2:04

Y2. High-frequency backscattering from marine zooplankton. Charles F. Greenlaw (School of Oceanography, Oregon State University, Corvallis, OR 97331)

It is often assumed that backscattering from marine zooplankton may be satisfactorily estimated from the Rayleigh fluid-sphere scattering model at frequencies such that $ka<1$. At higher frequencies the fluid sphere model of Anderson [J. Acoust. Soc. Am. **22**, 426—43 (1950)] has been thought approximately valid at least for the more spherical plankton. A series of acoustical and physical measurements was made on preserved specimens of three common zooplankters (a copepod, *Calanus marshallae*; an euphausiid, *Euphausia pacifica*; and a penaeid shrimp, *Sergestes similis* Hansen). Target strengths of individual specimens were measured in a freshwater tank at eight frequencies between 220 and 1100 kHz. Densities, compressional wave sound speeds, and displacement volumes of the samples were measured to enable calculation of predicted target strengths from the Anderson model. Measured target strengths of the copepod agreed with predictions up to $ka=1$, but were increasingly higher than predicted up to the highest ka obtained ($ka\sim4$). The euphasusiid and sergestid were found to highly directional scatterers; anterior aspect target strengths were 10—20 dB lower than side or dorsal aspect values. Surprisingly, the general levels and gross structure of the side/dorsal aspect target strengths were in reasonable agreement with the Anderson model up to $ka\sim11$ (euphausiid) and $ka\sim7$ (sergestid). Data in the range $ka\leq1$ could not be obtained for these plankters because of equipment problems. [Supported by ONR.]

2:08

Y3. New model of resonant acoustic scattering by swimbladder-bearing fish. Richard H. Love (Naval Ocean Research and Development Activity, Bay St. Louis, MI 39520)

A new model of a swimbladder-bearing fish has been developed in order to provide improved predictions of the resonant frequency and acoustic cross section of such a fish. The model consists of a small spherical shell in water, enclosing an air cavity which supports a surface tension. The shell is a viscous, heat-conducting Newtonian fluid, with the physical properties of fish flesh. A comparison of the results obtained with the new model to experimental data indicates that the new model constitutes a definite improvement over previous models. The new model can predict the high values of damping and elevated resonant frequencies that previous models could not. The model appears to be most accurate for fish in which tension in the swim-bladder wall has a minor effect on resonant scattering. This includes the fish which are of interest in studies of volume reverberation and therefore, the new model should be of considerable value in such studies.

2:12

Y4. Abstract withdrawn.

2:16

Y5. Sound-scattering properties of curved surfaces with complex impedance. Jacob George and H. Überall (Department of Physics, Catholic University, Washington, DC 20064)

Specular reflection which accounts for most of the reflected signal at farfield depend on both the curvature of the scatterer and its acoustic impedance. As specific cases, we calculate the backscattering cross section for plane waves reflected from circular cylinders and spheres. Results using both the Kirchhoff approximation and the Luneburg—Kline (LK) method [J. B. Keller *et al.*, Commun. Pure Appl. Math. **9**, 207—265 (1956)] are presented and compared. The LK expression for cross section contains up to $(ka)^{-2}$ terms for the cylinder and up to $(ka)^{-1}$ terms for the sphere. The cross sections for the limiting cases of rigid and soft spheres are compared with those obtained by retaining up to $(ka)^{-4}$ terms in an asymptotic expansion. It is found that the LK method gives better results in the presence of a complex impedance. Dependence of the cross section on relative magnitudes of real and imaginary parts of the impedance are studied. Variation of the LK cross section with the angle of reflection is discussed. [Supported in part by ONR.]

2:20

Y6. Relation between creeping waves and normal modes of vibration of a curved body. H. Überall (Catholic University, Washington, DC 20064) and L. R. Dragonette and L. Flax (Naval Research Laboratory, Washington, DC 20375)

The natural way for a disturbance to propagate over the surface of a smoothly curved, fluid-loaded elastic body is in the form of a series of damped circumferential (creeping) waves. Mathematically, the process is most conveniently described by a sum of normal modes, each characterized by a wavelength that fits the body's circumference an integer number of times. We demonstrate that any such mode will resonate at all those "eigenfrequencies" where the mode velocity coincides with the speed of one of the creeping waves. For an elastic cylinder, the 180° sound-scattering amplitude is shown to possess marked minima at many of the eigenfrequencies, whose spacing over a sequence of modes thus determines the group velocities of circumferential pulsed signals. [Work supported by ONR.]

2:24

Y7. Amplitudes of transmitted and circumferential waves in sound scattering from an elastic cylinder. J. W. Dickey (Naval Ship Research Development Center, Annapolis, MD 21402) and H. Uberall (Catholic University, Washington, DC 20064)

The phenomenon of sound scattering from a smoothly curved, submerged elastic body involves two different mechanisms, namely (a) geometrical reflection, refraction and multiple internal reflections and (b) diffracted fluid-type and elastic-type surface waves. These have previously been studied individually [(a) Brill and Überall, J. Acoust. Soc. Am. **50**, 921 (1971); (b) Frisk, Dickey, and Überall, J. Acoust. Soc. Am. **58**, 996 (1975), and (in press)] for the case of an aluminum cylinder in water, obtaining dispersion and absorption curves for the diffracted field. We now evaluate the amplitudes of both (a) and (b) and compare their relative strength for values of ka (k is the wave number and a is the cylinder radius) from 25 to 200. While the lower-order geometrical contributions are generally larger than the diffracted ones by an order of magnitude, some of the latter may surpass the former, and the relative elastic-type (Rayleigh etc.) surface-wave amplitudes do not markedly decrease with ka while the fluid-type waves (Franz, Stoneley) do. We have searched for resonances in the surface-wave amplitudes, possibly related to mode resonances at their eigenfrequencies.

2:28

Y8. Theory of scattering by rigid bodies with thin liquid coatings. T. J. Eisler (Department of Mechanical Engineering, Catholic University, Washington, DC 20064)

We consider a plane-wave incident on a rigid body which is partially or totally surrounded by a thin liquid coating whose (possibly variable) density and sound velocity differ from those of the ambient medium. The wavelength is assumed to be small compared with the dimensions of the body but large