Sound Under Water

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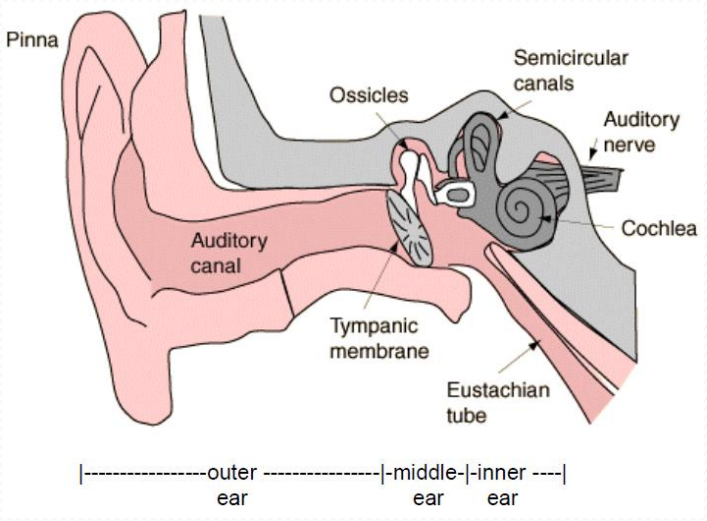
Ear Underwater



- Underwater very weak diffraction effects occur at the head since the acoustic impedance of the head and the water are similar
- Pinna contributes to auditory effects in air, but being composed of soft tissues, it can have no acoustic function underwater
- If the ear canal is filled with water and the head submerged then the outer portion of the canal is acoustically non existent
- Length of the external canal is effectively reduced by 1/3 -1/2 its normal length upon immersion

Ear Underwater

- Characteristics of the medium, the head, the pinna, the canal, and the tympanic membrane/ middle ear system may account for a reduction in sensitivity of about 84 dB at 2.5 khz upon immersion
- Wavelengths of sound in water, for a given frequency are 4.5 times longer than the wavelengths in air
- Resonant frequency of the canal is about 6.75- 9 times higher in water than it is in air

Ear Underwater

- Within this frequency band, underwater hearing is 35-40 dB less sensitive than in air

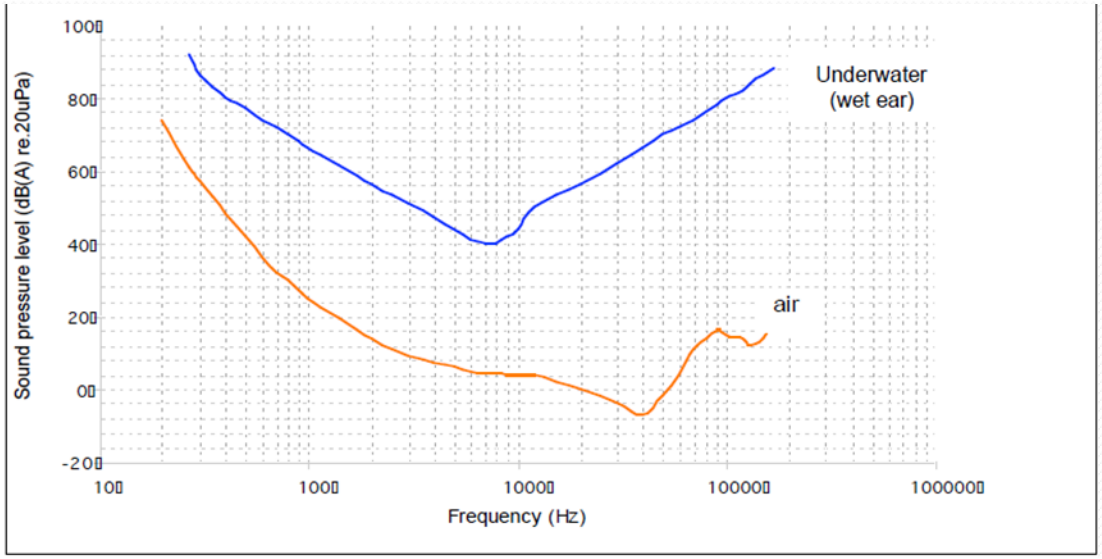


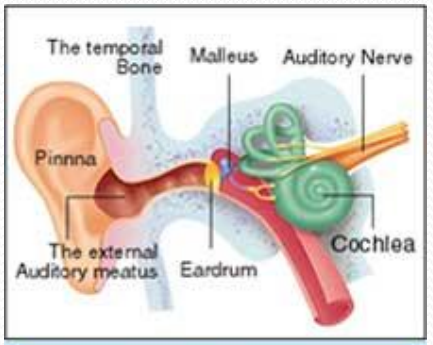
Figure 2.2: The threshold of hearing in air and in water [13]

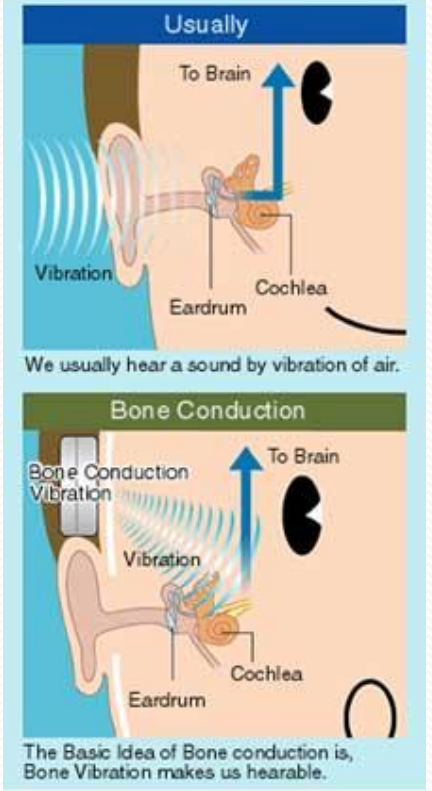
Human Study

- The average underwater threshold is approx. 49 & 45 dB
- Swimmers had depressed AC and BC hearing levels at frequencies above one kHz
- Sivian concluded that underwater hearing is mediated by BC
- Subjects could not localize sound underwater supported bone conduction theory

Human Study

- A Study done on 8 men showed that hearing sensitivity under water is mainly due to bone conduction rather than air conduction
- Threshold for hearing underwater is approximately 74dB reverberation
- Threshold sensitivity DECREASES at a rate of 3 db/octave
- Sensitivity underwater is POORER than in air by about 40-70 dB depending on the frequency





U.S. Navy

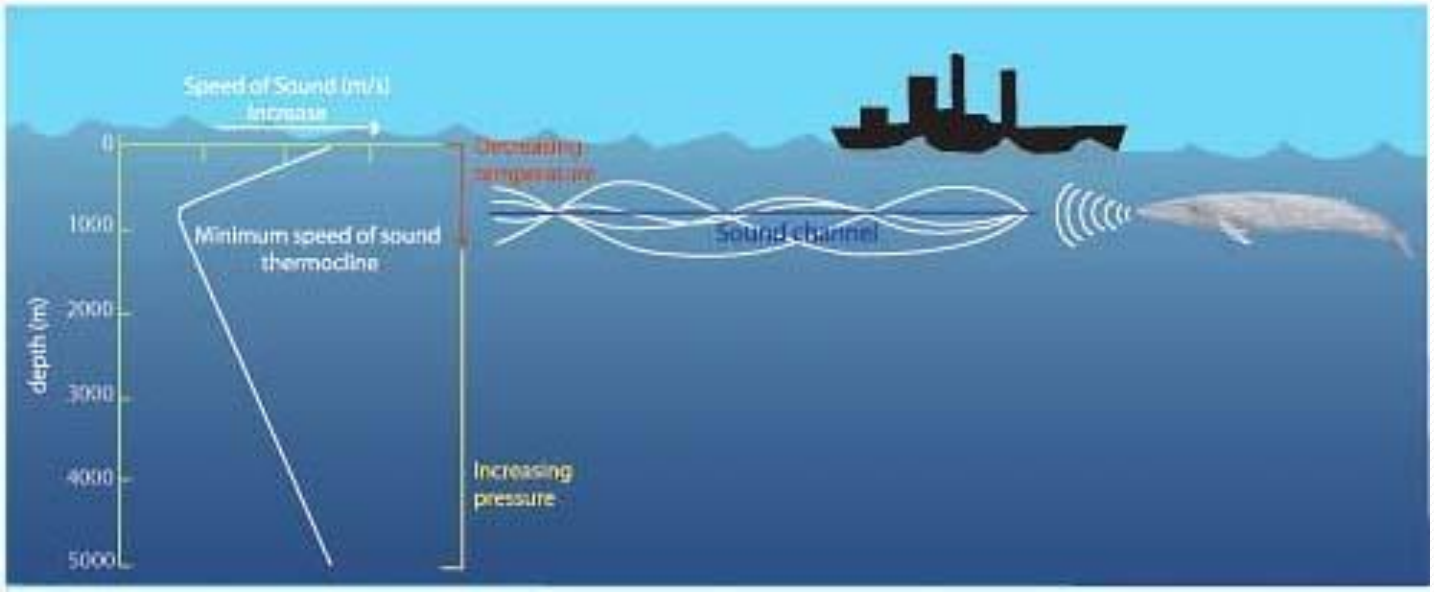
- Water 800 times denser than air
- Velocity air 344 m/s, water 1460 m/s
- Detonation of high explosive (TNT and nitroglycerine based explosives) have velocity of 5,000-10,000 m/s
- produces shock wave that propagates in all directions

U.S. Navy

- “Tissues, like water, are relatively incompressible but Gas within the body is easily and instantaneously compressed. Thus, damage will tend to be concentrated at gas/tissue interfaces where the differential in compressibility is greatest. Lungs and intestines are the prime targets…”
- hearing most sensitive at 2Hz in air & at 800Hz in water

Sea Life

- 1996 Study by NATO Undersea Research Center in Greece
- Two sources of sound, low and mid frequencies
- Centered at 600Hz-3kHz and max level 228db
- Mass stranding of beaked whales occurred in vicinity of sonar test



References

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- Underwater hearing in Man: I. Sensitivity by Paul F. Smith
- “Correlating Military Sonar Use with Beaked Whale Mass Strandings” via Proquest
- NSMRL Report 1218
- Perception and Performance Under Water by John Adlofson