Session 3pAB

Animal Bioacoustics: Acoustical Monitoring of Animal Populations

John R. Potter, Chair
Scripps Institution of Oceanography, 9500 Gilman Drive, La Jolla, California 92093-0238

Chair's Introduction—12:55

Contributed Papers

1:00

3pAB1. Tracking zooplankton at sea with a three-dimensional acoustical imaging system. Duncan McGehee and Jules S. Jaffe (Marine Phys. Lab., Scripps Inst. of Oceanogr., Univ. of California, San Diego, La Jolla, CA 92093-0205)

The Acoustical Imaging Group in the Marine Physical Laboratory, Scripps Institution of Oceanography, has developed a real time, high-resolution three-dimensional acoustical imaging system for use in the ocean. The system, called Fish TV (FTV) is designed for the observation of macrozooplankton and small fish. FTV can synoptically examine a 16° by 16° volume of seawater with a 1-Hz frame rate. The sonar has recently been used at sea in two configurations. In the first experiment, the sonar was mounted 40 m deep, looking laterally from the research platform R/P FLIP. A video camera provided ground-truthing. In the second experiment, the sonar was attached to a Phantom DS4 remotely operated vehicle and deployed, again with video ground-truthing. Results indicate that the system can be used both to track animals in three dimensions and to estimate their density.

1:15

3pAB2. Application and comparison of neural nets for marine mammal call classification. John R. Potter (MPL 0238, Scripps Inst. of Oceanogr., Univ. of California, San Diego, 9500 Gilman Dr., La Jolla, CA 92093-0238) and David Mellinger (Cornell Laboratory of Ornithology, Ithaca, NY 14882)

Recent work has successfully applied a linear matched filter to calls made by Bowhead whales recorded off the coast of Alaska in frequency-time (spectrogram space) to detect and classify marine mammal calls. This method relies on an empirical matrix weighting for the matched-filter coefficients. A neural net, trained on spectrogram estimates as the feature vector space, offers two advantages over this approach; (a) the equivalent weighting matrix is determined by training and may coverage to a more optimal solution and (b) the response of a neural net is nonlinear and can embody more sophisticated responses. A simple three-layer feedforward neural net is ideally suited to this application and has been implemented on 204 calls, of which 163 were used for training and 31 kept as "unseen" test data. The neutral net was configured to identify both whale calls and other mammal interference. The success rate including failures in both estimates on training data was 88%. The combined false-positive and false-negative whale detection errors on unseen data was only 7%, which compares very favorably with any other known method. The neural net approach is compared with the matched filter and the role of the hidden neurons and equivalent weighting matrix are discussed. [Work supported by the Office of Naval Research.]

1:30

3pAB3. Fortuitous underwater acoustic measurements of baleen whale vocalizations by large aperture arrays. G. L. D'Spain, J. A. Hildebrand, M. A. McDonald, and W. S. Hodgkiss (Marine Phys. Lab., Scripps Inst. of Oceanogr., San Diego, CA 92152-6400)

Over the past several years, the Marine Physical Laboratory has designed, built, and deployed innovative, large-aperture sensor systems in order to measure the low-frequency properties of the ocean acoustic field. In many of these experiments, baleen whale vocalizations have been a significant feature of the infrasonic sound field. For example, finback whale (Balaenoptera physalus) sounds have been recorded by a 120-element, 900-m, vertical line array of hydrophones. Finback whale sounds were also recorded by a 12-element, 165-m, vertical array of "TRIFAR" elements (i.e., each element records simultaneously the three components of acoustic particle velocity and pressure). In addition, blue whale (Balaenoptera musculus) signals were the overwhelming feature of a data set recorded by some neutrally buoyant, freely drifting, acoustic particle motion/acoustic pressure sensors. Finally, new-design ocean bottom seismometers (OBS) have recorded both finback and blue whale signals. Where possible, these measurements are used to estimate both the position and the actual time signature of the source by removing the effects of multipath arrivals.

1:45

3pAB4. Detection of salt-marsh mosquito swarms in remote mangrove swamps. Richard W. Mankin (Agric. Res. Service, Insect Attractants, Behavior, and Basic Biology Lab., P. O. Box 14565, Gainesville, FL 32604)

Swarms of *Aedes taeniorhynchus* mosquitos produce sounds that can be detected from 10–50 m at 25–35 dB (*re*: 20 μPa) in a quiet environment. The loudness of the swarms is above the 21-dB acoustical background between frequencies of 0.6 and 3.4 kHz in an isolated salt marsh, but below the 40–60 dB background of a typical urban environment. Individual *Ae. taeniorhynchus* have wingbeat frequencies ($\pm$standard error) of 441 ± 21 Hz and 703 ± 17 at 24 °C, detectable from 3 cm at 22–25 dB in an anechoic chamber. In the marsh, females beat their wings at 400–500 Hz and males at >800 Hz, depending on their size and the temperature. Because of their low wingbeat sound intensities, the only individual *Ae. taeniorhynchus* mosquitoes that can be detected are those flying within 2–5 cm of the microphone. These frequency and loudness measurements suggest that it is technologically feasible to construct an acoustical device for remote surveillance of *Ae. taeniorhynchus* swarms or individuals attracted to a bait. Further studies to correlate detection of wingbeat sounds with numbers of mosquitoes captured at a bait are in progress.

2:00

3pAB5. Acoustic features of tonal "grunt" calls in baboons. Michael J. Owren, Christopher D. Linker, and Matthew P. Rowe (Dept. of Psychol., Univ. of Colorado, Campus Box 173, P. O. Box 173364, Denver, CO 80217-3364)

The acoustic features of "grunt" calls recorded from free-ranging baboons (*Papio ursinus*) in Botswana were investigated. Analysis parameters typical of those used to analyze human speech were employed

and these sounds were found to closely resemble speech vowels in several respects. They were brief (approximately 97 ms) and highly tonal with a stable fundamental frequency (approximately 122 Hz.) Like adult human males, baboons are estimated to have a vocal tract length of 17 cm (glottis to lips) and this concordance was reflected in the formant structure of the grunts. Three formants (range 2 to 7) were typically found between 0 and 5 kHz, in a pattern resembling that of the vowel "schwa." Variation due to individual caller and behavioral context are discussed, as well as the implications of these findings for relationships between nonhuman primate vocal communication and human speech.

WEDNESDAY AFTERNOON, 6 OCTOBER 1993 SILVER ROOM, 1:00 TO 3:20 P.M.

Session 3pPA

Physical Acoustics: Observing Scattering with Time-Frequency Representations

Charles F. Gaumond, Chair

Acoustics Division, Physical Acoustics Branch, Naval Research Laboratory, Washington, DC 20375-5000

Chair's Introduction—1:00

Invited Papers

1:05

3pPA1. Time-frequency description of signals—A review. Leon Cohen (Dept. of Phys., Hunter College and Graduate Center of CUNY, New York, NY 10021)

The frequency content of many natural and man-made signals changes drastically with time and standard Fourier analysis does not fully describe such highly nonstationary signals. Among such signals are speech, sonar and radar, optical images, and biological and geophysical signals. In the past 10 years there have been dramatic strides made in our ability to understand and process such signals. The basic idea is to develop a method that describes the intensity of a signal jointly in time and frequency. This would give the frequency content at each instant of time and hence describe how the spectrum is changing in time. A review is presented of the ideas and methods that have been developed to describe a time-varying spectrum and their application is illustrated with concrete examples from a wide variety of fields.

1:35

3pPA2. Decomposition of scattered waves from an isolated elastic object with time-frequency representation. Nai-chyuan Yen (Phys. Acoust. Branch, Naval Res. Lab., Washington, DC 20375-5320)

In observing the scattering phenomena from an isolated elastic object, one would like to understand the composition of the scattered waves so the characteristic structure of the scatterer can be estimated. This paper reviews such an inverse scattering problem in terms of wave packet decomposition. Particularly, the focus is on a heuristic approach that has been developed from the study of acoustic scattering. The basic scheme of this approach is to examine the coherence property of the wave signature of the scattered waves and to compute its energy distribution in a joint time and frequency representation. Also shown is how to apply signal synthesis techniques to determine the dominant components, namely wave packets, expressed as the natural frame (basis), the building block for the formulation of the scattered wave. The magnitude and the phase of each wave packet are evaluated by algorithms that treat them as the independent nonorthogonal components from a set of linear equations. Examples of the response of the scattered waves from shell type elastic objects are used to illustrate the physical implication of this decomposition method in resolving the inverse scattering problem. It is concluded that the wave packet decomposition by means of the natural frame (basis) can be considered as a generalized Gabor and/or wavelet transform. Their relationships are discussed through the fundamentals of linear functional analysis.

Contributed Papers

2:05

3pPA3. Time-frequency spectrograms of impulse scattering by shells: Quantitative comparisons with ray theory for Lamb wave contributions. D. H. Hughes (815 Main St., Boonville, MO 65233) and P. L. Marston (Washington State Univ., Pullman, WA 99164-2814)

The Wigner distribution function (WDF) and quantities derived from it were used to investigate high-frequency scattering processes for a spherical shell in water [D. H. Hughes, Ph.D. thesis, Wash. State Univ. (1992)]. The investigation includes: (i) display of Gaussian smoothed WDF for *ka* as large as 500 with smoothing functions of different time and *ka* resolution; (ii) measurements of the leaky Lamb-wave decay rates from the smoothed WDF for different *ka* regions showing good agreement with ray theory based on complex partial-wave index poles; and (iii) evaluation of a derived quantity, the local temporal variance of the WDF as a function of frequency, showing how the temporal spread changes near a resonance [D. H. Hughes and P. L. Marston, J. Acoust. Soc. Am. **94**, 499–505 (1993)]. The temporal variance at resonance was in general agreement with the ray theory predictions for the dominant scattering contribution. Structure in the smoothed WDF was also investigated for the prompt backward wave contribution that causes a prominent scattering enhancement at high frequencies. [Work supported by ONR.]