Fundamentals of Shallow Water Acoustics
Boris Katsnelson, Valery Petnikov and James Lynch
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The Office of Naval Research (ONR) began a technical monograph series in the technical area of underwater acoustics in 2001. The authors selected by ONR for each of the series' individual specialized monographs are independently judged and assisted by an ONR-assembled editorial board. Titles of previously published books in this series include "Transducers and Arrays in Underwater Sound," "High-Frequency Seafloor Acoustics," and "Ocean Ambient Noise: Measurement and Theory." The most recent book, "Fundamentals of Shallow Water Acoustics," authored by Boris Katsnelson, Valery Petnikov, and James Lynch and published in 2012, is the subject of the present book review.

The newest "Fundamental of Shallow Water Acoustics" monograph is built on the foundation of the well-known and respected earlier book titled "Shallow Water Acoustics" published in Russia in the mid-1990's by the first two authors of the present book, B. Katsnelson and V. Petnikov and later translated into English. The current instantiation or outgrowth of that previous book teams those two original Russian authors with J. Lynch, their long-time collaborator from the United States, with authors' stated goals for the new book to bring up to date the technical coverage of the field since 1995 and to explore more strongly and clearly where the future of the field of shallow water acoustics research might be heading.

Before delving into the more specific aspects and details of this book, it is worth noting that in a general sense the book authors largely prescribe to the modal, rather than the ray, representation for describing much of the lower frequency acoustics physics in the book. The authors directly address this decision in the book's preface and this reviewer sees no problem with this approach/decision whatsoever. Relatedly, as anticipated in a book focusing on the low and medium frequency acoustic sound field in shallow water, the presence, nature, and properties of the sea bottom are prominent throughout the book; this in contrast to the much lower prevalence that consideration of the bottom boundary would be expected to be given if the technical examination was instead on deep-water ocean acoustics.

It is noted that the technical treatment of the more complex acoustics topics comprising this book is relatively advanced mathematically and therefore this book is more suited for use in graduate level classes and by practicing researchers in underwater acoustics than as an introductory or undergraduate-level text book. In addition, this book contains no homework problem sets and the numerous superb practical examples that are included are more interspersed within the text just to illustrate various concepts and to provide real-world data than as explicit worked examples of the various mathematical equations normally included for pedagogical purposes. Therefore, this book would probably need to be supplemented in some fashion with other written material to provide the ability to use it with graduate students in a formal problem-solving, classroom setting.

For a book that is quite mathematical in its treatment of the technical material, the excellent figures interposed throughout the book are plentiful and quite illustrative. The quality of all figures examined is very good and all appear to be clearly labeled and well documented. Furthermore, many of the illustrations and plots are printed in color which, while also justified and required in most of the cases of their inclusion, nevertheless is a very nice addition to the book.

On the chapter layout and overall topic ordering and breakdown, although there are a few similar chapters to the earlier Katsnelson and Petnikov "Shallow Water Acoustics" book, one immediately finds upon examination of the new book's Table of Contents as well as eleven chapters and six appendices that substantial reform and updating have been made in this new monograph along with the addition of several new topic headings. This includes newer chapters dedicated to shallow water acoustics signal processing, the inverse problem (with consideration of both water column and bottom property parameters), and the future direction of research in shallow water acoustics.

Specifically, the first short chapter in the book begins with a short description of the authors' definition of shallow water acoustics followed by a brief but plainly written general discussion of the past, present, and future of the topic. Chapter 2, titled "Coastal Oceanography, Geology, and Biology," contains an excellent treatment of the coastal acoustical environment which includes, from a nicely balanced empirical and mathematical perspective, discussion of coastal acoustic topics such as vertical stratification of sea water properties, surface waves, tides, internal waves, biological contributors, and the effects of bottom material properties and geometric roughness.

Chapter 3 starts the book's stronger mathematical focus and includes an outstanding discussion of several related models of the shallow water acoustic waveguide. Though there is a short section discussing the ray description of the acoustic sound field, most of the materials in this chapter adhere to a mode-based model for description of the shallow water sound field. Sample topics included in Chapter 3 include the relatively simple constant-parameter Pekeris model, both perturbation and Wentzel–Kramers–Brillouin (WKB) approximation methods, shallow water mode coupling, and the parabolic equation (PE) approximate method for inhomogeneous media wave propagation.

In Chapter 4, the authors consider several examples of shallow water acoustic waveguide factors and parameters

such as bottom-related acoustic attenuation, dispersion, the so-called ideal frequency (with minimum loss) concept, and the sound field interference invariant. Departing from the deterministic approach taken in earlier chapters regarding representing the important effect of inhomogeneities in shallow water acoustics, Chapter 5 switches to examining the sound field in a randomly inhomogeneous medium, primarily through consideration of its coherent (averaged) and incoherent (fluctuating) components.

Chapter 6 considers the complex yet essential long-range, low frequency bottom reverberation physics in shallow water, including a short discussion of modeling this phenomenon and again considering the effects of randomly inhomogeneous media discussed in Chapter 5.

The next two chapters are devoted to two general topics widely examined recently in the literature, the inverse problem and underwater acoustics signal processing methods, respectively, with specific focus towards describing their applicability in shallow water acoustics physics. Though covered in several other texts as well, this reviewer particularly enjoyed the many real-world experimental examples included in both chapters (as well as in many other chapters) and found them exceptionally instructive and illuminating.

In contrast to the relatively narrowband, spatially discrete acoustic sources discussed earlier in the book, highly distributed and wideband ambient noise sources such as wind-induced surface noise are examined in Chapter 9. Chapter 10 contains a brief and introductory-level discussion of some of the more common equipment and systems used in measuring shallow water sound fields including several low frequency projectors as well as both fixed hydrophone and powered unmanned vehicle arrays for full scale acoustic monitoring of sound fields. The eleventh and last chapters in the book are a very short and informal yet contemplative and thought-provoking examination of the possible areas of emphasis and future directions in most of the technical topic areas discussed in earlier in the book.

The book concludes with six appendices that buttress and extend the technical and mathematical material contained within the eleven chapters of the book. Appendix A, which at nearly the same number of pages as some of the book's longer chapters, could be a separate chapter itself. It represents a very handy supplement to the book containing a detailed set of general mathematical derivations related to shallow water acoustics physics such as analytical signals and waves, surface waves, internal waves, and acoustic waves. Although these derivations can be found elsewhere in other texts, having all of them consolidated within the book helps provide comprehensiveness of the technical material. Similarly to Appendix A, the remaining five appendices in the book contain additional derivations and background mathematics for related topics such as modal decomposition of point source generated sound fields, the derivation of the mode coupling equations discussed in Chapter 3, the use of empirical orthogonal functions for interpolation of ocean sound speed field data, an approximate solution for localized scattering, and the derivation of the well-known equations for plane wave reflection from a half-space.

Overall, this book is superbly written and clear and conveys strong insights into the underlying fundamental physics and governing mathematical equations of shallow water acoustics. Again, it should be noted that it is written at a relatively advanced mathematical level and is therefore ideally geared to researchers and graduate and post-graduate level students. The book successfully provides a unique and commendable balance between (a) providing an advanced and comprehensive mathematical treatment of shallow water acoustics theory and (b) also supplying a real-world, practical examination of voluminous experimental data and investigations by the authors who are each incredibly experienced and practiced underwater acoustics researchers with decades of real-life at-sea and laboratory experience personally applying the principles and methods they are discussing in the book. In summary, it is an excellent book that is highly recommended for interested researchers and experienced practitioners interested in learning both the fundamental mathematical physics and current state of the art in research in shallow water acoustics.

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