

Name: _____

GEOL1551 - Seafloor Mapping and Marine Provinces

Readings: Textbook chapter covering Marine Provinces;

- <https://oceanexplorer.noaa.gov/explorations/09bermuda/background/multibeam/multibeam.html>
- http://oceansjsu.com/105d/exped_mapping/10.html

Objectives

- To understand methods of mapping the seafloor and how data may be presented and interpreted.
- To discover some important geographic features in the ocean basins.
- To understand the characteristics of different marine provinces.

Seafloor Mapping

In Exercise 1 it was indicated that today measurements of depth (soundings) are made primarily by bouncing acoustic (sound) energy off the seafloor. Devices called transducers create an electronic sound at the ship, which travels downward and echoes off the seafloor. If you know the velocity of sound in seawater and measure the travel time of the sound (divided by two since it makes a round-trip, called the two-way travel time), you can determine the depth. Devices that do this are called echo-sounders, fathometers, precision depth recorders (PDR), or in general SONAR (SOund Navigation And Ranging).

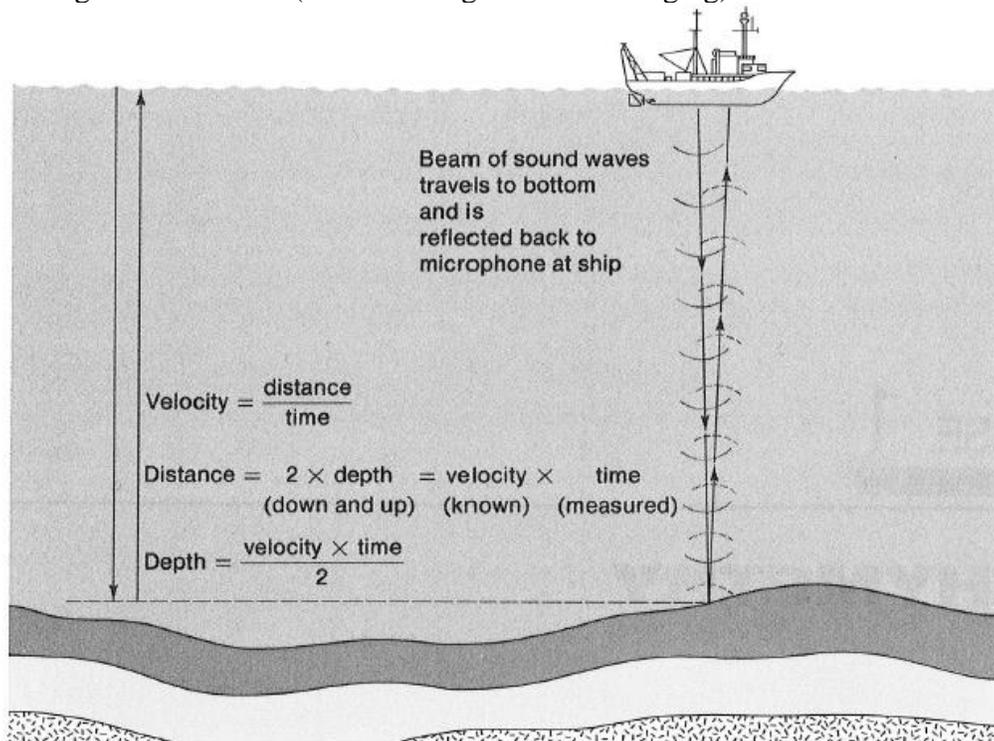


Figure 1. Illustration of the path of a sound (acoustic) pulse used for mapping the seafloor.

1. The known water depth is 4500 m. An acoustic energy pulse travels down and back in 6 seconds. What is the velocity of the acoustic energy through the seawater medium? *Remember your units!*

Answer: _____

The answer you got is a good rule of thumb for the velocity of sound in seawater. It does vary slightly in response to temperature and salinity (it is directly related; i.e., it increases with an increase in T or S).

2. How deep is the water where the two-way travel time of an acoustic pulse is 3.0 seconds?

Answer: _____m

Multibeam Sonar

When multiple sonar transducers are arranged in certain configurations, they may produce multiple beams of acoustic energy, and it's possible to analyze (insonify) a wide swath of the seafloor in one pass. The position of each beam and the two-way travel time are precisely monitored to produce very high resolution (centimeter scale) maps of the seafloor. These devices are called **multibeam echo-sounders (MBES) or multibeam sonars**. See examples of multibeam data in Figures 2 and 3. **Watch the short video at:**

http://oceansjsu.com/105d/exped_mapping/10.html

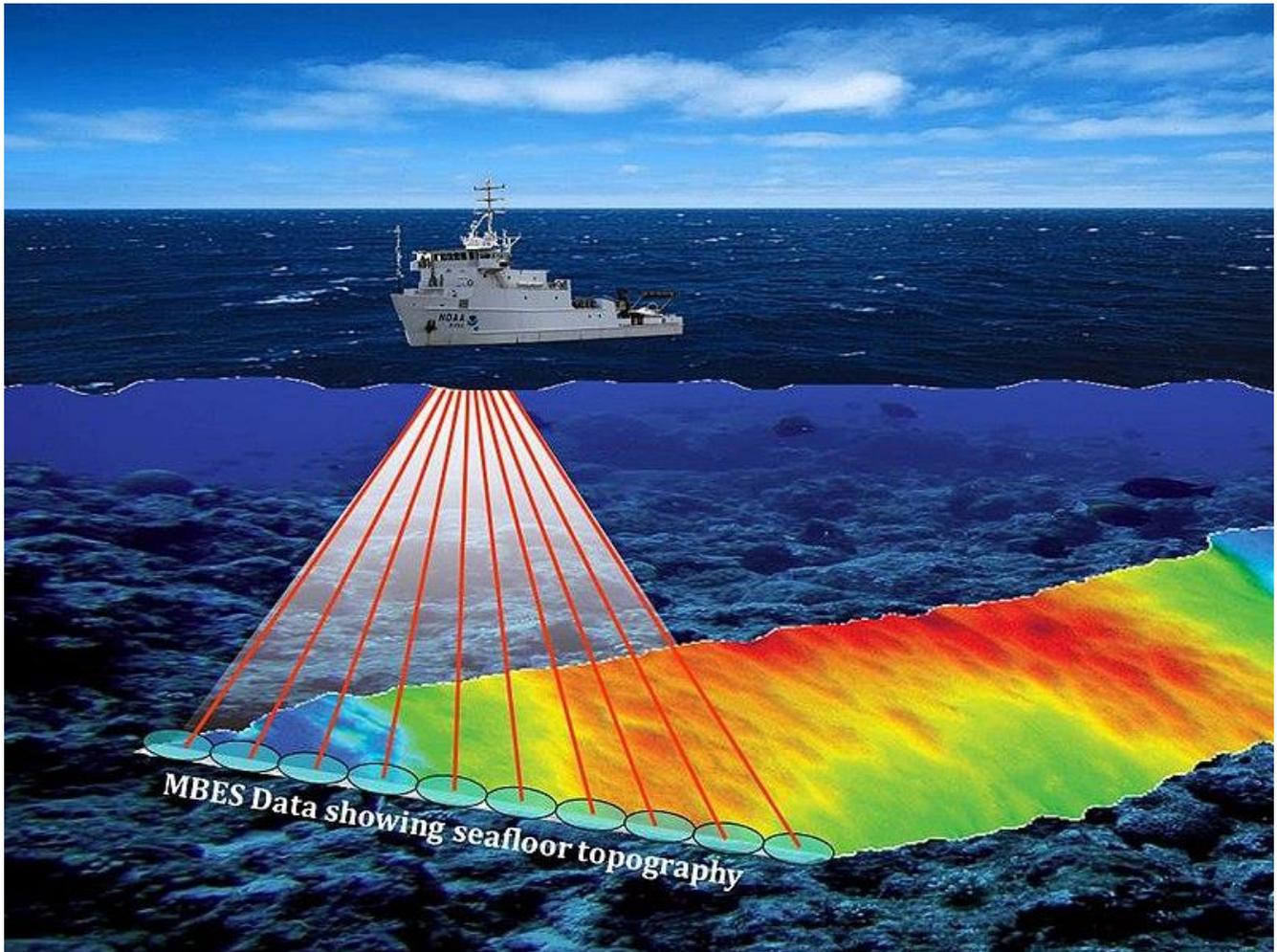


Figure 2. Image showing the swath of a multibeam sonar as it images the seafloor (much like painting the seafloor with a wide brush). Colors represent depth, and shading enhances the relief. Multiple transects are necessary to create a large map (a mosaic). Each pass across the seafloor produces a ribbon of data (the swath), which are then combined into a larger dataset to produce the mosaic.

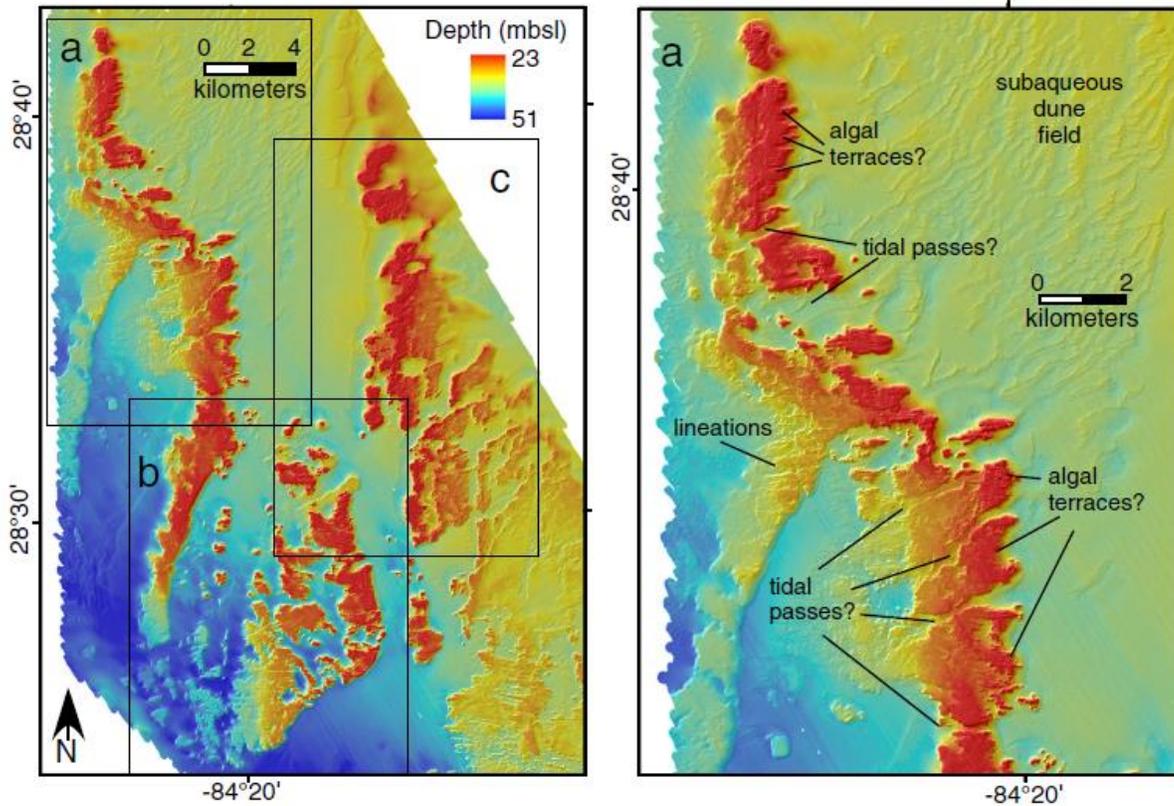


Figure 3. Color-coded bathymetry of the Florida Middle Ground reefs produced using a multibeam echosounder (MBES) (Mallinson et al., 2013. *New Perspectives on the Origin of the Florida Middle Ground Carbonate Banks*, Marine Geology v.).

3. Explain how the multibeam data are presented to illustrate the depth and relief.

Side-scan sonar

Another device is a side-scan sonar. This device has two transducers on either side of the tow-fish that insonify the seafloor (send out acoustic pulses and receive the echo from the seafloor) but they primarily show the intensity of the echo (the backscatter intensity) that allows imaging seafloor features (ripples, scarps, reefs, sunken ships, etc.), and provides information on the type of material (rock, mud, sand, gravel). See examples of side-scan sonar data in Figure 3. The acoustic energy spreads out laterally, like a fan, away from the tow-fish, and scans the seabed (see figure 3A). Where you have very fine sediment (mud, very fine sand) and a smooth surface, much of the energy is reflected away from the tow-fish, thus the echo (backscatter) has very low intensity. When the surface consists of coarser sediment or objects sticking above the bottom (e.g., boulders, ripples, etc.), the energy is reflected directly back to the tow-fish and it records high backscatter intensity. If an object blocks the energy altogether (e.g. on the far side of an object), no reflection is recorded, and an acoustic shadow occurs (much like a shadow you would see if you were shining a light on an object).

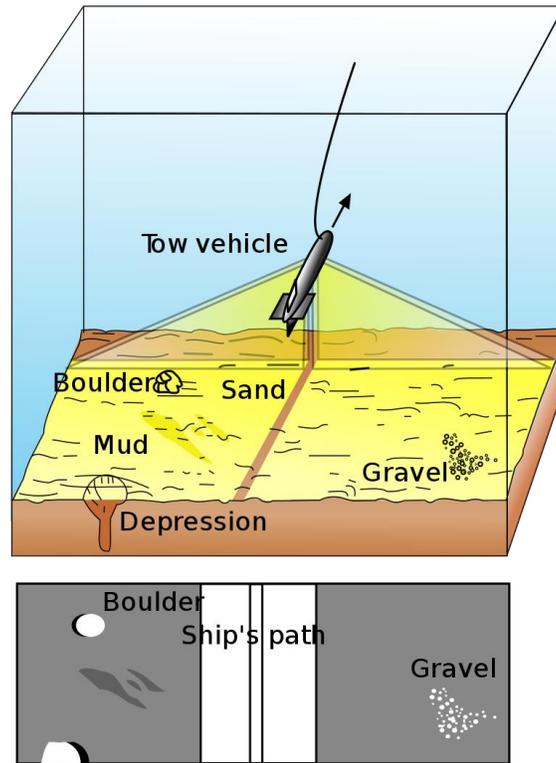


Figure 3A. Illustration of a side-scan sonar towfish as it insonifies the seafloor (top). The image below it shows the appearance of the acquired data.

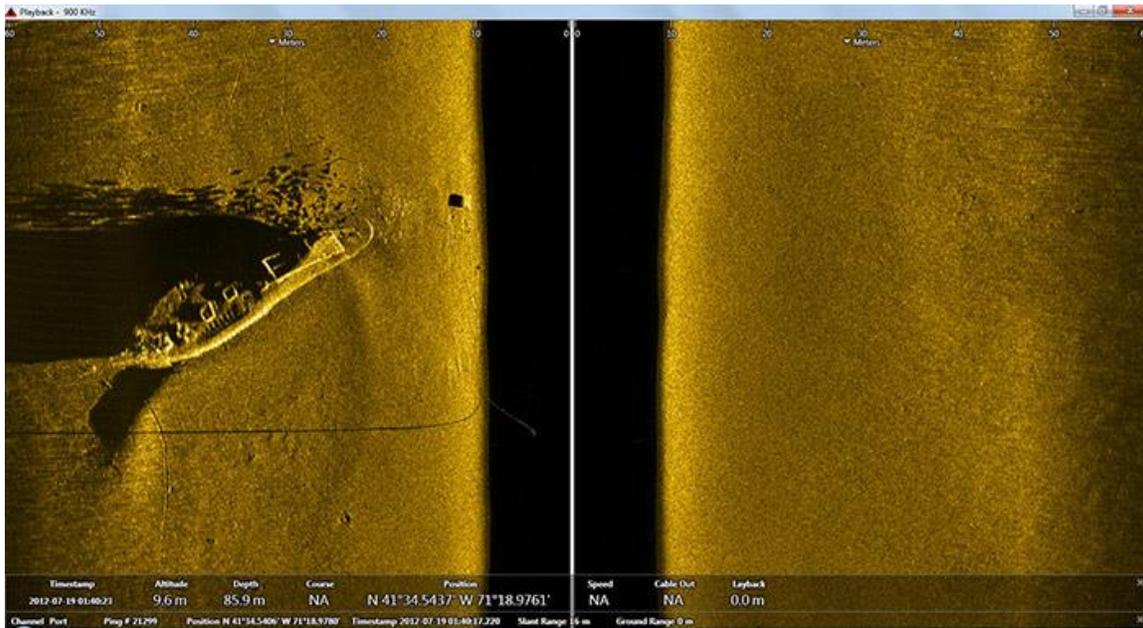


Figure 3B. Side-scan sonar data showing a ship and debris field (port channel). Note the scale across the top. Port channel is on the left, starboard channel is on the right, relative to the direction of travel (up in this case). The white line separating the two data fields is the nadir (directly below the towfish). The black section represents the water column, which transitions to the sediment (the sediment/water interface or the seafloor) at a depth of about 10 meters. In this image, dark is low backscatter intensity (note the acoustic shadow to the left of the ship), and bright reflections are high backscatter intensity.

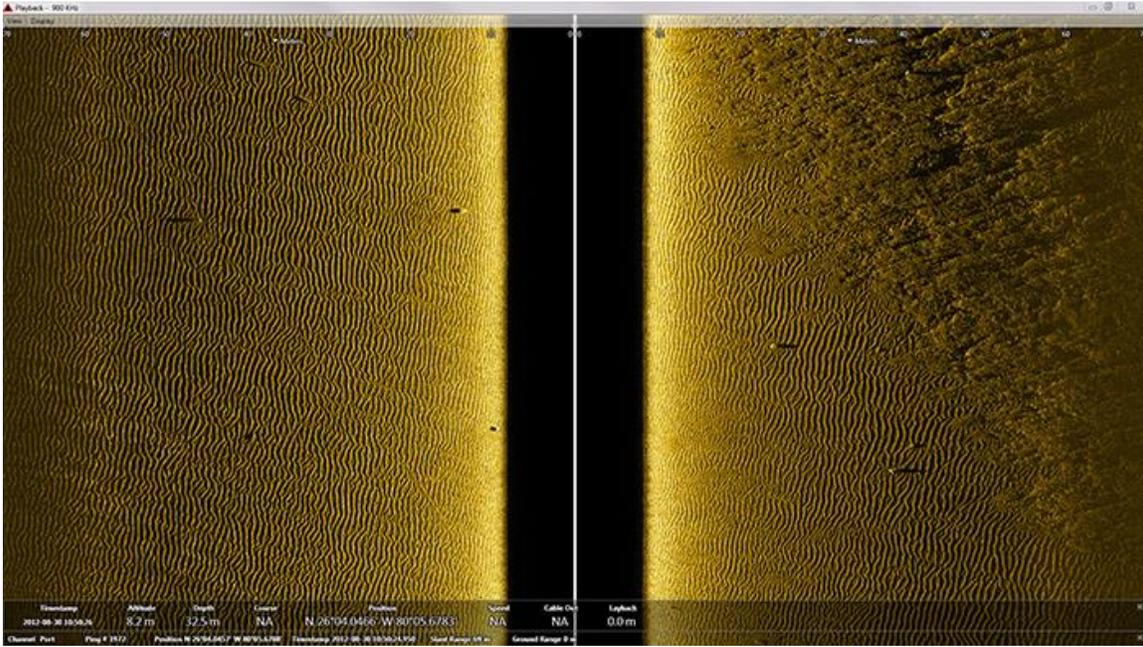


Figure 3C. Side scan sonar image showing sediment ripples on the seafloor, indicating current activity. The rough, chaotic pattern to the right (starboard channel) is an irregular rocky surface.

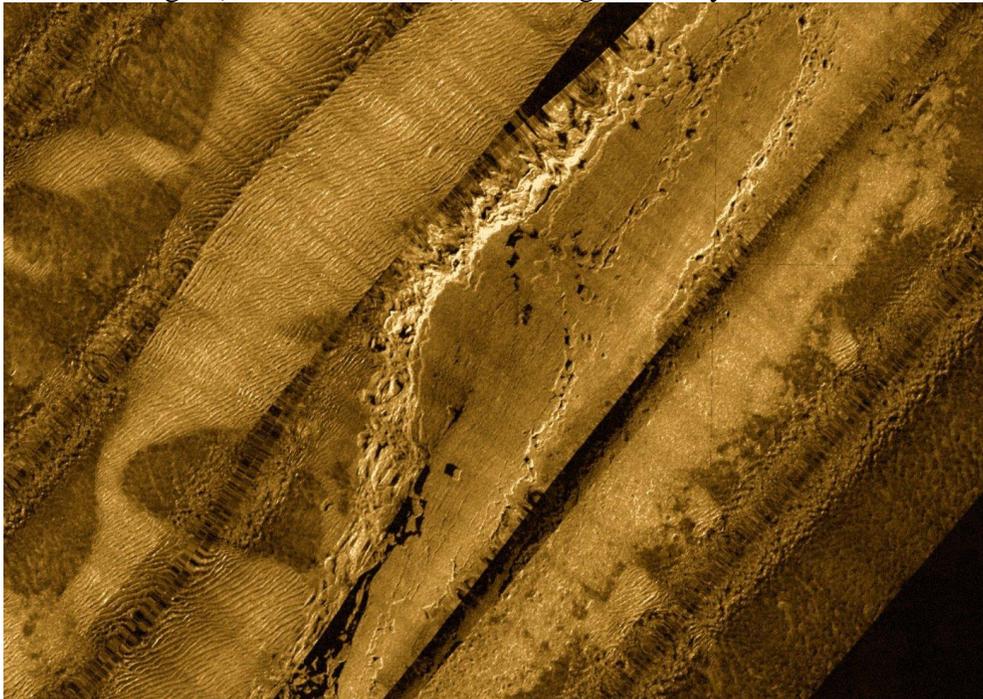


Figure 3D. Side-scan sonar mosaic made by combining data from multiple transects. The bright feature in this is a scarp (cliff). It shows high backscatter intensity because it faces the tow-fish, thus energy is reflected directly back. Darker patterns are fine-grained sediment (mud or very fine sand) and lighter shades are coarser sediment (sand or gravel). Note ripples in the lighter patterns (sand).

4. Give two examples for how you would use A) multibeam data and B) side-scan sonar data.

A)

B)

Marine Provinces and Geography

This next exercise uses **Google Earth**. You'll need to find a computer with it already installed, or install it on your own computer from the following link: <http://www.google.com/earth/download/ge/agree.html>

If you've never used Google Earth, don't worry, it's extremely easy to find your way around. Use the "Fly To" tab in the upper left corner and you can type in a latitude and longitude (as the example shows), or you can type in the name of a location and hit enter or click the magnifying glass. Experiment with the tools on the upper right to learn to move around and zoom in and out and rotate. **In addition to answering these questions, take the time to explore! There are a lot of really interesting places on our planet!**

Note: When you "fly" somewhere, **zoom out** and look at what is around you – Ask yourself: What is the ocean depth where you are? What does the seafloor do around you (is it flat, sloped, rising, falling)? **This will help you identify the marine province.** Consult a textbook or your lecture notes for the terms to use for marine provinces. "Deep Ocean" for example, is not specific enough.

Questions:

5. Fly to latitude 31 degrees 2 minutes north, and longitude 42 degrees 4 minutes west (you'll need to type it as 31 2'N, 42 4'W). What marine province is this?

6. What would the valley (oriented north-south) be called just east of this site?

7. What marine province exists at 13 degrees south, 5 degrees east?

8. Fly to latitude 1 degrees 14 minutes north, and longitude 46 degrees 40 minutes west. What marine province is this (note how depths are rapidly increasing)?

9. Fly to latitude 2 degrees 17 minutes north and longitude 48 degrees 51 minutes west. What marine province is this?

10. Just to the northeast of this site, what is the v-shaped structure cutting into this marine province?

11. Fly to the Japanese Islands. What do we call this variety of volcanic islands that are arranged in an arc-like fashion?

12. What kind of tectonic boundary occurs at these islands (be specific as far as types of crust and how they are interacting)?

13. Fly to 17 degrees S, 74 degrees W (19 00'S, 72 00'W). What marine province is this?

14. Is this province an indication of an active or passive continental margin?

15. What is the depth in feet here? (place the mouse hand over the location and look at the elevation given at the bottom of the frame, next to the latitude and longitude).

16. What is the depth in meters?

17. Fly to the Marshall Islands. Note the similar orientation of this string of islands and seamounts to the Emperor Seamounts in the North Pacific. How do you suppose the Marshall Islands formed?

18. Below is a list of oceanographically/geologically interesting and important features, some of which will be discussed in lectures. Locate the following features in Google Earth (you might need to do a Google search initially). Add a pin on your globe for each location and give it the corresponding name. **Change the label and icon scale to 3.**

Zoom out so that you see an entire globe circle in your view.

Click print symbol in menu bar and choose: "Save pdf" to make 3-4 pdf files showing different views in order to see all of your globe with pins and labels visible.

- Faeroe Islands
- Romanche Fracture Zone
- Walvis Ridge
- Rio Grande Rise
- Kerguelan Plateau
- Challenger Deep/Mariana Trench
- Ninety East Ridge
- Juan de Fuca Plate
- Central Indian Ocean Ridge
- Great Barrier Reef
- Azores
- Puerto Rico trench
- South Sandwich Island trench
- East Pacific Rise
- Galapagos Islands and Hot Spot
- Red Sea
- Persian Gulf
- Beaufort Sea
- Aleutian Island Trench
- West African Shelf