

Preface

“It came from nowhere, snapping giant ships in two. No one believed the survivors . . . until now”

—New Scientist magazine cover, June 30, 2001

Rogue waves are the focus of this book. They are among the waves naturally observed by people on the sea surface that represent an inseparable feature of the Ocean. Rogue waves appear from nowhere, cause danger, and disappear at once. They may occur on the surface of a relatively calm sea and not reach very high amplitudes, but still be fatal for ships and crew due to their unexpectedness and abnormal features. Seamen are known to be unsurpassed authors of exciting and horrifying stories about the sea and sea waves. This could explain why, despite the increasing number of documented cases, that sailors’ observations of “walls of water” have been considered fictitious for a while.

These stories are now addressed again due to the amount of doubtless evidence of the existence of the phenomenon, but still without sufficient information to enable interested researchers and engineers to completely understand it. The billows appear suddenly, exceeding the surrounding waves by two times their size and more, and obtaining many names: abnormal, exceptional, extreme, giant, huge, sudden, episodic, freak, monster, rogue, vicious, killer, mad- or rabid-dog waves, cape rollers, holes in the sea, walls of water, three sisters, etc. Freak monsters, though living only for seconds, were able to arouse the superstitious fear of the crew and cause damage to the ship and death to heedless sailors. All these epithets are full of human fear and frailty.

Serious studies of the phenomenon started about 20–30 years ago and have intensified during the recent decade. The research is being conducted in different fields: physics (search of physical mechanisms and adequate models of wave enhancement and statistics), geoscience (determining the regions and weather conditions when rogue waves are most probable), and ocean and coastal engineering (estimations of the wave loads on fixed and drifting floating structures). Thus, scientists and engineers specializing in different subject areas are involved in the solution of the problem. Freak waves annually become the subject of special sessions at the European Geophysical Union Assembly (2001–2008); Ifremer (France) organized workshops “Rogue Waves” in Brest (2000, 2004, 2008) ‘Aha Huliko’ (a Hawaiian Winter

Workshop in 2005) and a workshop held the same year by the International Centre for Mathematical Sciences (Edinburgh) were also dedicated to this phenomenon.

We start this book with a brief introduction to the problem of freak waves, aiming at formulating what is understood as *rogue* or *freak* waves, what consequences their existence imply in our life, and why people are so worried about them.

Chapter 1 is devoted to observations and measurements of freak waves. After some citations of personal descriptions of unexpectedly high waves, we proceed to speak about available instrumental measurements of rogue waves that can allow some quantitative analysis. In spite of recent success in developing the measuring systems, there are difficulties and problems that embarrass the high wave registration and analysis; they will be also discussed in Chap. 1.

Two approaches to the rogue wave description (deterministic and statistical) are discussed in Chap. 2, where some definitions and a mathematical toolkit are provided that are necessary for the following chapters. A brief survey of the physical mechanisms that have been already suggested as possible explanations of the freak wave phenomenon completes Chap. 2. They are:

- wave-current interaction
- geometrical (spatial) focusing
- focusing due to dispersion (spatio-temporal focusing)
- focusing due to modulational instability
- soliton collision
- atmospheric action

This brief survey anticipates the detailed description given in Chaps. 3, 4, 5. We have chosen to divide the rogue wave occurrence mechanisms into (i) quasilinear ones (that usually are efficient in different geographical conditions with minor modifications, Chap. 3), (ii) nonlinear ones in water of infinite and finite depths (Chap. 4) and (iii) nonlinear ones in shallow water (then the specific wave dispersion and influence of the bottom may play an important role, Chap. 5). The essential physics of the processes of wave focusing by different mechanisms is generally well understood but their occurrence in the ocean is poorly documented. That is why we start Chaps. 3, 4, 5 with theory, modeling, and a description of the physical mechanisms followed with available testimonies of manifestations of this physics in laboratory tanks and nature.

In the Conclusion, we emphasize that most of the developed theories are applicable to other physical phenomena starting from ocean waves of different nature (wind waves, tsunamis, edge and Rossby waves) and ending with nonlinear optics (for instance optical rogue waves in fibers) and astrophysical plasma processes. This is a great implicit benefit of the freak-wave problem exploration, since rogue waves motivated significant development of nonlinear wave theories, including integrable systems and the study of instabilities, higher-order statistics, and rediscovering physical effects in new applications, etc.

This book is designed for Master and PhD students, as well as researchers and engineers in the fields of nonlinear waves, fluid mechanics, physical oceanography, ocean and coastal engineering, and applied mathematics. In Chap. 2, the fundamen-

tal basis and tools that are needed to understand and analyze the various mechanisms generating the extreme wave events given in Chaps. 3, 4, 5 are presented. For a deeper knowledge of some specific methods, the reader can refer to the bibliography, which is well stocked with references.

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