Guest Editorial: Continued Exploration of Fine-Grained Sediments from SBCEX2017

MANY properties of fine-grained sediments that affect acoustic propagation are still actively being researched. To allow this research to progress, a rich data set was collected during the Seabed Characterization Experiment in 2017 (SBCEX2017). This international, multidisciplinary, multi-institutional research project is devoted to the following scientific goals:

1) to understand the physical mechanisms that control acoustic propagation in fine-grained sediments;
2) to quantify uncertainties in the estimation of seabed parameters;
3) to correlate the observed horizontal variations in the acoustical field with the measured horizontal variability of the seabed;
4) to assess the performance of the resulting geoacoustic models, inversions, and statistical inference methods.

To facilitate these scientific goals, the experiment was designed to minimize complexity in both the water column and the seabed. Referring to the prediction of acoustic fields in shallow water waveguides, the general goal of the experiment was to identify remote sensing techniques that could provide the necessary acoustic characterization of the seabed, which in turn could provide accurate prediction of the acoustic field in the 10-Hz to 10-kHz band.

SBCEX included a comprehensive sub-bottom chirp profile of the experimental area, about 200 sediment cores, and a number of direct *in situ* measurements of the acoustic properties of the seabed. Numerous acoustic propagation measurements throughout the experimental site provided data for inversion processes and statistical inference techniques to remotely sense the acoustic properties of the bottom. In 2020, the first special issue of IEEE JOE about SBCEX2017 included 15 papers that reported the results of coring and geoacoustic inversions. A complete description of the experiment, the institutions involved, and the acoustic sources and sensors deployed is available in the guest editorial for that special issue [1].

In this second special issue on analyses of SBCEX data, substantial additions to our understanding of fine-grained sediments have been achieved. These include a more complete documentation of the physical analysis of the sediment core material by the United States Geological Survey, a modified Biot theory for fine-grained sediments, and methods that increase the sophistication of remote sensing techniques. Other papers in this special issue study the frequency, range, and depth-dependence of the sound speed in the mud using different geoacoustic inversion techniques. Also included is a study on probabilistic representation for sound sources and a seabed classification approach using deep learning. A brief synopsis of each of these papers is now provided.

II. PHYSICAL ANALYSIS

The work of Chaytor *et al.* [A1] analyzes 89 sediment cores [piston/trigger, gravity (acoustic), and vibracore], and with comprehensive database of laboratory-based sediment analyses, geophysical core logs, and the results of seismic reflection profiling, a three-layer lithostratigraphic model is formulated of the area within and immediately adjacent to the SBCEX17 focus area, referred to as the seabed experiment area (SEA). The uppermost unit, Unit 1, is relatively homogenous clayey to sandy silt, with consistent downcore textural, mineralogical, and physical property attributes. Unit 2 is a variable-thickness transitional layer between Unit 1 and Unit 3, whose properties reflect a decrease in proximal erosion and transition to a lower energy depositional environment. Unit 3 is clean quartz sand containing abundant shells and shell fragments that were regionally deposited during Holocene sea-level rise. Paired 210 Pb and 14 C radiocarbon geochronologies spanning the past 13000 years were used to facilitate intercore comparison across the SEA. The three discrete units of this model can be identified via changes in sediment grain size and texture, in addition to subtle changes in the mineral content, physical properties, and the geophysical response of the sediments, namely heavy mineral content, wet bulk/gamma density, grain density, water, and porosity.

Lithostratigraphic–seismostratigraphic comparison plots were presented for NW-SE and SW-NE propagation paths which were overlain with seismic horizons mh2, mh3, and mudbase time horizons from Goff *et al.* [A2] and were converted to depth using a fixed 1500 m/s velocity. The seafloor-to-mh3 horizon is entirely occupied by Unit 1 sediments, with the extension of Unit 1 and transition to Unit 2 sediments into the mh3–mh2 and mh2–mudbase intervals. Shallower than expected Unit 3 appearance in cores 3 PC, 14 PC, and 15 PC does not yet have a satisfactory explanation.

III. REMOTE SENSING

The remaining 11 papers and two technical communications in the special issue increase the diversity of remote sensing

---

Date of current version July 13, 2022.
Digital Object Identifier 10.1109/JOE.2022.3174252

techniques, push limits of known methods, and apply new sediment parameterizations to data from SBCEX2017. A brief description of each of these papers and their primary contributions is provided.

A. *Modal Dispersion*

In a technical communication from Rajan *et al.* [A3], the Airy phase in some of the normal modes in the SBCEX2017 data is utilized to obtain estimates of the compressional wave speed and density profiles in the upper 60 m of sediment. To investigate the Airy phase, the modal dispersion is estimated with the warping method [2] on data from a Source, Underwater Sound (SUS) explosive source signal at a distance of 15.5 km from that recorded on a single hydrophone near the seafloor. This hydrophone is close to the one used in the analysis in [3], in which the Airy phase in the New England Mud Patch (NEMP) was first identified. A linear approach is used to obtain estimates of the depth-dependent profiles for compressional wave speed and density along with the variance and resolution of the estimates.

Jiang *et al.* [A4] show how an acoustic payload-equipped underwater glider can be used for seabed characterization. Gliders have many advantages including being cost-effective with low power consumption and are able to perform long-range and long-endurance missions with flexible deployment. The glider followed a sawtooth-like track through the water as combustive sound sources (CSS) were deployed. A transdimensional Bayesian geoacoustic inversion was applied to modal-dispersion data obtained from time-warping [2] the time–frequency modal dispersion diagrams. A comparison of the inversion results for the marginal probability densities for sound speed, density, and interface probability inferred from data from different receiver depths is performed. The advantage of including signals from two depths in the inversion is also displayed. In all three cases, the low-speed, homogeneous upper layer is resolved, similar to previous studies. The uncertainties are reduced when signals from two depths are included. This study demonstrates the viability of using gliders for geoacoustic inversions.

Knobles *et al.* [A5] explore the dispersion relation on the sound-speed ratio at the sediment/water interface using two statistical measures and the viscous grain shearing (VGS) model [4]. Acoustic recordings of signals in the 1.5–4.0–kHz band recording on a 16-channel Scripps-Marine Physical Laboratory (MPL) vertical line arrays (VLAs) are used in a statistical inverse problem to estimate four parameters: porosity, strain hardening index, and mineral grain bulk modulus in the VGS model for the upper sediment layer, and the speed of the research vessel that was towing the acoustic source. Marginal probability densities for inversions based on five data samples are compared; the similarity of the results suggests that mud variability near the two VLAs is small. From the inferred VGS parameters, depth-dependent compressional and shear wave speeds and attenuations are calculated for the 1.5–4.0–kHz band. A detailed look at the dispersion of the compressional wave speed over the 25–4000–Hz band for the upper 9.3 m of the sediment; dispersion is evident over this band. It was also found that the Buckingham model predicted a frequency-dependent nonlinear depth gradient that increased with increasing frequency. Perhaps the most important result was that the resulting sound-speed ratio dispersion curve is in agreement with the direct sound-speed measurements made by the sediment acoustic measurement system in the 2–10-kHz band by Yang and Jackson [5].

B. *Compressed Sensing*

Paviet-Salomon *et al.* [A6] advance their prior work on grid-free compressed sensing and apply the enhanced method to signals from a combustive sound source recorded on a 1 km long horizontal line array (HLA). The grid-free approach to compressed sensing mitigates issues of basis mismatch. The modal wave numbers are estimated in the 10–100–Hz frequency band, and ten sensors are found to be sufficient when a speed correction is applied. The speed correction allows fewer sensors to be used without wave number aliasing because of how physical information becomes embedded within the compressed sensing framework. The results were evaluated using the Jaccard distance based on the rates of true positives, false negatives, and false positives. These quantities are evaluated for wave number tracking at each frequency of interest using four different methods: a traditional orthogonal matching pursuit algorithm, a soft Bayesian pursuit method that uses dispersion relation to relate wave numbers at adjacent frequencies, a grid-free orthogonal matching pursuit algorithm with gradient descent, and their proposed continuous, physics-based orthogonal matching pursuit approach that includes the dispersion relation. The recovered wave number spectra using 64, 40, and 10 sensors on the HLA indicate that their proposed method is both reliable and robust.

C. *Range-Dependence*

Holland *et al.* [A7] use seabed reflection and scattering measurements to provide bounds on the sound-speed ratio at the water–sediment interface and compare local conditions for two sites with different mud thicknesses. These measurements were conducted at short source–receiver distances to reduce complications due to inhomogeneity of the seabed that can exist for long-range measurements. Two primary questions are addressed regarding how the geoacoustic properties vary vertically and over different range scales. The data show an 8° angle of intromission: evidence that the sound speed in the upper portion of the sediment is less than that of the water column. This angle of intromission leads to an estimate of the sediment/water sound-speed ratio of 0.9865 with outer bounds [0.985 0.989] in the upper 1.7 m of the sediment. The data also contain evidence of a critical angle associated with the mud-sand boundary. Comparisons between sites show that the critical angle at the location with a thinner mud layer is approximately 5° larger than at the thicker mud layer location.

Dahl *et al.* [A8] extend their previous work on vector sensor based inversions to range-dependent inversion based on the circularity: the normalized curl of the active intensity. The circularity is a bounded, nondimensional quantity that has greater information content about seabed properties because of the way multimodal interference impacts the circularity. A Bayesian framework is applied to the circularity of data from a transiting cargo ship as measured on the Intensity Vector Autonomous

Recorder (IVAR) platform as the ship traveled 5 km from east to west, with a Closest Point of Approach (CPA) range of 2.5 km. An elastic parameterization is used for a single low-speed layer over a half-space. Four parameters are included in the inversion: thickness and compressional wave speed of a low-speed sediment layer and the compressional and shear wave speeds of the half-space. Plots of the MAP estimates and 95% probability width for each of the four parameters are shown, and the moving average indicates slow variations in the average and effective seabed parameters as the ship moves along the 5-km track. The range-dependent averaged parameterization produces good agreement between modeled circularity spectrum and that obtained from the data.

Bonnel *et al.* [A9] expand the transdimensional Bayesian geoacoustic inversions to include a range-dependent track. The first step is to perform the transdimensional inversion at one location using seven modes identified using modal warping [2]. For the range-dependent version, adiabatic normal mode theory is applied to calculate modal arrival times over 500 m long range-independent "steps." A three-way comparison is made between the marginal posterior probability densities (PPDs) for the sound speed and density obtained with the range-independent approach and a range-dependent case assuming parallel layers and a range-dependent case that makes use of the bathymetry and sub-bottom layers from the two-way travel time (TWTT) results along a specific track (shown in [1, Fig. 3]), to extract range-dependent slopes of the different layers. All three sets of marginal PPDs are strikingly similar showing that the range-independent inversion provides a good synoptic estimate of the environment. However, the range-dependent approach using the TWTT reveals a large change in the sound speed slightly above the mud base, similar to the gradient at the bottom of the mud seen in other studies; likely, the range-independent and range-dependent with parallel layer approaches miss this effect. Thus, while range-dependent modeling is not required to fit the modal dispersion data, it may provide a superior geoacoustic model that can capture the range-dependent variability in the seabed for cases where seismic surveys have been obtained.

D. Higher Order Modes

Bonnel *et al.* [A10] demonstrate how modal warping can obtain dispersion curves for high-order modes and how the additional information content from the high-order modes impacts the transdimensional Bayesian geoacoustic inversion results. Using the warping method [2] on a CSS signal at a range of 5.4 km, the dispersion properties of 21 modes are obtained—the highest number yet reported. This accomplishment is not possible with traditional mode filtering approaches because the fine-grained sediments make is impossible for water-borne sensors to span complete mode functions, which are not confined to the water column. Comparisons are made between transdimensional Bayesian results using frequency-dependent arrival times for modes 1–7, 1–15, and 1–21 modes. Using only seven modes, the sound speed in the top 8 m is homogeneous and the sediment/water sound-speed ratio is greater than one. For the 21-mode case (with frequencies of 20–550 Hz), three slightly different layers are detected in the top ≈10 m and the sound-speed marginal PPDs show a 23% probability that the sediment/water sound-speed ratio is less than 1. These results demonstrate how the data information content in high-order modes leads to new insights into seabed properties. The result from using 21 modes—that the mud is composed of three slightly differing layers—is consistent with a global analysis of the cores collected during SBCEX [2].

Dosso *et al.* [A11] also use the higher order modal dispersion data in the 15–550–Hz band described in [A10] to obtain depth-dependent sound speed and density in the seabed. Previous transdimensional Bayesian geoacoustic inversions have yielded an almost-isospeed mud layer. This new paper investigates if this trend is caused by a bias in the transdimensional approach toward isospeed layers because each 1-m layer of sediment is assumed to be isospeed. To check for a potential bias, a hybrid parameterization is used in which the depth-dependent sound speed and density in the upper sediment layer has generalized representation of smooth gradients based on Bernstein polynomials; the lower sediment layers are solved with the transdimensional approach. The Bayesian information criterion (BIC) is used to determine the order of the polynomials consistent with the data information content. This hybrid approach is applied to arrival times of 18 of 21 modes extracted from the combustive sound source signals collected on the ARL:UT 14-channel VLA. The hybrid inversions show that the sound speed in the upper 7–8 m of sediment is almost isospeed with a positive gradient over the next 3–4 m, similar to previous transdimensional inversions. The two inversion methods do yield different probability densities for the sound-speed ratio at the sediment/water interface: the transdimensional and hybrid inversions give a probability of 27% and an 89%, respectively, that the sound-speed ratio is less than unity. This generalized parameterization illustrates how model selection is intertwined with the nonuniqueness of inverse problems.

E. Modified Biot Theory for Mud

Chotiros *et al.* [A12] present a porous medium model for mud with seven input parameters. An inversion problem is defined for the NEMP. The seven parameters that need to be measured or inverted are as follows:

1) fluid fraction of the skeletal frame;
2) solid fraction of the pore water;
3) high-frequency asymptotic frame bulk modulus;
4) creep relaxation frequency;
5) creep exponent;
6) mean grain size;
7) bulk water fraction.

A distinguishing feature of the porous mud model is that the skeletal frame may contain adsorbed water, and the pore water may contain suspended solid material. This means that the effective properties of the skeletal frame and pore water are different from that of the pure solid and pure seawater, and the effective porosity is not the same as the bulk water fraction. The model contains two loss mechanisms: creep and viscous loss due to relative motion between skeletal frame and pore water. It is demonstrated that the input parameters could be inverted from measured wave speeds, attenuations, and reflection loss. The inversion from reflection loss exclusively is more difficult due to the relative insensitivity to shear properties.

F. Probabilistic Source Representation

The article by Tollefson *et al.* [A13] proposes a transdimensional Bayesian marginalization approach to ship radiated noise recorded on a VLA of hydrophones to infer ship source level (SSL) and properties of a mud-sand shallow water seabed on the New England Shelf. The transdimensional reversible-jump Markov Chain Monte Carlo (rjMCMC) sampling approach samples probabilistically over complex spectral source strengths, source depths/ranges, and number of seabed layers and geoacoustic parameters of each layer. The BIC is applied to determine the appropriate number of (point) sources used to describe a ship. Radiated noise due to two merchant ships passing the VLA at beam aspect at 3.2–3.4– km range is considered. The average SSL uncertainty is 3.2 dB/Hz for low-frequency narrowband (20–120 Hz) and 1.8 dB/Hz for broadband noise (190–590 Hz). Seabed layering and geoacoustic parameter estimates agree reasonably well with mud-over-sand seabed models from other inversions in the area.

The approach was applied to radiated noise due to two merchant ships, a vehicle carrier and a container ship, recorded on a VLA in shallow water on the New England Mud Patch. The BIC indicated that two point sources were the most appropriate to describe the Tombarra: one source to represent narrowband frequencies and one source to represent broadband radiated noise. The source depth marginal densities differed between these sources; for the source representing broadband noise, a narrow density centered in the lower half of the ship draft; for the source representing narrowband frequencies, a wider density centered near one-half of the ship's draft. The BIC indicated that that the source amplitude should be considered constant over snapshots.

The SSL measurements were conducted in shallow water (depth 76–82 m) at long range (3.2–3.4 km), over a seabed of *a priori* uncertain layering and composition. Within uncertainties, the SSL estimates agreed reasonably well with reference spectra reported for large ensembles of measurements on merchant ships.

G. Tracking and Inversion

Michalopoulou *et al.* [A14] has pushed the limits of the particle filtering technique and compares two different approaches to accomplish both source tracking and geoacoustic inversion. The input data consists of multipath arrival times in 1-s long waveforms from a towed midfrequency source recorded on the 16 sensors on the MPL VLA. Five data samples are utilized, corresponding to different source–receiver ranges. The process begins with the closest data sample. A linearization approach with particle filtering is used to find the range and source depths of the 16 sensors, the water depth, the water column sound-speed bias (indicating the deviation from the isospeed assumption), and a time indicating the source instant. These source–receiver–water parameters are found using the arrival times of the direct, surface-reflected, and bottom-reflected paths using particle filtering and a linearization approach. Next, an exhaustive search for the sound speed and thickness of the upper sediment layer is conducted. Two approaches are then applied to analyze subsequent data samples. The first method uses a linearization approach incorporating the prior information from the previous location. The second method employs a second particle filter to propagate the PDF and map the dynamic evolution of the parameters of interest along the track. The results from the two methods agree, indicating a sediment layer thickness of 8–9 m and a sediment/water sound-speed ratio greater than unity. The consistency of the two methods supports the robustness of using multipath arrival times for inversions.

H. Deep Learning Classification

In a technical communication, Howarth *et al.* [A15] use spectrograms from transiting merchant ships in a convolutional neural network (CNN) to classify between 17 seabed types. The 17 seabed types are representative of previous statistical inferences and geoacoustic inversions using data from SBCEX2017. One-second long pressure time series of SUS charges are simulated for the 17 seabeds and different water sound-speed profiles. The synthetic data sets are used to train and validate a five-layer CNN to classify the seabed type. The trained network is then applied to 31 SUS waveforms from the pressure sensor in the IVAR system deployed by the Applied Physics Laboratory at the University of Washington, Seattle, WA, USA [6]. The purpose of this work was to illustrate how a seabed classification system performs when the seabed classes are not acoustically distinct and the impact of the sound-speed variability used in creating the training data sets. The classifier output—the chosen seabed—for the measured data samples depends on the training data, but trends in the classifier output are evident when considered in terms of the sediment/water sound-speed ratio and the interval velocity.

IV. CONCLUSION

This new group of papers includes reports on basic measurements, a new seabed physics model, and several studies that introduce a variety of seabed parameterizations including techniques that merge source parameters such as those associated with tracks and source level, and geoacosutic parameters into the random space of model parameters. The paper reporting on the analysis of 89 piston cores in the NEMP by Chaytor represents an important milestone for the seabed characterization experiment analysis. It provides a basis with which to construct prior geoacoustic models and parameter bounds for future analyses of NEMP acoustic data, including planned experiment in May–June 2022.

One thing missing from the present special issue is a plot (like Ref. [1, Fig. 7]) collecting all the results of sound speed and attenuation from all of the various measurements and inferences. Since the time that the first special issue was published [1], a number of papers (not reviewed here) on the analysis of acoustic data taken in NEMP have appeared in other journals. Further, given the publication of Chaytor's physical analyses in the present special issue [A1], and future results coming from the 2022 field campaign, the expectation is that a significant amount of new results will emerge. The authors have, therefore, chosen not to include such a plot in the present special issue, but, instead, they plan to present a more-complete (approaching definitive) plot in a future publication.

ACKNOWLEDGMENT

The authors would like to thank Office of Naval Research Code 322 Ocean Acoustics Program for sponsoring Seabed Characterization Experiment 2017.

PRESTON S. WILSON, *Guest Editor*
The University of Texas at Austin
Austin, TX 78713 USA

DAVID P. KNOBLES, *Guest Editor*
Knobles Scientific and Analysis
Austin, TX 78731 USA

TRACIANNE B. NEILSEN, *Guest Editor*
Brigham Young University
Provo, UT 84602 USA

REFERENCES

[1] P. S. Wilson, D. P. Knobles, and T. B. Neilsen, "Guest editorial an overview of the seabed characterization experiment," *IEEE J. Ocean. Eng.*, vol. 45, no. 1, pp. 1–13, Jan. 2020.

[2] J. Bonnel, A. Thode, D. Wright, and R. Chapman, "Nonlinear time-warping made simple: A step-by-step tutorial on underwater acoustic modal separation with a single hydrophone," *J. Acoust. Soc. Amer.*, vol. 147, no. 3, pp. 1897–1926, Mar. 2020.

[3] L. Wan, M. Badiey, D. P. Knobles, and P. S. Wilson, "The airy phase of explosive sounds in shallow water," *J. Acoust. Soc. Amer.*, vol. 143, no. 3, pp. EL199–EL205, 2018.

[4] M. J. Buckingham, "On pore-fluid viscosity and the wave properties of saturated granular materials including marine sediments," *J. Acoust. Soc. Amer.*, vol. 122, no. 3, pp. 1486–1501, Sep. 2007.

[5] J. Yang and D. R. Jackson, "Measurement of sound speed in fine-grained sediments during the seabed characterization experiment," *IEEE J. Ocean. Eng.*, vol. 45, no. 1, pp. 39–50, Jan. 2020.

[6] P. H. Dahl and D. R. Dall'Osto, "Vector acoustic analysis of time-separated modal arrivals from explosive sound sources during the 2017 seabed characterization experiment," *IEEE J. Ocean. Eng.*, vol. 45, no. 1, pp. 131–143, Jan. 2020.

APPENDIX: RELATED ARTICLES

[A1] J. D. Chaytor *et al.*, "Measurements of geologic characteristics and geophysical properties of sediments from the New England Mud Patch," *IEEE J. Ocean. Eng.*, early access, Sep. 22, 2021, doi: 10.1109/JOE.2021.3101013.

[A2] J. A. Goff, A. H. Reed, G. Gawarkiewicz, P. S. Wilson, and D. P. Knobles, "Stratigraphic analysis of a sediment pond within the new England mud patch: New constraints from high-resolution chirp acoustic reflection data," *Mar. Geol.*, vol. 412, pp. 81–94, 2019.

[A3] S. D. Rajan, L. Wan, M. Badiey, and P. S. Wilson, "Seabed characterization experiment: Analysis of broadband data," *IEEE J. Ocean. Eng.*, early access, Dec. 17, 2021, doi: 10.1109/JOE.2021.3122165.

[A4] Y. M. Jiang, S. E. Dosso, J. Bonnel, P. S. Wilson, and D. P. Knobles, "Passive acoustic glider for seabed characterization at the New England Mud Patch," *IEEE J. Ocean. Eng.*, May 6, 2021, doi: 10.1109/JOE.2021.3066178.

[A5] D. P. Knobles *et al.*, "Statistical inference of sound speed and attenuation dispersion of a fine-grained marine sediment," *IEEE J. Ocean. Eng.*, early access, Aug. 17, 2021, doi: 10.1109/JOE.2021.3091846.

[A6] T. Paviet-Salomon *et al.*, "Estimation of frequency-wavenumber diagrams using a physics-based grid-free compressed sensing method," *IEEE J. Ocean. Eng.*, early access, Oct. 20, 2021, doi: 10.1109/JOE.2021.3109432.

[A7] C. W. Holland, C. M. Smith, Z. Lowe, and J. Dorminy, "Seabed observations at the New England Mud Patch: Reflection and scattering measurements and direct geoacoustic information," *IEEE J. Ocean. Eng.*, May 31, 2021, doi: 10.1109/JOE.2021.3070028.

[A8] P. H. Dahl and D. R. Dall'Osto, "Range-dependent inversion for seabed parameters using vector acoustic measurements of underwater ship noise," *IEEE J. Ocean. Eng.*, Jul. 20, 2021, doi: 10.1109/JOE.2021.3086880.

[A9] J. Bonnel *et al.*, "Transdimensional geoacoustic inversion using prior information on range-dependent seabed layering," *IEEE J. Ocean. Eng.*, Apr. 13, 2021, doi: 10.1109/JOE.2021.3062719.

[A10] J. Bonnel, S. E. Dosso, D. P. Knobles, and P. S. Wilson, "Transdimensional inversion on the New England Mud Patch using high-order modes," *IEEE J. Ocean. Eng.*, Jun. 2, 2021, doi: 10.1109/JOE.2021.3075824.

[A11] S. E. Dosso and J. Bonnel, "Hybrid seabed parameterization to investigate geoacoustic gradients at the New England Mud Patch," *IEEE J. Ocean. Eng.*, vol. 2, pp. 1–36, 2021.

[A12] N. P. Chotiros, "Geoacoustic inversion for mud as a porous medium," in proc.*IEEE J. OCEANS Conf.*, 2021, pp. 1–4, doi: 10.23919/OCEANS44145.2021.970613.

[A13] D. Tollefsen, W. S. Hodgkiss, S. E. Dosso, J. Bonnel, and D. P. Knobles, "Probabilistic estimation of merchant ship source levels in an uncertain shallow-water environment," *IEEE J. Ocean. Eng.*, early access, Nov. 13, 2021, doi: 10.1109/JOE.2021.3113506.

[A14] Z. H. Michalopoulou, P. Gerstoft, D. Rios, and W. S. Hodgkiss, "Tracking and inversion using midfrequency signals in the seabed characterization experiment," *IEEE J. Ocean. Eng.*, early access, Dec. 16, 2021, doi: 10.1109/JOE.2021.3122284.

[A15] K. Howarth, T. B. Neilsen, D. F. V. Komen, and D. P. Knobles, "Peer-reviewed technical communication on explosive sounds," *IEEE J. Ocean. Eng.*, vol. 45, no. , 1, Jan., 2020, doi: 10.1109/JOE.2021.3110322.

Preston S. Wilson received the B.S. and M.S. degrees in mechanical engineering from the University of Texas at Austin (UT Austin), Austin, TX, USA, in 1990 and 1994, respectively, and the Ph.D. degree in mechanical engineering from Boston University, Boston, MA, USA, in 2001.

He is currently the Paul D. and Betty Robertson Meek Centennial Professor of engineering with UT Austin, with joint appointments with the Mechanical Engineering Department and Applied Research Laboratories (ARL:UT). He was a Research Engineer with ARL:UT from 1993 to 1997, served as a Postdoctoral Fellow with Boston University from 2001 to 2003, and has been a Faculty Member with UT Austin since 2003. His research areas are broadly focused on physical acoustics, underwater acoustics, engineering acoustics, and bioacoustics, with specific areas of interest in sound propagation in shallow water, in water-saturated sediments, bubbly liquid, and multiphase material. He holds six US patents, and is a Cofounder of AdBm, Inc., Austin, TX, USA, operating in the underwater noise mitigation arena. He is currently serving as a Cochief Scientist for the ONR Seabed Characterization Experiment.

Dr. Wilson received the A.B. Wood Medal from the Institute of Acoustics, Milton Keynes, U.K. He is a fellow of the Acoustical Society of America (ASA), the past Chair of the Committee for Education in Acoustics of the ASA, a past member of the Executive Council of the ASA, and an Associate Editor for the *Journal of the Acoustical Society of America*. His work has been reported in over 400 peer-reviewed papers, conference proceedings, technical reports, and published presentation abstracts.

David P. Knobles received the Ph.D. degree in nuclear physics from the University of Texas at Austin, Austin, TX, USA, in 1989.

From 1989 to 1992, he did a postdoctoral fellowship in nuclear theory at the University of Texas at Austin. He is the chief executive officer (CEO) of Knobles Scientific and Analysis (KSA), Austin, TX, USA, a private corporation that specializes in defense and environmental applications. In addition to ocean acoustics, his research interests include nuclear theory, elementary particles and fields, cosmology, and bioacoustics. He is currently serving as a Cochief Scientist for the ONR Seabed Characterization Experiment.

Dr. Knobles is a Fellow of the Acoustical Society of America.

Tracianne B. Neilsen is currently an Associate Professor with the Department of Physics and Astronomy at Brigham Young University, Provo, UT, USA. She completed her Ph. D in physics at the University of Texas at Austin in 2000. Her postdoctoral research was completed at the Applied Research Laboratories, University of Texas at Austin, investigating iterative optimizations for source localization and seabed parameterization in shallow ocean environments. Working as a part-time Research Scientist in 2007, her focus shifted to optimizations for 566 high-frequency seabed parametrization using the Biot model. For more than a decade, she was a part-time Assistant Professor at Brigham Young University and did research on jet noise source characterization. In May 2018, she became a full-time Associate Professor and returned to underwater acoustics research. She has recently been exploring effective ways to apply deep learning in ocean acoustics.