Amphibious hearing in pinnipeds, revisited

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Auditory sensitivity in pinnipeds is influenced by the need to balance efficient sound detection in two vastly different physical media: air and water. Comparisons between absolute aerial and underwater auditory sensitivity have previously been made for several pinniped species, and media-dependent differences in low-frequency hearing have been related to aspects of acoustic communication, ecology, and life history. In the last ten years, new data have been acquired that necessitate a re-evaluation of amphibious hearing in these marine mammals. These data include audiometric measurements across a wider range of frequencies, with aerial hearing profiles obtained in much quieter ambient noise conditions. When these recent measurements of absolute auditory sensitivity are compared within species and between media, it becomes clear that the old notion that all pinnipeds are more sensitive to sounds received under water than to sounds received in air is wrong. Later claims that that the hearing of many phocinae seals is equally adapted for both media, and that the hearing of at least one monachinae seal is primarily adapted for underwater function, also require revision in light of new information.

To date, behavioral assessment of hearing sensitivity has been conducted with at least one individual representing eight different pinniped species, including the walrus (Family Odobenidae), the California sea lion, Steller sea lion, and northern fur seal (Family Otariidae), and the harp seal, ringed seal, harbor seal, monk seal, and elephant seal (family Phocidae). For most of these species, there has been some effort made to evaluate auditory sensitivity to both airborne and underwater signals.

While underwater testing of pinnipeds has been conducted in pools or sea pens, aerial testing has occurred in both indoor and outdoor conditions with variable amounts of ambient noise. Some studies have employed the use of headphones to aid in the reduction of potential masking noise, while others have attempted to create artificially quiet testing environments through the construction of acoustically dampened enclosures. As airborne ambient noise has been better controlled, frequency-dependent hearing thresholds have decreased considerably (25 to 30 dB in some species), suggesting that many of the previous pinniped audiograms that have been obtained in air have been limited by background noise.

The underestimation of aerial hearing sensitivity in pinnipeds has resulted in flawed conclusions with respect about some aspects of amphibious hearing in these animals. Presently, there are at least three species for which absolute (unmasked) aerial and underwater audiograms are available. When these data are compared on the basis of either sound pressure or sound intensity, another perspective emerges.

Current data show that harbor seals, who breed in water, actually hear better in air, as do otariid pinnipeds, which breed on land. Thus far, only the deep diving elephant seal, which also breeds on land, is more sensitive to some waterborne signals than to aerial sounds of the same frequency. The early observation that frequency range of hearing is greatly expanded under water for phocid but not for otariid pinnipeds is consistent with recent behavioral hearing measurements showing that phocinae and monachinae seals hear much higher frequencies in water than in air, while otariid and odobenid pinnipeds appear to have similar frequency ranges of hearing in both media. Audiometric research which accurately describes the absolute hearing capabilities of amphibious marine mammals such as pinnipeds informs understanding of auditory mechanisms in air and water and elucidates the potential selective pressures acting on these auditory systems.