Mapping Deep-Sea Features

Background Information

This activity focuses on how bathymetric maps are created from multi-beam bathymetric data. Students will construct a false color map of the Loihi submarine volcano, using real data. They will then make a model seamount from craft foam to help visualize the translation of a two-dimensional model (a map) into three-dimensional model.

A chain of small islands and atolls stretches for more than 1,000 nautical miles northwest of the main Hawaiian Islands. While scientists have studied shallow portions of the area for many years, almost nothing is known about deeper ocean habitats below the range of SCUBA divers. Only a few explorations have been made with deep-diving submersibles and remotely operated vehicles (ROVs). These brief excursions led to the discovery of new species and species previously unreported in Hawaiian waters.

A major constraint to exploration of deepwater regions around the Northwestern Hawaiian Islands is the absence of accurate maps. In fact, recent expeditions found that some islands are not where they are supposed to be according to official nautical charts. Since time in submersibles is limited and expensive, every dive is carefully planned to ensure that the submersible goes to places of scientific interest. Good bathymetric maps are essential to good planning.

Scientists aboard the University of Hawaii's research vessel *Kilo Moana* used multi-beam swath bathymetry to create detailed pictures of the underwater topography around the Northwestern Hawaiian Islands. Multi-beam swath bathymetry, also called high-resolution multi-beam mapping, uses a transducer —a combination microphone/loudspeaker —on the ship's hull to send out sound pulses in a fan-shaped pattern below the ship. It records sound reflected from the sea floor through receivers focused at different angles on either side of the ship. This system collects high-resolution water depth data, distinguishing differences of less than one meter. It also measures back scatter—the amount of sound energy returned from the sea floor—which identifies different materials such as rock, sand, or mud on the sea floor.

The multi-beam system, coupled with a global positioning system (GPS), pinpoints sea-floor locations within one meter. Data are collected in digital form for computer analysis which produces maps, three dimensional models, and even fly-by videos simulating a trip through the area in a submersible.

Bathymetric maps are the most common output. Points with the same depth are connected by lines, showing mountains and valleys as a series of concentric, irregular closed curves. Lines that appear close together indicate steep slopes while lines that are farther apart indicate more gentle slope.

Each group will find ALL the recorded depths and color the entire square the assigned color for that depth. Colors may vary with pen sets but use in sequence of the spectrum of light.

Data Range:
5000-4600 m - purple
4500-4100m - blue violet
4000-3600m - blue
3500-3100m - blue green
3000-2600m - green
2500-2100m - yellow
2000-1600m - orange
1500-1000m - red

Student Handout

Loihi Submarine Volcano Bathymetric Data

Grid Cell (row, column)	Depth (m)	Grid Cell (row, column)	Depth (m)	Grid Cell (row, column)	Depth (m)	Grid Cell (row, column)	Depth (m)
1,1	no data	3,12	1900	6,8	1800	9,4	3400
1,2	no data	3,13	2000	6,9	1600	9,5	3900
1,3	no data	3,14	2100	6,10	1300	9,6	4000
1,4	4600	3,15	2200	6,11	1200	9,7	3800
1,5	4400	4,1	no data	6,12	1700	9,8	3700
1,6	4400	4,2	no data	6,13	2000	9,9	3600
1,7	4000	4,3	4400	6,14	2200	9,10	3800
1,8	3800	4,4	3800	6,15	2000	9,11	3600
1,9	3600	4,5	3500	7,1	4500	9,12	3500
1,10	3300	4,6	3200	7,2	4400	9,13	3400
1,11	2700	4,7	2800	7,3	4000	9,14	3300
1,12	2400	4,8	2800	7,4	3800	9,15	3200
1,13	2500	4,9	2300	7,5	3000	10,1	4500
1,14	2600	4,10	1800	7,6	2400	10,2	4200
1,15	2800	4,11	1400	7,7	2400	10,3	4200
2,1	no data	4,12	1500	7,8	2300	10,4	4700
2,2	no data	4,13	1600	7,9	2300	10,5 - 10,15	no data
2,3	no data	4,14	1800	7,10	2500	11,1	4700
2,4	4200	4,15	1900	7,11	2500	11,2	4500
2,5	4100	5,1	no data	7,12	2700	11,3	4700
2,6	4100	5,2	no data	7,13	2900	11,4 - 11,15	no data
2,7	3900	5,3	4600	7,14	3000		
2,8	3400	5,4	4000	7,15	2500		
2,9	3200	5,5	3400	8,1	4500		
2,10	2800	5,6	2900	8,2	4000		
2,11	2400	5,7	2300	8,3	3600		
2,12	2200	5,8	1800	8,4	3100		
2,13	2300	5,9	1600	8,5	3000		
2,14	2300	5,10	1000	8,6	3200		
2,15	2400	5,11	1100	8,7	3200		
3, 1	no data	5,12	1200	8,8	3100		
3,2	no data	5,13	1400	8,9	3000		
3,3	no data	5,14	1600	8,10	3100		
3,4	4000	5,15	1800	8,11	3100		
3,5	3800	6,1	no data	8,12	3200		
3,6	3800	6,2	no data	8,13	3200		
3,7	3700	6,3	4500	8,14	3200		
3,8	3300	6,4	4000	8,15	2800		
3,9	2800	6,5	3400	9,1	4400		
3,10	2400	6,6	2700	9,2	4000		
3,11	2000	6,7	2000	9,3	3600		

Use Colored Pencils, Markers or Crayons for Data Ranges:

5000-4600 m - purple
4500-4100m - blue violet
4000-3600m - blue
3500-3100m - blue green
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2500-2100m - yellow
2000-1600m - orange
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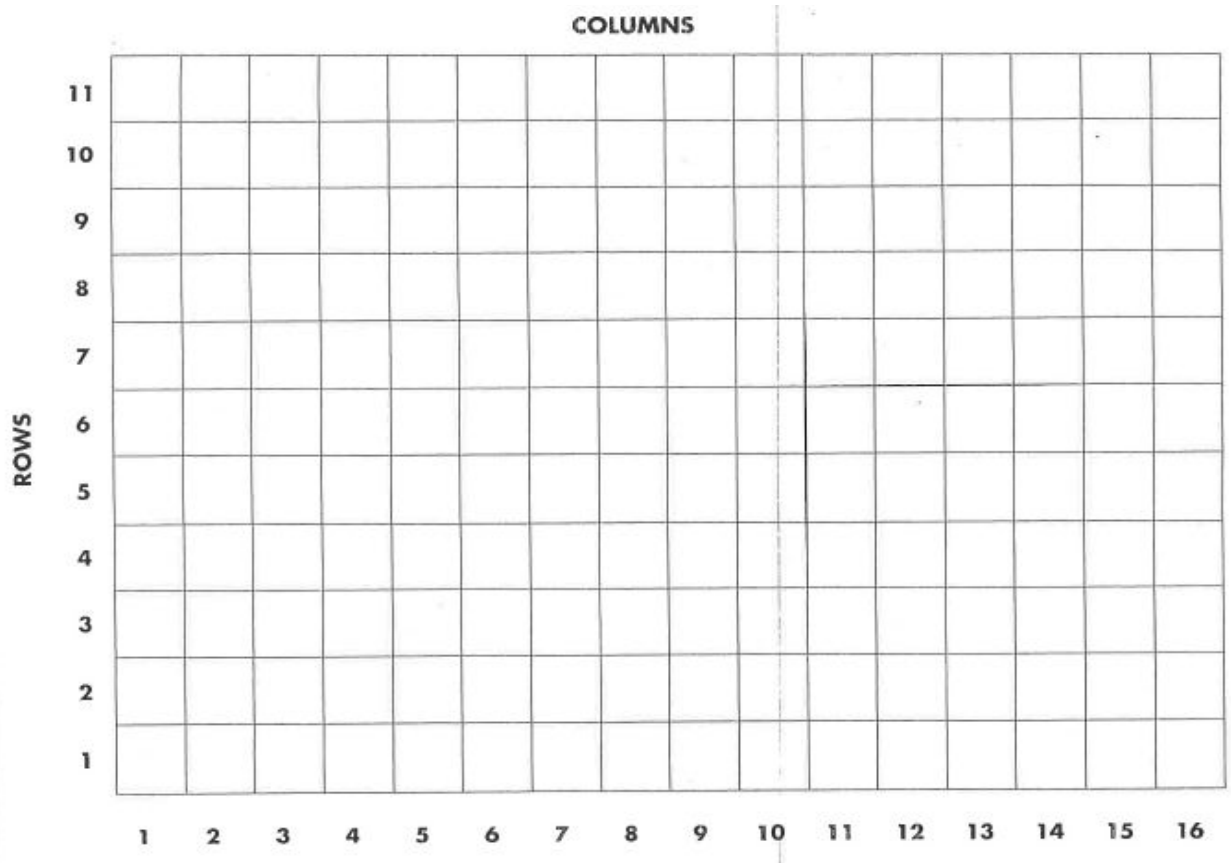

Background Information Questions:

1. Name a major constraint to exploration of deepwater regions around the Northwestern Hawaiian Islands.

2. What is the Kilo Moana?

3. What is multi-beam swath bathymetry?

4. What is the accuracy of this sonar method?

5. How is the composition of the sea floor determined?

6. What may this data be used for?

Map Questions:

(COVID version - use this map instead of coloring your own)

7. How is a bathymetric map different from the ocean floor profile you created earlier in the course?

8. What is a benefit of this map over the ocean profile?

9. What is a benefit of the ocean profile over the bathymetric map?

10. This type of map is called a false-color map. Why do you think that is so?

11. Identify areas of steep terrain on the map (row/column coordinates).

12. Identify areas of flat terrain on the map (row/column coordinates).

13. If you were a research diver looking for new species, where would you look and why?

Website Questions:
Visit the website: https://volcanoes.usgs.gov/volcanoes/loihi/ to answer the following questions.
14. What is Loihi? Describe its general characteristics.

15. What was the cause of Pele's Pit?

16. How long will it take for Loihi to breach sea level?

17. Click on "Monitoring Map" on the left side of the page and describe the recent earthquake activity surrounding Loihi.

18, What did you learn during this lab?