Underwater Acoustic Modeling and Simulation, Fourth Edition
Paul C. Etter
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The 2013 fourth edition of Paul C. Etter's text entitled *Underwater Acoustic Modeling and Simulation* deals predominantly with physical and/or empirical modeling methods and approaches for predicting a variety of underwater acoustic phenomena including acoustic propagation, noise and reverberation occurring in the ocean environment. Practical information on the application of these models to sonar operation and performance and also the implementation of models over time (termed "simulation" by the author and introduced to the title and the text back in the third edition) are discussed in later chapters. New topics specifically added in the fourth edition include the impact on underwater acoustic modeling tools of a variety of more recent undersea subjects including marine mammal protection, the impact of increasing ocean acidification, undersea noise pollution, effects of climate change, marine wind farm development, etc.

Etter's evolution from the first edition of this book (entitled *Underwater Acoustic Modeling* and published in 1991) to the present fourth edition has occurred over a period of nearly four decades. Overall, looking back on the changes made to the book during that period with each new edition, it has been a fine progression. Real-world changes to the technical interest areas and priorities relating to underwater acoustics modeling (e.g., the shift in emphasis to acoustic prediction in shallow- rather than deep-water environments) have successfully been incorporated into later editions over the years. Relatively weighty improvements and updates to the material have been made with each edition and the fourth edition is no exception.

As with the prior editions, Etter's fourth edition text is ideally suited for use by professional and student acousticians, acoustical oceanographers, applied mathematicians, sonar technologists and operations analysts and system engineers. The author assumes that the reader already has a basic technical foundation in underwater acoustics and the text therefore concentrates primarily on covering the wide-ranging variety of modeling approaches applicable to this area.

While the text is fairly detailed and extensive, this reviewer believes that it is intended primarily as an introductory or illustrative examination of a broad field of underwater acoustic modeling methods. As such, it is likely aimed more at graduate students and professionals interested in learning about the full spectrum of underwater acoustics modeling and simulation methods or classes of models rather than for practitioners requiring more focused and in-depth information into any one particular model or numerical code.

Starting from his first edition and carrying through to this latest 2013 edition, one of Etter's chief stated goals is to provide the reader with precise information on both the underlying assumptions behind each modeling type or method as well as describing its domain or limits of applicability. The author has been very successful in this goal, since virtually every modeling approach considered is accompanied by useful information on its specific uses, selection guidelines, shortcomings and restrictions.

The text begins with an introductory chapter offering an excellent overview of the current state of underwater acoustics modeling and simulation. This chapter, as with the remainder of this new edition book, has clearly been extensively updated with regard to recent work and developments in the literature. Following an updating of developments in both modeling and simulation since the third edition, Chapter 1 also contains a short treatment of recent real-world operational challenges in the areas of naval operations (e.g., Unmanned Underwater Vehicles (UUV's)), the offshore commercial sector (e.g., marine-based oil exploration) and general oceanography research.

Chapter 2 contains a good summary or review of a variety of phenomena related to basic acoustical oceanography including ocean fluid properties, their relation to sound speed and propagation direction determination, the effect of sea surface and bottom boundaries, dynamic features including wind and ocean currents and internal waves and finally the impact on sound of biologics.

Most of the "meat" of the text's coverage of underwater acoustics modeling is contained in Chapters 3–10 which together cover broad classes of modeling approaches in the important acoustical areas of propagation (Chapters 3–5), noise (Chapters 7–8), and reverberation (Chapters 9–10). In each of these three areas, the text treatment of the topic includes chapters on both the physical and then the mathematical modeling of these phenomena. Chapter 6, a new chapter added in the fourth edition, covers a wide variety of specialized modern topics and applications related to propagation including broadband modeling, nonlinear acoustics, underwater acoustic networks and vehicles, time-reversal techniques and marine mammal protection modeling efforts.

Chapter 11 shifts concentration from the underwater acoustics modeling of propagation, noise and reverberation covered in the earlier chapters towards a more applied examination of the use of these aforementioned

models in the field of sonar system performance. However, unlike other navy sonar texts which delve heavily into specific sonar array designs and operation, Etter's treatment of the topic continues to place emphasis on modeling the underwater acoustic and oceanographic environment itself and how that relates to general sonar system performance and objectives.

The seemingly straightforward process of model evaluation is discussed from a variety of real-world perspectives in Chapter 12, which also contains a historical account of a number of larger-scale evaluation efforts sponsored by the US Navy and others. Finally, as mentioned, Chapter 13 is devoted solely to issues related to simulation, defined by Etter as the implementation of models over time. The brief coverage of simulation follows as a natural and logical extension from the detailed modeling concepts discussed in the earlier chapters.

One of the unique strengths of Etter's book is how comprehensively referenced it is throughout. Following the last chapter is a very impressive list of references, each individually cited in the book for a definite purpose. In addition to the reference citations included within the body of the text, an Author Index is included after the Subject index which is also convenient. Furthermore, unlike a recent trend with some other authors of later edition texts to just "tweak" the earlier edition and correct minor errata, it is clear that Etter has taken the time with this latest edition to reinvestigate the literature in each chapter's topic and included additional up-to-date information and references.

Finally, a newly added Appendix D to the fourth edition includes Problem Sets for each chapter. This has likely been added in an attempt to allow use of the text in a graduate-level course setting. While the number of problems included for each chapter is so far very small, it is a good start on a useful and welcome addition to the book.

Overall, Paul C. Etter's 2013 fourth edition of *Underwater Acoustic Modeling and Simulation* is an excellent and comprehensive introduction to an extremely broad spectrum of modeling methods and approaches in underwater acoustics and oceanography. While earlier editions of this text were already widely recognized as noteworthy and authoritative in the field, useful and meaningful updates and improvements have been made in this current edition and it is a highly recommended read.

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