source at 4 ft. away from the center position of the front wall it was found that the effect of room size is significantly different between the two methods under the 2- and 16-ft. radius curvatures only; also, the background noise level showed almost the same effect on both calculated AI and RASTI. Under low background noise levels, spaces with curvatures showed that the effect of change in room size for both methods is identical. The center location for the sound source showed better speech intelligibility under all different testing conditions. Finally, a modification factor is developed and applied to the calculated AI so that reliable estimates of speech intelligibility in spaces with curvatures may be obtained.

11:20

3aAA10. Relations between the apparent source width (ASW) of the sound field in a concert hall and its sound pressure level at low frequencies (GL), and its inter-aural cross correlation coefficient (IACC). Toshiyuki Okano, Takayuki Hidaka (Takenaka Res. and Develop. Inst., 1-5, Ohtsuka, Inzai-machi, Inba-gun, Chiba, Japan, 270-13), and Leo L. Beranek (975 Memorial Dr., Ste. 804, Cambridge, MA 02138)

The influence of GL (amplifier gain the low-frequency range below 355 Hz) and IACC on ASW was determined by psychoacoustic experiments with simulated concert-hall sound fields using anechoic symphonic music presented to subjects by multiple loudspeakers. "Equal ASW curves" were determined for 1/1 octave band filtered source signals with mid-frequencies from 125 to 4000 Hz. The ASW's for the upper four bands are found to be equal for the same IACC and SPL band values, indicating equal importance of those bands in determining overall ASW's. Combinations of GL's and IACCE3's (average of IACC's in the 500, 1 and 2 kHz bands) for wide-band musical source signals were determined that produced the same ASW's. The early sound was comprised of 2 to 11 early "reflections" and judgments were made with and without later reverberation. It was found that both larger values of GL and smaller values of IACCE3 result in larger values of the subjectively determined ASW's. It is shown that GL and IACCE3 jointly are physical measures of spatial impression in a concert hall and that, combined, they cover the frequency range from low to high frequencies.

11:35–12:05

PANEL DISCUSSION: Weighing Cost Versus Benefit in Music Education and Performance Facilities
Panel Moderator: J. Christopher Jaffe
Panel Members: Timothy J. Foulkes, J. Godden, David P. Walsh

WEDNESDAY MORNING, 30 NOVEMBER 1994 SABINE ROOM, 8:00 A.M. TO 12:15 P.M.

Session 3aAO

Acoustical Oceanography and Animal Bioacoustics: Effects of Sounds on Marine Mammals: Update and Discussion on the Need for Standards II

Charles R. Greene, Jr., Chair
Greeneridge Sciences, Inc., 4512 Via Huerto, Santa Barbara, California 93110

Chair's Introduction—8:00

Invited Papers

8:05

3aAO1. Modulation detection interference on presentation of two amplitude-modulated tones. William F. Dolphin (Dept. of Biomed. Eng., Boston Univ., Boston, MA 02215)

Psychophysical studies have shown that the processing of modulation in one frequency channel is interfered with when a similar modulation pattern is present in another frequency channel. To test for physiological correlates to this phenomena a sinusoidally amplitude-modulated (SAM) probe tone was presented in the presence of a simultaneously gated, modulated, or unmodulated interfering tone while recording from the scalp of anesthetized gerbils. Responses were recorded from the scalp, amplified, digitized, and averaged. The amplitude of the response was determined as the magnitude of the Fourier transform measured at the frequency corresponding to the probe f_{mod} and f_c. Responses in the presence of the interfering tone were compared to responses obtained to the SAM probe tone alone. The shape of the interference pattern was highly dependent on the modulation frequency of the interfering tone. With some modulation frequencies an increase in interference relative to control responses was observed at the probe f_{mod}, while at other modulation frequencies either no interference, or even enhancement of the response was apparent. In contrast, at the probe f_c interference patterns were very similar for all interference tone modulation frequencies.

8:25

3aAO2. A change in sperm whale (*Physeter macroephalus*) distribution correlated to seismic surveys in the Gulf of Mexico. Bruce R. Mate (Hatfield Marine Sci. Ctr., Oregon State Univ., Newport, OR 97365), Kathleen M. Stafford (Oregon State University, Newport, OR 97365), and Donald K. Ljungblad (Elk Mountain, WY 82324)

From 7 to 29 June 1993, vessel surveys for sperm whales were conducted in the Gulf of Mexico off the Louisiana coast. Ninety sperm whales were seen in water 600 to 1400 m deep. On four of the first five survey days, whales were found routinely in an area 100 km S.E. of the Mississippi River before a seismic survey operation began (0.092 whales/km). Within the seismic operations area, whale abundance changed significantly to 0.038 whales/km during the first two days and then to 0.0 whales/km for the following five days (p value <0.001). During the first two days of seismic activity, whales were only seen around the periphery of the seismic area. Survey effort for the last 5 days (920 km) and revealed only one group of four animals 61 km S.W. of the seismic survey area and also 56 km N.E. from another active seismic survey. Although the observation of seismic survey activity was serendipitous, it was highly correlated to numbers of sperm whales. This relationship deserves further investigation. If validated, additional efforts will be needed to identify areas used by sperm whales and assure that the effects of simultaneous seismic surveys do not overlap and prevent sperm whales from using important habitat.

8:45

3aAO3. Developing standards for protecting marine mammals from noise: Lessons from the development of standards for humans. Ann E. Bowles (Hubbs-Sea World Res. Inst., 2595 Ingraham St., San Diego, CA 92109)

Models for protecting marine mammals from noise have been suggested that are analogous to human noise criteria, specifically (1) weighting functions that model species-specific auditory threshold functions (analogous to A-weighting); (2) threshold models for predicting the proportion of individuals that avoid a noise (analogous to the Schulz model of annoyance); and (3) the equal-energy hypothesis for predicting hearing loss. Models for reducing sleep interference, speech interference, and attention deficits might also be applicable. All these models will be reviewed. Unfortunately, human noise criteria do not apply to a number of effects that could occur in free-ranging marine mammals. Noise could affect nonauditory physiology. Noise could also mimic natural sounds (e.g., seismic impulses that are similar to tail beats), or attract marine mammals into dangerous areas (e.g., attracting killer whales to fishing gear). Given the paucity of research available on noise effects in marine mammals, standards may be difficult to establish, although they are badly needed. At present, management agencies have adopted extremely conservative noise criteria. The experience of regulating noise in human communities suggests that such stringent criteria cannot be enforced consistently. Solutions that *have* proved practical for human communities will be reviewed.

9:05

3aAO4. Basic understandings of whale bioacoustics: Potential impacts of man-made sounds from oceanographic research. Christopher W. Clark (Cornell Lab. of Ornithology, Bioacoust. Res. Program, 159 Sapsucker Woods Rd., Ithaca, NY 14850)

The recent increased public awareness and concern over the potential impact of acoustic sources for oceanographic research, particularly the source for the Acoustic Thermometry of Ocean Climate (ATOC) study, has raised the difficult issue of assessing both short-term and long-term effects. A baseline study in Kauai, HI has been underway for two seasons as part of the Marine Mammal Research Program associated with ATOC. This research specifically addresses the questions related to short-term (<4 months), small scale (<30-km radius zone of influence) issues using traditional visual and acoustic field methods. This includes shore-based and aerial observations, passive hydrophone array tracking, and aerial survey methods. These efforts, conducted prior to any operation of an ATOC source, provide a baseline measure of the level of short-term impact under "normal" conditions off Kauai, where normal includes regular exposure to noise from small craft, ships, helicopters, and airplanes. Potential long-term impact is addressed through statewide aerial surveys and through integration of the inter- and intra-seasonal variability of whale behaviors and distributions. Results of the Kauai research will be presented and discussed in terms of baseline impact and the need for standards.

9:25–9:40 Break

9:40

3aAO5. Marine mammals and ocean-acoustic experiments: A personal view from Monterey Bay. Stanley M. Flatté (Dept. of Phys., Univ. of California, Santa Cruz, CA 95064)

Experience in presenting technical descriptions of the relationship between marine mammals and the Acoustic Thermometry of Ocean Climate project to environmental groups, business groups, students, and researchers is described. It is pointed out that the greatest gap in the knowledge base of the general public is the lack of realization that low-frequency acoustic noise in the ocean is at present dominated by anthropogenic sources. [Work supported by ONR Ocean Acoustics.]

10:00

3aAO6. Auditory-evoked potentials for assessment of hearing in marine animals. S. H. Ridgway and D. A. Carder (Biosci. Div., Naval Command, Control and Ocean Surveillance Ctr., RDTE Div., Code 5107B, 49620 Beluga Rd., Rm. 200, San Diego, CA 92152)

Brain-wave activity (EEG) even at minute levels recorded from the dolphin head surface may be processed in synchrony with sound to reveal an auditory-evoked potential (AEP). AEPs can provide objective information about the auditory system and many features are consistent across species so that experience with common laboratory animals and humans may be of help in evaluating responses. Although AEPs do not require a behavioral response, they may be compared with behavioral responses as sound is attenuated toward threshold. Some components of the AEP are unaffected by level of consciousness, allowing their use to evaluate hearing in sleeping infants and to determine brain damage or brain death. Auditory thresholds, and related information such as temporary threshold shifts, are critical for evaluating the potential impacts of ocean noise pollution on marine animals. Most species that are of concern, such as the great whales will not likely be brought into the laboratory so that their auditory system can be studied; however, many opportunities exist for brief studies when such animals become stranded or entrapped. Physiological studies, including AEPs, could go a long way toward providing critical information needed to define some limits for safe noise exposure for marine animals.

10:20

3aAO7. Whale ears: Structural analyses and implications for acoustic trauma. D. R. Ketten (Dept. of Otolaryngol., Harvard Medical School, MEEI, 243 Charles St., Boston, MA 02114)

Over 75 species of dolphins and whales are spread throughout every aquatic habitat. Although echolocation abilities of some dolphins are well documented, little is known about hearing in most whales. Dolphin signals range as high as 200 kHz, while baleen whales routinely produce 10- to 20-Hz signals. Whales have, therefore, two important auditory considerations: (1) the broadest signal