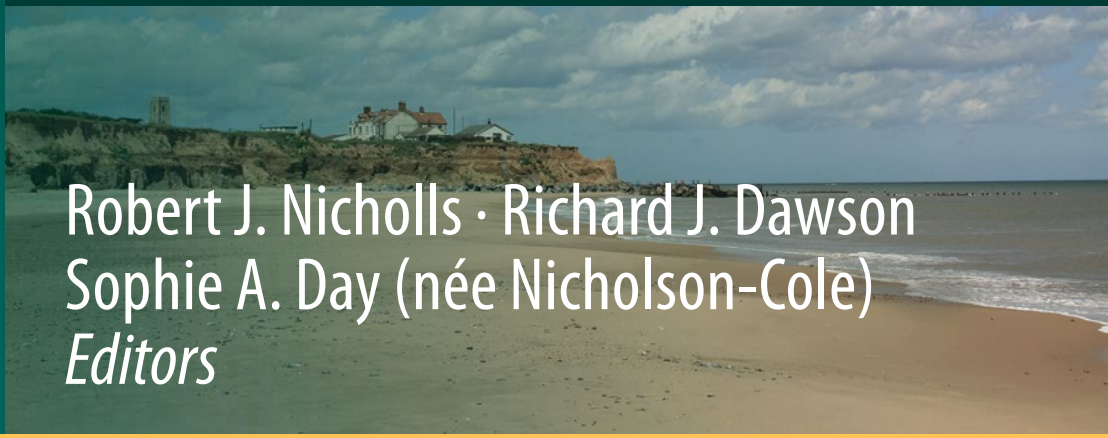
Advances in Global Change Research 49



Robert J. Nicholls · Richard J. Dawson
Sophie A. Day (née Nicholson-Cole)
Editors

Broad Scale Coastal Simulation

New Techniques to Understand and Manage Shorelines in the Third Millennium

Springer

Advances in Global Change Research

Volume 49

Series editor
Martin Beniston, Carouge, Geneva, Switzerland

More information about this series at http://www.springer.com/series/5588

Robert J. Nicholls • Richard J. Dawson
Sophie A. Day (née Nicholson-Cole)
Editors

Broad Scale Coastal Simulation

New Techniques to Understand and Manage Shorelines in the Third Millennium

Springer

Editors
Robert J. Nicholls
Tyndall Centre for Climate Change Research, Faculty of Engineering and the Environment
University of Southampton
Southampton, UK

Richard J. Dawson
School of Civil Engineering and Geosciences, Tyndall Centre for Climate Change Research
Newcastle University
Newcastle upon Tyne, UK

Sophie A. Day (née Nicholson-Cole)
Tyndall Centre for Climate Change Research, Faculty of Engineering and the Environment
University of Southampton
Southampton, UK

ISSN 1574-0919 ISSN 2215-1621 (electronic)
Advances in Global Change Research
ISBN 978-94-007-5257-3 ISBN 978-94-007-5258-0 (eBook)
DOI 10.1007/978-94-007-5258-0

Library of Congress Control Number: 2015946609

Springer Dordrecht Heidelberg New York London
© Springer Science+Business Media Dordrecht 2015
This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.
The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.
The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

Springer Science+Business Media B.V. Dordrecht is part of Springer Science+Business Media (www.springer.com)

Foreword

Global change, including climate change, presents one of the greatest challenges facing the world today. It is affecting food, water and human security as well as biodiversity and ecosystems and their services, with developing countries and poor people being the most vulnerable. Nowhere are the pressures of global change more evident than along our coastlines, where an ever-increasing number of people live. Hundreds of millions of people are threatened by rising sea levels and storm surges, especially those living in deltaic areas, such as Bangladesh; low-lying small island states, such as Kiribati; and cities sinking due to excessive groundwater extraction, such as Bangkok. Even rich cities such as New York are not immune to flooding as witnessed with Hurricane Sandy.

The systems approach that the Tyndall Centre researchers describe in this book has developed an appropriate conceptual framework for integrated coastal assessment at the scales of coastal management. It has enabled them to answer previously intractable questions about how climate change interacts with changing coastal systems. Whilst the work focussed upon North Norfolk in the East of England, the methods and insights are generic and potentially transferable to other coastlines around the UK and the world.

Coasts are complex systems that evolve over a range of time and space scales. Marine climate, beaches, cliffs, farmland, urban areas, erosion and flood protection infrastructure change over timescales of decades, so we need to understand the implications of those changes and start to prepare for them to avoid being burdened with long-term problems. This research recognised that coastlines are embedded within wider socio-economic and environmental systems and sought to understand the implications of climate, socio-economics and coastal management policy as drivers of long-term change. The Tyndall Coastal Simulator simulates the interactions between these processes in order to develop scenarios of change at spatial scales of relevance to coastal decision-makers.

Coastal governance is also a key issue as it is complex and involves multiple actors. By mapping out the process of long-term change, the Tyndall Coastal Simulator can help assess the potential effectiveness of policy instruments and their

implications in terms of a range of different issues, including erosion, flooding and biodiversity.

Central to the success of the Tyndall Centre's holistic and policy-relevant approach has been the transdisciplinary nature of the research. This engaged a range of relevant stakeholders, including national and local government, the private sector and members of the public, in co-developing the research programme in order to address the full range of societal issues and concerns. This research showed that integrated modelling, as delivered by the Tyndall Coastal Simulator, can help to bring different stakeholders together in order to develop common understanding of processes and consequences of long-term change. That collective understanding is essential if society is to manage coastal change rather than become its victims.

There is no doubt that this work has broken new ground in terms of transdisciplinary climate change research by demonstrating that individual academic disciplines can advance the state of their art whilst importantly addressing questions of relevance to society that cut across these disciplines. The importance of the work was recognised by industry when an earlier synthesis paper (Dawson et al. 2009, included in Chap. 1 of this book) won the Lloyd's Science of Risk Prize in 2012.

Whilst significant advances have been made, inevitably a host of challenges and scientific uncertainties remain, and so I am pleased to see the Tyndall team reflect on these issues with practitioners and international experts in the final two chapters of this book. Not only does this offer a manifesto for an international research agenda but also a framework/demonstration of how interdisciplinary research should be conducted in international programmes such as the recently launched ICSU/ISSC Future Earth programme. That, however, is for the future. The purpose of this book is to summarise the results from eight years of Tyndall Centre research, which has significantly advanced our understanding of climate change and coastal systems.

Tyndall Centre
University of East Anglia
Norwich, UK

Bob Watson

Monash University
Melbourne, VIC, Australia

Louis Matheson

Preface

Coastal scientists, engineers and policy makers around the world are increasingly recognising the challenge of sustainable coastal management in the third millennium. Long-term geomorphological, climatic and socio-economic changes are influencing coastal systems at unprecedented spatial scales and over extended timeframes – with profound implications for people, coastal infrastructure and settlements, biodiversity, ecosystem services and governance of the coastal zone.

Coastal researchers and decision-makers are presently ill-equipped to deal with the problems emerging from multiple drivers of change across multiple coastal sectors. This reflects that the coast is a linked system, and any change in one area or sector may influence the impacts for other areas or sectors. An integrated systems-based approach that seeks to represent the interactions between different issues within the coastal zone is fundamental to understanding the impact of global change on coastlines and to assist the sustainable management of our shorelines over the twenty-first century.

In 2000, the Tyndall Centre for Climate Change Research, an interdisciplinary consortium of engineers, scientists and social scientists, was established in the UK. This provided a unique platform to develop a coastal research programme with a major focus on an integrated assessment – this became known as the Tyndall Coastal Simulator – and is now reported in full, for the first time, in this book. An earlier synthesis paper from this research by Dawson et al. (2009) (included within Chap. 1 of this book) won the Lloyd's Science of Risk Research Prize for Climate Change in 2012.

However, there are already a number of books on coastal management, so why might we need another one? Whilst this is certainly a valid question, this book is not a handbook for design, nor is it a compendium of methods that cover every aspect of coastal systems or a compilation of case studies with differing aims. Rather it is a perspective on integrated assessment as applied to coastal problems, which represents a topic where there is an important gap in the literature. This book is structured as follows: Chapter 1 expands upon the challenges of sustainable coastal management and provides an overview of the integrated assessment for the core case study site in

North Norfolk in England. Chapters 2 and 3 describe how global changes in marine climate may alter future sea level, storm surge and offshore wave conditions around the British Isles and especially North Norfolk. Similarly, Chap. 4 quantifies the effects of global and local socio-economic drivers on changes to land use and development in the East of England. The following five chapters consider a range of impacts associated with the climatic and socio-economic changes considered above. Chapter 5 analyses broadscale geomorphic change in the region and Chap. 6 analyses habitat degradation and loss. Chapter 9 brings together the cliff erosion and flood modelling in Chaps. 7 and 8, respectively, to evaluate future erosion and flood risks in terms of expected economic damages under different climatic, socio-economic and management scenarios. Central to the success of this programme was comprehensive engagement with stakeholders. Chapters 10 and 11 describe the visualisation techniques and graphical user interface used to present results in an interactive manner to stakeholders, whilst Chap. 12 considers current decision-making processes and how the management of transitions in the coastal zone could be more adaptive and equitable and effectively implemented. The final two chapters of the book reflect on the key findings of the research, describe a general framework for transferring the Tyndall Coastal Simulator and identify future research priorities for integrated assessment in the coastal zone. This includes reflection on the range of coastal problems across the globe.

Each chapter could be read in isolation, but distinctive to other books on coastal management, each chapter also contributes to the wider integrated assessment. Throughout the book, we reflect on the process of integrating information on the different environmental, social and economic dimensions of coastal management.

Taking a systems perspective of the natural, physical and social environment at a scale that is relevant to livelihoods and the economy has enabled us to analyse how the coastal system as a whole might evolve in a changing physical and socio-economic environment. The application of the Tyndall Coastal Simulator to North Norfolk, UK, demonstrates that it is now feasible to explore long-term integrated projections of coastal processes such as geomorphology, flood risk and land use change, greatly increasing the evidence base available for coastal management decisions. Moreover, the methods and integrated assessment framework are transferable to other coastal areas.

The integrated assessment presented here has highlighted a number of the opportunities, challenges and trade-offs and the need for a long-term perspective on coastal policy in order to allow adaptation to coastal change to occur, for example, the difficulties faced by coastal managers, who in reducing the risk of erosion may actually enhance flood risk (or the cost and viability of mitigating this risk) at sites within the same coastal system. Such results were captured within the Tyndall Coastal Simulator interface allowing the technical results to be accessible to a wide range of stakeholders.

It is now clear that the management of any coastline and the governance structures upon which that management depends need to reflect the connectivity between the various coastal features that comprise the natural and human coastal system and consequential trade-offs in management policy. Furthermore, the Norfolk analysis

relates the technical aspects of coastal change to the present, and often emotive, debate around long-term shoreline management – in particular it strengthens the argument for a change in the widespread historic management approach of increasing lengths of "hold the line" towards allowing as much of the coastline as possible to return to a more natural and dynamic configuration, including the associated sediment supply from eroding coasts. Inevitably, this raises a number of fundamental questions from stakeholders, which we have explored through using results from the Tyndall Coastal Simulator, about how to address the concerns of directly and indirectly affected landowners and householders to facilitate this fundamental change in management approach.

More generally, the work presented here shows that there is great potential for coastal stakeholders to develop improved understanding of coastal futures and for decisions to be based on a stronger evidence base. However, our integrated analysis exposed the magnitude of many uncertainties about coastal futures, and so in the context of adaptation, although the broadscale coastal simulation of the type presented here can provide a rich evidence base, it should be regularly reassessed, debated and reviewed as part of an ongoing process to reflect improving knowledge and changing priorities. Thus, we believe the Tyndall Coastal Simulator and tools like it have the potential to provide a platform for the longer-term adaptation process.

Southampton, UK — Robert J. Nicholls
Newcastle upon Tyne, UK — Richard J. Dawson
Southampton, UK — Sophie A. Day (née Nicholson-Cole)

Acknowledgements

The majority of this work was supported by the Tyndall Centre for Climate Change Research, which was funded by the Natural Environment Research Council (NERC), the Engineering and Physical Sciences Research Council (EPSRC) and the Economic and Social Research Council (ESRC). The methodological development of the risk analysis benefitted from additional support through the Flood Risk Management Research Consortium which was funded by EPSRC in partnership with the DEFRA/EA Joint Research Programme on Flood and Coastal Defence, UK Water Industry Research (UKWIR), Office of Public Works (OPW) (Ireland) and the Rivers Agency (Northern Ireland). In addition, the habitat and stakeholder analysis was supported through the Biodiversity Requires Adaptation in North-West Europe under a changing climate (BRANCH) Project which was funded by EU INTERREG IIIB funds. Richard Dawson's EPSRC fellowship (EP/H003630/1) provided him the flexibility and space to work on this.

For the first phase of work, the Tyndall Centre was led by Professor Mike Hulme (now at King's College London) and Professor John Schellnhuber (currently director of the Potsdam Institute for Climate Impact Research) who both provided practical support and developed an exciting vision for interdisciplinary research. Professor Andrew R. Watkinson (University of East Anglia), who led the coastal research programme during its first phase and latterly the Tyndall Centre, is thanked not just for these roles but for his regular advice and critical review throughout the production of this book.

Stakeholder engagement and collaboration has been central to the Tyndall Centre's philosophy. We are extremely grateful to the many individuals, organisations and coastal communities who contributed their time, data and expertise to provide valuable feedback on the research and insights into the case study location. It is impossible to name them all, but we extend particular thanks to Steve Hayman, Gary Watson and Julian Wright from the Environment Agency; Peter Frew and Robert Young from North Norfolk District Council; Malcolm Kerby, a resident of Happisburgh and founder of the Coastal Concern Action Group; and Clive Stockton, also of Happisburgh and landlord of the Hill House.

The analysis presented here would not have been possible were it not for access to data collected and managed by the Environment Agency, Natural England, North Norfolk District Council, the Met Office, the Ordnance Survey, the British Geological Survey, the British Oceanographic Data Centre (BODC) and the Centre d'Etudes Techniques Maritimes et Fluviales (CETMEF) for their Atlas Numérique d'Etats de Mer Océanique et Côtier.

The aerial photographs that appear in this book were taken by Mike Page and the historical images were provided by Norfolk County Council's Library and Information Service. Others were taken by Sophie Day and Richard Dawson during the course of their research.

The inspiration from this book stemmed from the Dawson et al. (2009) paper that was published in Climatic Change. A number of co-authors of this earlier paper did not contribute directly to this book, but we are grateful for their earlier contribution: Julie Richards (ABPmer), Jianguo Zhou (University of Liverpool), Steve Pearson (British Geological Survey), Jon Rees (NERC and British Geological Survey) and Paul Bates (University of Bristol). However, were it not for Margaret Deignan at Springer inspiring us into action, this book may not have happened, and we also thank Takeesha Moerland-Torpey and the rest of the publishing team at Springer for their guidance and patience.

David Walker and Andrew R. Watkinson also provided useful reviews of some of the earlier chapter drafts. Finally, we are grateful for Susan Hanson at Southampton University for reviewing the final book chapters and sparing us many blushes.

Contents