Lesson Plan

9-12 BATHYMETRY BASICS

Essential Questions:

1. How can we use bathymetry data to learn about our oceans?
2. How does SONAR help identify geologic features?

GSE Standards:

- **SO2**: Obtain, evaluate, and communicate information about the characteristics, physical features, and boundaries of the oceans.
- **SO2.d:** Develop and use models to investigate geological features from the continental margins to the deep ocean basins.

NGSS Standards:

- **HS-PS4-1:** Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Materials:

- Bathymetry worksheet and maps
- Three different colored writing utensils
- Calculator
- "What is Bathymetry?" Video
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Vocabulary:

- SONAR
- Sound Waves
- Bathymetry
- Continental Shelf
- Trench
- Seamount

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Background:

- Sound travels in transverse waves from a source.
  - Transverse waves require a medium to travel through. A medium is any matter (solid, liquid, or gas) that the waves can interact with.
  - The more dense the matter, the faster the transverse wave will travel, as there are more particles for the wave to make contact with as it travels.
  - Sound waves travel much faster in water than in air.
  - In air, sound waves travel at approximately 340 meters/second (~760 miles per hour). In water, that increases to 1,500 meters/second (~3,355 miles per hour)!
- SONAR stands for Sound Navigation and Ranging.
  - A ship uses SONAR by sending out a loud noise down from the surface of the water to the seafloor, where the sound bounces back to the ship.
  - By determining how long the sound takes to return, the ship can figure out the depth of the water below.
- Bathymetry is the study of the depth of water.
  - Bathymetric maps can tell us what geologic features may be present underwater by mapping the apparent depth at any point in the ocean.
  - So far, less than 25% of the ocean has been mapped with SONAR.
  - There are many kinds of underwater geologic features in the ocean, many resemble terrestrial features on land.
- **Seamounts** are underwater mountains, usually remnants of an underwater volcano or a long-since eroded island.
  - The Hawaiian Island Chain is a hotspot volcano that moves with the tectonic plates. Behind the visible islands, many seamounts are found in a line extending from the big island of Hawaii to nearly the Bering Sea in the Arctic Circle.

Background:

    - Because the tops of seamounts are far shallower than the surrounding water, the additional light reaching the top of seamounts can create underwater islands of life that can include coral reefs.
- Trenches are deep underwater chasms that resemble canyons on land.
    - Often formed due to tectonic plates meeting and sliding below one another.
    - The deepest point in the ocean, the Mariana Trench, is one such trench. It is more than 36,000 feet deep! That's as far below sea level as the cruising altitude of commercial airplanes are above it.
- A **Continental Shelf** is a shallow expanse of water surrounding a large land mass, usually followed by a sudden drop.
    - These parts of the ocean are abundant with sea life as they are much shallower, letting more light reach the bottom.
    - Additionally, they receive the benefits (or detriments) of freshwater runoff from rivers that cut through land.
- The features of the ocean floor are largely driven by plate tectonics, a process where the Earth's crust is broken into individual tectonic plates that slide around each other.
    - These plates sit atop ever-shifting magma below the crust, and will often slide past each other, run in to each other, or split apart over the course of millions of years.
    - These shifting plates interacting with each other is often the cause of these underwater geographical features.
        - Plates that split apart can create features like the Mid-Atlantic Ridge, where the Eurasian and North American plate are slowly drifting away.
        - Plates that come together can create deep trenches, like the Mariana Trench in the Pacific Ocean.

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Lesson Structure:

1. Show students the "What is Bathymetry?" video from the USGS on YouTube. Discuss why bathymetry data is essential for ocean exploration and safe ship navigation.
2. Introduce the vocabulary words by explaining the different types of underwater geological features and the methods with which we measure ocean depth.
3. Give students the data set sheet, the graph, and the images of the ship tracks, and introduce the activity.
4. Have students use three different colors to graph their data points, each one overlapping the others.
5. After graphing the data points, have students match their graph to real-world ship tracks, assigning a data set to each.
6. Students should justify their answers in the response area below each ship track image.

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Evaluate:

1. Ensure students can interpret their data set graphs and have matched them to the correct ship track image.
2. Encourage students to share their justifications with each other to determine if other students found similar results in their data.
3. Ask students to imagine how other underwater geographical features might appear and how their findings can inform scientists.

Extend:

1. For an added mathematical challenge, encourage students to try the challenge questions based on real-world scenarios.
2. Ask students to develop their own data set and have other students in the class graph their data points.
3. Encourage students to attempt to create a data set that reflects real-world underwater geography.
4. If a student is interested in a career field in seafloor mapping, explore this web page with an accompanying video from the Ocean Exploration Trust.

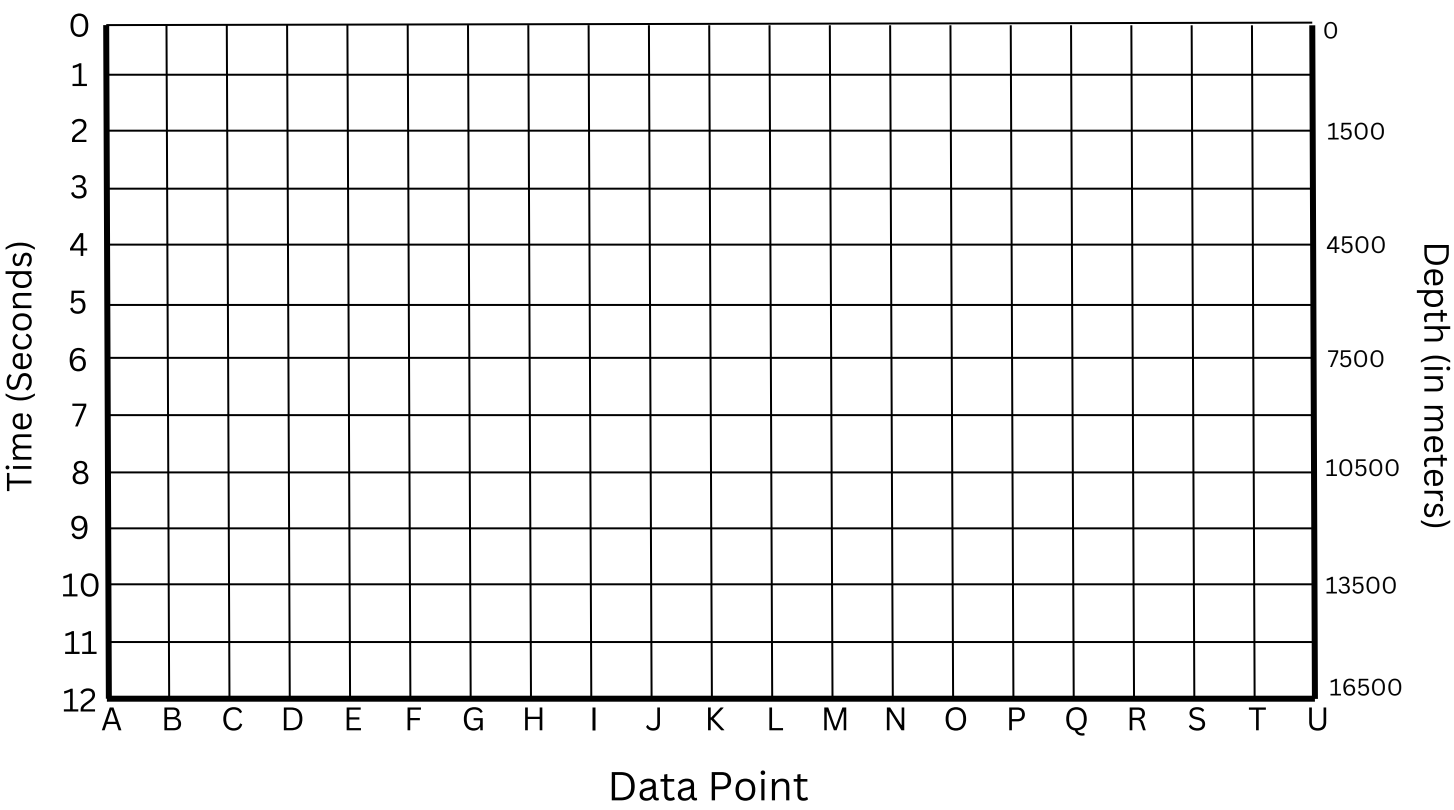
Data Set
WORK SHEET

Data Set A	Data Set B	Data Set C
A3	A10	A1
B4	B11	B1
C3	C11	C1
D5	D10	D2
E4	E10	E2
F7	F11	F2
G7	G12	G3
H9	H11	H5
I11	I11	I6
J12	J9	J6
K11	K7	K10
L9	L5	L11
M8	M3	M12
N6	N4	N11
O5	O3	O11
P6	P5	P11
Q5	Q7	Q12
R4	R9	R11
S3	S11	S11
T3	T11	T10
U3	U12	U12

Bathymetry
DATA POINT GRAPH

A research vessel using SONAR to measure the geographic features of the seafloor sailed over several coordinates. Each data set represents one ship track over a different geologic feature.

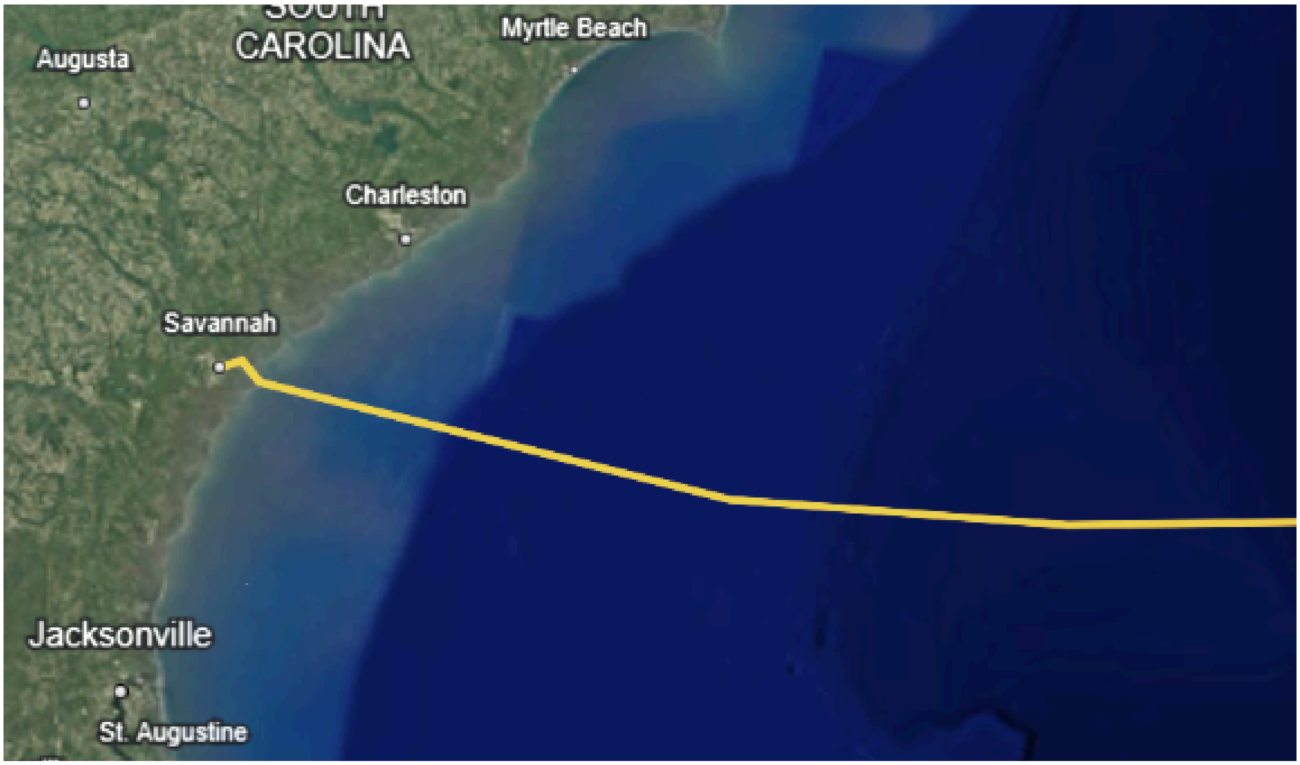
Graph the data points from the sets using three different colored utensils, one color per data set. Then, match the data set to the ship track image.



Ocean Trench

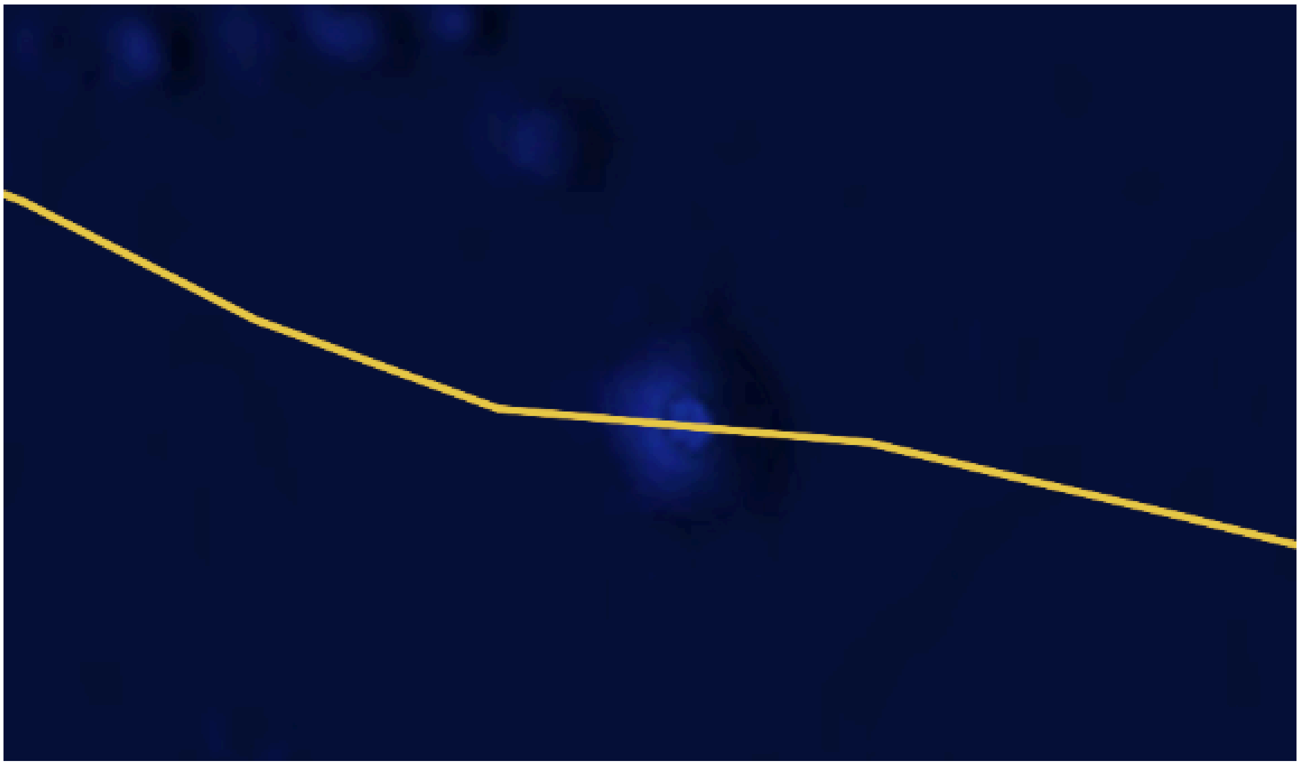
Which data set matches the bathymetry data for this ship's track? How do you know?

Continental Shelf



Which data set matches the bathymetry data for this ship's track? How do you know?

Seamount



Which data set matches the bathymetry data for this ship's track? How do you know?

Challenge Questions

1. Sound travels through water at 1,500 meters per second. If a ship sends a SONAR scan to the bottom of the ocean and it takes 3 seconds to return, approximately how deep is the water? Hint: The sound has to travel from the ship, to the bottom, and back to the ship again.

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2. A hydrophone is an underwater microphone that marine biologists use to listen for scientific data, such as whale calls. If a whale is 7,000 meters away from the hydrophone, approximately how long would it take for the whale call to reach the hydrophone?

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3. If it takes a ship engine's sound 12.8 seconds to reach a hydrophone, approximately how many meters away is the ship?

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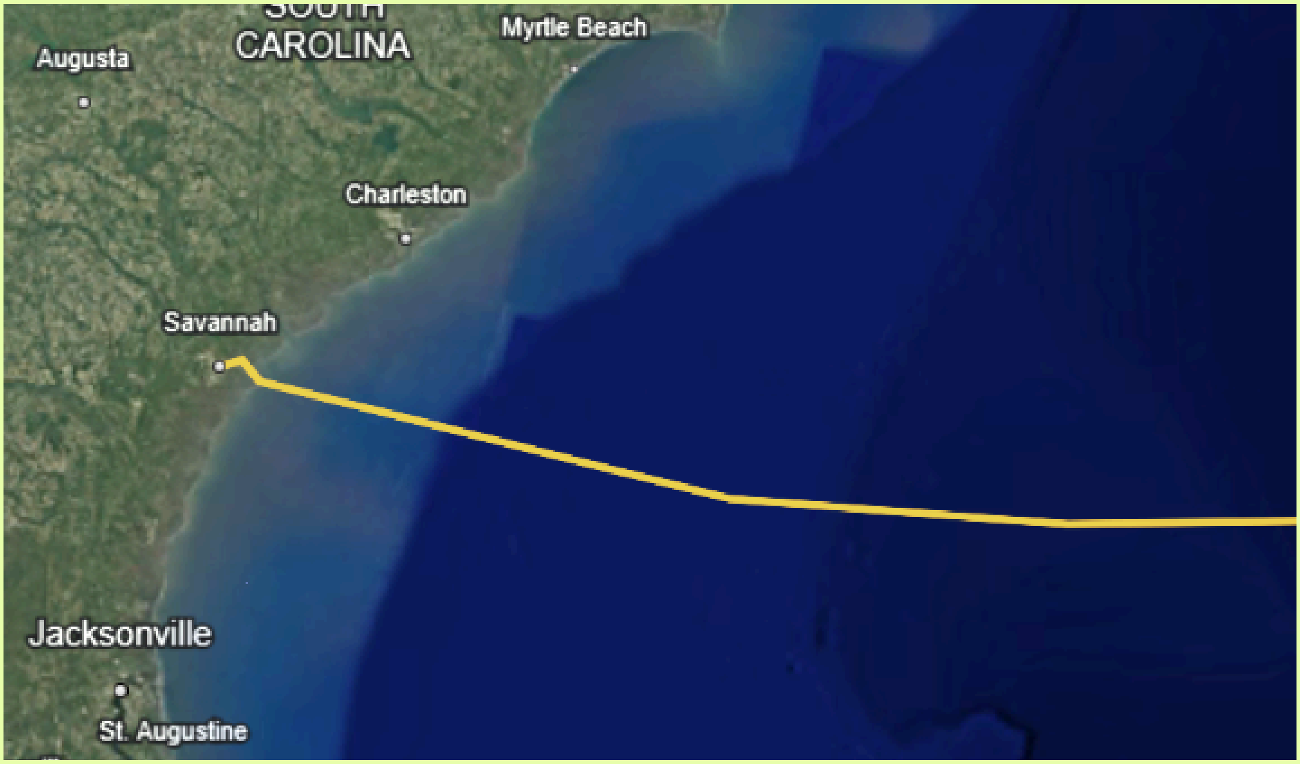
Ocean Trench
ANSWER KEY

Which data set matches the bathymetry data for this ship's track? How do you know?

Students should select dataset A and recognize how the graphed data matches the general topography of a deep-ocean trench.

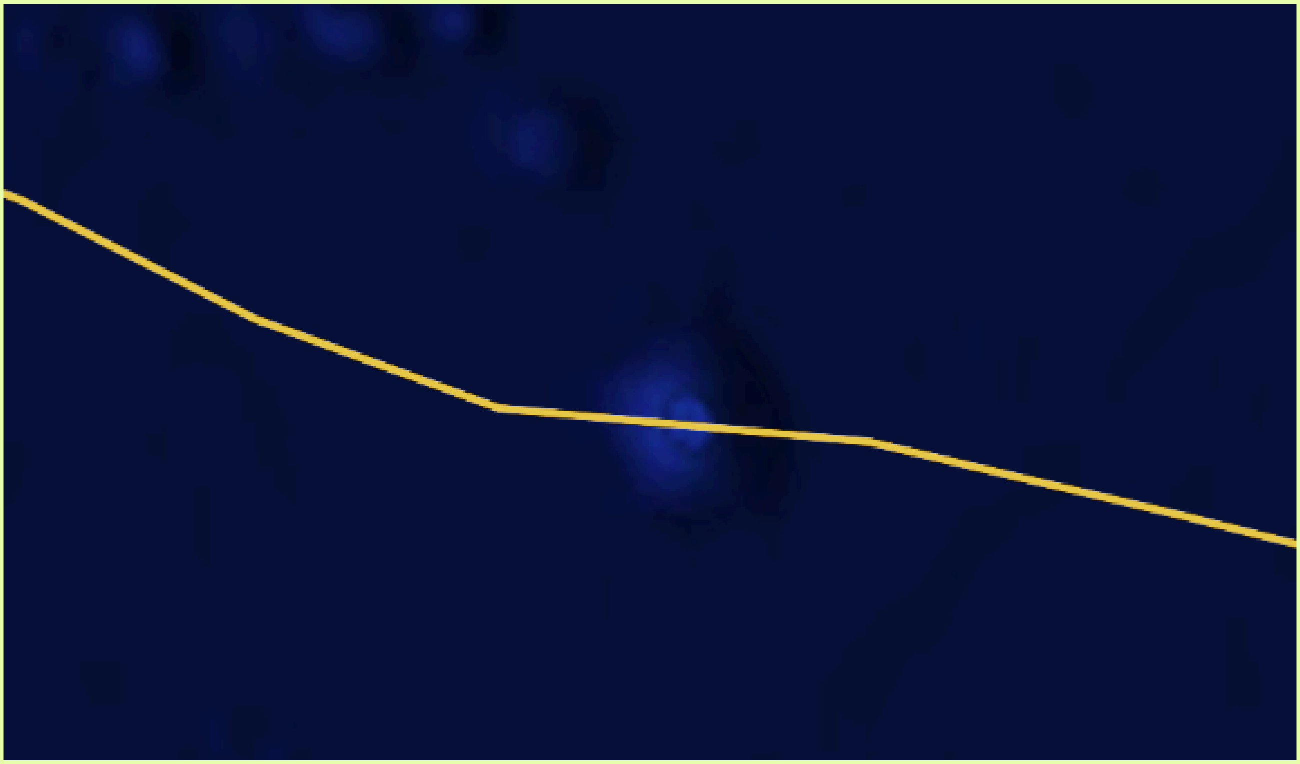
Continental Shelf
ANSWER KEY



Which data set matches the bathymetry data for this ship's track? How do you know?

Students should select dataset C and recognize how the graphed data matches the general topography of a continental shelf.

Seamount
ANSWER KEY



Which data set matches the bathymetry data for this ship's track? How do you know?

Students should select dataset B and recognize how the graphed data matches the general topography of a seamount.

Challenge Questions
ANSWER KEY

1. Sound travels through water at 1,500 meters per second. If a ship sends a SONAR scan to the bottom of the ocean and it takes 3 seconds to return, approximately how deep is the water? Hint: The sound has to travel from the ship, to the bottom, and back to the ship again.

1500 meters x 3 seconds = 4500 total, divide by 2 to account for the return time.

Final answer is 2250 meters.

2. A hydrophone is an underwater microphone that marine biologists use to listen for scientific data, such as whale calls. If a whale is 7,000 meters away from the hydrophone, approximately how long would it take for the whale call to reach the hydrophone?

7,000 meters / 1500 m/s = 4.6667 seconds.

3. If it takes a ship engine's sound 12.8 seconds to reach a hydrophone, approximately how many meters away is the ship?

12.8 seconds x 1500 m/s = 19200 meters.