Laser Quest 1 – below the waves
Seeing evidence for plate tectonics beneath the oceans - using echo sounding.

Ask students to zoom onto any part of the ocean floor using Google Earth. Here they will find bands or tracks of high-resolution data, criss-crossing the ocean floor, that pick out details of the ocean floor landscape (mountains, ridges, and valleys) whilst on either side of the tracks much of the ocean floor is much less clear. These bands represent the tracks followed by ships where high resolution echo sounding data of the ocean floor have been collected. However, only 25% of the ocean floor has been mapped in this way, with the rest having been estimated from satellite observations (Fig 1).

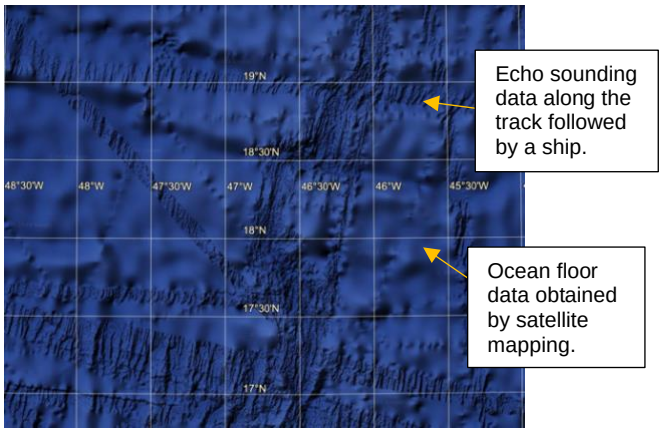

Fig 1: Mid-Atlantic ridge system showing higher resolution echo sounding mapping along ship tracks with satellite data interpretation between. (*Google Earth: Data SIO, NOAA, U.S. Navy, NGA, GEBCOData LDEO-Columbia, NS, NOAALandsat/Copernicus*)

This Earthlearningidea is an attempt to simulate the echo-sounding data collection method that allows scientists to map the ocean floor and interpret its plate tectonic formation.
('Laser Quest 2 – above the waves' in this series shows the satellite method - table on page 2).

How deep is the ocean?
Echo sounding is a technique in which a type of sonar uses sound waves to determine the water depth (bathymetry) and therefore the shape of the ocean floor surface (topography). Sound waves are beamed from an instrument on a ship (a transducer) and the time taken for the waves to be reflected from the ocean floor (two-way time) is measured and converted into an ocean depth. This gives a resolution of about 100 metres in the deep water of the abyssal plains.

The echo sounding method can be simulated in the classroom by using a D.I.Y. laser measure (or laser rangefinder) – a hand-held measuring device that records the distance between two points by sending a laser beam of light from the device to a target and measuring the time it takes for the reflection to return. This provides a practical demonstration of the principle involved. (It also complements the Earthlearningidea *'Modelling seafloor mapping'* referenced in the table on page 2)

The simulation

- Take a cardboard box or lid and cut a 1 cm wide slit along the top to allow the beam from the laser measure to penetrate the box and for its reflection to be received back to the meter. This will represent one survey track of a ship across the ocean.
- Mark 1 cm intervals along the slit to assist with a systematic data collection survey.
- Using Lego™ bricks (or equivalent), create an ocean floor within the box showing sufficient topographic variation. You may choose to represent any ocean floor features - trench, seamount, mid-ocean ridge, continental shelf, abyssal plain - along the line of survey below the ship.
- Explain the two-way measuring principle of the laser measuring meter. Move the meter across the top (ocean) surface of the box over the slit and vertically measure the depth to the 'ocean floor' every centimetre. (It is more engaging if the model is enclosed and students can't initially see the topography). (Fig 2).

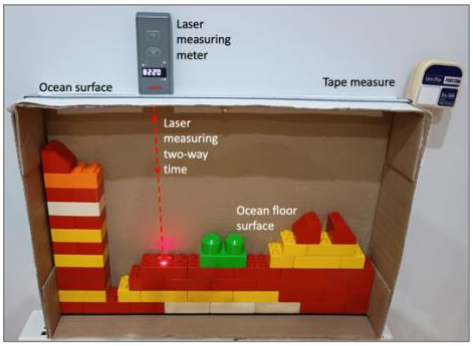

Fig 2: A laser distance meter measuring tool in operation to record the depth to a simulated ocean topography section – with box side removed to show the principle. (*Pete Loader*)

- Prepare a spreadsheet file (Excel or similar) to convert the raw data (in cm) collected to appropriate depths (km) - abyssal plain (~4km), ocean ridge (~2km), trench (>7km) - and use the graphing facilities (or graph paper) to draw the profile. (Fig 3).

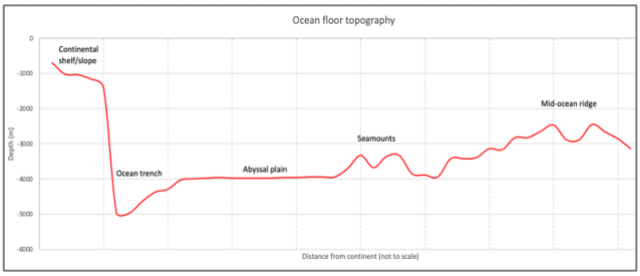

Fig 3: A simulated topographic profile of data collected from the model above with annotation. (*Pete Loader*)

- Ask students to annotate their graph and discuss the ocean floor features they can identify in terms of plate tectonics.

The back up

Title: Laser Quest 1 – below the waves

Subtitle: Seeing evidence for plate tectonics beneath the oceans - using echo sounding.

Topic: A simulation to demonstrate the principle behind the echo sounding method of mapping the ocean floor topography.

Age range of pupils: 10 – 16+ years

Time needed to complete activity: 20 minutes.

Pupil learning outcomes: Pupils can:
- understand that different methods are used to measure the depth of the ocean floor (echo sounding and satellites);
- understand the principle of the two-way time echo sounding method of ocean floor mapping;
- use an analogue model to map a simulated ocean floor topography;
- draw a 2D graph of the model ocean floor using spreadsheet software or by hand;
- verbally describe the characteristics of their depth profile to other pupils;
- relate the topographic profile identified to plate tectonic theory.

Context: This is the latest in a series of activities involving mapping the ocean floor that leads to the relationship between the topographic features and plate tectonic theory. The other activities are shown in the table on page 2.

Following up the activity: This activity is designed to precede Earthlearningidea 'Laser Quest 2 – above the waves' and may be used alongside other associated Earthlearningidea activities listed in the table below.

Underlying principles:
- Echo sounding is a technique in which a type of sonar uses sound waves to determine the water depth (bathymetry).
- Water depth is measured by the time it takes for a sound wave to travel from an echo sounding transducer, mounted on a ship, to the ocean floor and back; **two-way time**.
- By knowing two-way time and the speed of soundwaves in water, the depth of water beneath the ship can be calculated.
- Modern multi-beam swath bathymetry allows us to scan the ocean floor in strips and to reconstruct its topography at a resolution of just 100 metres.

Thinking skill development: Measuring and looking for patterns in the depth data is a construction activity, with possible cognitive conflict arising when unexpected values are calculated. Discussion among the class involves metacognition and relating the data and graph to plate tectonic models uses bridging skills.

Resource list:
- laser distance meter measuring tool (simple battery-operated device)
- box/box lid
- suitable materials for constructing an ocean floor profile (e.g. Lego™)
- Spreadsheet software/graph paper.

Useful links: See the NOAA web pages on seafloor mapping: https://oceanexplorer.noaa.gov/world-oceans-day2015/mapping-the-seafloor-one-ping-at-atime.html

Source: Activity written by Pete Loader of the ELI Team for the EGU General Assembly 2025 GIFT Workshop.

The Earthlearningidea ocean floor mapping activities	
Measuring the depths of seas and oceans: How is it done? A simple demonstration of how we measure sea floor depths and relief	https://www.earthlearningidea.com/PDF/350_Sea_floor_mapping1.pdf
Modelling seafloor mapping: How to simulate an echo sounder study of seafloor topography	https://www.earthlearningidea.com/PDF/351_Sea_floor_mapping2.pdf
Sounding the Pacific Ocean: An echo sounder traverse of the eastern Pacific	https://www.earthlearningidea.com/PDF/352_Sea_floor_mapping3.pdf
Marie Tharp: 'The valley will be coming up soon'. Bruce Heezen: 'What valley?' A woman scientist in a man's world – what was it like?	https://www.earthlearningidea.com/PDF/353_Sea_floor_mapping4.pdf
Laser Quest 1 – below the waves. Seeing evidence for plate tectonics beneath the oceans using echo sounding	https://www.earthlearningidea.com/PDF/454_Laser_quest1.pdf
Laser Quest 2 – above the waves. Seeing evidence for plate tectonics above the oceans using satellites	https://www.earthlearningidea.com/PDF/456_Laser_quest2.pdf