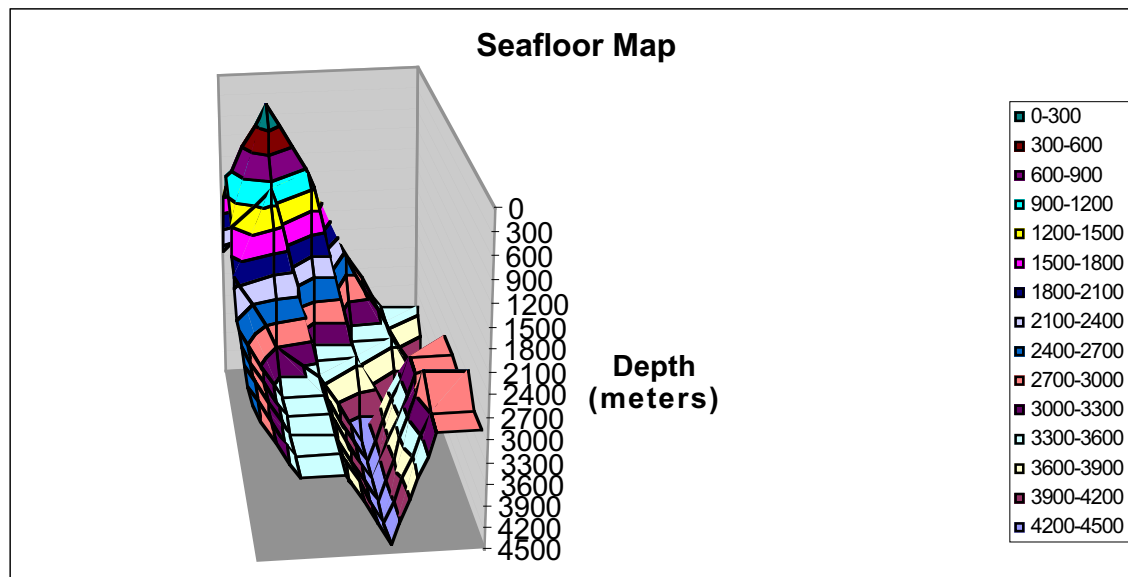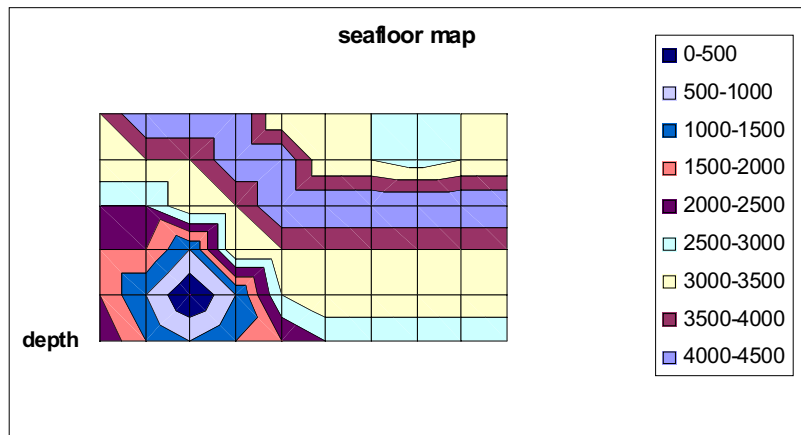
Answers to Questions:

1. Students should not see evidence of the submarine at this point.

2. Collecting data at more locations (more holes in the box) would give a more complete picture of the seafloor.

3. The seafloor is similar to the classroom floor in that they are both at the bottom. They are different in that the seafloor is not flat and the classroom floor is.

4. The submarine is located at H5 and H6.

5. There is a mountain located at C2, and a trench that runs from B6 to J3.

6. The 60-hole lid provides more sounding data and a more complete picture of the seafloor.

7.
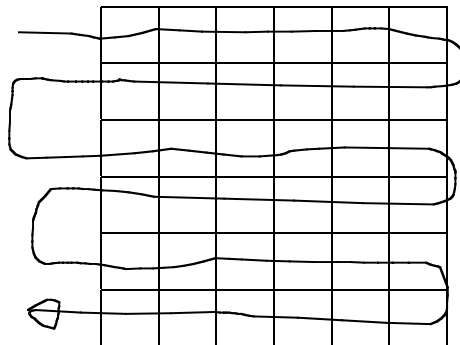
Post Activity Assessment:

- Have students present their findings to a group. In their presentation they should
    1. discuss the process they used (sonar) to collect their data
    2. present their data so that it is easy for the group to read and understand
    3. present their findings as a result of the data they collected

- Have students try the whole process in reverse. Start by giving them a section of a nautical map that has depths on it. What would be the time data that they would get if they were in a boat traversing that quadrant?

Extensions:

- Students can make their own Seafloor boxes.

Vocabulary:

Oceanographer - A scientist who studies the ocean

Sonar - A method or devise that uses sound waves to see beneath the surface of the ocean

Salinity - The amount of salt dissolved in seawater

Grid - A network of horizontal and vertical lines used for locating points on a map using coordinates

Coordinates - A set of numbers used to locate a point on a map

Depth - How deep the water is in an area

Trenched - A long deep depression in the seafloor

Resources/References:

Fish, John P. and Carr, H. Arnold; Sound Underwater Images; American Underwater Search and Survey Ltd.; Cataumet, Massachusetts; 1990.

Web Sites:
Discovery of Sound in the Sea (https://dosits.org/)

Side scan and Multibeam Sonar Information- NOAA (http://chartmaker.ncd.noaa.gov/hsd/wrecks.htm)

Mapping the Seafloor and Biological Habitats of the Stellwagen Bank (http://pubs.usgs.gov/factsheet/fs78-98)

Pacific Seafloor Mapping Project (check out the fly-by movie section) (http://walrus.wr.usgs.gov/pacmaps)

Images of the Seafloor off the U.S. Coast (http://www.ldeo.columbia.edu/us_margins/)

Stellwagen Bank National Marine Sanctuary (http://stellwagen.nos.noaa.gov)

Sonar Images (http://www.kleinsonar.com/imgal.html)