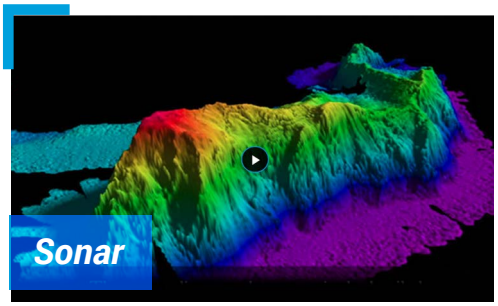
Multibeam Sonar

Good maps are critical tools for exploration. Seafloor mapping is the first step of ocean exploration operations during expeditions to new areas. Explorers use state-of-the-art mapping technologies to determine seafloor details before planning remotely operated vehicle (ROV) dives to collect images, video and samples that help to further understand our ocean and its inhabitants.



A three-minute video about multibeam and side scan sonar, including a visualization that shows how sonar data is used to make products like nautical charts. *Video courtesy of National Ocean Service, NOAA.*

Sonar

Mapping techniques have improved considerably over the last 150 years. From ancient times to the early 20th century, navigators measured ocean depths with a single weighted rope called a lead line. Imagine measuring the world's ocean using that basic technology!

Sonar (SOund NAvigation and Ranging) is a tool that uses sound waves to explore and map the ocean. This technology was developed during World War I (1914-18), but even at the time, this mapping was slow and crude. With the launch of satellites and radar in the 1970s, scientists were able to get a general idea of the entire ocean's depth, but only the use of more advanced acoustics technology has allowed large-scale, high-resolution seafloor mapping.

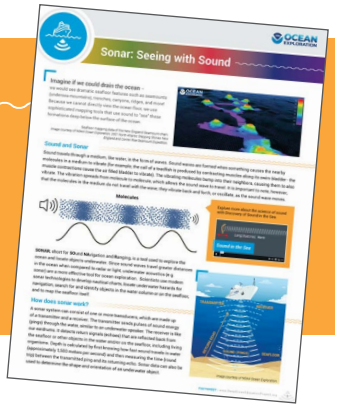
Multibeam Sonar is one of the most powerful tools available for modern deep-sea exploration and mapping. It allows for the creation of detailed 3D bathymetric maps of seafloor features like underwater volcanoes, canyons, trenches, and much more.

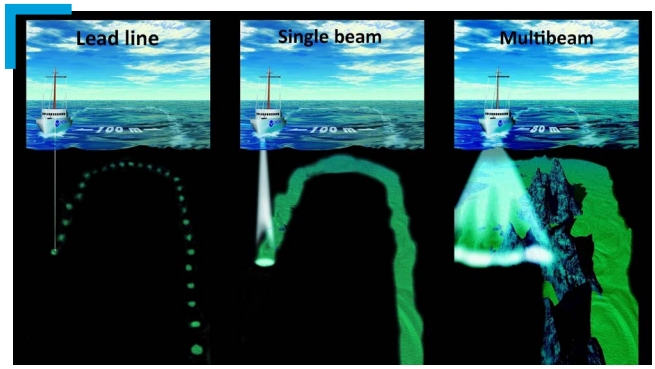
On modern ships of exploration, a multibeam sonar system uses multiple transducers, called an array, mounted to the ship's hull and pointing at different angles on either side of the ship. This system produces a fan-shaped swath of sound pulses and can generate up to 864 soundings per ping. In simplest terms, the depth is measured by the time it takes for the sound to leave the transducers, hit the seafloor, and return to the system (as an echo).

Sophisticated multibeam sonar systems are designed to produce maps in depths ranging from 10 to 7,000 meters, sometimes more! A system mounted on a ship's hull can map an area more than six times wider than the water depth!

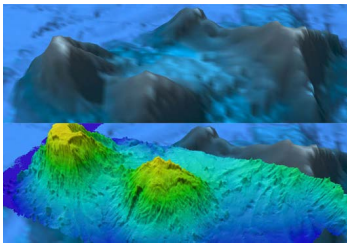
LEARN MORE

Learn more about how and why sound is used to "see" the seafloor.





The quality of seafloor imagery has improved dramatically over the years as technology has advanced from using single lead lines to single-beam sonar (one sound pulse at a time) to multibeam sonar (multiple sound pulses at a time). *Adapted from the Canadian Hydrographic Service.*



New England seamounts map created using satellite altimetry data. Bottom map: The same seamounts mapped to much greater detail with multibeam sonar data. *Image courtesy of NOAA Ocean Exploration.*

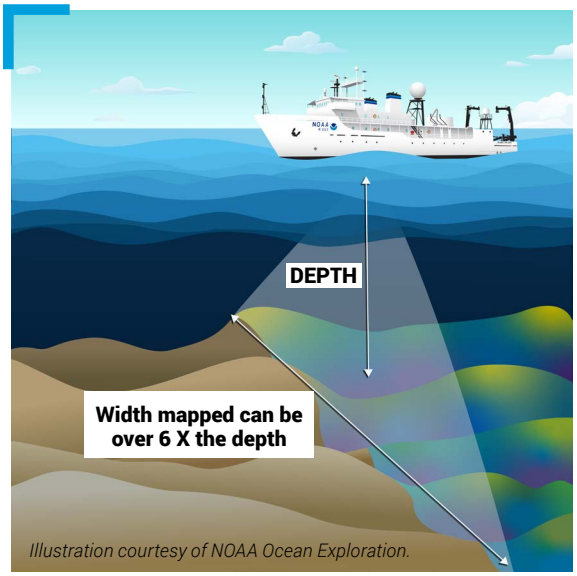
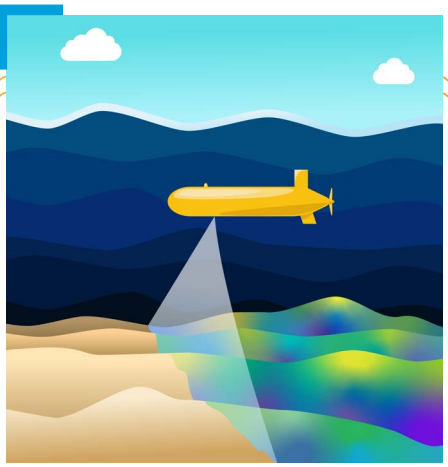


Illustration courtesy of NOAA Ocean Exploration.

Mapping in the Highest Resolution

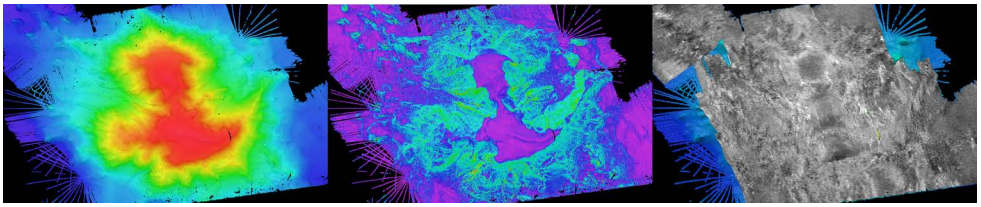
When mapping the seafloor, a multibeam survey does a broad sweep of the area, and is therefore an efficient way to systematically map large regions. However, one challenge of mapping from a vessel on the ocean surface is that the deeper the water depth, the lower the resolution of the map that can be produced. In order to map the deepest parts of the seafloor in very high resolution, it is necessary to have mapping sonars closer to the seafloor, which can mean towing them from ships or mounting them on remotely operated vehicles (ROVs) or autonomous underwater vehicles (AUVs). As this technology continues to develop, scientists across the globe hope to create a high resolution map of the entire seafloor by 2030.



An autonomous underwater vehicle (AUV) can be used to collect seafloor data using multibeam sonar. *Illustration courtesy of NOAA Ocean Exploration.*

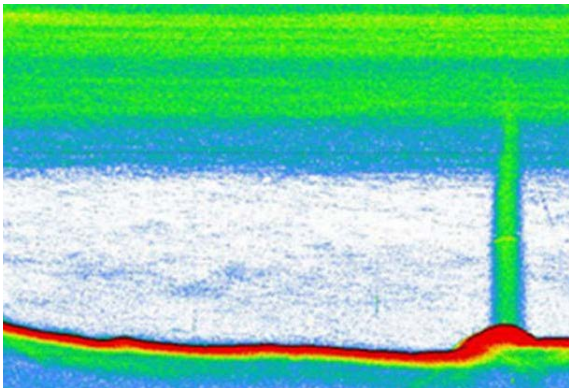
Backscatter

Multibeam sonar systems not only create a picture of what the seafloor looks like, but they also provide information about the geological makeup of the seafloor or objects on it. This is done by measuring **backscatter**, or the intensity of the reflected sound echo. Hard, rocky seafloor substrate generally reflects more sound than softer materials like mud or sand.

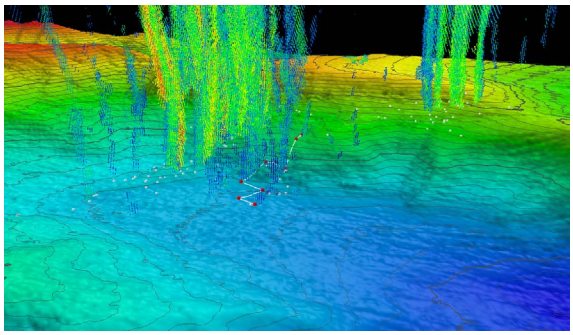


Michael Seamount: bathymetry (left), slope (mid), backscatter (right). *Image courtesy of NOAA Ocean Exploration, 2021 North Atlantic Stepping Stones: New England and Corner Rise Seamounts.*

Backscatter data can also be used to reveal objects in the water column, such as three-dimensional structures associated with shipwrecks, dense layers of organisms, and bubble plumes percolating from the seafloor.



In this sonar image, the red feature is the seafloor. Green and blue areas in the water column are features with high backscatter – the lines near the surface show dense layers of biology (zooplankton, fish, gelatinous creatures, etc.), while the vertical lines are bubble plumes coming from the seafloor. *Image courtesy of NOAA Ocean Exploration.*



Methane bubble plumes rising over 900 meters (2,950 feet) above the seafloor at Norfolk Seeps off the eastern US coast. *Image courtesy NOAA Ocean Exploration, Windows to the Deep 2019.*

Because these echosounders can also detect bubbles in the water column, explorers have been able to discover hundreds of previously unknown methane seeps off the Atlantic and Pacific U.S. coasts, many supporting robust chemosynthetic communities.

LEARN MORE

Many other types of sonar are used by ships of exploration. With continuing scientific and technological advances, our ability to observe the ocean environment and its resident creatures is beginning to catch up with our imaginations!

Sonar (video): https://oceanexplorer.noaa.gov/technology/sonar/sonar.html
Sonar (fact sheet): https://oceanexplorer.noaa.gov/edu/materials/sonar-fact-sheet.pdf
Surveying (image): https://noaacoastsurvey.files.wordpress.com/2015/07/surveying.jpg
Satellite altimetry and multibeam sonar (image): https://oceanexplorer.noaa.gov/world-oceans-day-2015/how-much-of-the-seafloor-is-left-to-explore.html
Multibeam sonar swath illustration (illustration): https://oceanexplorer.noaa.gov/edu/materials/ship-MB-depth-width-illustration.png
AUV collecting multibeam data (illustration): https://oceanexplorer.noaa.gov/edu/materials/auv-MB-illustration.png
Map of the entire seafloor (webpage): https://seabed2030.org/
Michael seamount (image): https://oceanexplorer.noaa.gov/okeanos/explorations/ex2104/features/mapping/media/planning-hires.jpg
Water column backscatter (image): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1703/logs/mar11/media/echogram.html
Norfolk seeps (image): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1903/logs/july12/media/norfolk-plume-hires.jpg
Methane seeps (webpage): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1903/logs/july12/july12.html
Scientific and technological advances (webpage): https://oceanexplorer.noaa.gov/technology/technology.html

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