2:40

2pAO3. Resonance frequencies of absorption lines due to pelagic fish. Orest Diachok (Naval Res. Lab., Washington, DC 20375)

Resonance frequencies, f_0, of absorption lines due to pelagic fish with swim bladders change at twilight in accord with systematic changes in their depths and separations. Measurements of f_0 at night, and calculations of f_0, based on measurements of the effective radius, r_0, and eccentricity, ε, of sardine swim bladders, and the average depth of dispersed sardines at night, are in good agreement. This result implies that swim bladder compression by internal organs did not have a large effect on r_0 and ε during this experiment. Close agreement between laboratory measurements and calculated values of f_0 of individual physotomes suggests that this inference is generally valid. Possible exceptions to this ''rule'' will be considered in the context of Ona's (1990) laboratory observations of the effects of internal organs on swim bladder compression, and measurements of the state of internal organs of fish in the ocean. The resonance frequencies of absorption lines attributed to sardines in schools, $f_0' \approx 0.6 f_0$. This result is consistent with a modified form of d'Agostino and Brennan's (1988) equation for the fundamental mode of a bubble cloud. Their equation accounts for realistic numbers of fish per school (10^4–10^5). Modifications, which account for realistic separations between fish in schools and school eccentricity, will be presented. [Work supported by ONR.]

3:00

2pAO4. Modeling the target strength of Calanus finmarchicus. David T. I. Francis (School of Electron. and Elec. Eng., Univ. of Birmingham, Edgbaston, Birmingham B15 2TT, UK, francist@ee-admn.bham.ac.uk), Kenneth G. Foote, Tor Knutsen (Inst. of Marine Res., N-5024 Bergen, Norway), and Lucio Calise (Centro Marino Internazionale, I-09072 Torregrande (OR), Italy)

The boundary element method is applied to the copepod Calanus finmarchicus, treated as a composite body, with fluidlike oil sac embedded in a fluidlike, mostly transparent prosome. The generally complex shapes of the two bodies are modeled on the basis of the actual dorsal- and lateral-aspect cross sections, as observed by videomicroscopy with the living, unanaesthetized animal encased in a droplet of sea water. Physical properties of the two bodies, namely mass density and longitudinal-wave sound speed, are derived through a combination of measurement and inference. Computations of backscattering cross section as a function of orientation and frequency are presented over the range 25 kHz to 3.2 MHz for a number of specimens. A sensitivity analysis is performed to quantify some uncertainty in the assumed values of the physical properties. [Support by the following is acknowledged: EU through RTD Contract No. MAS3-CT95-0031, Norwegian Research Council through Grant No. 113809/122, and Bergen Large-Scale Facility (LSF) for Marine Pelagic Food Chain Research.]

3:20

2pAO5. Comparing predictions from backscatter models to *in situ* measurements of a dual-chambered, swimbladdered fish. John K. Horne, J. Michael Jech (CILER, Univ. of Michigan, 2205 Commonwealth Blvd., Ann Arbor, MI 48105, horne@glerl.noaa.gov), and Paul D. Walline (Israel Oceanograph. and Limnological Res., Tiberias, Israel 14102)

Most acoustic backscatter models predict echo amplitudes of single or aggregations of fish with single-chambered swimbladders. Lavnun (*Acanthobrama terraesanctae*), a planktivorous fish in Lake Kinneret, Israel, possesses a dual-chambered swimbladder. Target strength, length, frequency, or aspect relationships do not exist for this commercially important species. What is the most appropriate way to model backscatter amplitudes from single and aggregations of fish with multi-chambered swimbladders? Carrier frequency, organism length, organism aspect, and swimbladder shape all influence amplitudes of returned echoes. Predicted backscatter amplitudes and intra-species variance predictions from an anatomically-based Kirchhoff-ray mode model were compared to *in situ* measures of lavnun backscatter at 120 and 420 kHz. The lavnun swimbladder was modeled as a single chamber (with equivalent volume of both chambers), as two independent chambers, and as two acoustically interacting chambers. Wider application and comparison of theoretical models to field measurements increases understanding of factors influencing backscatter amplitude and variability for all fish species, and should improve methods for identifying organisms. [Work supported by ONR and US–Israel BSF.]

3:40

2pAO6. Comparison of Ayu target strength estimates determined from tank measurement and calculations. Kouichi Sawada (Natl. Res. Inst. of Fisheries Eng., Ebidai, Hasaki, Kashima, Ibaraki, 314-0421 Japan, ksawada@nrife.affrc.go.jp), Masahiko Yoshida (Mie Univ., Mie, 514-8507 Japan), Yoichi Miyanohana (Natl. Res. Inst. of Fisheries Eng., Ibaraki, 314-0421 Japan), and Kunio Shirakihara (Mie Univ., Mie, 514-8507 Japan)

Ayu, *Plecoglossus altivelis*, is one of the most popular freshwater fish which can be seen in many rivers in Japan. Especially in the North Basin of Lake Biwa, Ayu is the highest predator. It is important to know the spatial and temporal variations of Ayu biomass to understand the predator's effect to the food chain in the lake. Acoustic survey has been conducted since 1995. There is little information about the target strength (TS) of Ayu. Since Ayu has an open swimbladder, it is necessary to measure TS before the swimbladder was deflated by the suspension method in a tank. Target strength of live Ayu was measured in a tank and a three-dimensional image of swimbladder was obtained by an x-ray computer tomography (CT) system. In addition, a side and a dorsal image of the swimbladder were obtained by a soft x-ray system. All measurements were done in live condition. Kirchhoff approximation was used for the calculation on the basis of the three-dimensional image of swimbladder. A deformed cylinder model and a prolate spheroid model were also used for the calculation on the basis of side and dorsal image of the swimbladder. Calculation and measurement are compared and discussed in this paper.

4:00–4:20 Break

4:20

2pAO7. Analyzing ship-borne acoustic Doppler current profiler measurements to estimate the vertical and spatial distribution of southern Black Sea zooplankton. Funda Erkan and Ali C. Gucu (Inst. of Marine Sci., Middle East Tech. Univ., P.O. Box 28, Erdemli, 33731, Icel, Turkey, funda@ims.metu.edu.tr)

The acoustic Doppler current profiler was used in Summer–Autumn 1996 and 1997 cruises of R/V BILIM of Middle East Technical University to study the distribution of zooplankton in the southern Black sea. The backscattered signal intensity is compared with macro and mesozooplankton samples collected with Nansen closing net and 30-L Niskin water samplers. Analyzing the taxonomic groups and the length distribution of the individuals in the samples, size classification has been done. Total cross-sectional areas of the zooplankton in the length classes were compared with the resultant MVBS values. Highly significant correlations were observed. The relations between acoustic units and the size classes of zooplankton were presented by an empirical model which described a high percent of the total variance. The data sets from basin-wide surveys were used to obtain spatial distribution of zooplankton in the southern Black Sea. The spatial distribution of zooplankton was to a great extent determined by hydrography of the Black Sea. Daily migration patterns of zooplankton were studied, and the descending and ascending rates of different zooplankton groups were also calculated.