INFLUENCE OF MODAL ATTENUATION ON SHALLOW WATER PROPAGATION

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ABSTRACT

A recent simplification of Biot theory is used to illustrate relationships between the intrinsic sediment attenuation, the attenuation of individual modes (as expressed by the modal attenuation coefficients or MACs), and the energy loss of the total field. The simplest two-layer, isospeed waveguides yield MACs that decrease from f^{-2} to f^{-1} as frequency f becomes large. A heuristic modification of the environment suggests how a change in the magnitude and frequency behavior of the MACs may arise. We demonstrate how the MACs increase with the incorporation of a fluid-saturated porous layer in the waveguide by using a convenient parameterization and numerical results. The frequency power-law behavior observed increases from $f^{0.7}$ to $f^{1.7}$ as the thickness of this layer increases from 2% to 15% of the water depth.

Numerical calculations for more realistic waveguides use sandy bottom sediments and isospeed, linear, and piecewise linear water depth profiles. These are environmental simplifications that preserve key features of waveguides from experiments near the New Jersey continental shelf. Principal characteristics of the calculated MACs at frequencies up to 2 kHz include: increased magnitude in the presence of near-interface gradients, reordering of least-attenuated modes for downward refracting water sound speed profiles, and variations of frequency behavior from f^{-1} to f^{1}. We also demonstrate the sensitivity of the MACs to experimentally-determined upward, isospeed, and downward-refracting sound speed profiles in a shallow water environment with sandy, depositional layers located in the Gulf of Mexico. A comparison of these results with previous numerical studies shows good agreement with water sound speed profiles for nearly isospeed and weakly downward refracting cases.

Water sound speed has a significant influence on modal attenuation and, consequently, on the effective attenuation coefficient, which estimates the average transmission decrease with range. The effective attenuation coefficients behave with frequency from $f^{0.0}$ for isospeed to $f^{0.9}$ for strongly downward refracting water. Analysis demonstrates how a band of least-attenuated modes contribute to this rate

of decrease with range. For a strongly downward refracting linear water sound speed profile, very good approximations of effective attenuation coefficients are shown. At 500, 1000, 1500, and 2000 Hz, the least-attenuated modes, which contribute 90% or more of the effective attenuation coefficient, are modes 1–17, 1–26, 5–21, and 13–31. At large frequencies a parallel trend is apparent between the envelope of the family of MAC curves and EAC. These new results may help interpretation and prediction of data when seasonal changes occur and provide insights into the influence of depth structures and frequency-dependent characteristics of the upper sediment layer on field attenuation.