# Wet Maps

## Overview

**TOPIC:** Bathymetric mapping

**FOCUS:** Students explore the use of sound to create 2D and 3D models of seafloor features.

**GRADE LEVEL:** 6–8 Earth Science, Technology

**TIME NEEDED:** Two 50-minute class periods (plus additional time for optional extensions)

**DRIVING QUESTION:** How do scientists create and use maps to help them identify features on the ocean floor?

**OBJECTIVES/LEARNING OUTCOMES:**

Students will:

- Develop and use models of multibeam sonar mapping to explore seafloor features

- Analyze and interpret data to determine similarities and differences among the versions of the 2D and 3D models

- Communicate the limitations of the models by obtaining and evaluating information and data

- Analyze and interpret data to explain the influence of science and technology on how society explores, models and understands the ocean floor
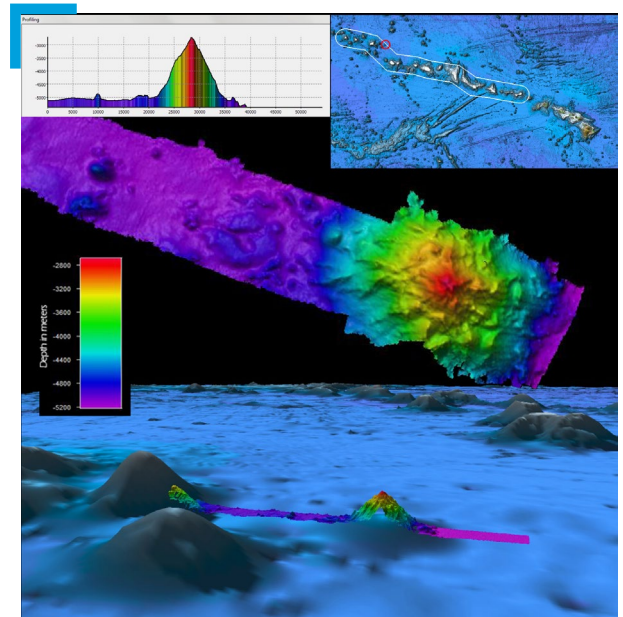


Composite image showing satellite-derived bathymetry data at the bottom, with multibeam bathymetry revealing an unnamed seamount. The middle image is a top-down view of bathymetry data showing the seamount, and the graph in the upper left corner shows the vertical profile of seamount's height relative to seafloor. *Image courtesy of NOAA Ocean Exploration.*

**Performance Expectations (PEs):** MSETS1-3

**Disciplinary Core Ideas (DCIs)**
ETS1.B: Developing Possible Solutions

**Crosscutting Concepts (CCs)**
Systems and System Models

**Science & Engineering Practices (SEPs)**
Analyzing and Interpreting, Data Constructing, Explanations Developing and Using Models

**COMMON CORE CONNECTIONS**
RST.6-8.7, RST.6-8.9

**OCEAN LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS**
Principle 7: FCs d, e.

OCEAN EXPLORATION

# Overview cont.

**MATERIALS:**

**Student Handouts**

- Student Worksheet: Wet Maps (1 copy per student)
- Mapping Simulation Group Data Sheet (1 copy per group)
- Row Data Graph Sheet (9 copies per group)

**Videos:**

- Multibeam Sonar (0:16) *NOAA*
- Using Sonar to Map the Deep Seafloor (8:59)
  *NOAA Ocean Exploration*

**Student Mapping Simulation (set-up for each group of 3-4 students)**

- 1 premade box containing a seafloor feature
- 4 premade sounding rods
- Colored pencils or crayons (red, orange, yellow, green, blue, purple)
- Tape
- Scissors
- 1 blank piece of cardstock or a manila folder



*Multibeam Sonar*

*Video courtesy of NOAA Ocean Exploration.*

**EQUIPMENT:**

- Computer and projector for class viewing of videos and slides
- *Optional: Student laptops or tablets for extensions and/or additional research*

**SET-UP INSTRUCTIONS:**

- Cue up videos to show the class.
- Prepare all boxes and rods for each group well in advance. For example, for 6 groups you will need to make 6 boxes and 24 rods.

  **Preparation Materials**

  - (~8 x 9 x 14 in or 20 x 23 x 14 cm) cardboard box or plastic box (opaque or painted black if needed)
  - Various materials: styrofoam, paper mache, or hardening clay to create seafloor feature
  - Sounding Rod Scale copies
  - Glue gun, glue sticks or duct tape to be used when creating seafloor features
  - Dowel Rods or unsharpened pencils (~1/4-inch diameter x ~8 inches in length)
  - Clear packing tape for sounding rods
  - Drill or sharp tool to pierce holes into box lid
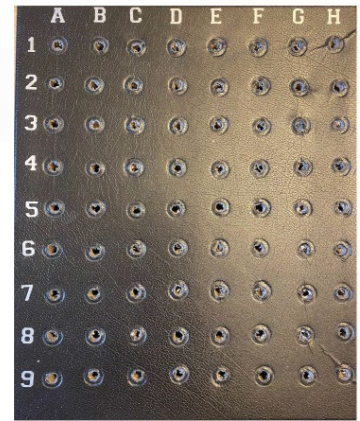  - *Optional -* Small toy boat or plane

Reference image of grid layout of rows and columns on box lid.

# Overview cont.

**SET-UP INSTRUCTIONS cont.**

**Preparation Instructions for Boxes and Rods**

- Label each box with a letter or number so that it can be quickly identified.

- Make a grid of 1-inch squares on the lid of the box and label each row with a number **(1-9)** and each column with a letter **(A-H)**.

- Drill or poke holes into the box lid. Each hole should be slightly larger in diameter than a pencil or dowel rod so the sounding rods can fit through. *Note: If you want to increase or decrease resolution, use a different grid size.*

- Use various materials to create seafloor features that could include an ocean ridge, seamount or seamount chain, trench, canyon and/or an optional archaeological feature, i.e. plane or ship

- Print out and cut the Sounding Rod Scale in color or in black and white and color your own.

- Use a piece of clear tape to secure each scale around the dowel rod or pencil.



Reference image of seafloor feature box.

# Educator Guide

**Background**

**Bathymetry** is a measure of the depths and shapes of underwater terrain. Scientists use sonar, SOund NAvigation, and Ranging, to create bathymetric maps that provide information on geological, archaeological, and biological features. These maps allow scientists to make informed decisions about where to explore using additional tools such as remotely operated vehicles (ROVs).

Since sound waves travel greater distances in water when compared to radar or light, sonar is a more effective tool for ocean exploration. Sonar systems use transmitters to send out pulses of sound energy called "pings" through the water. The sound travels, bounces off of items in the water or on the seafloor, like a seamount or a shipwreck, and returns to a receiver. The time it takes for each ping to make the round trip allows scientists to determine the distance from the ship to the item/feature.





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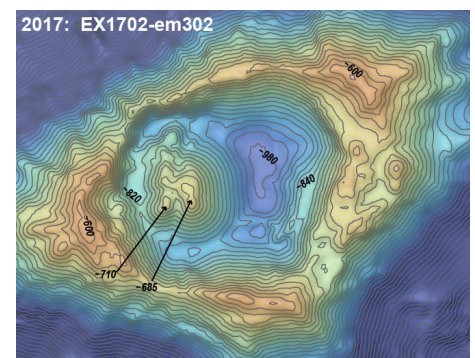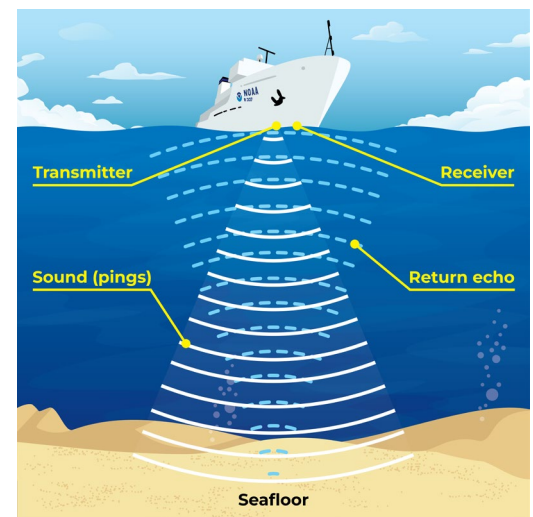
Bathymetric map of Vailulu'u Seamount, an active hotspot volcano in the Samoan archipelago. *Image courtesy of NOAA Ocean Exploration, American Samoa 2017.*

## Educator Guide cont.

**Background cont.**

The quality of seafloor imagery has improved dramatically over the years as technology has advanced from using single lead lines to single-beam sonar (one sound pulse at a time) to multibeam sonar (multiple sound pulses at a time).

**Multibeam sonar** transmits a fan-shaped swath of hundreds of sound pulses to efficiently create modern high-resolution maps. In these "false color" maps, the colors of the spectrum are used to represent relative depth of the location and features mapped with the deepest points usually represented in purple and the shallowest points in red.
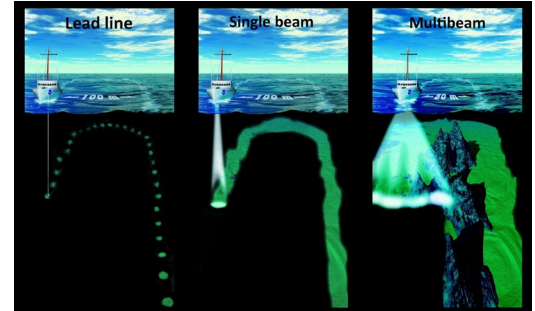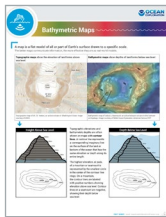


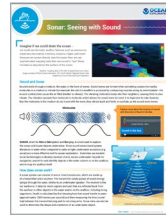*Adapted from the Canadian Hydrographic Service*

**Educator Note**

- Students should have a basic understanding of seafloor topography, plate tectonics, and sound waves, including how they move through a medium like water.

**FOR MORE INFORMATION:**

▸ *Bathymetric Maps* Fact Sheet

▸ *Sonar: Seeing with Sound* Fact Sheet

▸ *Multibeam Sonar* Fact Sheet

## Introduction

**Present** the Driving Question to the class: *How do scientists create and use maps to help them identify features on the ocean floor?*

**Provide** a brief review by discussing the following questions. Fact sheets can also be used to give students more context. Just be sure not to reveal too much information.

*Guiding Questions*

- How do we know what the seafloor looks like deep below the sea surface?
- What tools have been developed to make it easier to visualize the seafloor?
- What is sonar? How do you think it works?
- What do you think "multibeam" means?  How does it differ from a single beam?

# Educator Guide cont.

## Learning Procedure

**Distribute** the Student Worksheet to each student and 1 premade seafloor feature box with 4 sounding rods to each group. Remind students since we cannot see the bottom of the ocean, they must keep the box closed. Emphasize they will model measuring the depth from the surface of the water to the bottom, *not* from the bottom up.

**Ask** students to observe the measurements and colors on the sounding rods and answer the questions on page 1 of their worksheet.

**Show** the multibeam sonar clip so students get an idea of how multibeam sonar works.

> *What do the pencils/wooden dowels represent?* *Sound waves used to measure depth in the real ocean.*

> *Which way should you insert these into the box to measure the depth? Why?*
> *Insert the red end first. Possible answers are that measurements are taken from the top of the box down - deepest areas = blue/purple with higher #'s and shallowest areas = red/orange with lower #'s.*

Now, hand out the Mapping Simulation Group Data Sheet, 9 copies of the Row Data Graph Sheet (1 for each row of data), and a black paper or a manila folder to each group.

**Tell** students they will work together to "map" their mystery seafloor feature and create a 3D model. Mention they need to carefully read and follow the step by step instructions on their worksheet. Instructions are also listed below for the educator to review beforehand.



Figure 1. Image of seafloor box with sounding rods demonstrating the taking depth measurements.

**Multibeam Mapping Simulation Instructions**

- **Student 1** starts with Row 1 and inserts the 4 sounding rods into holes 1A, 1B, 1C, and 1D to measure each depth. **Student 2** reads off the depths, **Student 3** confirms the measurements, and **Student 4** records the data on the **Mapping Simulation Data Sheet**. **Student 1** will remove the sounding rods and move to holes 1E, 1F, 1G, 1H to complete "mapping" their first row. Students repeat this procedure for all rows. See Figure 1.

- Once all depths have been measured and recorded on the **Mapping Simulation Data Group Sheet**, students will begin to plot the results for each row on the **Row Data Graph Sheet** (Figure 2). Remind them to follow the coloring instructions before they begin to graph. *Note:* The purpose for coloring the paper before they begin to graph is because if you ask them to color the rows after they make the graph, many students will do it incorrectly and will color each bar a single color.

- Make sure they use one copy of the data sheet for **each** of the 9 rows.

- When all nine graphs are completed, they will be cut, as shown in Figure 3, fold and tape in order of the rows onto a black paper or a manila folder you provided. They will need to leave the border at the bottom of each graph, and the folded edge of each graph should lie on the folder. Finally, they will stand the graphs up to see the 3D model of the mystery landscape inside the box!
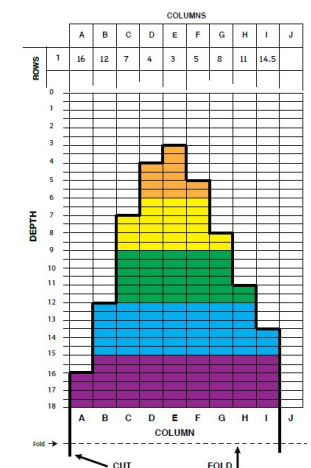


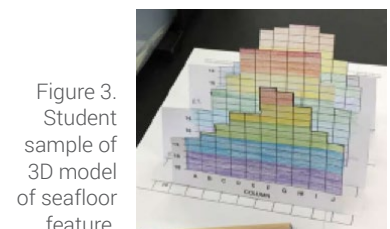Figure 2. Reference image of colored Row Data Graph.



Figure 3. Student sample of 3D model of seafloor feature.

## Educator Guide cont.

### Putting the Pieces Together

Once the students have finished their 3D models, have them work together and answer their discussion questions. If time allows, have the class share and discuss some of the pros and cons of their models and what features they mapped. The video Using Sonar to Map the Deep Seafloor can also be used as a final wrap up resource.

### Extensions

History and Inequality in Science: Have students read about the history of mapping the ocean floor and the essential role of Marie Tharp.

- Marie Tharp: Mapping the Ocean Floor: https://blogs.loc.gov/loc/2021/08/marie-tharp-mapping-the-ocean-floor/

- Celebrating Marie Tharp: https://www.google.com/doodles/celebrating-marie-tharp

- How One Brilliant Woman Mapped the Secrets of the Ocean Floor: https://www.youtube.com/watch?v=vE2FK0B7gPo&t=125s

Have students compare low and high resolution mapping.

- Seafloor Mapping Module, Ocean Exploration Trust: https://nautiluslive.org/resource/seafloor-mapping-simulation

- Draining the Oceans, NASA: https://svs.gsfc.nasa.gov/4823

For a creative culinary application of false-color mapping, try Bathymetry Cupcakes, Ocean Exploration Trust.
- https://nautiluslive.org/sites/default/files/documents/2020-03/Bathymetry%20Cupcakes.pdf

### Scientific Terms

**Sonar:** Short for **SO**und **NA**vigation and **R**anging; is helpful for exploring and mapping the ocean because sound waves travel farther in the water than do radar and light waves.

**Multibeam sonar:** A type of active sonar system used to map the seafloor and detect objects in the water column or along the seafloor.

**Sounding:** Water depth measurements

**Bathymetry:** The measurement of "submarine topography" or the depths and shapes of underwater terrain.

# Educator Guide cont.

## Assessment

Opportunities for formative assessment are embedded throughout the lesson through class discussions. The models constructed as well as the discussion questions can be used as an opportunity for summative assessment.

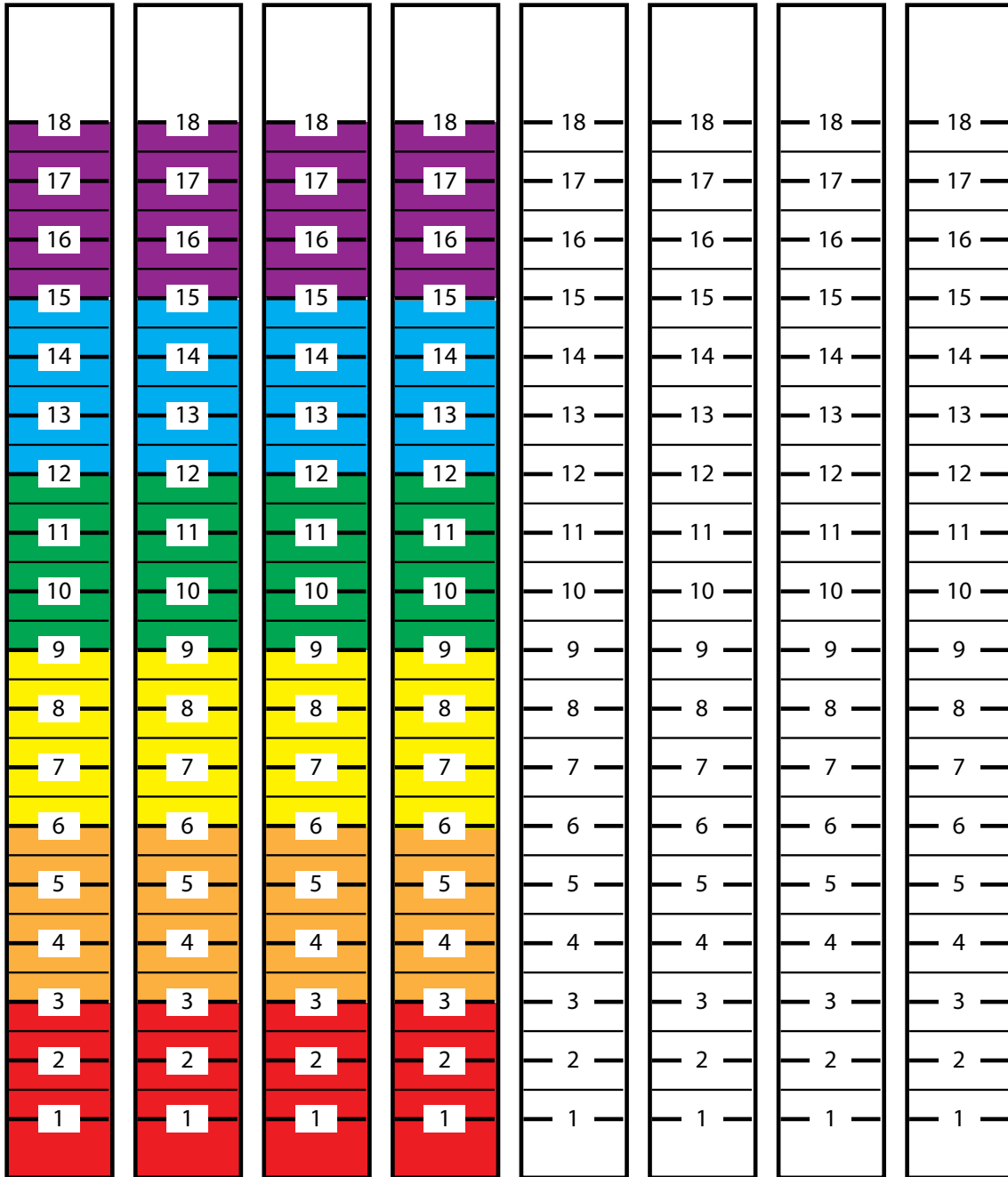**Teacher Answer Key: Wet Maps**

1.  Each box will have a different feature and therefore a different student prediction and explanation. Answers should include justifications about increases or decreases in depths (bumps, slopes, changes in depth, etc.) from their data to explain their prediction.

2.  After students compare their paper model to what is inside the box, answers will vary but should include a description of similarities and differences between the models. For example, did they miss any aspects of the object(s) in the box or is their map as detailed as the actual object?

3.  At this point, it can also be helpful to have them look at other student models to see the range of features and accuracy of models.

    Answers should include terms (rod, sounding, false-color, sound, depth, ship), and a detailed description of how students modeled multibeam sonar using rainbow-colored rods to model the sound waves from the ship traveling into the water and bouncing off the seafloor feature. The "depth" number recorded was like a "sounding". The rods were placed in a row to model a swath of sound to better model multibeam sonar. Each number recorded from the sounding rods represented the depth of the ocean at that location. Higher numbers represented deeper depths or longer times the sound would take to reach the bottom and return to the ship. The colors on the pencil represent the range depth with red being the shallowest and purple being the deepest.

4.  Students should identify that the rods collect a point of data, and that true sonar collects all the data between the holes and not just a single point. Advanced students could discuss discrete vs. continuous data. Sound was not used at all in this model, which is an inaccuracy in comparison to real multibeam sonar.

5.  Answers will vary but could include a description of making the grid have more points with less space between the points or using a "pinger" to use sound to better represent sonar.

# Sounding Rod Scale

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 |
| 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 |
| 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Mapping Simulation Group Data Sheet**
Use this sheet to record all your mapping data for Rows 1-9 and Columns A-H.

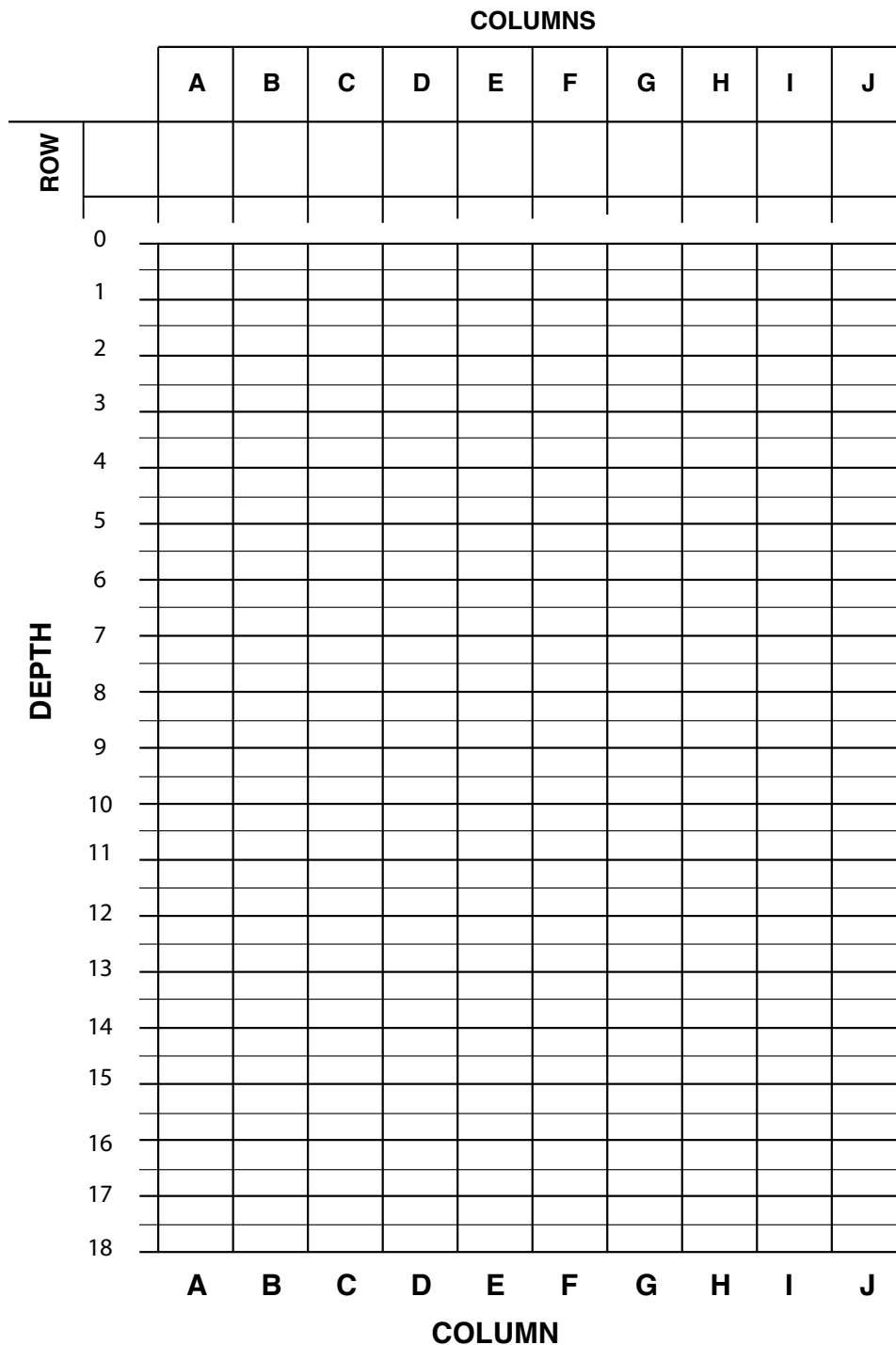Group Member Names: _____     Which box do you have?_____

|  | COLUMNS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
|  | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** |
| **1** |  |  |  |  |  |  |  |  |  |  |
| **2** |  |  |  |  |  |  |  |  |  |  |
| **3** |  |  |  |  |  |  |  |  |  |  |
| **4** |  |  |  |  |  |  |  |  |  |  |
| **5** |  |  |  |  |  |  |  |  |  |  |
| **6** |  |  |  |  |  |  |  |  |  |  |
| **7** |  |  |  |  |  |  |  |  |  |  |
| **8** |  |  |  |  |  |  |  |  |  |  |
| **9** |  |  |  |  |  |  |  |  |  |  |
| **10** |  |  |  |  |  |  |  |  |  |  |

**ROWS**

## Row Data Graph Sheet

BEFORE you begin to graph your data, FIRST color the entire grid below like a rainbow to match the sounding rod's row markings.

**Rows 1-3 = RED    Rows 4-6 = ORANGE    Rows 7-9 = YELLOW**
**Rows 10-12 = GREEN    Rows 13-15 = BLUE    Rows 16-18 = PURPLE**

**COLUMNS**

| ROW | A | B | C | D | E | F | G | H | I | J |
|-----|---|---|---|---|---|---|---|---|---|---|
|     |   |   |   |   |   |   |   |   |   |   |

**DEPTH**

0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

A   B   C   D   E   F   G   H   I   J

**COLUMN**

## Educator Guide URLs/Links

**Page 1:** ▸ Satellite-derived bathymetry (image): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1504/dailyupdates/media/aug14-hires.jpg

**Page 2:** ▸ Student Worksheet: Wet Maps (PDF): https://oceanexplorer.noaa.gov/edu/materials/wetmaps-student-worksheet.pdf
▸ Multibeam sonar (video): https://www.youtube.com/watch?v=8ijaPa-9MDs
▸ Using Sonar to Map the Deep Seafloor (video): https://oceanexplorer.noaa.gov/edu/multimedia-resources/dsd/media/2023-DSD-Mapping-v6-1920x1080.mp4
▸ Snap-N-Store Collapsible Organizer: https://www.amazon.com/Snap-N-Store-Durable-Collapsible-Index-SNS02090/dp/B08PDX9WMQ/ref=sr_1_10?crid=2H0JAC81GQIS2&keywords=index%2Bcard%2Bboxes%2Bfoldable%2B5x%2B8&qid=1707164143&sprefix=index%2Bcard%2Bboxes%2Bfoldable%2B5x%2B8%2Caps%2C106&sr=8-10&th=1

**Page 3:** ▸ Seafloor features (image): https://www.noaa.gov/education/resource-collections/ocean-coasts/ocean-floor-features
▸ Sonar: Seeing with Sound factsheet (PDF): https://oceanexplorer.noaa.gov/edu/materials/sonar-fact-sheet.pdf
▸ Bathymetric Maps factsheet (PDF): https://oceanexplorer.noaa.gov/edu/materials/bathymetric-mapping-fact-sheet.pdf
▸ Vailulu'u bathymetric map (image): https://oceanexplorer.noaa.gov/edu/materials/bathy-vailuluu.jpg
▸ Sonar pings (illustration): https://oceanexplorer.noaa.gov/edu/materials/sonar-pings-illustration.png

**Page 4** ▸ Multibeam (diagram): https://noaacoastsurvey.files.wordpress.com/2015/07/surveying.jpg
▸ Multibeam sonar (video): https://www.youtube.com/watch?v=8ijaPa-9MDs
▸ Bathymetric Maps factsheet (PDF): https://oceanexplorer.noaa.gov/edu/materials/bathymetric-mapping-fact-sheet.pdf
▸ Sonar: Seeing with Sound factsheet (PDF): https://oceanexplorer.noaa.gov/edu/materials/sonar-fact-sheet.pdf
▸ Multibeam Sonar factsheet (PDF): https://oceanexplorer.noaa.gov/edu/materials/multibeam-sonar-fact-sheet.pdf

**Page 5** ▸ Student Worksheet: Wet Maps (PDF): https://oceanexplorer.noaa.gov/edu/materials/wetmaps-student-worksheet.pdf
▸ Multibeam sonar clip (video): https://youtu.be/8ijaPa-9MDs

**Page 6** ▸ Using Sonar to Map the Deep Seafloor (video): https://oceanexplorer.noaa.gov/edu/multimedia-resources/dsd/media/2023-DSD-Mapping-v6-1920x1080.mp4

Extension 1:
▸ Marie Tharp: Mapping the Ocean Floor: https://blogs.loc.gov/loc/2021/08/marie-tharp-mapping-the-ocean-floor/
▸ Celebrating Marie Tharp: https://www.google.com/doodles/celebrating-marie-tharp
▸ How One Brilliant Woman Mapped the Secrets of the Ocean Floor: https://www.youtube.com/watch?v=vE2FK0B7gPo&t=125s

Extension 2:
▸ Seafloor Mapping Module, Ocean Exploration Trust: https://nautiluslive.org/sites/default/files/documents/2020-04/SeafloorMappingModule.pdf
▸ Draining the Oceans, NASA: https://svs.gsfc.nasa.gov/4823

Extension 3:
▸ Bathymetry Cupcakes: https://nautiluslive.org/sites/default/files/documents/2020-03/Bathymetry%20Cupcakes.pdf

## Information and Feedback