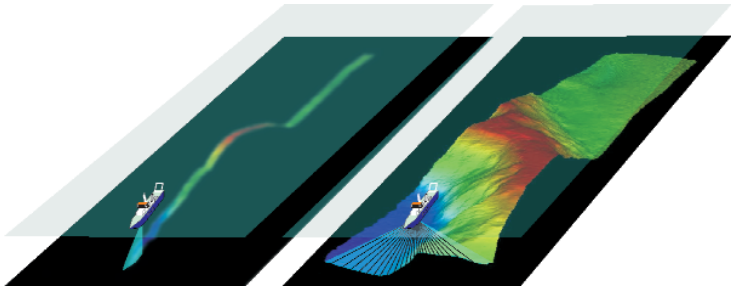
THE NEW MULTIBEAM ECHO SOUNDER ON BOARD THE RESEARCH VESSEL PELAGIA: 3-DIMENSIONAL MAPPING OF THE SEABED FROM THE SHELF TO THE DEEP OCEAN.

Henk de Haas*, Marck Smit and Tjeerd van Weering

Knowledge of the seabed is important in the marine sciences. Physical oceanographers study currents and internal waves that are influenced by the topography of the ocean floor, biologists study animals living at and in the seabed under conditions determined by hydrography and geologists and geochemists study ocean floor properties and processes. For all these disciplines of the marine sciences it is extremely important to not only know the water depth in the research area is, but also to have knowledge about the smaller scale variation in the seabed topography (or bathymetry) and the morphology of the sedimentary deposits. To accurately determine the bathymetry and seabed morphology in study areas of interest, Royal NIOZ has installed a Kongsberg EM300 multibeam echo sounder on board R.V. "Pelagia" in spring 2006. This allows composition of high resolution 3-dimensional images of the seabed, from the coastal seas to the deep oceans, down to at least 5 km water depth.

Introduction

With the increasing knowledge on geological, chemical, biological and physical processes in the seas and oceans, present day and future research will more and more focus on detailed studies to fine-tune our understanding of processes in the marine realm. For those scientists dealing with seabed related processes (for example benthic biologists, physical and chemical oceanographers, climatologists, geologists, geochemists), it becomes increasingly important to know the bathymetry in specific areas in detail. Variations in seabed morphology influence currents or may force internal waves, which in turn influence the transport of sediments and food particles essential for the life of animals and sediment-water exchange processes at the seabed, etc.



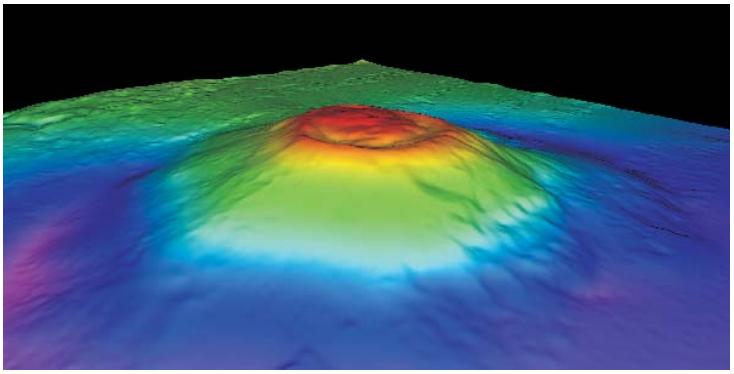
The difference between a single beam (left) and a multibeam (right) echo sounder. The single beam echo sounder uses 1 relatively wide sound beam, resulting in a not very accurate depth measurement along a line. The new multibeam echo sounder uses 135 very narrow beams, resulting in many accurate depth measurements along a broad strip of seabed. (Multibeam data from Galicia Bank, off shore northwest Spain.)

From 2D to 3D.

During the recording of old fashioned 2-dimensional (single beam) echo sounder lines the ship sails in a straight line with a continuous speed while the echo sounder produces a sound signal at regular intervals. The single beam echo sounder produces one sound beam, directed towards the seabed directly underneath the ship. The sound pulse is reflected at the seabed and the echo is recorded on board. By taking into consideration the speed of sound in water, and by accurate measurement of the time difference between submitting and receiving a sound pulse, the local depth is defined. The result of continuous measurements along the ships track is a profile of the seafloor. If several lines are recorded in parallel, then this gives a rough indication of the

* Corresponding author: haas@nioz.nl

local bathymetry. By contrast, the Kongsberg EM300 multibeam echo sounder produces 135 sound beams, in a fan-shaped geometry perpendicular to the ships track. In this way not a single line, but a broad strip of the seabed is scanned simultaneously. These strips are recorded in parallel and result in a 100% coverage of the seabed. These data can be used to produce detailed maps with depth contours, but also 3-dimensional images of the seafloor. Because each of the 135 beams is much narrower then the beam of a single beam echo sounder, covering of an area with the multibeam echo sounder not only goes much faster then with a traditional echo sounder, the resulting map produced with the new device is also more accurate.

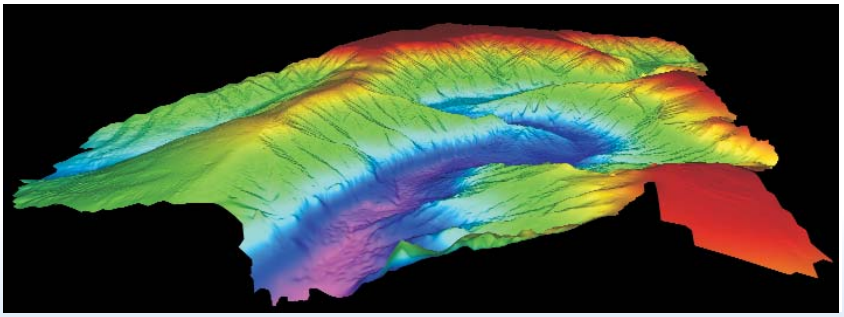


A 3-dimensional representation of the Al Idrisi mud volcano, located in the Atlantic Ocean about 20 miles off shore the north-western Moroccan coast. The water depth on this image ranges from 180 (red) to 450 m (purple). The horizontal scale varies in this view. In front the image covers about 6 km from left to right. From the front of the image to the corner at the back is about 9 km. View towards the southeast. Studies of mud volcanoes and gas seepage at the seabed are carried out through ESF/NWO and EU grants by the departments MCG, MEE and MBT. [Data collected by Henk de Haas, ESF-NWO funded project MiCROSYSTEMS.]

The use of multibeam images

In bathymetric complex areas the availability of accurate maps is an absolute need to select optimal locations for example for deployment of moorings, deployment of landers or bottom sampling. If for instance geologists need sediment cores with high sedimentation rates, they should avoid steep slopes, since sediments have the tendency to slide down steep slopes. If high resolution sampling is essential, for paleoclimatic or –oceanographic studies, specific sites may be chosen. Prior to the sampling, with the new multibeam echo sounder an accurate bathymetric map providing insights into most suitable station locations in relation to the seabed structure and morphology can be composed. Likewise, multibeam echo sounders are of great use to benthic biologists.

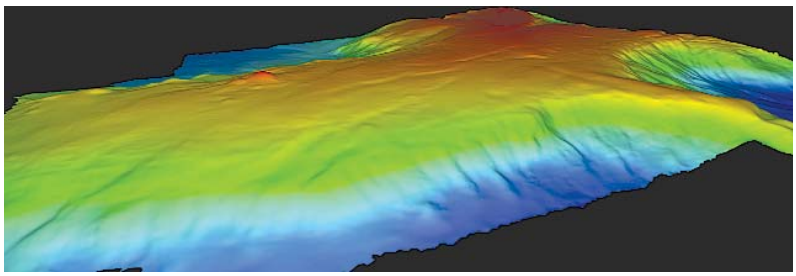
A multibeam echo sounder not only provides detailed bathymetry, but can also supply information of the sediments composing the seabed, as the intensity of the reflected sound is different if it is reflected from a clayey bottom compared to a sandy or rocky seabed. Three-dimensional images of the seafloor also give information on the sedimentary processes at hand. Mud volcanoes (where soft mud is expelled from the deep subsurface, similar to lava being expelled from a normal volcano), submarine canyons (underwater channels running across the continental slope and through which sediments are transported from the



The upper part of the Lisbon Canyon as recorded in 3D by the new EM300 multibeam echo sounder. The viewer is located above the Portuguese shelf and looks northwards towards Lisbon. This part of the seafloor is about 11 km wide (left to right) and 13 km long. The water depth ranges from 50 m (red) to 1750 m (purple). [Data courtesy Henko de Stigter, collected within the framework of the EU project HERMES]

shallow coastal seas to the deep ocean) and deep water reefs and mounds are easy to detect on 3D bathymetric images. Thus, the images alone can provide direct insight into recent and past processes that are active in the oceans.

The purchase of the multibeam echo sounder has been made possible through a grant of the Netherlands Organisation for Scientific Research – Earth and Life Sciences (NWO-ALW).



3D Image of one of the Horse Shoe Seamounts. The Horse Shoe Seamounts is a group of mountains located in the Atlantic Ocean, about 800 km west of the Strait of Gibraltar. The mountain on this image is 2.5 km high, 24 km long (left to right on the image) and 20 km wide. The top of the mountain is at 1700 m water depth. The view is towards the northwest.