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Using acoustics to count fish in the sea

Abstract:

Acoustical scattering from individual and ensembles of swim bladder fish in the sea is important for both military and commercial reasons. At low frequencies (250 Hz?10 kHz), scattering from these fish is dominated by the bladder resonance response. Dense schools of bladder fish frequently consist of individuals of similar size, arranging themselves about one fish length apart. At near–resonance frequencies, acoustical interactions between fish can cause the ensemble scattering to become highly complex. Additionally, since the wavelength at resonance is generally many times the fish spacing, the scattered fields interfere strongly. Both features must be incorporated to realistically describe scattering from fish schools. An effective methodology is available through the application of self-consistent multiple scattering techniques, coupled with the solution of sets of coupled differential equations, and incorporates a verified swim bladder scattering "kernel" for an individual fish. All orders of multiple scattering interactions between the fish are included, and the aggregate scattering field calculated by coherent summation. The resulting mathematical model leads to two important developments. First, the ?forward? problem of predicting the expected strength of SONAR echoes from schools of fish, for varying oceanic conditions, and different species of fish, is facilitated. Second, the inverse problem of estimating the number of fish in a school, using measurements of both the scattered field of the school, and the transmitted field, which is attenuated as it passes through the school, becomes tractable. This second application has potential importance as a method for monitoring fisheries and fish stocks.