Measuring Depth

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Introduction

- Earlier mariners believed that oceans are deep depressions on the earth
- They don’t have idea on submarine features
- Hundreds of years unknown about deep water depth
- 85 BC Greek geographer – Posidonus – used long rope and rock to measure depth
- Slight modification done during last 2000yrs
- Rope with greased lead weight at its end.
- Large piano wire with cannonball

Measuring Depth

- Ocean has features like mountain chain, deep valleys, great canyons, plain etc.
- When map became detailed, Ocean travel and commerce increased.
- So It was necessary to know shallow depth for safe landing of ships
- To map the ocean floor we need to know the depth at a number of places.
- The process of measuring the depths is known as bathymetry.
- 1920 acoustic sound equipment was developed
- 1950 mid Atlantic ocean ridge was discovered

- In the past the weighted line (lead line) was let out by hand until it touched the bottom, and the depth could be recorded from the length of the line

- This technique led to the fathom as a unit of depth; as sailors hauled in the sounding line they would stretch it out to cover their arm span.

- The average arm span of a sailor was about six feet, so one fathom equals six feet(1.8m), and the sailors could simply count the number of “arm spans” as they pulled in the line.

- This technique had a number of drawbacks, and was usually limited to shallower water. It was very time consuming, and only gave depth data for a single point, so many individual soundings were needed to map an area

- After the Titanic disaster in 1912, there was an effort to develop better methods of detecting icebergs from a ship. This led to the development of sonar (SOund Navigation And Ranging) technology, which was soon applied to mapping bathymetry

Figure shows traditional way of measuring depth

Figure 1.4.1 *Lead line survey from a catamaran hull in Alaska, 1942 (http://celebrating200years.noaa.gov/transformations/hydrography/image7.html).*

Sound

- Sound is a form of energy transmitted through a medium
- In ocean sounds, the energy is transmitted via water molecules vibrating back and forth parallel to the direction of the sound wave, and passing on the energy to adjacent molecules.
- Therefore, sound travels faster and more efficiently when the molecules are closer together and are better able to transfer their energy to neighboring particles.
- That’s why sound travel faster in water than the Air

- The speed of sound in the ocean is not constant; it is influenced by a number of variables including Temperature, Salinity, and Pressure, and an increase in any of these factors will lead to an increase in the speed of sound

- We have seen that these variables change with depth and location; so the speed of sound differ in different regions of the ocean.

- The temperature effects dominate at the surface, so the speed of sound is fast in surface waters.

- As depth increases, the temperature and the speed of sound decline.

- Near the bottom, the extreme pressure dominates, and even though temperatures are low, the speed of sound increases with depth.

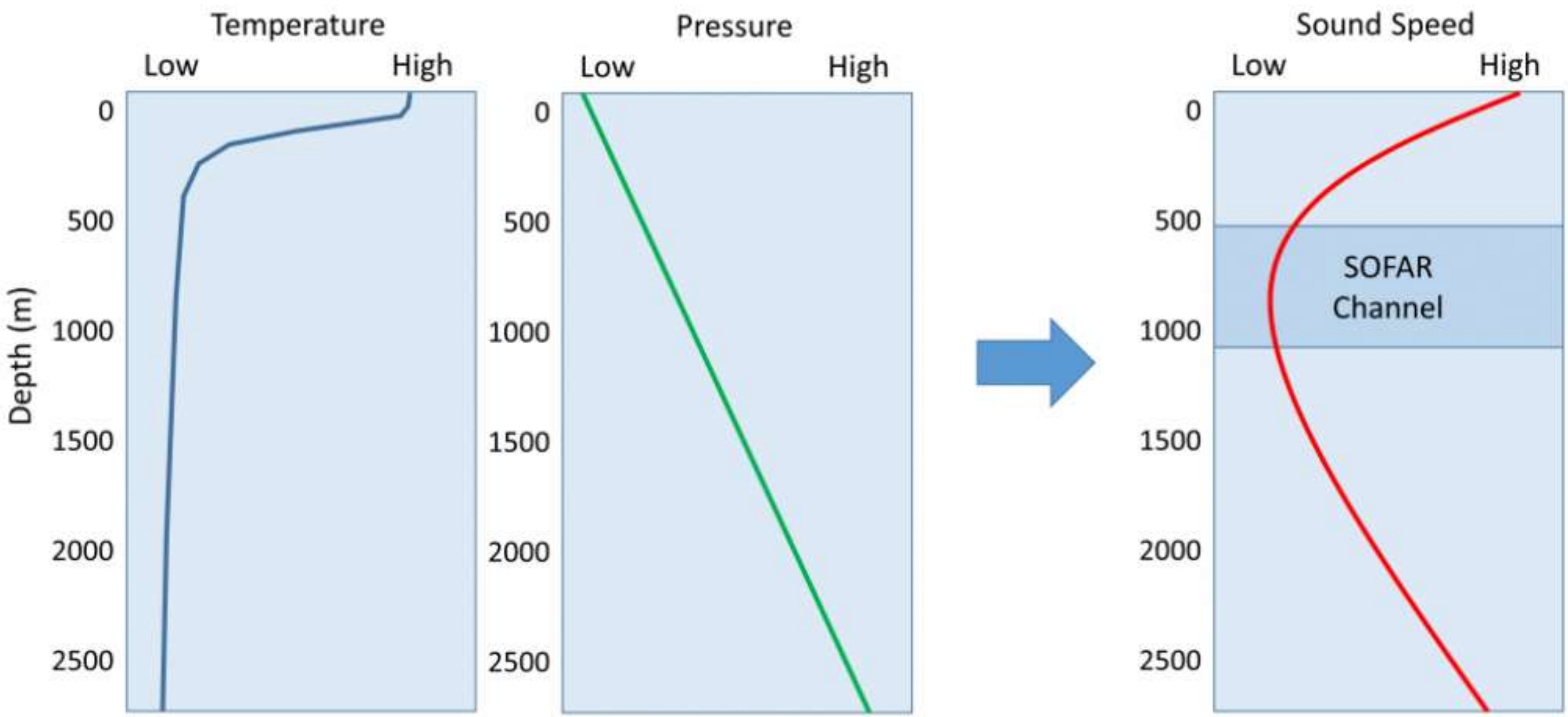
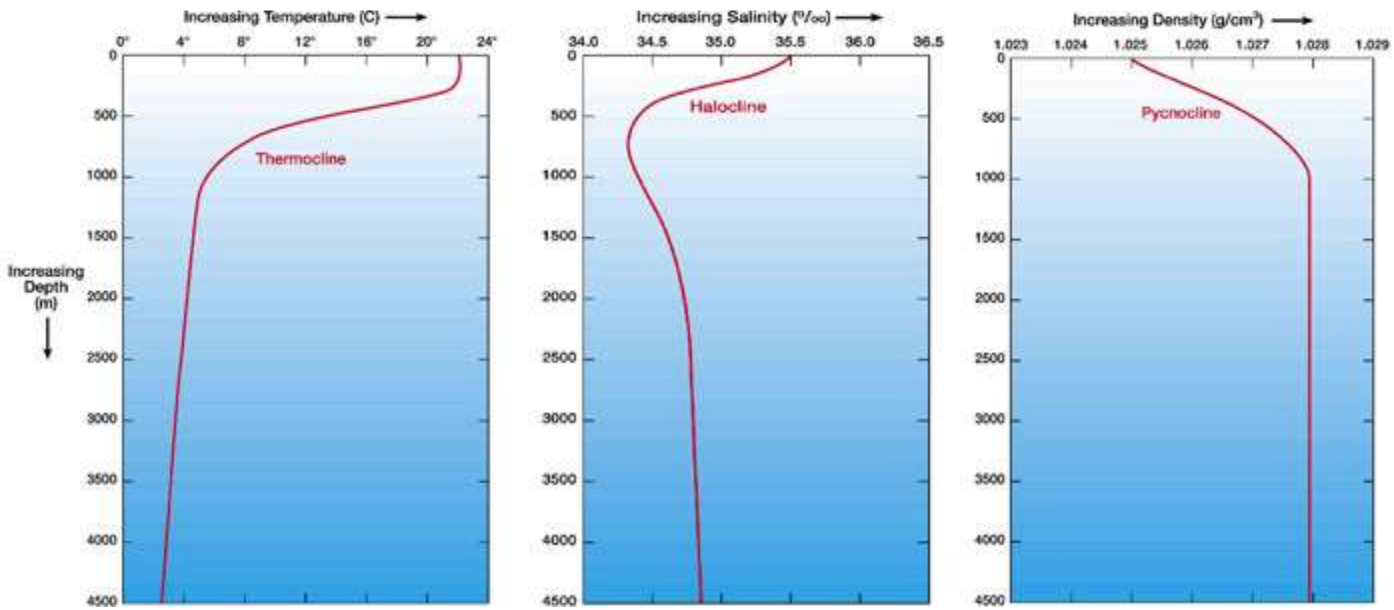


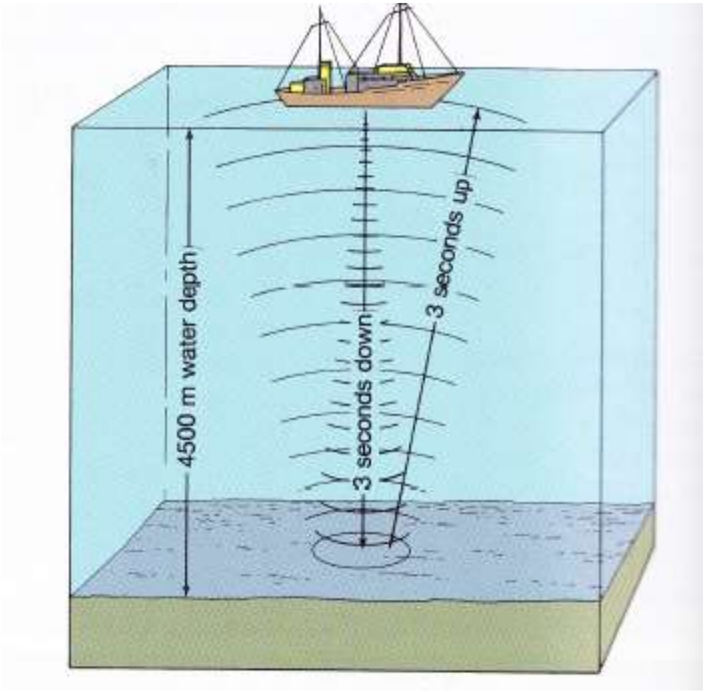
Figure 6.4.1 *Profiles of temperature, pressure, and sound speed with depth. Sound speed is high at the surface due to the high temperatures, and is high at depth because of the high pressure. At moderate depths lies the SOFAR channel, the region of slowest sound speed (PW).*

Plots of typical water properties in the open ocean

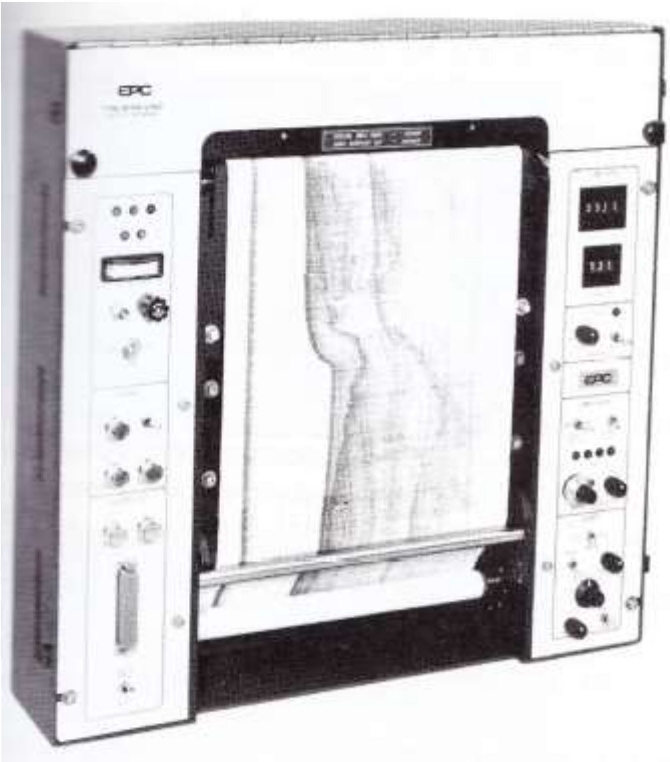


The **thermocline** is where the temperature changes rapidly, the **halocline** is where the salinity changes rapidly and the **pycnocline** is where the density changes rapidly.

- A sonar device called an echosounder sends out a pulse of sound, then listens for the returning echo. The timing of the returning echo is used to calculate depth.
- We know that the speed of sound in water is approximately 1500 m/s. Since the returning echo travelled to the bottom and back, the water depth corresponds to half the time it takes for an echo to return, multiplied by the speed of sound in water
- depth=1/2*(two-way travel time)*(speed of sound in water)



- Most hydrographic operations use a 200 kHz transducer, which is suitable for inshore work up to 100 metres in depth. Deeper water requires a lower frequency transducer as the acoustic signal of lower frequencies is less susceptible to attenuation in the water column. Commonly used frequencies for deep water sounding are 33 kHz and 24 kHz.

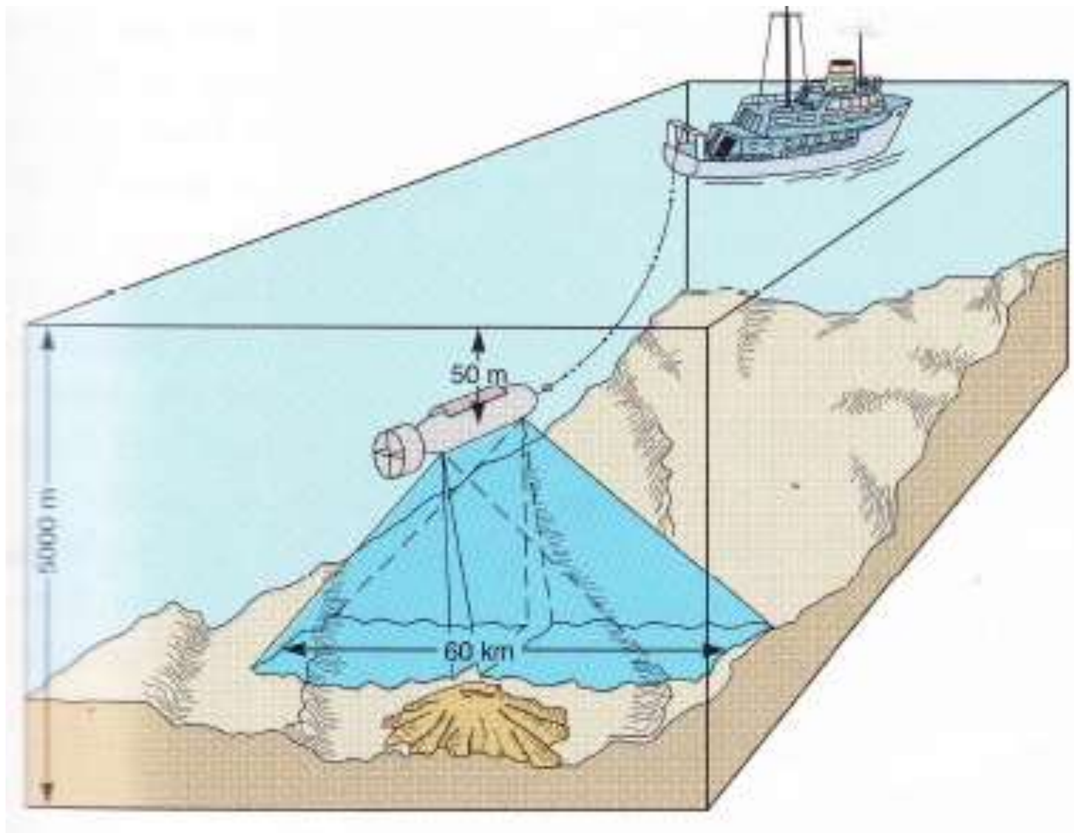


- Echosounders allowed a fast, continuous record of bathymetry under a moving ship. However, they only give the depth directly under a ship's path

- After the Titanic disaster in 1912, there was an effort to develop better methods of detecting icebergs from a ship. This led to the development of sonar (SOund Navigation And Ranging) technology, which was soon applied to mapping bathymetry

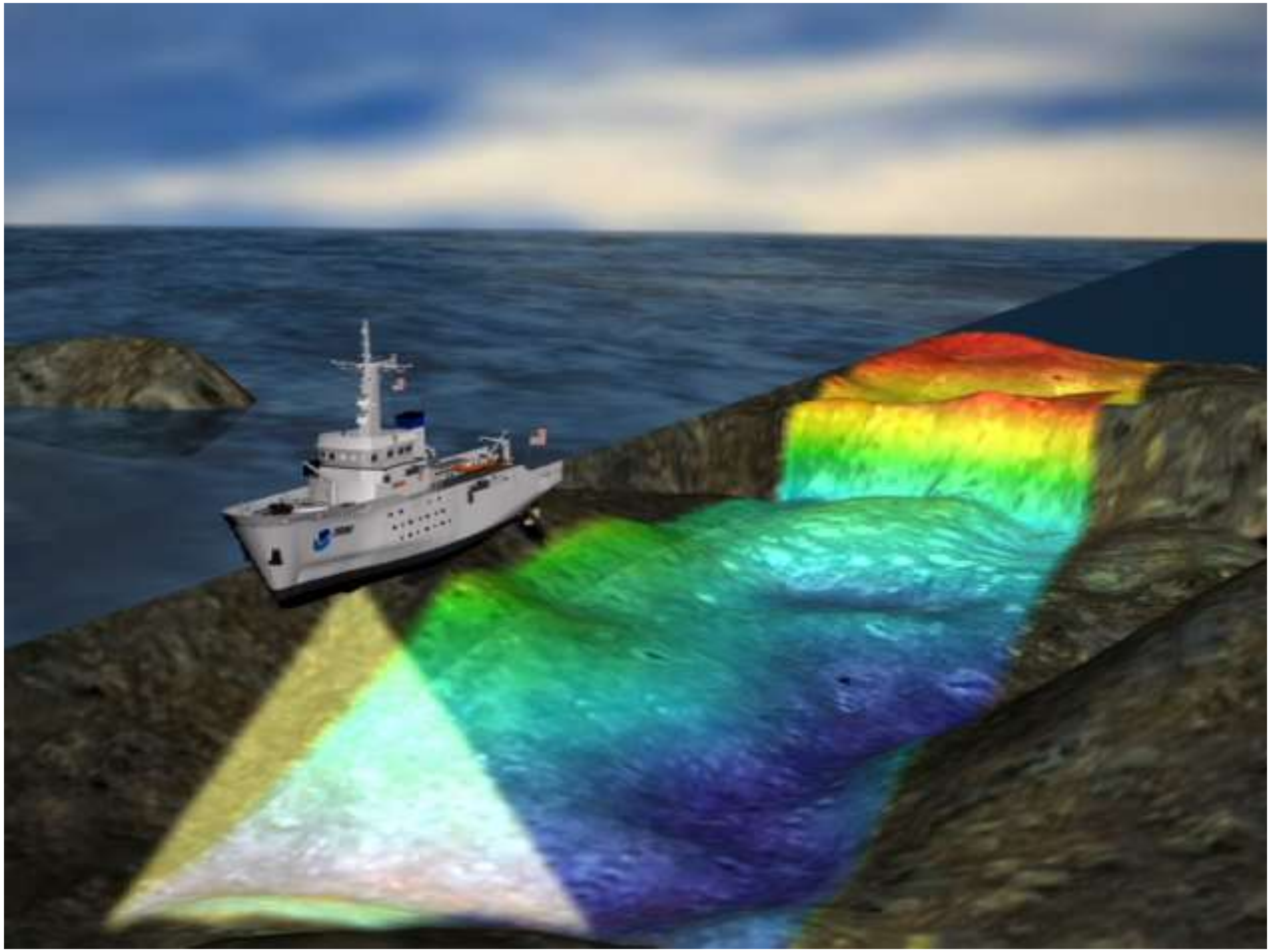
- Today, high resolution seafloor maps are made through multibeam or side scan sonar, either from a ship or from a towed transmitter

- Multibeam sonar produces a fanshaped acoustic field allowing a much a wider area (>10 km wide) to be mapped simultaneously

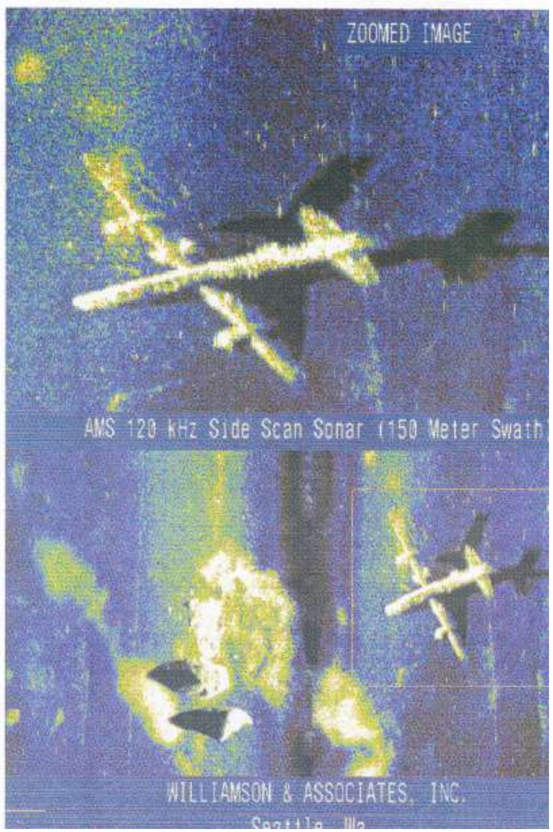


50 m
60 km
5000 m

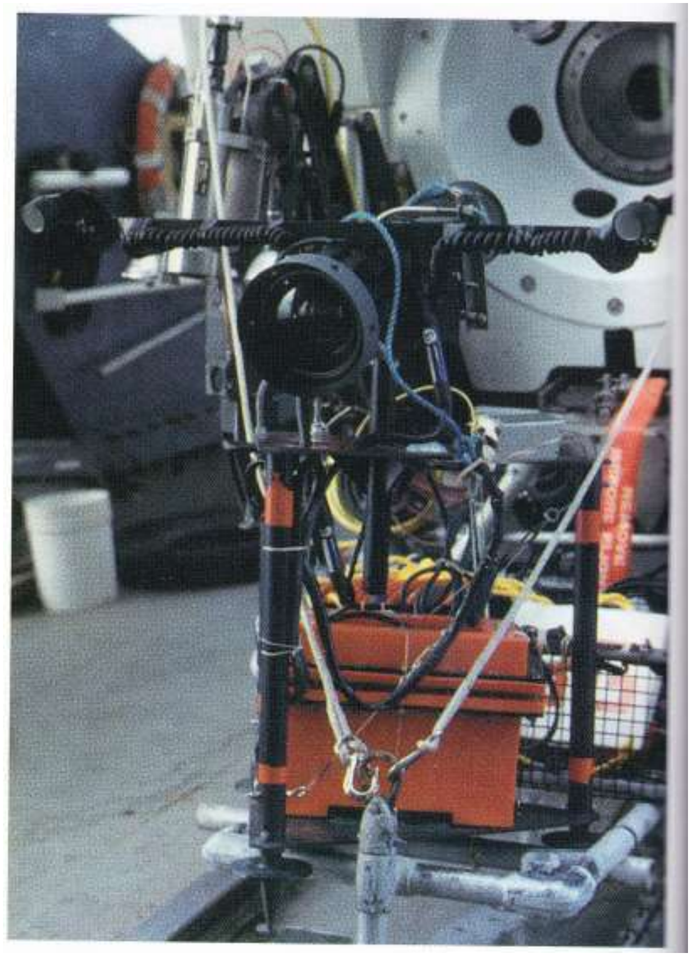
Multi beam sonar system



LADS



- The laser airborne depth sounder (LADS)
- Coral reef 70m
- Other water 20-50 m
- Very large scale sea floor survey



- Large-scale mapping of the ocean floor is also carried out by satellites (originally SEASAT, then GEOSAT, now the Jason satellites) which use radio waves to measure the height of the sea surface (radar altimetry).
- The sea surface is not flat; gravity causes it to be slightly higher over elevated features on the ocean floor, and slightly lower over trenches and other depressions.
- Satellites send out radio waves, and similar to an echosounder, can use the returning waves to detect differences in sea surface height down to 3-6 cm
- These differences in sea surface heights allow us to determine the topography under the surface.
- The current satellites can map over 90% of Earth's ice-free sea surface every 10 days!

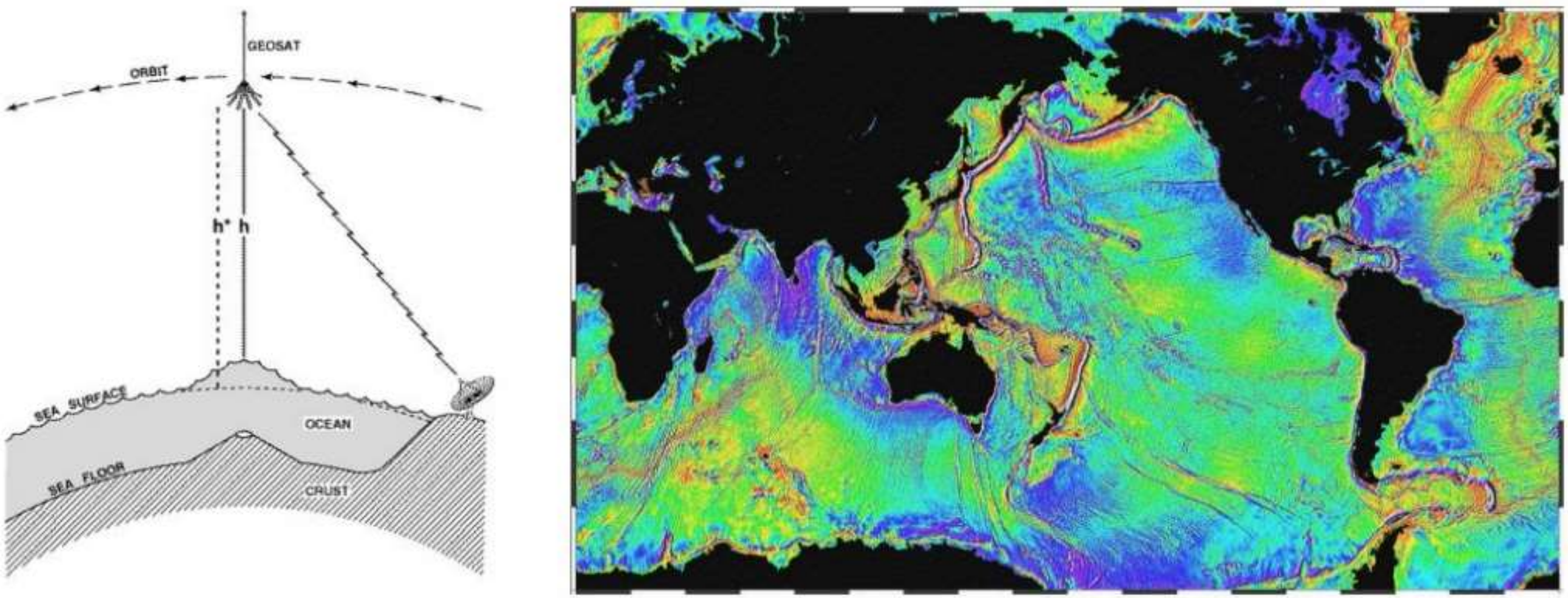
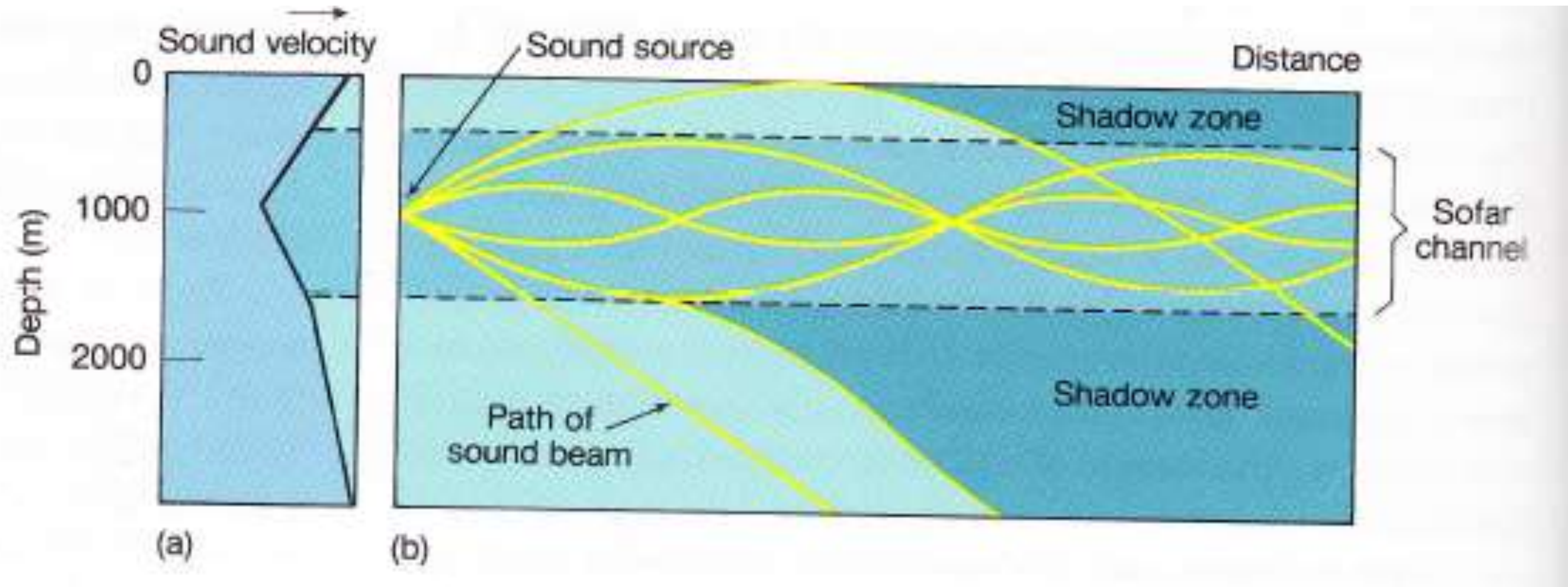


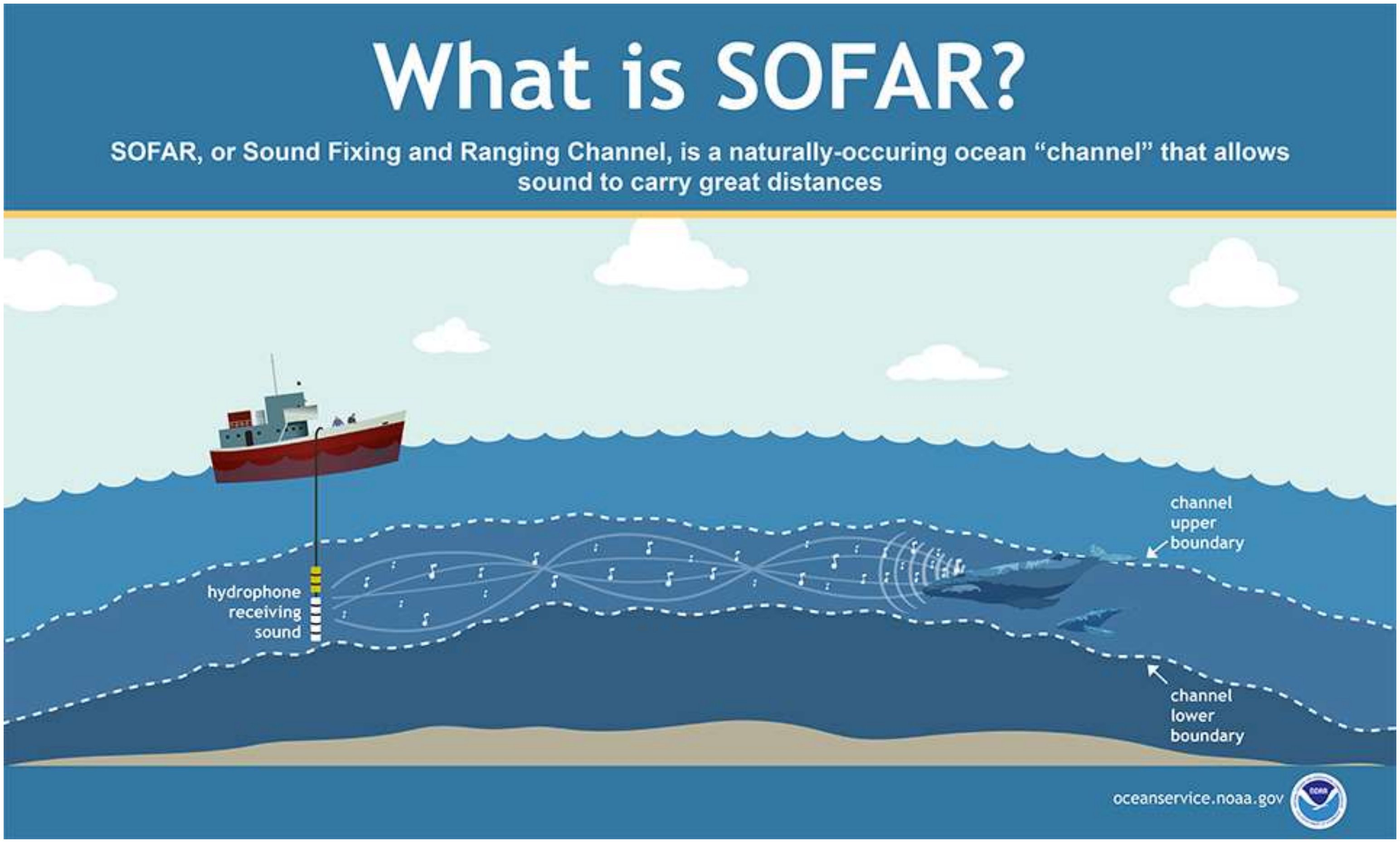
Figure 1.4.5 *Radar altimetry (left) and a map of the seafloor produced by radar altimetry satellites (right) (NOAA).*

SOFAR channel

- Sound Fixing And Ranging.
- is a horizontal layer of water in the ocean at which depth the speed of sound is at its minimum.
- In the deep ocean at mid-latitudes, the slowest sound speed occurs at a depth of about 800 to **1000 meters**.
- The sound speed minimum creates a sound channel in which sound waves can travel long distances.

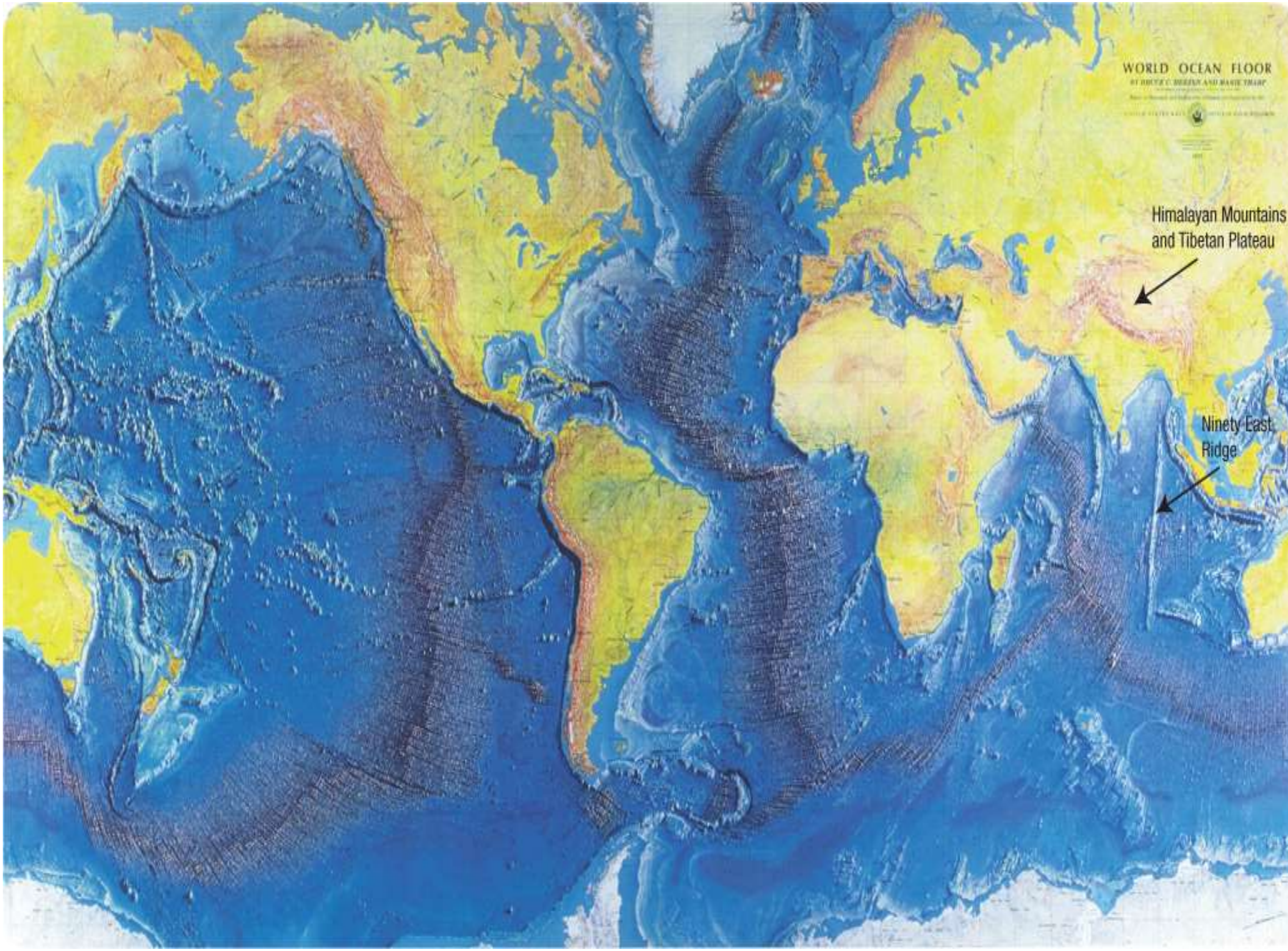
Sofar channel

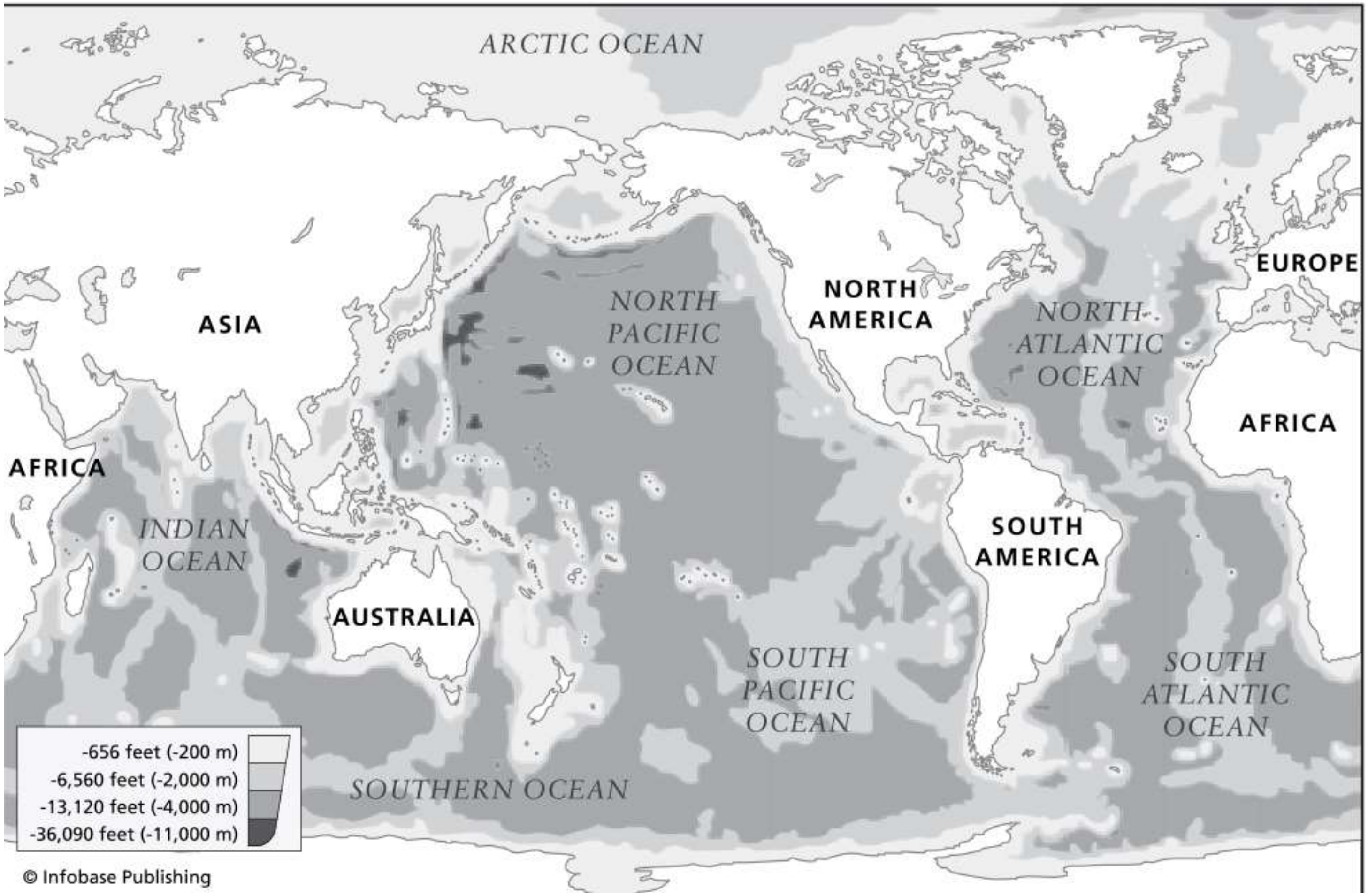



What is SOFAR?
SOFAR, or Sound Fixing and Ranging Channel, is a naturally-occuring ocean "channel" that allows sound to carry great distances
hydrophone receiving sound
channel upper boundary
channel lower boundary
oceanservice.noaa.gov

- Acoustic Thermometry of ocean climate (ATOC)
- Sound surveillance systems (SOSUS)
- 1950-1960 USA installed number of hydrophones


NOAA FISHERIES
How far can low frequency sound travel in the ocean?
Sound pathways
Sound Origin


WORLD OCEAN FLOOR
Himalayan Mountains
and Tibetan Plateau
Ninety East
Ridge


ARCTIC OCEAN
ASIA
NORTH PACIFIC OCEAN
NORTH AMERICA
NORTH ATLANTIC OCEAN
EUROPE
AFRICA
AFRICA
INDIAN OCEAN
AUSTRALIA
SOUTH AMERICA
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
SOUTHERN OCEAN
-656 feet (-200 m)
-6,560 feet (-2,000 m)
-13,120 feet (-4,000 m)
-36,090 feet (-11,000 m)

Speed of Sound

- Cold Water (0°C): Around 1402 m/s.
- Seawater (20-25°C): Approximately 1531 m/s.
- Distilled Water (20°C): Around 1480 m/s.