Preface to the Second Edition

This is the second edition of our book *Computational Ocean Acoustics*, revised and supplemented, including much new material reflecting the progress in computational acoustics and related signal processing issues over the past 17 years. New material appears throughout the book, but we should like to draw attention to the following topics: the basic theory of waveguide invariants in Chap. 2, with a generalization of the concept to realistic, range-dependent waveguides in Chap. 5. The presentation of ray methods in Chap. 3 has been significantly modified to provide a more intuitive development of the fundamental ray concepts. Some intricate issues (aliasing, etc.) related to discrete wavenumber integration in Chap. 4 have been explained in detail, including several illustrative examples. Also, the extension of the wavenumber-integration technique to 3-D scattering and reverberation scenarios in horizontally-stratified waveguides has been included in Chap. 4, together with several illustrative numerical examples. Within the framework of normal-mode theory (Chap. 5), there is new material on mode identification, as well as on normal modes in elastic media. In addition, a section on scattering from objects in a waveguide has been added, together with a 3-D example of mode coupling around seamounts. Chap. 6 has been updated with recent developments in parabolic-equation modeling, notably improvements in dealing with elastic media, and 4-D code implementations for pulse propagation in general 3-D environments. In Chap. 7, we have added a description of the virtual-source concept (VSC) for target scattering, and also expanded on the finite-element (FE) section to address the use of this technique for target scattering in ocean waveguides. Several numerical examples illustrate current capabilities in FE/VSC modeling. Chapter 8 contains new material on Doppler shift in a waveguide, based both on wavenumber-integration and normal-mode theory. Chapter 9 has a new section dedicated to the extraction of time-domain Green's functions from noise correlation functions. Finally, recent developments in signal processing for sonar applications have been added to Chap. 10, specifically on time-domain processing, vector-sensor beamforming, synthetic signal and sensor stimulation, and phase conjugation and time reversal. Finally, extensive use of color illustrations throughout has improved the appearance of this book significantly.

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Since this book represents a major milestone in the authors' research careers, we wish to acknowledge the unwavering support from our wives, *Patrizia, Gaby, Laurel*, and *Satu*, to whom this new edition is dedicated.

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Preface to the First Edition

The importance of computers in scientific research today is universally recognized. Several new journals dedicated to the fields of Computer Science and Computational Physics have appeared over the past decade, and it is evident that computers have already changed our approach to doing science, both experimentally and theoretically.

A statement by Prof. Norman Zabusky in the October 1987 issue of Physics Today clearly points to the crux of the matter: “We are in the midst of a computational revolution that will change science and society as dramatically as the agricultural and industrial revolutions did. The discipline of computational science is already significantly affecting the way we do hard and soft science. Computers with fast, interactive visualization peripherals have come of age and provide a mode of working that is coequal with laboratory experiments and observations and with theory and analysis. We can now grapple with nonlinear and complexly intercoupled phenomena in a relatively short time and provide insight for quantitative understanding and better prediction.”

The above comments on the impact of computers on research in virtually all disciplines of science certainly also apply to the field of ocean acoustics, where we have observed an explosive growth in the development and use of numerical models since the mid-1970s. Numerical models have become standard research tools in acoustic laboratories, and computational acoustics is becoming an ever more important branch of the ocean acoustic science. Only the numerical approach allows us to include the full complexity of the acoustic problem, and moreover, a *numerical* experiment is both faster and cheaper than an actual ocean experiment.

Since ocean acoustic modeling has now reached a mature state of development, we feel that the timing is right for a textbook on computational acoustics. The book is intended to present the state-of-the-art of numerical techniques as applied to solving the wave equation in heterogeneous fluid–solid media. Emphasis is on developing the theoretical foundation which directly leads to numerical implementations for real ocean environments. Various computational schemes are discussed in detail, and, in contrast to standard textbooks where acoustic effects are demonstrated through analytical expressions, fundamental propagation features are here illustrated graphically, often in color.

It is anticipated that the text will be useful to both universities and government laboratories. In universities, such material is covered in various departments including Applied Mathematics, Geology and Geophysics, and Ocean Engineering, or in special programs on Acoustics. The text would be appropriate either as a course directly in computational ocean acoustics or as a principal reference in a more general course on computational techniques for problems in wave propagation. The level of the text is suitable for either graduate students or undergraduates at the senior level.

The other important audience for this text is in government (especially Navy) and industry laboratories, which are involved in either the development or use of propagation models. For users, a principal problem is that of understanding both the mathematical and numerical limitations of the various modeling techniques.

The authors all have many years of experience in the field. By involving four authors, each one being an expert on one or more of the topics listed in the table of contents, it was hoped to provide an in-depth treatment of all aspects of computational ocean acoustics, ranging from the fundamentals of wave propagation theory, over particular solution techniques (rays, wavenumber integration, normal modes, parabolic equations), to the detection of signals in the presence of noise.

Much of the research which forms the basis for this book was carried out at the SACLANT Undersea Research Centre, La Spezia, Italy. This institution has had a consistent effort in acoustic modeling since the mid-1970s, and all four authors have spent varying lengths of time at SACLANTCEN since then. It is the inspiring and fertile research environment at this Centre together with its excellent computing and graphics facilities which is the real reason for this book becoming a reality. The authors also wish to express their gratitude to the members of the SACLANTCEN Environmental Modeling Group, Giancarlo Dreini, Carlo Ferla, Cinzia Isoppo and Giovanna Martinelli, for their assistance in the development and maintenance of the various acoustic models. We are also grateful to Alvaro Carrara for helping with the illustrations for the book.

Finally, we wish to thank the many colleagues who performed a critical review of parts of the manuscript at various stages of preparation. Among those are Dale Ellis, Richard Evans, Joo-Thiam Goh, Frank Ingenito, Ed McDonald, John Perkins, Richard Pitre, George Rolt, and Alex Tolstoy. Special thanks go to Mike Collins for helping us keep abreast of the most recent parabolic equation developments, and to Ken Rolt for doing a thorough and detailed editing of the entire manuscript.

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