Ocean Bathymetry: Mapping and Measuring

Learning Objectives:

- Be able to interpret 2D bathymetric contour maps as a 3D physical model (part I)
- Construct a 3-dimensional model of a feature on the ocean floor (part I)
- Simulate gathering depth data from an ocean vessel (part II)
- Draw a contour map from individual depth soundings (part II)

The ocean floor was once thought to be a featureless, flat terrain, due to the constant rain of "marine snow." Sailors have long used ropes with weights on the end to measure depths in shallow water. Often they tied knots 6 feet (1 fathom) apart in the rope for ease of measurement. The number of knots let out gave the depth in fathoms once the weight hit the bottom. The first accurate physical measurements of the deep ocean bottom were made by Sir J. Clark Ross in 1840 who measured a depth of 4435 meters off Antarctica. Later, extensive depth recordings were taken by scientists on the H.M.S. Challenger using steam-driven winches with one inch hemp rope that did not tangle. Scientists lowered the rope until it hit the bottom, recorded how much rope had been let out, and pulled the rope back. Letting out 3,000 meters of rope and reeling it back in could take as long as twelve hours.

In the 1950's, scientists and naval officers started using sonar to determine the depth of water. They would send a ping of sound from a transmitter, and measure the time for the sound pulse to echo off the ocean bottom, and return to the receiver. The depth of the water is calculated by multiplying the time by the speed of sound through water. The distance travelled by the ping is twice the depth from the vessel to the bottom. Later technological developments resulted in the side-scan sonar, which allowed a boat to determine a swath of ocean bottom contours to the side of the vessel. This created a more descriptive picture of the ocean floor than single point measurements could offer.

This lab will consist of a bit of puzzle-making, and puzzle-reconstruction, where the puzzle is the shape of the ocean floor!

Part I: Making the 3D model

Materials:

- Shoebox or rigid small stowaway box with holes punched in the lid
- Many sheets of corrugated cardboard, of uniform thickness (or clay/plaster) for simulated ocean bottom
- Heavy-duty scissors or exact-o knife (with cutting mat) to cut cardboard
- Glue and/or tape
- Permanent marker
- Ruler
- Graph paper

Each group will be provided with a bathymetric map of a seafloor feature. Your job is to convert this map into a properly scaled, 3-dimensional model of this sea floor feature inside of your shoebox.

1. **Tape graph paper to the top of the box.**

   Tape a piece of graph or gridded paper to the top of the box. This will help align the holes that will be punched in the top of the box.

2. **Mark locations for holes in the top of the box.**

   Mark locations on the graph paper for holes to be punched. These should be about every one or two centimeters in a grid pattern.

3. **Cut a piece of cardboard to the size of the shoebox.**

   Cut a rectangular piece of cardboard to fit into the bottom of your shoebox. You will use this as the base to form your seafloor. Do not attach this to the bottom of the cardboard box.

4. **Cut bathymetric layers into cardboard.** Aim for about 8–10 layers.

   Human safety first. Be careful not to cut yourself or your partners. Secondarily, take care not to damage the furniture in the room.

   Using your maps, choose a sub-set of equally-spaced contours and trace them onto paper. Then cut these shapes out of the cardboard and glue or tape them into your model. Decide how many meters of depth each layer of cardboard will represent. For example, you may choose 1000m contours, but represent each 1000m of bathymetric change by two layers of cardboard.

   Recommendation: Use two layers of cardboard for each depth level. This will make measurements easier!

5. **Form the ocean floor.**

   Create your ocean floor. Use the cardboard layers or plaster to form the floor over the piece of cardboard you cut in item 3. If it helps, you can also tape one of your printed maps to the piece of cardboard as a guide.

6. **Add a vertical scale to your model.**

   Determine how each centimeter of height corresponds to meters of depth in the real world. Make a scale and tape it to the outside of the box. The scale of your seafloor features will not be the same as the scale of the distance from the box lid (i.e. the ocean surface) since you can't adjust the height of the lid. So you will want one scale of conversion for height from bottom, and a second scale to indicate where the sea surface is.

   Check this by making a few measurements from the top of the box. Can you use your scale to determine the correct depth of those layers?

7. **Add the x- and y-axis annotations to your grid paper, and a simple compass rose.**

   Mark latitudes and longitudes or distances from a central point along the edge of the box lid. Draw a simple compass rose. Indicate north, south, east and west directions.

   Tips:

   - Sometimes bathymetric charts have contours that are not regularly spaced. Make sure that you select around 8–10 contours to trace that are equally spaced in depth. Each layer of cardboard should represent one depth.
   - You'll certainly want to divide labor for this lab, but have everyone do each job at least once. That way everyone gets to experience the different parts of the lab.

8. **Plan a sampling strategy**

   Given a region about the size in your box, plan a sampling strategy. How far will the ship travel? How much will it cost? Make assumptions about the speed and cost per day, assume that measuring takes no time.

9. Checklist for completion:

   - ◯ Layers of cardboard corresponding to contour layers in the bathymetric map
   - ◯ Axes annotations written on graph paper on the box lid, so that the location of each mark for a hole can be determined from the scales.
   - ◯ Vertical scale attached (and double checked for accuracy)
   - ◯ Distance to ocean surface attached or annotated on the vertical scale.
   - ◯ Lid closed
   - ◯ Names included on **inside** of the box, as well as the seafloor feature name

Based on practicals by Jessica Kleiss, Lewis & Clark College (`https://nagt.org/nagt/teaching_resources/teachingmaterials/124130.html`) and Bigelow (`https://archive.bigelow.org/virtual/handson/fathometer.html`).