Guest Editorial

THIS archival section of the JOURNAL is a continuation of an Office of Naval Research effort to make key experimental results from years past by obtaining permission to publish and by preparing the manuscripts in a suitable form for publication. The Oceanic Engineering Society participates in this effort by publishing these peer-reviewed articles in our JOURNAL. Needless to say, this is a daunting volunteer effort and those investigators willing to participate are more than welcome. This JOURNAL issue presents ambient noise, bottom loss, and fluctuation papers.

Ambient noise (AN) became an active area of research during World War II because of the availability of calibrated instruments and the necessity to understand the ambient noise levels in coastal waters. This wartime research was summarized by Knudsen (1948) [1], and later by Pryce and Urick (1954) [2]. After the war, during the '50s, ambient noise research waned in the open literature until the classic paper of Wenz (1962) [3]; this work initiated a renaissance of ambient noise as one of the most interesting areas of oceanic acoustic research. The classic paper of Wenz (1962) [3], was notable as it supplied a graphical or schematic model of the understanding of the sources of ambient noise, the resultant omnidirectional levels and provided the conceptual classification of noise by mechanism, frequency and Beaufort Wind Force. Even though this paper and schematic have been widely cited and are indeed descriptive of the qualitative ambient noise field, much progress has been made in the last four decades. For example, below 10 Hz, measurements which agree with the theory of the microseismic noise have been made; between 10 Hz and 1 kHz, the nonwind-dependent noise of Wenz and Knudsen has been replaced by the role of shipping and wind dependent breaking waves; above 1 kHz noise contributions from bubbles, spray, splash, and rain have been placed on a quantitative basis. Wenz wisely used the Beaufort Wind Force as the metric of ambient noise since it not only includes the 10-m wind speed but the appearance of the sea itself.

However, many of the research results between 1950 and 1980 were classified. The papers in this archival issue represent several of the key research results of this period and are important benchmarks to actual levels observed. The paper by Nichols [4] discusses results between 1951 and 1974. He used new and specially built BaTi hydrophones to perform the measurements and stresses transient noise sources (biological, machines, and offshore drilling) compared to the background of wind-driven and shipping noise. He discusses in detail the mysterious 20-Hz/20-cycle sounds correctly attributed to cetaceans. According to Urick [5], their observation in the 1950s was so mysterious that their occurrence was highly classified well into the 1960s.

The ambient noise problem was a primary focus of the scientists assembled by the Office of Naval Research under a special project called LRAPP (Long Range Acoustic Propagation Project). Their task was to first develop a quantitative understanding of both propagation and noise and second to develop predictive techniques to calculate acoustic levels in worldwide ocean areas of Naval interest. LRAPP was under the direction of Bracket Hersey and Roy Gaul. The papers that follow on noise were either directly or indirectly a consequence of LRAPP. In 1974, Bracket Hersey held an "International Workshop on Low frequency Propagation and Noise" and published three volumes of the proceedings [6]. The first two volumes were available to the general public and the third was not. Selected papers from the third volume were reviewed and are included in the following.

Ross [7] discusses the recognized importance of the noise from ships as a key factor in the low- to mid-frequency noise field. Since most experiments had been performed in the Northern Hemisphere, the nonwind-dependent noise of Wenz was recognized to be due to distant shipping. In his work with the LRAPP predicts an annual increase in ambient noise of about 1/2 dB per year, discusses the need for radiated noise measurements of ships, and the geographical variation in noise due to changes of shipping distributions. There is renewed research interest in this topic to determine whether the noise levels are increasing.

By 1976, multiple summaries, bibliographies, and a vast amount of literature (approximately 1500 references) had been published on the measurements, theory, and computational methods; and by the eighties, ambient noise was the second largest area of underwater acoustics. Perrone [8] published his year long summary of ambient noise in the waters near Bermuda. However, the paper by Walkinshaw [9] presents four years of noise measurements in the Norwegian Sea. This work is impressive because sensors and recording instrumentation in the 1957–1961 period was rather primitive and the difficulty in performing these measurements is hard to comprehend in our digital age. The results by Walkinshaw are indeed unique.

By 1976, multiple summaries, bibliographies, and a vast amount of literature (approximately 1500 references) had been published on the measurements, theory, and computational methods; and by the eighties, ambient noise was the second largest area of underwater acoustics. Perrone [8] published his year long summary of ambient noise in the waters near Bermuda. However, the paper by Walkinshaw [9] presents four years of noise measurements in the Norwegian Sea. This work is impressive because sensors and recording instrumentation in the 1957-1961 period was rather primitive and the difficulty in performing these measurements is hard to comprehend in our digital age. The results by Walkinshaw are indeed unique.

Vertical directionality was also a hot topic and the results presented by Garabed [13] were both timely and of interest to

---

Digital Object Identifier 10.1109/JOE.2005.856951

the Navy, although selected vertical noise measurements were made public [5, eqs. (5-4) to (5-14)], [14]. The measurements by Garabed are of archival interest because of their scope and their relevance to the continuing interest in noise levels and vertical directive effects. Garabed's work was in a band between 200-380 Hz and most of the LRAPP work was less than 1 kHz. There was, however, interest in noise at frequencies greater than 1 kHz, and the paper by Short addresses this issue (8–20 kHz) from a theoretical view and noise measurements made at multiple depths. His use of a theoretical model to draw definitive conclusions concerning these higher-frequency characteristics is still of current interest.

Urick [5] summarized the main features of ambient noise from the unclassified literature, but stated that a vast amount of classified literature existed. In fact, the Navy considered omnidirectional ambient noise a closed subject and the emphasis of classified research was on the statistical noise characteristics observed with arrays. Ambient noise was simply unwanted random signal to be discriminated. Knowledge of the statistical and spatial properties of this noise was required to optimize sonar system performance.

Wagstaff [16] developed an iterative technique to determine the horizontal directionality of ocean basin noise fields and conducted many experiments (LRAPP) with long arrays to characterize the beam noise cumulative distribution functions and the persistent horizontal directionality. Some of his results were released [5], [14], however, the bulk of this interesting work has not been published. The results presented here [17], [18] represent several definitive experiments that quantify the role of ships on the vertical and horizontal directionality of the low-frequency noise field. These experiments were large-scale basin experiments that included the determination of the shipping distribution and the ability of computational tools to qualitatively predict the horizontal and vertical directionality. The role of ships near a sloping boundary and the ability of the slope-reflected energy to couple to the sound channel was stressed in [14], [17] while the beam noise cumulative distribution functions for the persistent character of the horizontal directional field characteristic was treated in [18]. This work was done when the ease of analysis of acoustic array data and one's ability to perform basin scale computations was very difficult and limited. The sources, arrays, and processing were all experimental.

The final noise paper by Carey and Yen [19] was also an outgrowth of the LRAPP program. However, it was approved for publication independently of these other archival papers, and was rewritten and submitted for publication review. This paper follows the work of Wagstaff and addresses the dynamics of the beam noise characteristics for high-resolution arrays in basins that provided the ability to use one basin boundary as a means of resolving the left-right ambiguity of a high-resolution array. The short time samples of the noise field were examined and the cumulative noise-level distribution functions, CDF, were examined to reveal that a combination of the shipping distributions and system response determined the fundamental characteristic of the CDF. This paper also addresses the probability of finding low noise regions in bearing-time space.

The next three papers change the topic under discussion. The paper by Geddes [20] addressed a change in understanding of the bottom boundary condition. Reflection as a function of grazing angle curves at the higher frequencies (> 500 Hz) seemed to be adequate for the computation of sound transmission. However, at lower frequencies (~100 Hz) it appeared to Geddes that refraction in the sediment was an important factor and could account for the negative bottom loss observations. Currently, most low-frequency sound transmission calculations are performed with geoacoustic profiles, i.e., sound speed, density, and attenuation as a function of depth in the sediment.

The last two papers by Kronengold and Clark [21], [22] treat the important topic of signal fluctuations in both space and time. These papers present the initial results from their investigations and are included because of the uniqueness of the long-range measurement of space–time fluctuations. The authors discuss the potential influence on array processing at frequencies less than 400 Hz and place in perspective the role various ocean processes can play in producing these fluctuations for both fixed and moving sources. These results are consistent with the array coherence and signal gain result from the LRAPP program that arrays with lengths of 100 wavelengths could easily be formed in the deep ocean at a frequency of 400 Hz or less [23, Fig. 16].

This Editor trusts that these papers will be of interest to readers of the JOURNAL and that the effort will be continued by the Chief of Naval Research. The preparation of these papers could not have been accomplished without the encouragement of Drs. Herr and Livingston and the "can do" attitude of Ms. Peggy Lambert, the former ONR Security Officer. Anna Mastan of the NUWC Editoral Staff was responsible of the preparation of the papers for ONR review and then for submission to the JOURNAL. Her patience and hard work are greatly appreciated.

WILLIAM M. CAREY, *Guest Editor*
Boston University
Department of Mechanical Engineering
Boston, MA 02215

REFERENCES

[1] V. O. Knudsen *et al.*, "Underwater ambient noise," *J. Marine Res.*, vol. VII, no. 3, pp. 410–429, 1948.

[2] "A Summary of Underwater Acoustic Data, Part V, Background Noise," The Office of Naval Research, 1954.

[3] G. M. Wenz, "Acoustic ambient noise in the ocean: spectra and sources," *J. Acoust. Soc. Amer.*, vol. 34, no. 12, pp. 1936–1956, 1962.

[4] R. H. Nichols, "Some notable noises: Monsters and machines," *IEEE J. Ocean. Eng.*, vol. 30, no. 2, pp. 248–256, Apr. 2005.

[5] R. J. Urick, *Ambient Noise in the Sea*. Washington, DC: Undersea Warfare Technology Office, NAVSEA, DON U.S.,, 1984.

[6] J. B. Hersey, *International Workshop on Low Frequency Propagation and Noise, Vol. I, Vol. 2*. Arlington, VA: The Maury Center of Ocean Sciences, ONR, 1974.

[7] D. Ross, "Ship sources of ambient noise," *IEEE J. Ocean. Eng.*, vol. 30, no. 2, pp. 257–261, Apr. 2005.

[8] "Summary of a One Year Ambient Noise Measurement Program Off Bermuda," Naval Underwater Systems Center, New London Laboratory, NUSC T.R. 4979, Apr. 1976. (Available DTIC).

[9] H. M. Walkinsaw, "Measurement of ambient noise spectra in the south Norwegian sea," *IEEE J. Ocean. Eng.*, vol. 30, no. 2, pp. 262–266, Apr. 2005.

[10] S. W. Marshall, "Depth dependence of ambient noise," *IEEE J. Ocean. Eng.*, vol. 30, no. 2, pp. 275–281, Apr. 2005.

[11] Tracor Corporation,, Alexandria, VA, Rpt. T76RV5060, DTIC (AD 00692),, 1976.

[12] J. A. Shooter, T. E. DeMary, and A. F. Whittenborn, "Depth dependence of noise resulting from ship traffic and wind," *IEEE J. Ocean. Eng.*, vol. 15, no. 4, pp. 292–298, Oct. 1990.

[13] E. P. Garabed and R. A. Finkelman, "Measured vertical noise directionality at five sites in the Western North Atlantic," *IEEE J. Ocean. Eng.*, vol. 30, no. 2, pp. 282–285, Apr. 2005.

[14] W. M. Carey and R. A. Wagstaff, "Low-frequency noise fields," *J. Acoust. Soc. Amer.*, vol. 80, no. 5, pp. 1522–1526, 1986.

[15] J. R. Short, "High-frequency ambient noise and its impact on underwater tracking ranges," *IEEE J. Ocean. Eng.*, vol. 30, no. 2, pp. 267–274, Apr. 2005.

[16] R. A. Wagstaff, "Interactive techniques for ambient noise horizontal directionality," *J. Acoust. Soc. Amer.*, vol. 63, pp. 863–869, 1978.

[17] ——, "An ambient noise model for the northeast Pacific ocean basin," *IEEE J. Ocean. Eng.*, vol. 30, no. 2, pp. 286–294, Apr. 2005.

[18] R. A. Wagstaff and J. W. Aitkenhead, "Ambient noise measurements in the northwest Indian ocean,," *IEEE J. Ocean. Eng.*, vol. 30, no. 2, pp. 295–302, Apr. 2005.

[19] W. M. Carey and N.-C. Yen, "Beam noise characteristics," *IEEE J. Ocean. Eng.*, vol. 30, no. 2, pp. 303–311, Apr. 2005.

[20] W. H. Geddes, "Low-frequency bottom loss," *IEEE J. Ocean. Eng.*, vol. 30, no. 2, pp. 312–316, Apr. 2005.

[21] M. Kronengold and J. G. Clark, "Fluctuations I: Spatial and temporal scales of importance for low-frequency propagation,," *IEEE J. Ocean. Eng.*, vol. 30, no. 2, pp. 317–321, Apr. 2005.

[22] J. G. Clark and M. Kronengold, "Fluctuations II: Spatial and temporal scales of importance for low-frequency propagation," *IEEE J. Ocean. Eng.*, vol. 30, no. 2, pp. 322–326, Apr. 2005.

[23] W. M. Carey, J. W. Reese, and C. E. Stuart, "Mid-frequency measurements of array signal and noise characteristics," *IEEE J. Ocean. Eng.*, vol. 22, no. 2, pp. 548–565, Jul. 1997.