Meetings

Marine Bioacoustics

Marine bioacoustics is an interdisciplinary area of marine science that includes the study of sound production, hearing, and acoustic communication among marine animals. It is a rapidly expanding field that embodies the interests of biologists, physicists, mathematicians, acousticians, psychologists, oceanographers, and other specialists. The necessity of bringing up to date information about work recently done in the various disciplines led to a symposium, the second of its kind, on marine bioacoustics; it was held at the American Museum of Natural History, New York, on 13–15 April 1966.

This meeting was cosponsored by the American Museum and the U.S. Naval Training Device Center, Port Washington, New York, and Orlando, Florida. The 20 papers included topics on problems in underwater acoustics facing biologists, methods of utilizing acoustics in fisheries, sound detection and sound production in marine animals, and acoustic communications and echolocation. Over 160 scientists, engineers, and students attended the meetings. Also in attendance were visitors from England, France, Holland, Germany, and Japan.

A highlight of the symposium was the keynote address by Sidney R. Galler assistant secretary (science) of the Smithsonian Institution. Galler was formerly head of the biology branch of the Office of Naval Research, and he has been in a unique position to observe and stimulate the growth of this area of research. In summarizing the history of the field, he showed how marine bioacoustics had bridged the gap between basic and applied research.

One of the problems that has troubled most experimental workers in this field has been that of determining the acoustic parameters in an enclosed mass of water, such as an aquarium tank, because most physical acousticians deal with ideal, free-field conditions. In examining this problem Antares Parvulescu (Hudson Laboratories, Columbia University) showed the extreme complexity of reflections and reverberations in both rigid and non-rigid containers. Even heavy, lead wall tanks were found to vibrate in several modes with a high degree of variability depending upon the frequency, intensity, and position of the sound source. There was considerable discussion of ways and means to control the acoustic environment in containers to which most behavioral experimental studies are limited. Another solution, proposed by James Fitzgerald (J. Fitzgerald & Associates, Annapolis), consisted of a floating platform in which a virtually free-field condition could be simulated.

Another problem that has beset bioacousticians has been the use and interpretation of sound spectrograms. As shown by William Watkins (Woods Hole Oceanographic Institution), the horizontal bars on a spectrogram and their apparent harmonic intervals can often represent pulse repetition rates, rather than the frequencies within the pulses. The interplay of pulse frequencies, pulse repetition rates, and pulse bursts can produce complex and, often, ambiguous pictures. Watkins also emphasized the importance of specifying the bandwidth of the filters used in published figures of spectrograms.

During the session on the uses of acoustics in fisheries, the results with a high-resolution, sector echo-sounder were demonstrated by D. H. Cushing and F. R. Harden Jones (Lowestoft, England). In a motion picture of the view screen of this sector scanner, one could see clearly the entire trawl net and the behavior of both schools and individual fishes in response to the moving net. This equipment promises to become an invaluable tool in the study of schooling behavior.

In his study on sound-producing mechanisms in fishes, Hans Schneider (Tübingen University) confirmed the unique property of sonic muscles for rapid contraction, and demonstrated the importance of acoustical environmental control in recording underwater sounds in artificial, aquarium conditions. He also provided the link between behavioral and morphological investigations, as did N. B. Marshall (British Museum) in his deductive demonstration of the probable sound-producing capabilities of deep-sea, benthopelagic fishes.

Among the contributions on the hearing of marine animals, the neurological and behavioral study by James M. Moulton (Bowdoin College) showed that directional orientation by fishes in a sound field could take place by means of a reflexive "tail-flip" involving the giant Mauthner's cells. This type of reflex is characteristic of many fishes and larval amphibians. Through a combination of anatomical, neurophysiological, and behavioral approaches, Moulton showed not only how this unusual two-neuron reflex could operate, but also how it could be conditioned. In another aspect of hearing in fishes, William N. Tavolga (American Museum and the City College) presented data on the effects of masking noise on auditory thresholds. He postulated the existence of critical bandwidths, such as have been considered characteristic of cochlear function in higher vertebrates. Willem van Bergeijk (Bell Telephone Laboratories) provided what was dubbed the "bongo drum hypothesis" to explain the possible application of a place theory of hearing in animals without a cochlea or basilar membrane.

Among the several papers on echolocation and hearing in cetaceans, the first truly quantitative study of auditory thresholds in these aquatic mammals was presented by C. Scott Johnson (Naval Ordnance Test Station, China Lake, California). By means of carefully controlled psychophysical techniques and operant conditioning, the entire audiogram of the bottlenose porpoise (*Tursiops truncatus*) was determined. The highest sensitivity was in the range of 50 kilohertz. The sensitivity at this frequency was found to be almost 60 decibels below 1 microbar, which is equivalent, in water, to about 10^{-18} watts/cm^2. The audiogram showed a gradual decrease in sensitivity down to 100 hertz (about 30 decibels above 1 microbar), and a rapid decrease in sensitivity above 100 kilohertz, with occasional responses at 150 kilohertz. These data undoubtedly will become a standard of comparison in all future acoustic investigations of cetaceans and should serve to elucidate interpretations of the echolocating capacities of these animals.

The need for more communication among researchers in the field of marine bioacoustics was first expressed at a meeting held in March 1961, at the Lerner Marine Laboratory, Bimini, Bahamas. That meeting was held in connection with the then newly established acoustic-video system, installed at Bimini by the Institute of Marine Science, University of Miami [*Science* **134**, 288 (1961)]. Accordingly a symposium was planned and organized by William N. Tavolga, John C. Steinberg, and Robert F. Mathewson. This first symposium on marine bioacoustics was held at Bimini, in April 1963; it was cosponsored by the Office of Naval Research and the American Museum of Natural History. After the publication of the proceedings of this symposium [*Marine Bioacoustics* (Pergamon Press, 1964)], it became clear that the field was advancing rapidly and a second symposium was in order. The U.S. Naval Training Device Center has been developing a project, in collaboration with the American Museum, of accumulating available data on marine animal sounds. Recognizing the need for bringing communication in this field up to date, the center, particularly its technical director of research, Hanns H. Wolff, proposed the convocation of this second symposium on marine bioacoustics.

The discussions following each paper at this symposium were quite extensive. Both the papers and the discussions are in the process of being assembled and edited for eventual publication.

WILLIAM N. TAVOLGA
Department of Animal Behavior, American Museum of Natural History, and *Department of Biology, City College of the City University of New York*

Forthcoming Events

September

1–3. **Genetics** Soc. of America, Chicago, Ill. (R. P. Wagner, Dept. of Zoology, Univ. of Texas, Austin)

1–5. International College of **Angiology,** 8th annual mtg., Madrid, Spain. (H. E. Shaftel, 50 Broadway, New York, N.Y. 10004)

2–4. **Czechoslovak Soc. of Arts and Sciences in America,** 3rd congr., New York, N.Y. (R. Sturm, Skidmore College, Saratoga Springs, N.Y. 12866)