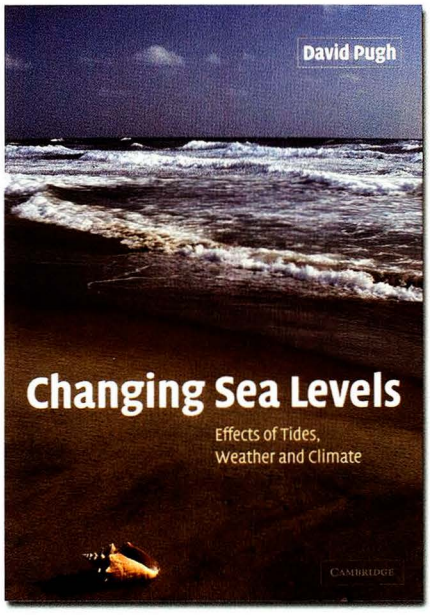
Book Review

Changing Sea Levels
Effects of Tides, Weather and Climate

By David Pugh, published by Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 2RU, UK, hardcopy ISBN: 0 521 82532 6 (US$ 115.00) and paperback ISBN: 0 521 53218 3 (US$ 50.00).

David Pugh's earlier publication *Tides, Surges and Mean Sea-Level* (1987) has been one of three indispensable tidal reference books in my bookcase for a number of years, so I was very pleased to have the opportunity to review his new book. As the author notes in the preface, *Changing Sea Levels* began as a development from that earlier (now out-of-print) book. *Tides, Surges and Mean Sea-Level* contains more detail on many topics, but this shorter, more basic book includes much new material, especially on satellite altimetry and climate change.



The layout of the book is very clean and easy to read. In the present style of most university textbooks there are wide margins for writing notes. An unfortunate side effect of this is that a few of the figures and their imbedded text are a little on the small side. All figures are provided in black and white, and in some instances colour versions are also provided (in a separate section) where the black and white image cannot convey all the required information. At the end of each chapter the author provides recommendations for further reading. Questions are also provided at the end of each chapter, with answers provided in an appendix.

The author's earlier publication was written as a handbook for engineers and scientists. The present publication is written for undergraduate students with a science background, as well as hydrographers, coastal engineers and other professionals. From my own experiences teaching tides, currents and water levels to hydrographers and surveyors I think the author has done an excellent job of addressing the requirements of these groups. David Pugh is very knowledgeable about this subject, and he is an excellent communicator in the way he presents and links his material. *Changing Sea Levels* succeeds in being shorter and more basic without loosing any of the necessary material or linkages.

The book looks at sea level change in terms of the three main causes – astronomical tides, weather and climate changes. The nine chapters of the book are presented in that order. The first chapter looks at the measurement of tides and the classes of instruments typically used to measure tides in coastal areas and in the offshore. The use of satellites to measure sea level is discussed in some detail and the author provides an excellent overview of the operating parameters of an altimetry satellite. Chapter 2 discusses the basic astronomical tidal forces and the special patterns they produce in the ocean. It also discusses the geoid, a very important concept for mean sea level and its variations worldwide. Chapter 3 builds on the previous chapter by showing how we can use this understanding of tidal forces to extract information on the tides from sea level records. Harmonic analysis and prediction of both tides and currents are discussed, as are the non-harmonic and response analysis methods of tidal prediction.

Chapter 4 first develops useful tools for describing the behaviour of tidal waves. Those tools are then applied to describe the tidal patterns and behaviours observed in the world's oceans and continental shelves. Chapter 5 examines what happens to these waves as they propagate into the even shallower coastal areas and into rivers. Chapter 6 then focuses on weather and other non-tidal effects. The author provides examples of regional storm surges and describes the physical processes that combine to produce these surges. Reference to real-world examples is used frequently and effectively throughout the book. Chapter 6 also provides the reader with information on seiches and tsunamis.

Up to this point in the book there is little focus on long term sea level changes. Chapter 7 discusses mean sea level, observed annual and inter-annual changes, and longer term effects due to isostatic adjustment and changes in water volume. The author appropriately provides a summary of the most recent findings of the Intergovernmental Panel on Climate Change in responding to the question of whether the rate of sea level change is accelerating. New tools such as altimetry and GPS are contributing to our understanding of sea level change, but as the author points out, even with this additional information longer periods of observation are still required.

Chapter 8 deals with extreme sea levels. Most hydrographers focus on extreme sea levels in a historical sense by looking at extreme low waters and high waters recorded at tide gauge stations over periods of many years. For engineers and coastal planners there is the need to predict flooding risks and how these might change in the future. The information provided on return periods and risk is likely new material for many hydrographers, but it is extremely important information for coast planners and engineers, and is useful information for anyone collecting or managing water level data. This chapter also looks at observed trends, some of the potential coastal impacts, and possible response strategies.

The final chapter of the book looks at some of the coastal and biological processes that are influenced by tides or by changing sea level. Related to this is the use of tidal reference planes as legal definitions for shoreline boundaries. This chapter also looks at mean sea level and tides from a geological perspective. Over geological time very significant land-sea level changes have occurred and the ocean tidal responses would have changed with changing ocean and continent configurations and with the continued evolution of the earth-moon system.

From a hydrographic perspective, the title of this book undersells its importance. In addition to information on changing sea levels it contains a great deal of valuable information on the measurement of tides and non-tidal effects, understanding the main and secondary features of tidal signals and the analysis and prediction of tides. As mentioned earlier, David Pugh is very knowledgeable about this subject and he is a masterful communicator. This is an excellent book and I strongly recommend it to hydrographic offices, hydrographers with responsibility for water level measurement or prediction, coastal engineers, oceanographers and other professionals in related disciplines. *Tides, Surges and Mean Sea-Level* sits in my bookcase looking somewhat like a well worn pair of favourite slippers. *Changing Sea Levels: Effects of Tides, Weather and Climate* will join it there and I am certain this book will see much use in the years to come. I anticipate this book will be very popular and I hope the publishers have printed sufficient copies to prevent it going out of print for a very long time.

Reviewed by Fred Stephenson, CHS