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Steady streaming near model cod otoliths

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Typical fish distinguish sounds at about 10-1000 Hz with particle motions as small as 0.1 nm and angular separation near 10° using their ears, which contain dense, bony otoliths weakly suspended in endolymph and tissue. The otoliths oscillate relative to incident sound, inducing flows in the surrounding fluid which are in turn sensed by the hair cells on the overlying macular membrane which project into the groovelike sulcus on the otolith. These fluid flows are then sampled by the hair cells and "heard" by the fish. The irregular geometry of the otolith shapes the flow patterns. The hair cells, which are organized into different ciliary orientation groups on the macula, preferentially sample the flow patterns along their axes. The steady component of the fluid motion near enlarged models of an actual cod otolith oscillated at 2–20 Hz along different directions was studied in the vicinity of the hair cells using phase-locked particle-image velocimetry (PIV) and pathline visualizations. The possible relationship between the flow patterns and hearing capabilities is discussed. Although the oscillation amplitudes studied are much larger than those for underwater sound, evidence suggests that the flow patterns are amplitude independent. [Supported by ONR.]