

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J. O'Shea and John E. Reynolds III

Frontmatter

[More information](#)

## Ecology and Conservation of the Sirenia

### Dugongs and Manatees

Dugongs and manatees, the only fully aquatic herbivorous mammals, live in the coastal waters, rivers and lakes of more than 80 subtropical and tropical countries and territories. Symbols of fierce conservation battles, sirenian populations are threatened by multiple global problems.

Providing comparative information on all four surviving species, this book synthesises the ecological and related knowledge pertinent to understanding the biology and conservation of the Sirenia. It presents detailed scientific summaries, covering sirenian feeding biology; reproduction and population dynamics; behavioural ecology; habitat requirements and threats to their continued existence.

Outlining the current conservation status of the sirenian taxa, this unique study will equip researchers and professionals with the scientific knowledge required to develop proactive, precautionary and achievable strategies to conserve dugongs and manatees.

Supplementary material is available online at: [www.cambridge.org/9780521888288](http://www.cambridge.org/9780521888288).

HELENE MARSH is Distinguished Professor of Environmental Science and Dean of Graduate Research Studies at James Cook University, Townsville, Australia. She is an international authority on the conservation biology of dugongs, sea turtles and coastal cetaceans, co-chairs the IUCN Sirenia Specialist Group and led the team that developed the United Nations Environment Programme's Global Dugong Action Plan.

THOMAS J. O'SHEA is Scientist Emeritus at the US Geological Survey, Fort Collins, Colorado. A mammalogist, he conducted research on manatees for many years and has served on the federal Florida Manatee Recovery Team, the Committee of Scientific Advisors to the US Marine Mammal Commission and the IUCN Sirenia Specialist Group.

JOHN E. REYNOLDS III is a Senior Scientist at Mote Marine Laboratory, Florida. He served as Chairman of the US Marine Mammal Commission between 1991 and 2010, is a former chair of the IUCN Sirenia Specialist Group and has recently worked closely with the United Nations Environment Programme to develop and implement a Caribbean-wide Marine Mammal Action Plan.

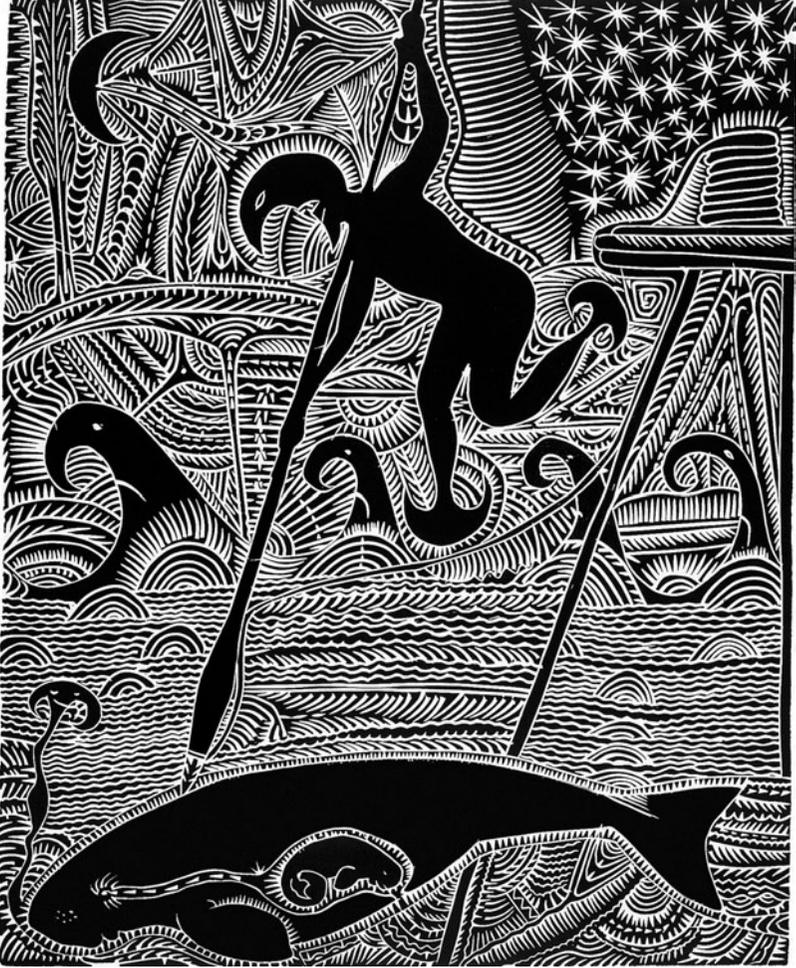
Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J . O'Shea and John E . Reynolds III

Frontmatter

[More information](#)



**Frontispiece.** One of the traditional ways of hunting dugongs in Torres Strait was by building a platform over the mud flats at low tide. A skilled hunter could tell, by looking for feeding trails, where a dugong would return over the next few nights and constructed a platform (nath) over this site with much magic and ritual. The rope was coiled up on the platform and then let out, running across to the shoreline where other villagers secured it, awaiting the kill. When a dugong came close, the hunter saw the phosphorescent glow in the water and aimed his harpoon slightly in front of it. The hunter is depicted in the form of a spirit with a moon-shaped head and feet for flying through the air. Nath (State II). Linocut – Kaidaral. Copyright © Dennis Nona. Reproduced with permission with slight modification for reproduction in black and white.

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J . O'Shea and John E . Reynolds III

Frontmatter

[More information](#)**Conservation Biology**

This series aims to present internationally significant contributions from leading researchers in particularly active areas of conservation biology. It focuses on topics where basic theory is strong and where there are pressing problems for practical conservation. The series includes both authored and edited volumes and adopts a direct and accessible style targeted at interested undergraduates, postgraduates, researchers and university teachers.

1. *Conservation in a Changing World*, edited by Georgina Mace, Andrew Balmford and Joshua Ginsberg 0 521 63270 6 (hardcover), 0 521 63445 8 (paperback)
2. *Behaviour and Conservation*, edited by Morris Gosling and William Sutherland 0 521 66230 3 (hardcover), 0 521 66539 6 (paperback)
3. *Priorities for the Conservation of Mammalian Diversity*, edited by Abigail Entwistle and Nigel Dunstone 0 521 77279 6 (hardcover), 0 521 77536 1 (paperback)
4. *Genetics, Demography and Viability of Fragmented Populations*, edited by Andrew G. Young and Geoffrey M. Clarke 0 521 782074 (hardcover), 0 521 794218 (paperback)
5. *Carnivore Conservation*, edited by John L. Gittleman, Stephan M. Funk, David Macdonald and Robert K. Wayne 0 521 66232 X (hardcover), 0 521 66537 X (paperback)
6. *Conservation of Exploited Species*, edited by John D. Reynolds, Georgina M. Mace, Kent H. Redford and John G. Robinson 0 521 78216 3 (hardcover), 0 521 78733 5 (paperback)
7. *Conserving Bird Biodiversity*, edited by Ken Norris and Deborah J. Pain 0 521 78340 2 (hardcover), 0 521 78949 4 (paperback)
8. *Reproductive Science and Integrated Conservation*, edited by William V. Holt, Amanda R. Pickard, John C. Rodger and David E. Wildt 0 521 81215 1 (hardcover), 0 521 01110 8 (paperback)
9. *People and Wildlife, Conflict or Co-existence?*, edited by Rosie Woodroffe, Simon Thergood and Alan Rabinowitz 0 521 82505 9 (hardcover), 0 521 53203 5 (paperback)
10. *Phylogeny and Conservation*, edited by Andrew Purvis, John L. Gittleman and Thomas Brooks 0 521 82502 4 (hardcover), 0 521 53200 0 (paperback)
11. *Large Herbivore Ecology, Ecosystem Dynamics and Conservation*, edited by Kjell Danell, Roger Bergstrom, Patrick Duncan and John Pastor 0 521 83005 2 (hardcover), 0 521 53687 1 (paperback)
12. *Top Predators in Marine Ecosystems*, edited by Ian Boyd, Sarah Wanless and C. J. Camphuysen 0 521 84773 7 (hardcover), 0 521 61256 X (paperback)
13. *Coral Reef Conservation*, edited by Isabelle Côté and John Reynolds 0 521 85536 5 (hardcover), 0 521 67145 0 (paperback)
14. *Connectivity Conservation*, edited by Kevin R. Crooks and M. Sanjayan 0 521 85706 6 (hardcover), 0 521 67381 X (paperback)
15. *Zoos in the 21st Century*, edited by Alexandra Zimmermann, Matthew Hatchwell, Lesley A. Dickie and Chris West 0 521 85333 0 (hardcover) 0 521 61858 8 (paperback)
16. *Setting Conservation Targets for Managed Forest Landscapes*, edited by Marc-André Villard and Bengt Gunnar Jonsson 0 521 87709 1 (hardcover) 0 521 70072 6 (paperback)
17. *Population Genetics for Animal Conservation*, edited by Giorgio Bertorelle, Michael W. Bruford, Heidi C. Hauffe, Annapaolo Rizzoli and Cristiano Vernesi 0 521 86630 9 (hardback) 0 521 68537 5 (paperback)

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J . O'Shea and John E . Reynolds III

Frontmatter

[More information](#)

---

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J . O'Shea and John E . Reynolds III

Frontmatter

[More information](#)

# Ecology and Conservation of the Sirenia

## Dugongs and Manatees

HELENE MARSH

*James Cook University, Queensland, Australia*

THOMAS J. O'SHEA

*Glen Haven, Colorado, USA (US Geological Survey, retired)*

JOHN E. REYNOLDS III

*Mote Marine Laboratory, Florida, USA*



**CAMBRIDGE**  
UNIVERSITY PRESS

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J. O'Shea and John E. Reynolds III

Frontmatter

[More information](#)

CAMBRIDGE UNIVERSITY PRESS

Cambridge, New York, Melbourne, Madrid, Cape Town,  
Singapore, São Paulo, Delhi, Tokyo, Mexico City

Cambridge University Press

The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by Cambridge University Press, New York

[www.cambridge.org](http://www.cambridge.org)

Information on this title: [www.cambridge.org/9780521888288](http://www.cambridge.org/9780521888288)

© H. Marsh, T. J. O'Shea and J. E. Reynolds III 2011

This publication is in copyright. Subject to statutory exception  
and to the provisions of relevant collective licensing agreements,  
no reproduction of any part may take place without the written  
permission of Cambridge University Press.

First published 2012

Printed in the United Kingdom at the University Press, Cambridge

*A catalogue record for this publication is available from the British Library*

*Library of Congress Cataloging in Publication data*

Marsh, H. (Helene), 1945–

Ecology and conservation of the Sirenia : dugongs and manatees / Helene Marsh, Thomas  
J. O'Shea, John E. Reynolds III.

p. cm. – (Conservation biology)

Includes bibliographical references and index.

ISBN 978-0-521-88828-8

I. Sirenia. I. O'Shea, Thomas J. 1948– II. Reynolds, John Elliott,

1952– III. Title. IV. Series.

QL737.S6M37 2011

599.55–dc22

2011008024

ISBN 978-0-521-88828-8 Hardback

ISBN 978-0-521-71643-7 Paperback

Additional resources for this publication at [www.cambridge.org/9780521888288](http://www.cambridge.org/9780521888288)

Cambridge University Press has no responsibility for the persistence or  
accuracy of URLs for external or third-party internet websites referred to  
in this publication, and does not guarantee that any content on such  
websites is, or will remain, accurate or appropriate.

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J . O'Shea and John E . Reynolds III

Frontmatter

[More information](#)

## Contents

- Foreword* [ix]  
BY JOHN G. ROBINSON
- Preface* [xi]
- Acknowledgements* [xv]
- 1 Introduction [1]  
*Notes to Chapter 1* [12]
- 2 Steller's sea cow: discovery, biology and exploitation  
of a relict giant sirenian [13]
- 3 Affinities, origins and diversity of the Sirenia through time [35]  
*Notes to Chapter 3* [77]
- 4 Feeding biology [79]  
*Notes to Chapter 4* [143]
- 5 Behaviour and habitat use [145]
- 6 Life history, reproductive biology and population dynamics [209]
- 7 Threats [263]  
*Notes to Chapter 7* [326]
- 8 Conservation status: criteria, methods and an assessment  
of the extant species of Sirenia [327]  
*Notes to Chapter 8* [393]

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J . O'Shea and John E . Reynolds III

Frontmatter

[More information](#)

---

viii | Contents

9 Conservation opportunities [397]

*Notes to Chapter 9* [434]

*References* [435]

*List of online supplementary material* [504]

*Index* [506]

*The colour plates are situated between pages [240] and [241]*

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J . O'Shea and John E . Reynolds III

Frontmatter

[More information](#)

---

## *Foreword*

On the surface of it, it seems preposterous to confuse mermaids and sirens with a 500 kg marine mammal with a face that only another sirenian might love. But knowledge and information have their own imperatives, and the more we know, the more fascinating these creatures become, and the more we are driven to protect them.

Knowledge itself is one of the tools that we can use to do that. Despite the difficulties associated with studying manatees and dugongs – they are inhabitants of turbid water, surface unpredictably and lie quietly on the bottom for long periods – researchers have pieced together much of their basic biology. Puzzles remain, however: Why do male dugongs have tusks? Is reproductive behaviour in sirenians characterised by scramble competition among males, or might they actually form mating leks? However, a rich understanding of these creatures has emerged from careful science.

Sirenians are biologically more different than most. They are the only herbivorous mammals that are fully aquatic. Their evolutionary affinity with elephants and hyraxes is intriguing. Even with only four extant species, there is wonderful variety: the Amazonian manatee lives in freshwater rivers and lakes, while the dugong is marine. Dugongs specialise on sea-grasses, while manatees are much more eclectic. Long-term social bonds seem to be restricted to mother–offspring relations, but sirenians can gather comfortably in aggregations of hundreds.

Manatees and dugongs live in rivers, lakes and coastal areas, which brings them together with our species. Throughout history, sirenians have inspired cultural responses, provided people with meat, hides and oils, and stimulated myths and stories. But today, artisanal fisheries, direct hunting, declines in sea-grasses, recreational boating and pollution are unrelenting pressures on sirenian populations.

Knowledge is necessary for effective conservation action, and information informs action. It is not coincidence that the populations for which we have the most scientific data – Florida manatees and Australian

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J . O'Shea and John E . Reynolds III

Frontmatter

[More information](#)

---

x | Foreword

dugongs – have the strongest management programmes and are the most likely to persist. This justifies further efforts, especially research to understand the interaction with people and the effectiveness of different management regimes on wild populations. But knowledge by itself is not sufficient; governmental agencies ultimately must use that knowledge to forge policies, and people must implement the practices that will allow us to co-exist with these wonderful animals.

John G. Robinson  
Chief Conservation Officer,  
The Wildlife Conservation Society, New York

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J . O'Shea and John E . Reynolds III

Frontmatter

[More information](#)

---

## *Preface*

This book was born out of passion, frustration, excitement and hope. Readers will perceive all these emotions throughout the following pages. If the hard-won lessons recounted here lead to improved conservation of some remarkable species and their ecosystems, we will have fulfilled our aim.

We have cumulatively spent well over a century studying the various members of the Order Sirenia. Our passions include learning about and trying to conserve manatees and dugongs. The word 'unique' has lost its force through inaccuracy and over-use, but we want to reclaim its original meaning here. The sirenians possess suites of morphological, ecological and physiological adaptations that allow them, truly, to hold a unique place in the animal kingdom. Although once a more diverse group, the sirenians are limited now to only four species, albeit with remarkably wide geographic ranges (especially the dugong). Reduced in numbers through much of that range, and with myriad threats to their long-term survival, the sirenians have nonetheless demonstrated tenacity and resilience, hopeful signs that they will persist, if given a chance.

We hope that this book will stir the passion of those best placed to achieve the survival of the four sirenian species, particularly the rising generation of scholars and conservationists. We have all had the privilege of spending some of our professional lives working with research students. We are proud of the fact that these young scholars have the tools and insights to conserve sirenians and other wildlife species and their habitats.

If passion has driven us, frustration has tempered us. The world has many gifted and enthusiastic people trying to achieve a better balance between human activities and conservation of wild, living resources. All too often, human values and actions have led to the loss of wildlife species and natural ecosystems. Some species of marine mammals have become extinct at the hands of people in the past 60 years. Sadly, all of these extinctions were preventable.

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J . O'Shea and John E . Reynolds III

Frontmatter

[More information](#)

xii | Preface

Human population and consumption of natural resources expand every year. The profit motive generally trumps conservation. This situation frustrates those of us who champion the natural environment. Nonetheless, we sense a sea change in people's attitudes, prompting excitement and hope that a new generation of scientists and conservationists may reverse the trends of our own generation and achieve better preservation of wildlife and ecosystems.

This book will fail if it does not instil passion, frustration, excitement and hope for the Sirenia. However, our purpose was also to document and encourage the meticulous acquisition and use of scientific data to ensure that decisions are evidence based. Passion and hope are great motivators; but information, effective partnerships and respect for cultural differences are essential for conservation to succeed. This book is a scholarly synthesis that provides detailed, complete information and perspectives on the ecology and conservation of sirenians, and acknowledges gaps in our understanding. In reviewing the literature for the book, we were struck by the amount of new information about the Sirenia that has been published in a wide variety of outlets over the last decade. By synthesising and distilling this information we hope to help readers more effectively access the diverse primary literature.

As described in Chapter 1, the dugong is at the heart of an international political, economic, military, cultural and environmental conflict. These animals have added fuel to the controversy over the presence of a US military base on Japanese soil, in Okinawa. Indeed, as we note later, dugongs and manatees are increasingly being used as 'flagship species' to represent larger environmental causes.

Chapter 2 introduces frustration, as we describe the demise of the largest sirenian species ever; one of the largest creatures ever to inhabit our planet. The tragic loss of Steller's sea cow at the hands of Russian explorers and hunters only 27 years after its discovery by Europeans exemplifies the triumph of human greed over Nature. Sadly, Steller's sea cow is not an isolated example, as people persist in 'doing business' in a manner that jeopardises wildlife and the natural world.

Chapter 3 provides the evolutionary history of the Order Sirenia. That history is peppered with unusual beasts and considerable diversity. Many sirenian species co-existed throughout tropical and subtropical waters, but today that diversity is limited. We are concerned that factors such as human population growth, habitat deterioration, changes in fishing technology and even recreational pursuits make the accelerated extinction of the remaining

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J. O'Shea and John E. Reynolds III

Frontmatter

[More information](#)

species of sea cows more likely. Societies must develop better conservation values and people must adjust their behaviours to ensure that does not occur.

Chapters 4–6 provide a thorough review and synthesis of the scientific information about sirenian feeding and foraging; habitat use; behaviour; life history; and population dynamics. Optimal efforts to conserve species and their habitats take advantage of all that is known about the species' needs and capabilities. Our detailed review of the science of these three broad areas sets the scene for our closing chapters on threats, status and conservation opportunities.

Chapters 7–9 get to the heart of our concerns for the future of the sirenians. Chapter 7 provides an assessment of the threats to sirenian populations from environmental factors such as climate change and harmful algal blooms, and human-related factors such as habitat destruction, directed hunting and incidental fishing take. Understanding and mitigating threats are vital to conservation. Chapter 8 examines how we understand the 'status' of a species or population and addresses hard-to-study factors that would ideally be included in a status assessment, but which are often difficult or impossible to integrate because of lack of funds or logistic difficulties. We then provide details of the conservation status of sirenian populations around the world. Some populations are actually doing quite well, whereas others have been lost or greatly reduced and are likely to disappear in a matter of years.

Although Chapters 7 and 8 contain information that may discourage those who wish to promote conservation of sirenians and their environment, hope returns in Chapter 9. This chapter is titled 'Conservation Opportunities' because we believe that new approaches, new tools and new perceptions about science, values and partnerships will equip motivated people with what they need to make a difference. In part, the change has occurred because people and governments are increasingly acknowledging that traditional ways of doing science and conservation do not always work; this admission can be liberating, as it encourages people to seek novel ways of working together.

We do *not* consider that conservation has become formulaic, and that 'plugging in' particular components or steps will automatically lead to success. Nonetheless, we believe that the time is right for informed, passionate, dedicated people to prevail. We hope that the conservation opportunities we describe will be useful not only to people concerned with sirenians, but for all conservation efforts, especially in developing countries.

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J . O'Shea and John E . Reynolds III

Frontmatter

[More information](#)

---

xiv | Preface

There is much to be done to ensure that sirenians and their ecosystems are conserved. We trust that this book conveys both humility and urgency and provides a foundation for future successes.

Helene Marsh  
Tom O'Shea  
John Reynolds

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J . O'Shea and John E . Reynolds III

Frontmatter

[More information](#)

## *Acknowledgements*

This book is the outcome of many years of research, during which our families have tolerated both lengthy absences for fieldwork and many hours spent in front of computers, especially recently. Our loving thanks to our spouses (Lachlan, Sherry and Kristen) and our children (Roderick, Duncan, Mary, Jackie and Jack) for their unfailing support.

The generosity of an insistent anonymous donor with a passion for dugongs enabled us to employ Shane Blowes as an invaluable research assistant, purchase the rights to use key photographs, pay for the production of the illustrations and maps and for assistance in editing and checking, all of which were central to the success of the project. John Robinson generously and graciously found the time to write the Foreword on his study leave in Cambridge. The US Marine Mammal Commission, the Friends of the Mote Marine Laboratory Library, Marine Mammal Science and the Convention of Migratory Species' Dugong Secretariat generously assisted in getting copies of this volume into the libraries of developing countries in the ranges of dugongs and manatees.

For introducing us to dugongs and manatees early in our careers we thank: George Heinsohn and Alister Spain; Robert Brownell and Galen Rathbun; Blair Irvine and Daniel Odell. We are grateful to our numerous other colleagues, including our graduate students, for teaching us much about sirenians over many years.

James Cook University underwrote periods of study leave for Helene Marsh in 2006 (hosted by Mote Marine Laboratory in Sarasota) and 2008 (hosted by University of Melbourne, Australia). These periods provided valuable time to focus on this book.

We gratefully acknowledge the assistance of the many people who helped with the production of the book as listed below:

**Cartography:** Adella Edwards, Alana Grech, Julian Lawn, Antoine Riou.

**Colleagues:** Nicole Adimey, Lem Aragones, Cathy Beck, Bob Bonde, Peter Corkeron, Daryl Domning, Alana Grech, Ellen Hines, Amanda Hodgson, Carol Knox, Donna Kwan, Janet Lanyon, Ivan Lawler,

Cambridge University Press

978-0-521-88828-8 - Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J. O'Shea and John E. Reynolds III

Frontmatter

[More information](#)

xvi | Acknowledgements

Lynn Lefebvre, Miriam Marmontel, James Sheppard, Tony Preen,  
Katie Tripp, Jim Valade, Leslie Ward, Graham Worthy.

**Editorial assistance:** Dominic Lewis, Sharon Read, Gary Smith, Charlotte  
Thomas, Liz Tynan, Megan Waddington, Kristen Weiss.

**General assistance:** Sheri Barton, Alvaro Berg-Soto, Willie Buchholz,  
Erin Easter, Rie Hagihara, Jennifer Helseth, Allison Honaker,  
Molly Jessup, Marisa Kaminski, Milena Kim, Rachel Krause,  
Cathy Marine, Lachlan Marsh, Molly McGuire, Kim Miller,  
Lucas Nell, Kerri Scolardi, Emma Witherington

**Illustrations:** Brandon Bassett, Shane Blowes, Catherine Collier, Robert  
Donaldson, Chip Deutsch, Brett Jarrett, Rhondda Jones, Butch  
Rommel, Anneke Silver, State Library of Victoria, Gareth Wild.

**Expert review:** Eduardo Mores Arraut, Cathy Beck, David Blair, Bob  
Bonde, Greg Bossart, Vic Cockcroft, Aurélie Delisle, Daryl  
Domning, Josh Donlan, Jodie Gless, Alana Grech, Ellen Hines,  
Amanda Hodgson, Hans de Iongh, Lucy Keith, Cathy  
Langtimm, Ivan Lawler, Frank Loban, Jackie Lorne, Winifred  
Perkins, Bill Perrin, Nick Pilcher, Tony Preen, Liz Tynan, Natalie  
Stoeckl, Dipani Sutaria, Tim Ragen, Chris Wilcox.

**Personal communications:** Nicole Adimey, Ibelice Anino, Eduardo Mores  
Arraut, Sheri Barton, Brian Beatty, Cathy Beck, David Blair, Vic  
Cockcroft, Daryl Domning, Glenn Dunshea, Holly Edwards, Rie  
Hagihara, William Haller, Wayne Hartley, Lucy Keith, Jeremy  
Kiszka, Donna Kwan, Cathy Langtimm, Janet Lanyon, Frank  
Loban, Benjamin Morales, Tony Preen, James Reid, Kherson Ruiz,  
Caryn Self Sullivan, Ketan Tatu, Lindsey West, Graham Worthy.

**Photographs:** Kanjana Adulyanukosol, Anselmo d’Affonseca, Australian  
Navy, Cathy Beck, Bob Bonde, Olivier Born, Alexander Burdin, the  
late Chip Clark, Rob Coles, Tomas Diagne, Martine deWit, Mandy  
Etpison, Luc Faucompré, Florida Fish and Wildlife Conservation  
Commission, Florida Power & Light Company, Alana Grech,  
Rachel Groom, Jay Herman (NASA), Amanda Hodgson, Hendrik  
Hoeck, Indigenous Art Network, Pierre Larue, Col Limpus, Ian  
McNiven, Chris Marshall, Benjamin Morales, Miriam Marmontel,  
Len McKenzie, Cynthia Moss, Mote Marine Laboratory’s Manatee  
Research Program, Dennis Nona, Grant Pearson, Charley Potter,  
Bob Prince, Galen Rathbun, James Reid, Peter J. Stephenson,  
Andrew Taylor, US Geological Survey, Karen Willshaw.

**Project management:** Shane Blowes.

**Traditional owner permissions:** Terrence Whap.