



Pacific Battleship Center
USS IOWA - BB 61
Educational Resource



Acoustic Properties of Seawater (Advanced)

Developed by: Tom Turner

Date:

Objective:

To discover how the acoustic properties of water affect the transmission of sound.

Vocabulary Words:

Materials:

Background Information:

Water is an excellent conductor of [sound](#), considerably better than [air](#). The attenuation of sound by absorption and conversion to other energy forms is a function of sound [frequency](#) and the properties of [water](#).

The attenuation coefficient, α , in [Beer's law](#), as applied to sound, where I_z and I_0 are now [sound intensity](#) values, is dependent on the viscosity of water and inversely proportional to the [frequency](#) of the sound and the [density](#) of the water. High-pitched sounds are absorbed and converted to heat faster than low-pitched sounds. [Sound velocity](#) in water is determined by the [square root](#) of elasticity divided by the water's density. Because water is only slightly compressible, it has a large value of elasticity and therefore conducts sound rapidly. Since both the elasticity and density of seawater change with temperature, salinity, and pressure, so does the velocity of sound.

In the oceans the [speed of sound](#) varies between 1,450 and 1,570 metres (about 4,760 to 5,150 feet) per second. It increases about 4.5 metres (about 15 feet) per second per each 1 °C increase in temperature and 1.3 metres (about 4 feet) per second per each 1 psu increase in salinity.

Increasing pressure also increases the speed of sound at the rate of about 1.7 metres (about 6 feet) per second for an increase in pressure of 100 metres in depth, which is equal to approximately 10 bars, or 10 atmospheres.

The greatest changes in temperature and salinity with depth that affect the speed of sound are found near the surface. Changes of sound speed in the horizontal are usually slight except in areas where abrupt boundaries exist between waters of different properties. The effects of salinity and temperature on sound speed are more important than the effect of pressure in the upper layers. Deeper in the [ocean](#), salinity and temperature change less with depth, and pressure becomes the important controlling factor.

In regions of surface dilution, salinity increases with depth near the surface, while in areas of high [evaporation](#) salinity decreases with depth. Temperature usually decreases with depth and normally exerts a greater influence on sound speed than does the salinity in the surface layer of the open oceans. In the case of surface dilution, salinity and temperature effects on the speed of sound oppose each other, while in the case of evaporation they reinforce each other, causing the speed of sound to decrease with [depth](#). Beneath the upper oceanic layers the speed of sound increases with depth.

If a sound [wave](#) (sonic pulse) travels at a right angle to these layers, as in depth sounding, no refraction occurs; however, the speed changes continuously with depth, and an average sound speed for the entire water column must be used to determine the depth of water. Variations in the speed of sound cause sound waves to refract when they travel obliquely through layers of water that have different properties of salinity and temperature. Sound [waves](#) traveling downward and moving obliquely to the water layers will bend upward when the speed of sound increases with depth and downward when the speed decreases with depth. This [refraction](#) of the sound is important in the [sonar](#) detection of submarines because the actual path of a sound wave must be known to determine a submarine's position relative to the transmitter of the sound. Refraction also produces shadow zones that sound waves do not penetrate because of their curvature.

At depths of approximately 1,000 metres, pressure becomes the important factor: it combines with temperature and salinity to produce a zone of minimum sound speed. This zone has been named the [SOFAR \(sound fixing and ranging\) channel](#). If a sound is generated by a point source in the SOFAR zone, it becomes trapped by refraction. Dispersed horizontally rather than in three directions, the sound is able to travel for great distances. [Hydrophones](#) lowered to this depth many kilometres from the origin of the sound are able to detect the sound pulse. The difference in arrival time of the pulse at separate listening posts may be used to triangulate the position of the pulse source.

[Hearing](#) is an important sensory mechanism for marine [animals](#) because seawater is more transparent to sound than to light. Animals communicate with each other over long distances and also locate objects by sending directional sound signals that reflect from targets and are received as echoes. Information about the size of a target is gained by varying the frequency of the sound; high-frequency (or short-wavelength) sound waves reflect better from small targets than low-frequency sound waves. The intensity and quality of the returning signal also provide information about the properties of the reflecting target. Much of the world's oceans are polluted

with chaotic sounds from ships, seismic tests, and oil drills, and [noise pollution](#) poses a serious problem for marine animals that rely on [echolocation](#) in seawater, such as whales and dolphins.

Alyn C. Duxbury

Activity Instructions:

Conclusion/wrap up:

Further Investigations:

Sources:

Britannica: <https://www.britannica.com/science/seawater/Acoustic-properties>