Acoustic Shadow-Zone Arrivals in the North Pacific Ocean

Lora Van Uffelen
Scripps Institution of Oceanography

Abstract
Deep acoustic shadow-zone arrivals were first observed on horizontal, bottom-mounted receiving arrays in the North Pacific Ocean in the late 1990s. These receptions revealed significant acoustic energy penetrating an estimated 500-1000 m into geometric shadow zones below cusps of predicted timefronts. Vertical line array receivers, deployed in the North Pacific as part of the SPICEX experiment, show the vertical structure of the shadow-zone arrivals for transmissions from broadband 250-Hz acoustic sources at ranges of 500 and 1000 km.

Comparisons of acoustic data with parabolic equation simulations incorporating a range-independent sound-speed profile confirm the presence of shadow-zone arrivals, and simulations incorporating sound-speed fluctuations consistent with the Garrett-Munk internal-wave energy spectrum accurately predict the vertical extent of and energy contained in the shadow-zone arrivals. Monthly averages of acoustic receptions from June to November indicate that the depth to which the timefront cusps extend as the seasons change is a complex combination of deterministic changes in the depths of the lower cusps as the range-average profiles evolve and of the amount of scattering, which depends on the depths of the upper turning points of the associated ray paths and the mean vertical gradients at those depths.