BY LIFTING THEIR HEADS ABOVE WATER, HARBOR SEALS (*PHOCA VITULINA*) CAN REDUCE THEIR EXPOSURE TO UNDERWATER SOUNDS ONLY BELOW 8 kHz

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High-amplitude anthropogenic sounds may result in hearing damage in marine mammals that are underwater and close to the sound source. Harbor seals (*Phoca vitulina*) often rest while 'bottling' with their head and ears above the water surface, perhaps as a self-mitigation method to reduce sound pressure levels (SPLs) received by their ears. We quantified the hearing sensitivity of two harbor seals for underwater sounds when they were 'bottling', and simulated sound propagation near a 'bottling' seal.

The head-above-water (HAW) hearing thresholds of the two seals for underwater sounds were very similar. For hearing test signals between 0.031kHz and 6.3 kHz, the HAW hearing thresholds were 14–62 dB higher than the underwater hearing thresholds of the same seals for the same sounds, showing that they were able to reduce their exposure to these underwater sounds by 'bottling'. For signals between 8kHz and 80 kHz, the HAW and underwater hearing thresholds were much more similar, differing by only 0–8 dB. Between 0.1kHz and 4 kHz, the mean corresponding SPLs in air radiated by the underwater signals at threshold levels were similar to the theoretical (background noise spectral density level + critical ratio) masked thresholds for harbor seals. The aerial hearing thresholds at 0.031 kHz (84 dB re: 20 µPa) and 0.063 kHz (80 dB re: 20 µPa) were unmasked and can be added as data points to the existing unmasked aerial audiogram of harbor seals (0.1-32.5 kHz).

Numerical simulations (up to 20 kHz) were consistent with exposure level differences at the ears between HAW and submerged positions, providing theoretical background for the observations. The apparent reduction in received SPL was frequency-dependent and changed between 4 kHz and 8 kHz: seals reduced the sound energy they experienced < 8 kHz by 'bottling', but > 8 kHz, the HAW hearing thresholds were similar to those of submerged seals. Most energy in anthropogenic sound is < 4 kHz. When estimating the effect of high-amplitude, long-duration, continuous underwater sound (e.g., from naval sonar, vibratory piling, or vibroseis) or high-amplitude repetitive impulsive underwater sound (e.g., percussion pile driving) on harbor seal hearing, their ability to self-mitigate their exposure to sounds <8 kHz at times when they are not diving or foraging can be taken into account.