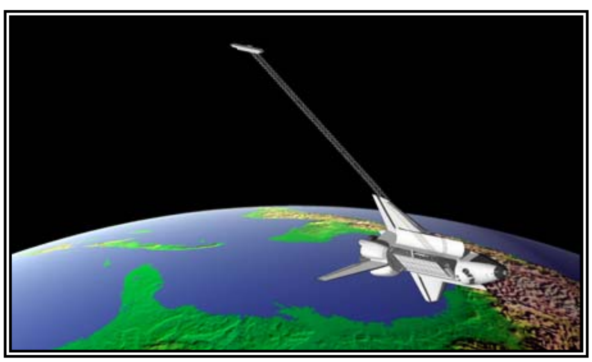
Lesson 2: Journey Across the Pacific – Student Version

Lesson Objectives: At the end of the lesson, students will be able to:

- Use the distance profile tool to draw a profile of the Ocean Floor, interpret and describe the variables displayed in the profile (distance traveled and elevation).
- Use GeoMapApp to find and match locations on the map with locations in the distance profile graph.
- Use the Bookmark feature to save a specific map layout in GeoMapApp.
- Change the way data layers are displayed on a map using the shapefiles and the global grid.
- Add contours and use them to interpret slope of the seafloor.
- Understand the difference between one slice of topography, as represented in a distance profile graph, and a larger 3D representation of the seafloor, as shown in a grid.

Background: A **hydrographic survey** in its strictest sense is the process of gathering information about navigable waters for the purposes of safe navigation of vessels. GeoMapApp contains data for all of the world's oceans. Some of the oceanic data sets were collected during scientific research cruises on ships using single or multibeam systems. These systems are attached to the hull or underside of a ship or towed in the water behind the ship's stern. The data collection instruments use sound pulses to gather data on the complexity and topography of the ocean floor (Figure 1). The data in GeoMap App contains a Global Multi-Resolution Topography (GMRT) compilation that hosts high resolution (~100 m node spacing) bathymetry from multibeam data for ocean areas and Shuttle Radar Topography Mission (SRTM) elevations over land. SRTM consisted of a specially modified radar system that flew onboard the Space Shuttle Endeavour during an 11-day mission around the Earth in 2000.



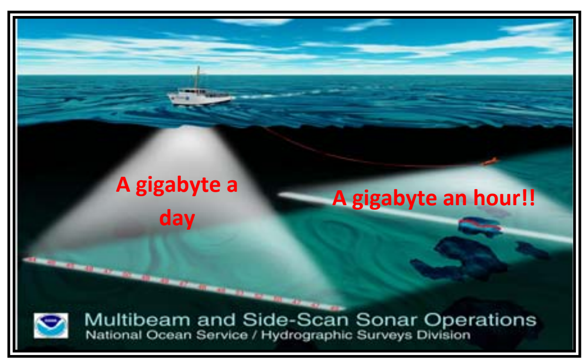
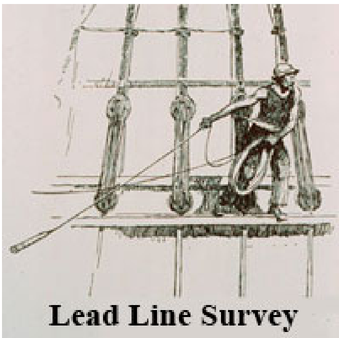


Figure 1. Geospatial Data Collection Methods for GeoMapApp; Shuttle Radar Topography Mission collected high resolution terrestrial data, while bathymetric data was collected using mutlibeam sonar at sea from research vessels. The advantage of multibeam sonar for hydrograhic survey seafloor mapping is evident from the schematic comparison with lead line and single beam sonar techniques.



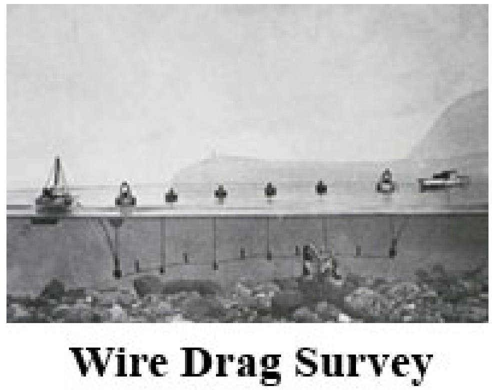


Figure 2. Historical drawing of seaman measuring the ocean floor depths with a lead line dropped to the ocean seafloor.

Figure 3. Historical image of boats rigged for a weighted wire-drag to survey the seafloor.

Modern technology allows for safe and efficient collection of large data sets. Historically, making maps of the ocean was an arduous and often dangerous process. Early hydrographic surveys consisted of depths measured by sounding pole and hand lead line with positions determined by three-point **sextant** fixes to mapped reference points.

Lead lines were ropes, or lines, with depth-markings and lead-weights attached that were lowered and read manually. Lead lines and sounding poles were a labor-intensive and time-consuming process. While the initial depth soundings may have been accurate, they were limited in number, and thus, coverage between single soundings was lacking.

In 1904, weighted wire-drag surveys were introduced into hydrography. The 1930’s saw the development and implementation of **single-beam echo sounders** using sound to measure the distance of the sea floor directly below a vessel. By running a series of lines at a specified spacing, single beam echo sounders and fathometers greatly increased the speed of the survey process by allowing more data points to be collected. However, this method still yielded gaps in quantitative depth information between survey lines.

The advantage of multibeam sonar for hydrograhic survey seafloor mapping is evident from the schematic comparison with lead line and single beam sonar techniques revealing the depth and position of submerged rocks and other obstructions (Figure 4).

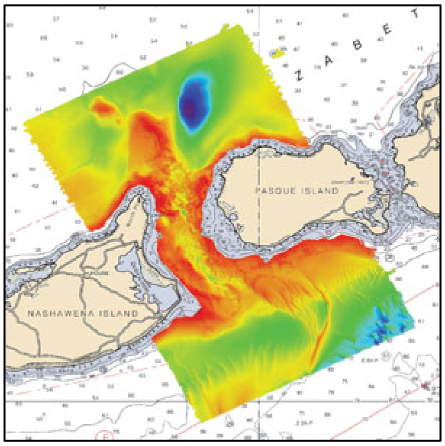


Figure 4: NOAA Nautical Chart with overlay of a Digital Terrain Model (DTM) seafloor imagery collected with Multibeam swath system. This high resolution Digital Terrain Model (DTM), overlaid on an NOAA nautical chart was collected in August of 2004 by the NOAA ship Thomas Jefferson in Quicks Hole, Massachusetts. A narrow passage, Quick's Hole is heavily trafficked as the only passage between Vineyard Sound and Buzzards Bay suitable for vessels with drafts greater than 10 feet. Analysis of the data revealed giant sand waves, huge glacial erratic boulders and several uncharted wrecks. In addition to being used for updating the charts of the region, data from this survey will be used by scientists at USGS and by the Massachusetts Coastal Zone Management Program.

In the 1950's, 1960's, and 1970's a number of evolutionary concepts were advanced that fundamentally changed how we look at and map the seafloor. **Side Scan Sonar** technology was developed as a qualitative means of obtaining the sonar equivalent of an aerial photograph and improving the ability to identify submerged wrecks and obstructions. **Multibeam** swath systems made it possible to obtain quantitative depth information for 100% of the bottom in a survey area. Hydrographic surveying techniques and procedures continue to evolve.

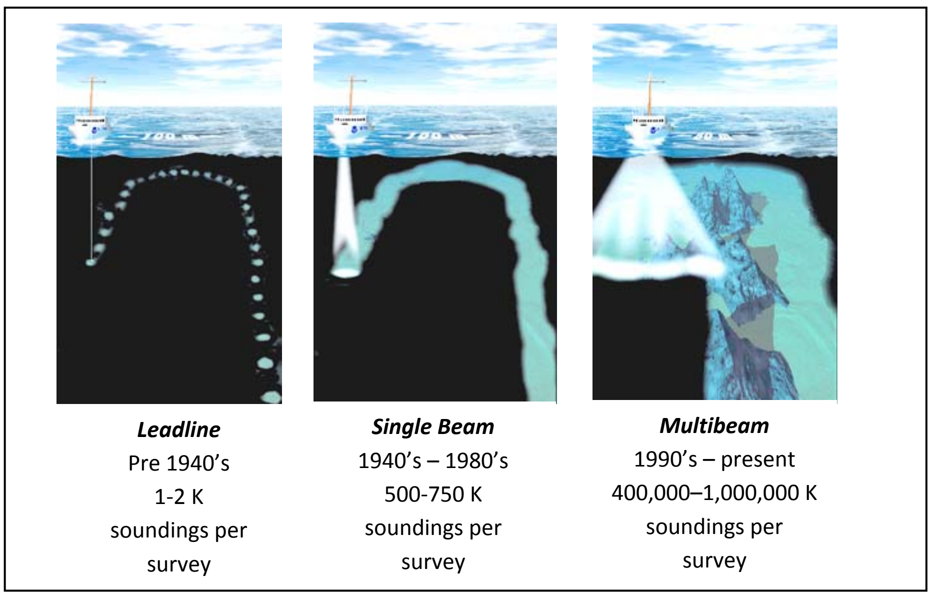


Figure 5. Comparisons of seafloor depth data collection methods, clearly showing the advantage of multibeam bathymetric sampling techniques.

Depths on any given NOAA chart may be based, in some areas, on hydrographic surveys conducted with leadlines prior to 1900, in other areas, on multibeam sonar surveys that attained full bottom coverage.

Over 50 percent of the depth information found on NOAA charts is based on hydrographic surveys conducted before 1940. Surveys conducted with lead lines or single-beam echo sounders sampled a small percentage of the ocean bottom. Due to technological constraints, hydrographers were unable to see between the sounding lines. Depending on the water depth, these lines may have been spaced at 50, 100, 200 or 400 meters.

Today, as NOAA and its contractors re-survey areas and obtain full-bottom coverage, uncharted features (some that are dangers to navigation) are routinely discovered. These features were either: 1) not detected on prior surveys, 2) manmade objects, like wrecks and obstructions, that have appeared on the ocean bottom since the prior survey or 3) the result of natural changes that have occurred since the prior survey.

Exercise 2: Journey Across the Pacific

In this exercise, you will learn how to use the Distance Profile tool to study the bathymetry and features of the ocean floor, interpret ocean floor profiles, locate features of interest on the graph in the map layout, bookmark areas of interest, change the appearance of our map layout, and save your profile and map images for printing or digital reports.

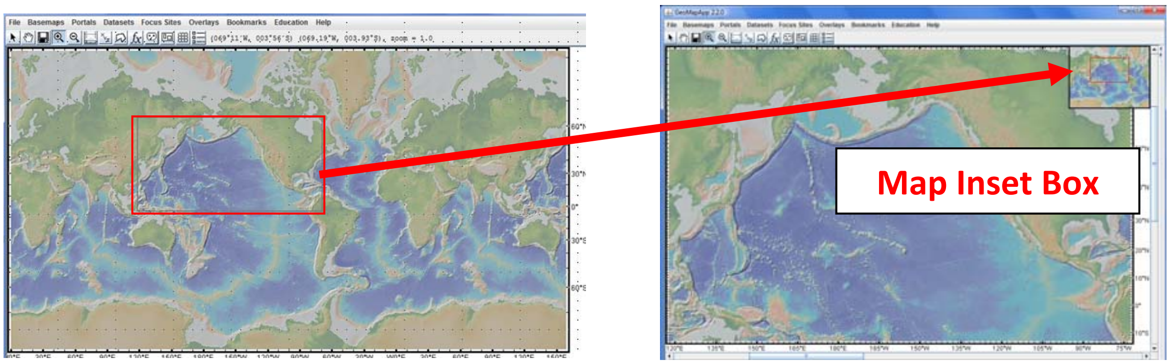
1. **Launch GeoMapApp.** Double click on the GeoMapApp icon GeoMapApp on your desktop.

2. **Choose a map projection.** Select the appropriate projection for the datasets you will use and the area of the world you are most interested in viewing. For this exercise, select the projection option, 'Mercator'.

3. **Maximize your GeoMapApp session**. Click on the maximize button in the upper right hand corner.

4. **Zoom in on your map view to focus on the Pacific Ocean.** Use the Zoom In Tool click on the map and draw a box that encloses the Pacific Ocean (as shown below). Be sure to include all of Japan in your zoomed in view.

5. Use the Map Inset box to center your map view. Notice the map inset that appears in the upper right hand corner when you zoom in closer than the Global Scale View. Click on the red box located inside the map inset and move it around to change the map layout view. Center your map layout view to feature the Pacific Ocean.



Question 1. What is the advantage of having a map inset box?

User Tip: The approximate locations of San Diego, California and Tokyo, Japan will be good enough for this exercise.

San Diego 33°N, 117°W
Tokyo 36°N, 140°E

6. Draw a profile across the Pacific Ocean using the distance profile tool. Click on the distance profile tool, then left click on an area of land in Japan and as you hold down the mouse, drag the cursor across the Pacific Ocean to an area on the West Coast of North America near San Diego, California. A white transect line appears on the map and a profile window opens up over the map layout. Move or resize the profile so you can see your transect on the map.

A **profile** is a slice through **topography**. In GeoMapApp, a profile is drawn as a graph, with the **x axis** representing distance along the transect line, and the **y axis** representing elevation, or depth relative to **sea level.**

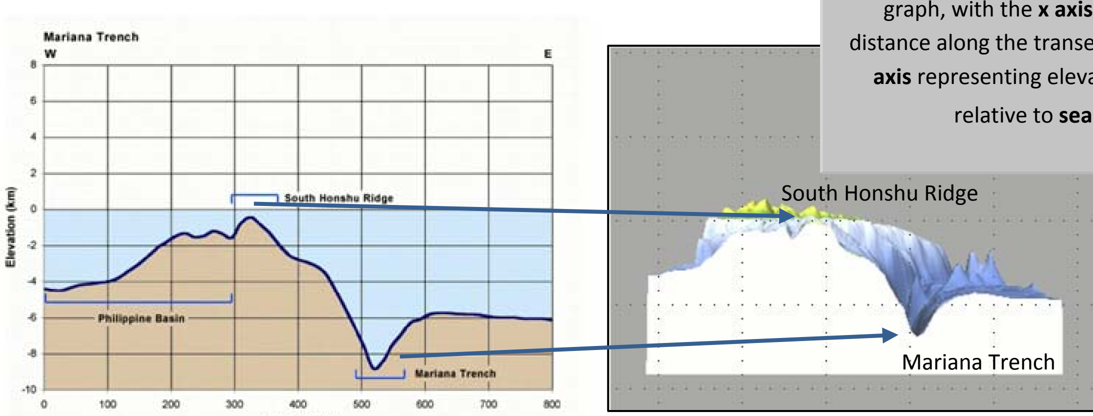
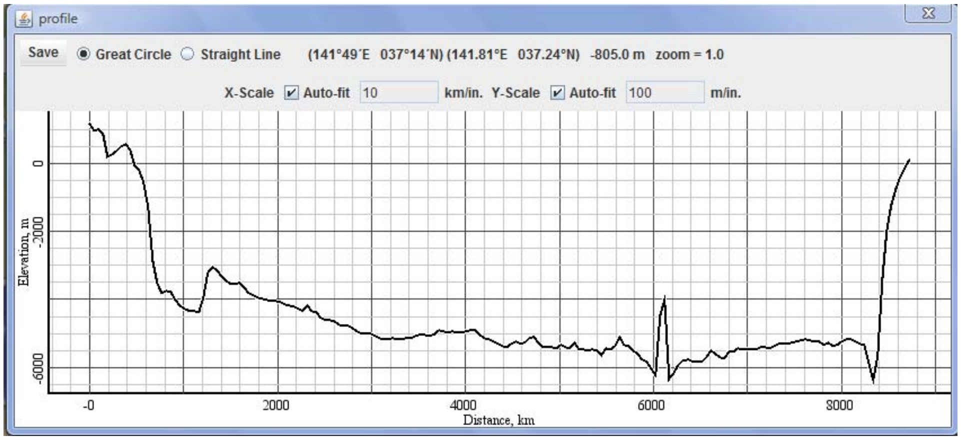


Figure 6. Graphical representation and 3D depiction of an ocean floor profile near the Mariana Trench in the Pacific Ocean.



Question 2. What does the y axis represent?

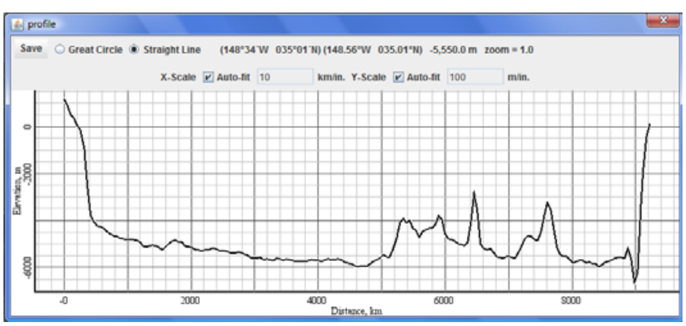
Question 3. What does the x axis represent?

Question 4. Why are there negative numbers in the elevation?

Question 5. What is the elevation at 2000 km along the transect? ________

at 8000 km? __________

7. Change the line from Great Circle to Straight Line in the profile window. Click the radio button next to straight line. Notice the length of your profile line (x axis distance) and the difference when choosing the Great Circle versus the Straight Line options.



Curved representations of straight lines are a manifestation of projection distortion. A **Great Circle** path is the shortest route when traveling on the surface of the Earth. The path appears curved when plotted against a projected map image.

Question 6. What is the difference between the Great Circle and Straight Line features? Hint: Hold your mouse over the radio buttons for clues.

Question 7. How many km in length was the distance between San Diego and Tokyo using the Great Circle method? Hint: estimate from the x-axis of your profile.

Question 8. How many km in length was the distance between San Diego and Tokyo using the Straight line method?

Question 9. Where is the deepest part of the profile?

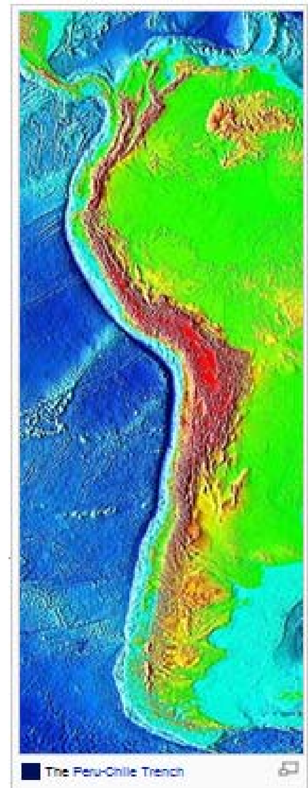
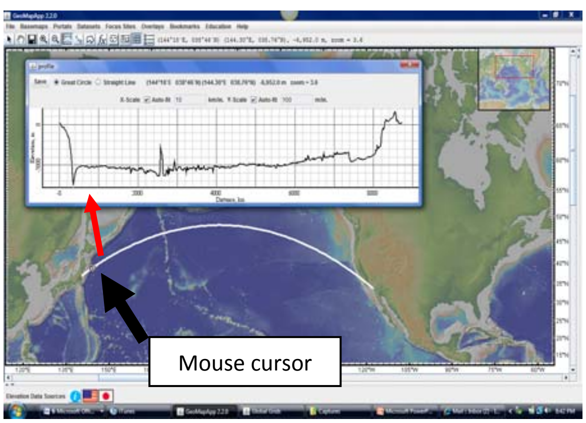


Figure 7. The Peru-Chile Trench along the coast of South America.

8. Match the features on the profile with features on the map layout. Place your mouse over the line on the profile and notice the red circle that pops up on the drawn transect (which displays as a white line) on the map.



An **oceanic trench** is a hemispheric-scale, long and narrow topographic depression in the sea floor. Trenches contain the deepest parts of the ocean floor and are located at areas of seafloor spreading, where layers of young crust fold underneath layers of old crust.

9. Add data sets on ridges and trenches to highlight these oceanographic features in your map layout. From the menu select File → Import Shapefile → From Local File System… (navigate to the GeoMapApp data folder for Lesson 2). Add the **Trenchs.shp** file. Follow the same steps and add the **Ridges.shp** file.

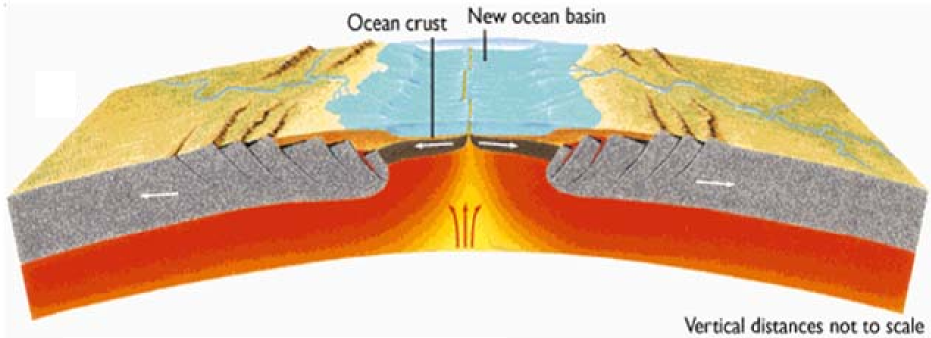


Figure 8. Diagram of a mid-oceanic ridge

A **ridge** is a geological feature that features a continuous elevational crest for some distance. Ridges are usually termed hills or mountains when referring to the features above sea level (on land). Oceanic spreading ridge: In [tectonic]() spreading zones around the world, such as at the [Mid-Atlantic Ridge](), the volcanic activity forming new plate boundaries forms volcanic ridges at the spreading zone. Isostatic settling and erosion gradually reduce the elevations moving away from the zone.

10. Change the color of the Trenches and Ridges features in your map view. Locate the shapefile manager. If necessary, click the shapefile manager button  to open the window. Double click on the rectangle in the 'color' column and use the 'Color Chooser' dialog box to select a color that will contrast with the ocean floor color palette.

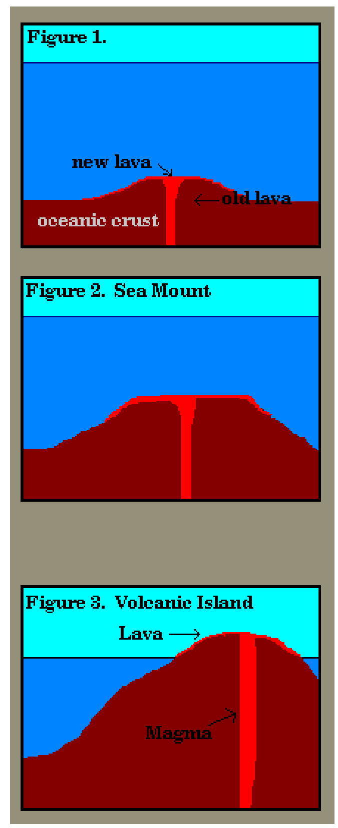


Figure 9. Formation of a volcanic island, showing the intermediary stage termed a **seamount.**

11. Find oceanic features on the seafloor and draw profiles across them. Add the Gazetteer layer Select 'Overlays' from the Command Menu → Select 'Geographic Names' → Select 'GEBCO Gazetteer (2006)'. Search the table for features. When you zoom into an area smaller than the global view, the Gazetteer resizes to show only features in that map view. Zoom into an area near San Diego, off the California Coast. Scroll down through the table of names and notice that only a subset of the original data set remains.

Question 10. Find these features with the GEBCO Gazetteer, create profiles with the Distance Profile Tool, and sketch the features in the gridded boxes. Which one looks like a mountain? A chain of mountains? A flat topped mountain? Label them with your answers.

A. Hawaiian Islands

B. Mendocino Ridge

C. San Juan Seamount

D. La Jolla Canyon

__User Tip__: You may need to resize the column width of the 'Geographic Names' in the Gazetteer. Hold your mouse over the column heading until it becomes a double headed arrow, click and drag the bar to the right.

E. Santa Monica Canyon

F. Monterey Canyon

__User Tip__:If you do not see any features marked with a gray circle, you may be zoomed in too close. Use the zoom out tool and search again.

A **seamount** is a mountain rising from the ocean seafloor that does not reach the water's surface (sea level). These features rise at least 1,000 m above the seafloor. One seamount, the active underwater volcano in the Hawaiian Islands, *Loihi,* is rising and predicted to be the next Hawaiian Island. Can you find it in GeoMapApp?

Question 11. Draw a profile of an area of the seafloor that interests you. Choose a map area, zoom in and center the region, draw a profile of the seafloor and sketch your results in the diagram below. Include labels for the x-axis and y-axis. Label the distance traveled and elevation for at least 5 data points (numerical values). Include labels for any distinct features, such as land, trench, ridge, seamount, etc.

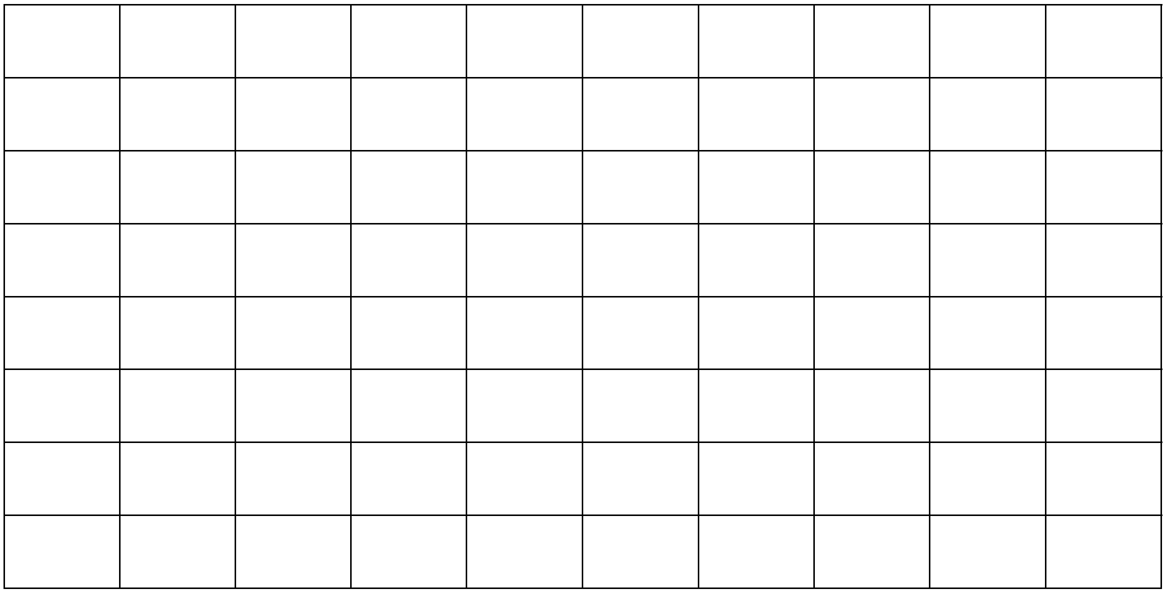
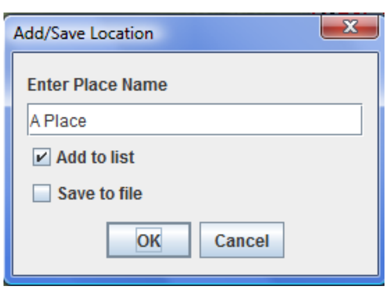


Figure 10. Sketch of GeoMapApp profile depicting seafloor bathymetry. Include your units for Elevation and Distance.

12. Use the bookmark feature to save a region of interest. Use the zoom and pan features to center an area of the map around an area you found in Step 11. Save this specific map layout with a bookmark. Choose Bookmarks → Add Bookmark for Current MapView.



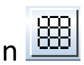
The Add/Save Location dialog box opens. In the Place Name box, enter a name for your region.

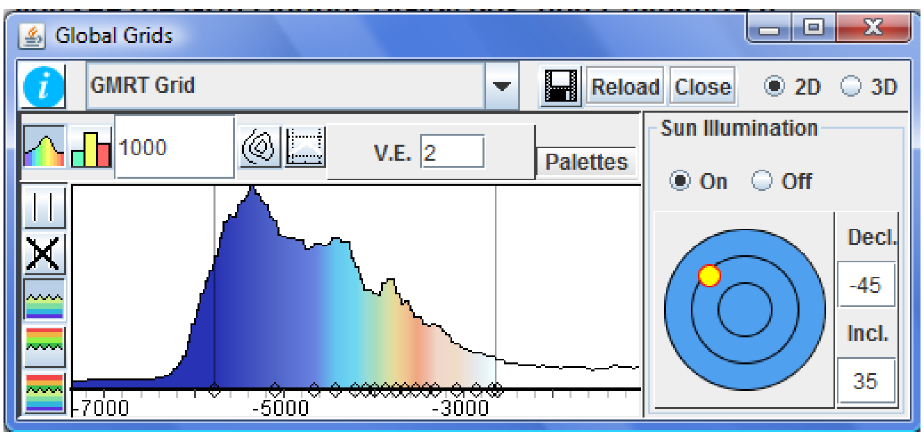
To see your bookmarked area, zoom back out to global view, then choose your bookmark from the Bookmark menu options. Select Bookmarks → *Your place name.*

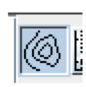
13. Return to the World View. Click Bookmarks → Zoom to Global Scale.

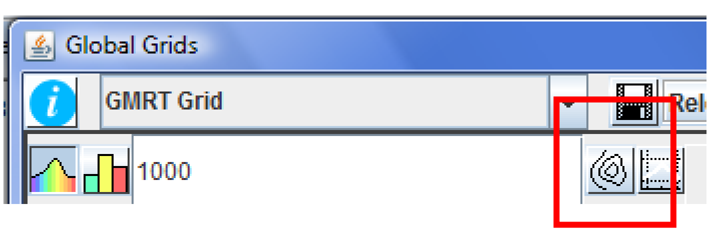
The profile you created in Step 6 showed how deep the ocean is along a single line across the Pacific. This is a representation of a slice of the topography of the ocean seafloor. In order to get a sense of the seafloor's three-dimensional (3-D) shape, you would need to take several more virtual cruises across the Atlantic, collecting depth data along other latitude lines. In this way, you could create a whole grid of depth measurements to help you understand the shape of the seafloor. In order to better understand a larger area of the ocean sea floor, let's take a look at areas to the north and south of the line you have drawn.

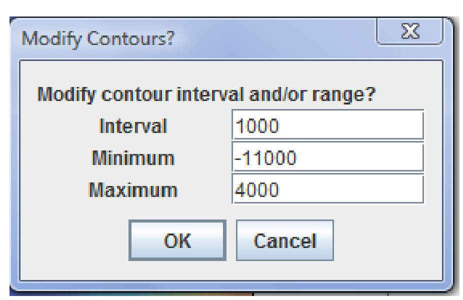
14. Use the magnifying tool to zoom in to an area along a transect that you drew in Step 11 that you would like to explore.

15. Open the Global Grids Dialog Box. Click the Show/Hide Grid icon button  to load the depth data for that region. This process can take up to a minute, depending on how large an area you have selected. When you see the Global Grids Dialog box, don't minimize it, just move it by clicking on the blue title bar and dragging to the side of your map window.

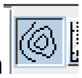


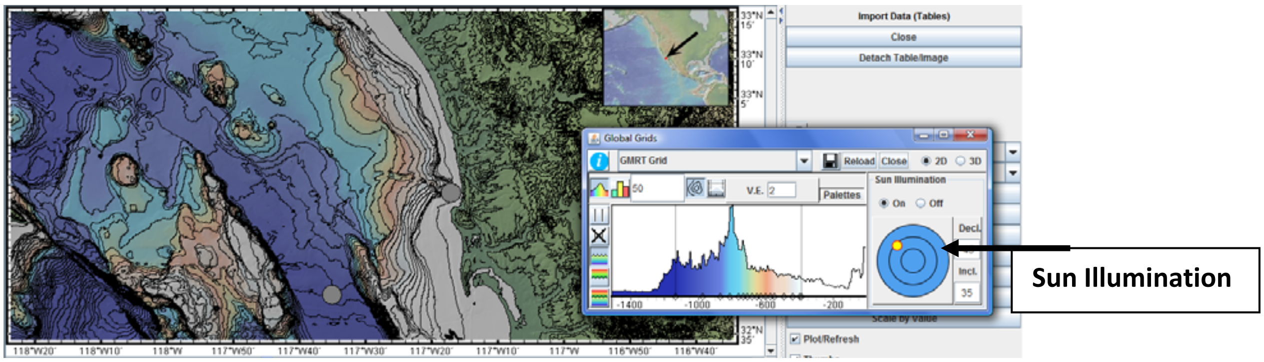
16. Add contours to your map. Click on the contours button  to add depth contours to your map.





17. Accept the default values in the 'Modify Contours?' Window. Click OK.

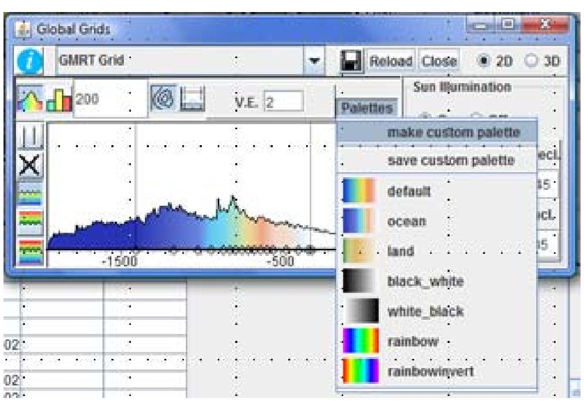
18. Turn off the contours and reset new interval values. Click the contours interval button  once to turn off contours and again to reset the intervals. In the Interval box of the ‘Modify Contours?’ window, set the intervals at 750, then again for 500, and again for 100 and finally for 50 by typing in the number in the box. After each new interval reset, zoom in to an area where the contour lines are close together.



The image depicted above shows La Jolla Canyon off the coast of San Diego, California, with contours drawn at 50m intervals.

Question 12. How are contour lines useful in a map image? Where are the steepest slopes in the above image? Where are the flat areas? In the image above, draw an S on 2 steep areas and draw an F on 2 flat areas.

19. Change the appearance of your map layout using the Global Grid window. Experiment with the various features in the Global Grid Window.



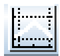
a. Turn the Sun Illumination radio buttons on and off.

b. Move the angle of the sun illumination by clicking on the yellow circle in the larger blue circles and dragging to a new location.

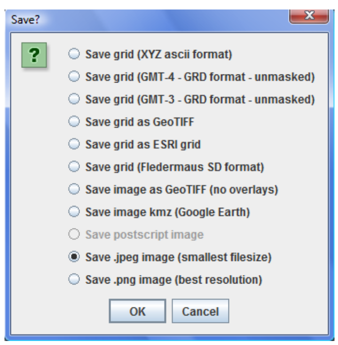
c. Explore the different color options by clicking the ‘Palettes’ button. A drop down menu appears with different options, such as ocean, land, black_white and rainbow.

Question 13. Think about the different map layouts you have created. When would you use a black and white image?

Question 14. What type of map product would you include contours on?

20. Use the distance/profile tool button in the grid dialog box. Click on the distance/profile tool button  and draw a profile through an area of the map layout that interests you.

21. Save your map layout as an image file. Using the skills you have learned in this lesson, create a map layout that is interesting to you and aesthetically pleasing from a cartographic standpoint. Save your image by using the Menu Options, and selecting File → Save Map Window as Image/Grid file… A Save Dialog Box appears:



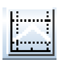
Choose an appropriate name for your map image, and type it in the 'File Name' box. Navigate to your student working folder and save the image as a .jpeg.

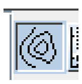
User Tip: A good map will convey a message and draw the reader's attention to a set of features or geographic area. Do you want to highlight the slope of the seafloor or diversity of the features? Include a profile. Is the land important for your map? Zoom out further or pan to include areas of the land.

Lesson Objectives: At the end of the lesson, students will be able to

- Use the distance profile tool to draw a profile of the Ocean Floor, interpret and describe the variables displayed in the profile (distance traveled and elevation).
- Use GeoMapApp to find and match locations on the map with locations in the distance profile graph.
- Use the Bookmark feature to save a specific map layout in GeoMapApp.
- Change the way data layers are displayed on a map using the shapefiles and the global grid.
- Add contours and use them to interpret slope of the seafloor.
- Understand the difference between one slice of topography, as represented in a distance profile graph, and a larger 3D representation of the seafloor, as shown in a grid.

Tools/Skills and Key Words Used in Lesson

 Distance/Profile Tool  Shapefile Manager  **Show/Hide Grid**

 Contours

- Use the Bookmark feature to save a specific map layout in GeoMapApp
- Import data in a shapefile format
- Draw and Analyze a Profile
- Add and search for oceanic features with the Gazetteer
- Add contour lines
- Change the appearance of your map layout

Key words: hydrographic survey, Shutle Radar Topography Mission (SRTM), Global Multi-Resolution Topography (GMRT), sextant, single-beam echo sounders, side scan sonar, multibeam sonar surveys, lead line, wire drag, profile, topography, x-axis, y-axis, Great Circle, Straight Line, ridge, Mid-Atlantic ridge, isostatic settling, oceanic trench, seamount, contours.

References and Web searches for Teachers and Students

1) NOAA History of Hydrographic Surveying http://www.nauticalcharts.noaa.gov/hsd/hydro_history.html

2) Figure 5. NOAA Nautical Chart and DTM overlay. http://www.nauticalcharts.noaa.gov/hsd/multibeam.html

3) Shuttle Radar Topograpy Mission http://www2.jpl.nasa.gov/srtm/.

4) GeoMapApp Multimedai Tutorials http://www.geomapapp.org/tutorials/index.html

Diving in Deeper - Extending the Lesson

1) **Explore Quicktime animations showing profiles.** These animations go very well with Step 6 of Lesson 2, drawing a profile across the Pacific Ocean. These short videos are excellent for helping students understand the concept of a profile slice through topography, and should be shown before and after the lesson to help with visualization skills.

The following Quicktime animated movie clips feature profiles, and visual representations of topography. The file sizes range from 3.2MB to 5.4MB, so please be patient while downloading. Tip: load them before class or while students are working and dock the website in the tool bar for quick launch.

Mariana Trench http://www.scieds.com/saguaro/movies/mariana_trench-north_2.mov ,
http://www.scieds.com/saguaro/movies/mariana_trench-south_2.mov

Hawaiian Islands http://www.scieds.com/saguaro/movies/hawaii_2.mov

Greenland http://www.scieds.com/saguaro/movies/greenland_2.mov

Website with more topographic movies http://www.scieds.com/saguaro/topo_movies.html

2) **Globe Toss: Water or Land**. Toss a large plastic globe around the classroom, and ask students when they catch the ball if the center of their right thumb is over water or land. Make a chart on the board of water or land. Toss the ball 10 times. What percent of students' thumbs were touching water? Toss to a student, (or pick up a globe that is not conducive to throwing) how many of your fingertips are touching water? How many are touching land?

3) Search the Gazetteer table for oceanographic features such as guyout, trough, rise, spur, fracture zone, ridge, shoal, rise, basin, hill, shelf, valley, plain.

4) Create profiles of different types of oceanographic features as found with the Gazetteer table. Describe and compare these features. Search the web for descriptions and images of these features. Compare your 2D profiles drawn with GeoMapApp with 3D images found on the web. You can find images by using Google – Images and entering in key words such as ridge, trench, seamount, and other used in this lesson.

5) Have students complete a hand written exercise drawing contours through data.

6) See the step by step instructions on the web for 'Selecting and Viewing Dive Photos',

http://new.geomapapp.org/gma_help/newHelp/View_Dive_Photos.html

7) In Lesson 4, *Maps As Scientific Tools*, we will explore map creation in more detail and create maps for presentations to be used in word documents, Powerpoint presentations and web pages. The map below was created to highlight the height and shape of *Mauna Loa* in the Hawaiian Islands.

If time permits, explore an area of the ocean that interests you and create a map layout of your own.

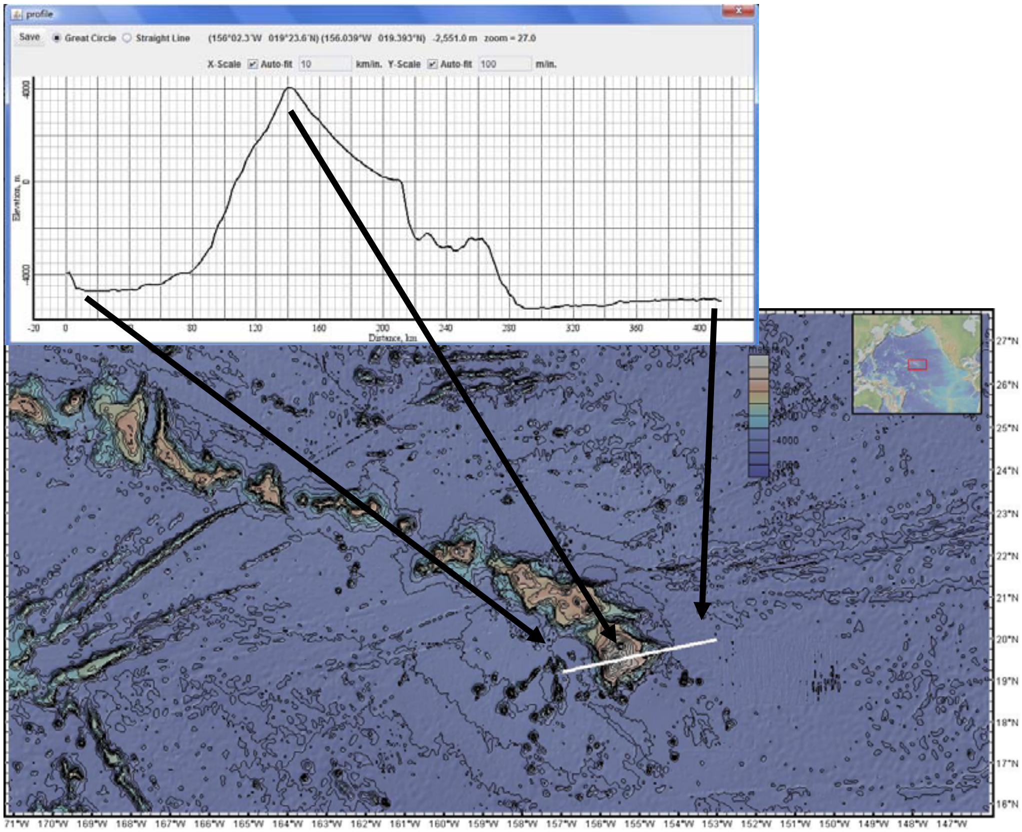


Figure 11. Sample map designed to show a profile representation of Mauna Loa in the Hawaiian Islands.

8) Read about the concepts of Latitude and Longitude with the document entitled '*Measuring the Earth – Lines of Latitude and Longitude'* included in the Lesson 1 folder.

9) Explore the work of researchers and scientists who study the ocean seafloor. Check out the adventures of 'Deepsea Dawn' oceanographer and professor at Oregon State University, and other women oceanographers, too!

http://www.womenoceanographers.org/Default.aspx?pid=E1E3254E-1C80-4e6d-ABBF-1EC5F5436C3E&id=DawnWright