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Stanisław R. Massel

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**To my wife Barbara
and children
Andrzej, Magdalena and Bartosz**

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Preface

Surface waves are one of the most obvious phenomena, almost constantly present on the surface of any water basin, such as ponds, lakes, rivers, artificial reservoirs, seas and oceans. The first studies on waves concentrated on the ideal, regular wave forms and resulted in a formulation of basic principles of surface wave mechanics. Regular waves can be considered only as a very crude approximation to real ocean waves. Modern marine science and ocean engineering practice need a more realistic representation of the ocean surface.

In the 1940s and '50s substantial progress in the theory of random functions and mathematical statistics provided powerful mathematical tools for a description of ocean waves as random phenomena. The first results of such studies were summarized by Kinsman in his book published thirty years ago.

Recent advances in instrument design and in data handling have allowed sampling of the ocean at rates and on scales hitherto inaccessible. Widespread use of high-speed computers has provided theoreticians with powerful tools and has made possible great improvement in the analysis of experimental data.

In the last three decades, numerous fundamental results were achieved and documented in hundreds of papers, distributed in many journals. However, at the same time, only a few books dedicated totally or partly to wind-induced waves were published. Several books on wind waves were also published in Russia, but due to the language barrier, these books are almost totally unknown among the Western scientific community. All published books fall into two distinct groups: those oriented towards classic oceanography, and those of an engineering nature. However, at the present time, the gap between oceanography, and coastal and ocean engineering, is becoming narrower in the sense that the discoveries in oceanography are transmitted almost immediately to practical applications in marine engineering.

The philosophy of the close link between ocean physics and ocean engineering is adopted in this book, which offers a very comprehensive and updated discussion of the fundamental scientific concepts of ocean wave mechanics and their practical applications. It is hoped that the very broad picture of ocean waves, given in the book, may provide some inspiration to new efforts and new solutions.

The book has two main objectives. The first is to provide a comprehensive review of the present understanding of the physics of ocean waves and their statistical and spectral description. The second objective is to provide a basic description of the

prediction models which can be used in ocean and coastal engineering, and in applied oceanography.

In order to achieve both of these objectives, the evolution of the scientific efforts in ocean wave physics during the last forty years is reviewed. Stochastic and probabilistic terminology is introduced, and the basic statistical and spectral properties of ocean waves are developed and discussed in detail.

Moreover, the book deals with practical prediction methods for waves in deep ocean and coastal zones, in island archipelagoes and coral reefs. Simple as well as very sophisticated methods are presented. The long-term evaluation of ocean wave parameters for design purposes are given and measurement techniques, including satellite applications and methods of wave data processing, are discussed.

This book is intended as a handbook for professionals and researchers in the areas of ocean and coastal engineering, physical oceanography, applied physics and as a useful book for graduate students in these fields. It should help bridge the gap between general texts on mathematical statistics and random processes and more descriptive texts on ocean engineering and oceanography.

The reader is assumed to have a working knowledge of calculus, and the analysis of the time series as well. A basic knowledge of hydrodynamic concepts would be helpful, although those subjects are reviewed shortly in the initial chapters of the book.

While the fundamental concepts of ocean wave physics are given in great detail, some advanced topics are only overviewed. However, an index and many cross references are provided in order to make the book more efficient as a handbook. The book's structure can be summarized as follows:

Chapter 1 discusses the basic assumptions and approaches to the description of ocean waves. The fundamentals of time series and spectra are discussed in detail.

Chapter 2 provides a brief description of the airflow over the ocean surface. This is followed by a presentation of the basic wave generation models. In particular, the various implementations to the classical Phillips-Miles model are considered. The spectral representations of wave energy balance, which are extensively used in the following chapters, are also discussed.

In **Chapter 3** emphasis is placed on the various representation of ocean wave spectra and their usefulness for engineering and oceanographic applications.

In **Chapter 4** a comprehensive and updated overview of the statistical properties of ocean waves is given. Topics include probability distributions for all surface wave parameters, as well as wave-induced velocities and pressure. For the particular ocean region (deep water, shallow water, surf zone etc.), corresponding wave statistics are identified.

Chapter 5 deals with wave prediction methods in deep water. First, the basic physical processes responsible for wave behaviour in the deep ocean are discussed. Topics include atmospheric forcing, nonlinear interactions between spectral components and wave energy dissipation. This is followed by a presentation of various

forecasting methods. Besides the sophisticated prediction methods of first, second and third generation models, more simple empirical methods are also discussed.

Chapter 6 deals with ocean waves in finite water depth. The basic physical processes involved in wave motion include wave refraction, diffraction, reflection, non-linear interactions and wave energy dissipation. As in **Chapter 5**, wave prediction methods are treated extensively.

Wave mechanics and wave forecasting techniques for island archipelagoes and coral reefs are still rather poorly known. **Chapter 7** presents the basic methods for the evaluation of wind-induced waves in such environments. Emphasis is placed on the transformation, scattering and dissipation processes at islands and coral reefs.

Chapter 8 focuses on the prediction of design wave parameters using long-term statistics principles. First, the available visual observations and instrumental data are reviewed, and then the probability densities for extreme values are discussed. Some information on the 'geography' of extreme waves is also given.

Chapter 9 overviews wave measurement techniques and methods for wave data processing. Satellite wave detection techniques, as well as the more traditional techniques (wave staffs, wave buoys etc.), are discussed.

A large list of references, symbols and notation, as well as subject and author indexes are included in the book. For convenience, the titles of non-English papers are given in the original transcript, as well as in the English translation.

I apologize for the inevitable errors which may occur in this book, despite my efforts to eliminate them. Please bring these errors to my attention.

I would like to express my thanks to the Australian Institute of Marine Science for support during the preparation of this book. I also wish to acknowledge the stimulating discussions provided by many colleagues and members of the staff of the Institute. Thanks are also due to Christine Cansfield-Smith for accurate proof-reading, and to Bartosz Massel and Steve Clarke who worked on the figures.

I thank Dr Tom Hardy (JCU) and Dr Derek Burrage (AIMS) for their review of chapters and invaluable suggestions.

I am especially grateful to my wife, Barbara, for her accurate and patient word processing, and for her support during the writing.

Townsville, August 1995

Stanislaw R. Massel

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