Session 3aUW

Underwater Acoustics: Multiple Volumetric Scattering

David R. Palmer, Chair
NOAA, Atlantic Oceanographic and Meteorological Laboratory, 4301 Rickenbacker Causeway, Miami, Florida 33149

Chair's Introduction—8:30

Invited Papers

8:35

3aUW1. Atmospheric lidar extinction and multiple scattering in haze, plumes, and clouds as analogues to ocean acoustic sounding. Wynn L. Eberhard (NOAA Environ. Technol. Lab., R/E/ET2, 325 Broadway, Boulder, CO 80303, weberhard@etl.noaa.gov)

Sonar probing of fish schools, black-smoker plumes, and bubble clouds can experience attenuation (or ''shadowing'') and multiple scatter. Similar kinds of effects are typical during atmospheric lidar (light detection and ranging) observations of turbid media, such as haze, smoke plumes, and clouds. Researchers have developed a variety of techniques to account for these effects on atmospheric lidar in different situations. Some of these methods might be adapted by ocean scientists with comparable problems. In order to be clear about the analogues, the physical conditions for the atmospheric problem will be listed. For example, scattering particles are usually assumed to be point targets randomly positioned in the air. Also, pertinent characteristics of the instrument will be specified, including the difference between ''photon-bucket'' detection (the common type of lidar) and ''diffraction-limited'' detection (more like sonar). The types of mathematical approaches for solving attenuation and multiple scattering problems in atmospheric lidar will be summarized. Some common atmospheric examples and the corresponding methods to correct the lidar data will be described.

9:00

3aUW2. Multiple scattering in ocean bubble clouds—When one expansion parameter is large. Frank S. Henyey (Appl. Phys. Lab., Univ. of Washington, Seattle, WA 98105)

Foldy constructed a model for collections of scatterers, such as a bubble cloud. He assumed the scatterers were arbitrarily small and placed at random, and that each one scattered isotropically. We are concerned with going beyond his approximate solution of his model. There are two expansion parameters in the multiple-scattering series for Foldy's model, $4\pi\rho f/k^2$ and kf. The first of these is often large (for the bubble-cloud application), while the second is small. ''Renormalization'' can be used to handle the large parameter, but also renormalizes the other parameter. The talk will be concerned with the resulting expansion and a related issue, the transition between the low-frequency coherent backscattering and the high-frequency incoherent backscatter.

9:25

3aUW3. Multiple scattering in fish and zooplankton acoustics is the exception. Kenneth G. Foote (Inst. of Marine Res., P.O. Box 1870, Nordnes, N-5817 Bergen, Norway)

Reference is made to the general literature on multiple scattering. This indicates that multiple scattering is negligible if the following condition is fulfilled: $\rho \ll 2\pi\lambda^{-2}\sigma^{-1/2}$, where ρ is the numerical density of scatterers, λ is the acoustic wavelength, and σ is the maximum single-scatterer differential scattering cross section. The condition is examined for three classes of aquatic organisms: fish, euphausiids, and copepods. It is amply satisfied for all plausible organism concentrations and frequencies excepting possibly those of schooling swimbladder-bearing fish at resonance. [Partial support of the EU through RTD-Contract No. MAS3-CT95-0031 is acknowledged.]

9:50

3aUW4. Low-frequency multiple scattering in fish schools: The self-consistent method for strongly coupled resonators. C. Feuillade (Naval Res. Lab., Stennis Space Ctr., MS 39529-5004)

Low-frequency acoustic scattering from fish is typically dominated by the swimbladder resonance response. Schools of fish frequently consist of closely spaced individuals of similar size and, at resonance frequencies, this can cause multiple scattering processes between the fish to become significant and complex. The acoustic wavelength at the swimbladder resonance frequency is generally many times the length of the fish, and frequently greater than the dimensions of a small school. Since schooling fish often arrange themselves so that they are about one fish length apart, the scattered wave fields from neighboring fish will interact coherently. This feature must also be incorporated to realistically describe scattering from fish schools. An effective methodology is available through the application of self-consistent multiple scattering techniques, and a school scattering model based on this approach has