Australian Government
Department of Defence

AUSTRALIAN HYDROGRAPHIC SERVICE

MAPPING THE SEABED

HOW IS THE SEABED 'MAPPED'?

This simple guide explains how a hydrographic surveyor can map something they cannot see, from a moving platform, while floating on a moving surface, all while avoiding unseen dangers ahead.

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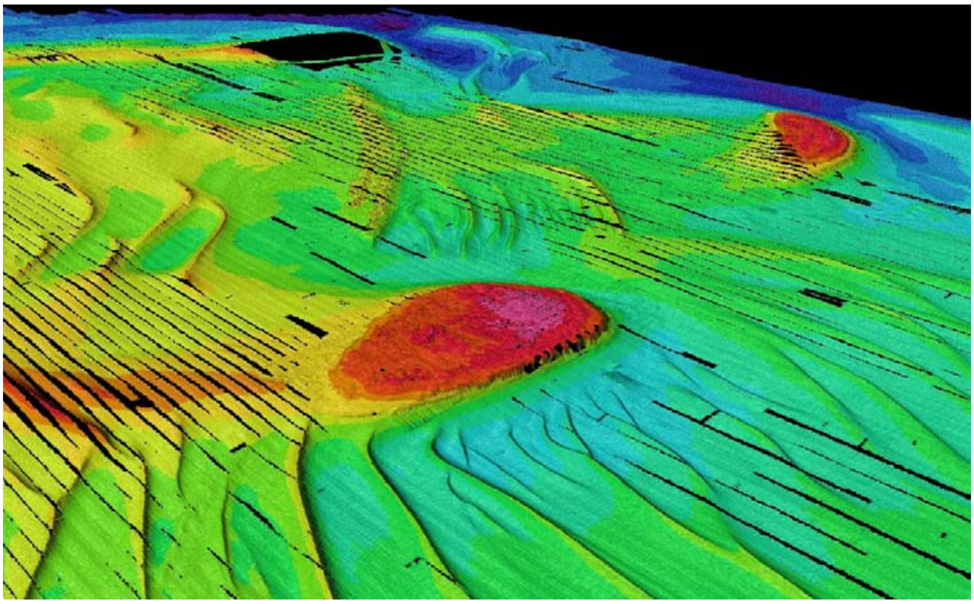
Mapping the seabed can be a challenging task. Most significantly, and unlike surveying the land, the surveyor can only very rarely see what they are mapping. Equally, they are doing it from a moving platform (a ship) floating on a moving surface (the sea) while dealing with the ever present danger of hitting the rocks and shoals they are trying to find. So, how is it done?



Coral reefs and the surrounding seabed surveyed by multi-beam echo sounder

In very simple terms, seabed mapping, or more accurately hydrographic surveying, is undertaken using some type of echo sounder. An echo sounder works on the principle of emitting a sound pulse in the water then timing how long it takes for that pulse to hit the seabed and return as a reflection. Given that the speed of sound in seawater can be determined, and is normally somewhere in the range of 1460 to 1540 metres per second, dividing the time taken to receive the return pulse by two, then multiplying by the prevailing speed of sound, gives the depth at a particular point.

Measured sound pulse travel time (echo sounder to seabed and back to echo sounder) =	0.1sec
Calculated sound pulse travel time (echo sounder to seabed) ÷ 0.1sec 2 =	0.05 sec
Speed of sound in seawater =	1500 metres / sec
Measured depth = 0.05sec x 1500m/s =	75 metres

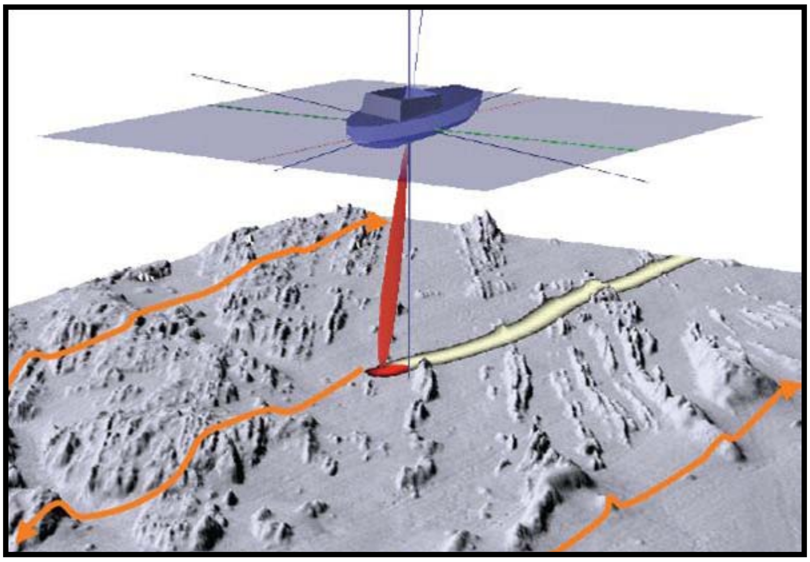
Complicating factors which affect accuracy of the measurement include the following:

- **The echo sounder isn't on the surface of the water but is mounted somewhere underneath the ship, so a correction has to be applied.** For example, if the measured depth from the echo sounder is 75 metres, but the depth of the echo sounder under the ship is 5 metres, then the real depth from the sea surface is 80 metres. Some forms of echo sounders are actually towed behind the ship and at much deeper depths, so, depending on the arrangement, this difference can be significant. Equally, in shallow areas (such as Spencer Gulf in SA and Torres Strait in QLD) used by deep draft cargo ships, just a small error can be the difference between safe passage and hitting the seabed. In certain areas of Spencer Gulf the water is about 20 metres deep, but the ships using the route have drafts of over 19 metres. In Torres Strait, the shallowest part of the route is only 10.5 metres deep but the ships passing through can be up to 12 metres deep.

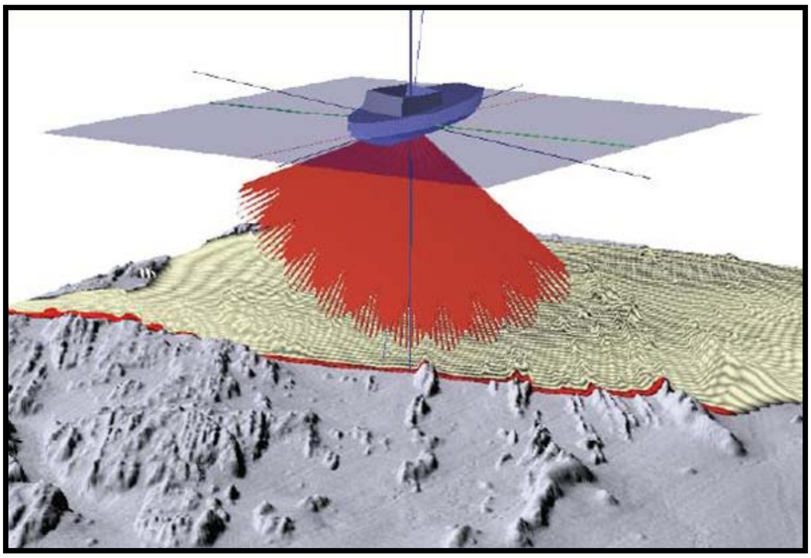
- **This brings us on to the next complication - tides.** While waves and swell affect all survey ships the effects of the rise and fall of the tide are normally more significant. In some areas the change of depth with tide can be as much as 8 or 9 metres – as much or more than the draft of many ships. Depths on nautical charts are therefore always referred to a datum – a horizontal plane somewhat lower than Mean Sea Level below which the tide rarely falls. Mean Sea Level isn't used on nautical charts as 50% of the time there would be less water than shown on the chart. Instead, depths on charts are referred to a datum known as Lowest Astronomical Tide. This is a level that the tide only very rarely falls below when there are some strong abnormal climatic effects. The predicted height of tide (from the Tide Tables) gets added to the charted depth to tell mariners how deep it will actually be at any particular place and moment. For example, if the chart says that the charted depth is 20 metres, the Australian National Tide Tables say that at that place and time the height of tide will be 2 metres, then the actual depth experienced by the ship will be 22 metres. In many ports and their approach areas, as well as in Torres Strait, this is significant as the ships can only get in and out of port, or through the Strait, at around the time of high tide.

- **Finally, the ship's navigation systems are important.** GPS gives very high accuracy positions. However, some surveys well over 100 years old still represent the best available information, particularly in remote areas. Up until the 1930s, it was not uncommon for remote features to be as much as a few miles out of position compared to modern GPS positions, so seamounts in the middle of the ocean often carry warnings on the chart if they haven't been resurveyed since (though most have been).

There are actually different types of echo sounders.

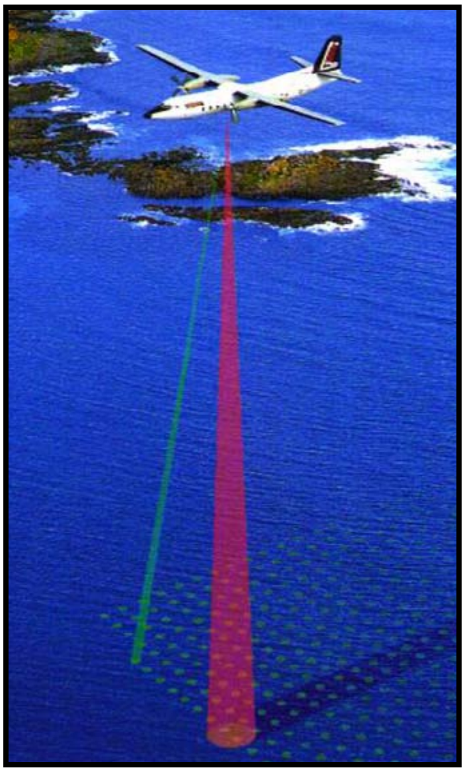


The simplest are single beam echo sounders that point vertically down beneath the ship. The geometry and maths to work out the depth are relatively easy. A high frequency pulse will give more accurate results but not penetrate the water column very deeply, while a low frequency unit is necessary to survey beyond the continental shelf but will give less accurate results. Survey ships achieve coverage by steaming back and forth in a series of parallel lines while running their sounders and recording the results. In shallow areas the spacing between lines is measured in tens to hundreds of metres, while in extremely remote areas and on the continental slopes it may be up to a kilometre between lines. In many areas not covered by systematic surveys, such as beyond the continental shelf, coverage is achieved only by combining the individual efforts of many ships over many decades as they steam across the ocean. In these cases recorded depths may be many miles apart with scant knowledge of what truly lies in between.



To address this lack of knowledge of what lies in between, the latest generation of echo sounders used by many dedicated survey ships are what is known as multi-beam echo sounders. These shoot many beams of sound from the echo sounder that spread outward and downward in a fan pattern. The echo sounder can not only discern how long each pulse takes to return, but also which direction it came from. Multi-beam echo sounders can typically achieve coverage in one pass up to around 8 times the water depth. So in 100 metres of water, the ship can survey up to an 800 metre wide strip in one pass. In contrast, a ship using a single beam system would require anywhere between 4 and 8 passes for the same area before then further investigating the shoals discovered. However, multi-beam systems are much more complicated as they are affected by small errors in sound velocity in seawater (which changes the apparent direction of the beams and hence the apparent depth and position of features) as well as being much more affected by waves, swell and resulting ship motion. Data volumes from a single beam echo sounder are measured in kilobytes per day, whereas data from multi-beam systems is typically measured in gigabytes per day. Examples of single beam and multi-beam surveys over the same area can be found in our Fact Sheet “Accuracy and reliability of charts”.

As a simple analogy of the difference between a single beam and a multi-beam echo sounder, picture the difference between trying to rake up fallen leaves off the ground with a single stick versus using a big, fan-shaped garden rake. Using the rake will sweep up far more leaves and not miss any for the same amount of effort.



The final system used is one which is only applicable to shallow water down to about 50 to 70 metres. It works in a similar fashion to a multi-beam echo sounder but instead uses light from a powerful laser mounted in a low flying aircraft. The laser scans side to side beneath the aircraft as it flies along, firing at over 1000 times per second. It then measures the difference between a strong reflection off the sea surface and weaker reflection off the seabed. There are two in use in Australia, and only a handful around the world. The original was developed by the Defence Science and Technology Organisation in Adelaide and both were built by TENIX LADS Corporation at Mawson Lakes. One is used by the Navy while the other is operated by a commercial hydrographic survey company.