Sea Floor Mapping and Ocean Circulation

Background Information:

GOCE will allow scientists to study the Earth’s gravity field and determine the shape of the geoid. This will allow them to more accurately track the direction and speed of ocean currents. Sonar stands for sound detection and ranging. It is still used on research vessels for sea floor mapping. Data sets produced in this way will be used to validate the results from the GOCE satellite. Radar works in the same way, but it uses radio rather than sound waves. Altimetry just means measuring height. Air traffic controllers use radar altimetry to monitor the position of aeroplanes. Topex/Poseidon is a satellite that uses radar to determine sea surface height. Radar altimetry data will also be used to validate the results of GOCE. In this way a better understanding of how the seas move heat around the planet will be achieved. This will allow improve the computer models that are used to forecast global climate change.

Learning Objectives:
Pupils are aware of the use of sonar in determining sea levels and can carry out distance, speed and time calculations. They will appreciate that in order to ensure the validity of GOCE’s results, scientists need to determine the movement of ocean currents by several different methods.

Curriculum Links:
Edexcel GCSE in Physics (2109)
P1b 11.16: Use the equation speed = distance/time including applications where waves are reflected back to source
P1b 11.5: Explain scanning by reflection in different applications using ultrasound, e.g. medical uses, sonar and evaluate the advantages/disadvantages of such technology
A03 Analyse and interpret qualitative and quantitative data from different sources
The Twenty First Century Science suite GCSE Physics A (J635)
P4: Illustrate the use of ICT in science, for example computer-enhanced use of radar to predict flight paths of aircraft.
P6: Illustrate the use of ICT in science, for example analysing wave reflections in seismic explorations.
P4.1.1: Apply the following equation to situations where an average speed is involved: speed = distance travelled/time taken
AQA Physics 2009 (4451)

12.1 Calculate the speed of a body from the slope of a distance-time graph

13.6 Determine the distance between interfaces in various media from diagrams of oscilloscope traces. Ultrasound waves are partially reflected when they meet a boundary between two different media. The time taken for the reflections to reach a detector is a measure of how far away such a boundary is. Ultrasound waves can be used in medicine for pre-natal scanning.

Materials:
Fish tank
Toy boat and toy treasure chest/jewellery
Loudspeaker
Microphone
Cathode ray oscilloscope
Computer with free Audacity sound analysis software installed

Suggested activities:
Place a toy boat at the top of a fish tank and a box of “treasure” at the bottom. Ask how you could locate where the treasure is. Revise SONAR either by using the traditional experiment with a loudspeaker and microphone connected to a CRO to determine the depth of the “treasure”. Alternatively connect them to a computer which has the freeware audio package Audacity installed. This is available from http://audacity.sourceforge.net/. Discuss how bats use this process to find their prey. Discuss ultrasound scans and how some blind people even use the time delay between producing a sound and hearing the echo to work out how far objects are away from them.

Extension:
An Excel file of satellite altimetry data can be downloaded by clicking on the link. A data analysis exercise can be carried out, providing students with the chance to plot graphs in excel and to enter a simple equation. The spreadsheet contains 8 columns of 800 numbers. Column 1 is longitude (degrees east). Column 2 is latitude (degrees N of equator, so negative means south). Column 3 is distance from the beginning of the section, in km. Columns 4-8 are sea surface height, above the ellipsoid, in mm.

These represent 5 sets of measurements made as the satellite altimeter passes over the same region at 5 different times. The particular track chosen goes from south to north through the Indian Ocean. It crosses the Antarctic Circumpolar Current, which is a region where sea level varies a lot. Tides have been removed from the data.
Ask students to plot the 5 passes in Excel. They look practically indistinguishable, highlighting the fact that the geoid dominates what is measured.

![Graph showing sea level height vs. distance from beginning](image)

Ask the students to then plot the differences between successive passes and to estimate the variability in the sea level. A sea level variability of the order of tens of cm can be observed.

![Graph showing differences in sea level vs. distance from beginning](image)

**References/Resources:**

An interactive explanation of the use of echoes to find distances:
http://www.acoustics.salford.ac.uk/schools/index1.htm

Video clip explaining ultrasound:
http://www.howstuffworks.com/ultrasound.htm

Video clip of a baby in the womb:
http://www.youtube.com/watch?v=aCXxbyv9_2N0

Video clip explaining RADAR:

Video clip explaining altimetry:
http://earth.esa.int/brat/html/alti/principle/welcome_en.html

Video clip on ocean surface topography from space: