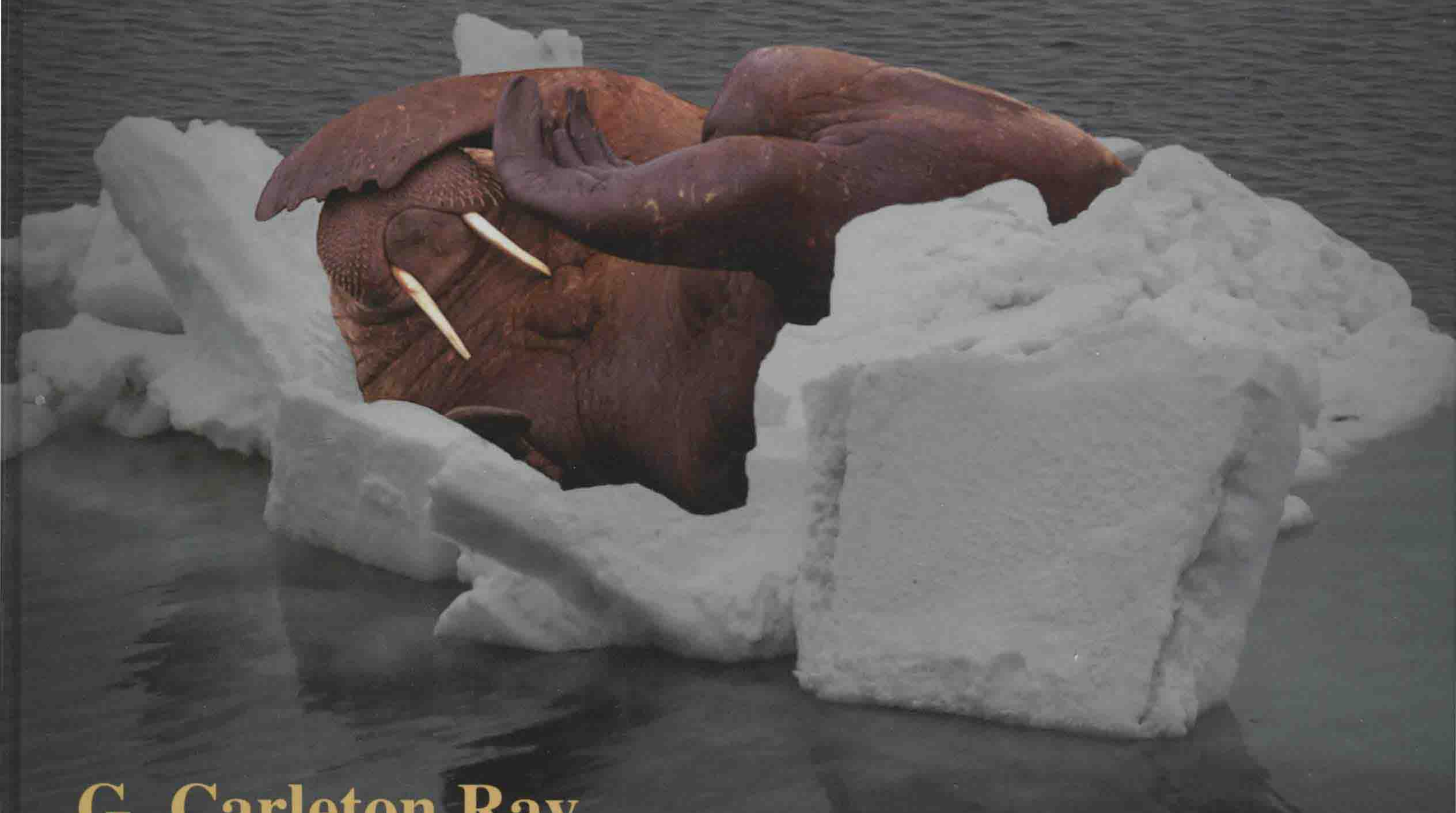
MARINE CONSERVATION

Science, Policy, and Management



G. Carleton Ray
Jerry McCormick-Ray

Illustrations by Robert L. Smith, Jr.

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MARINE CONSERVATION

SCIENCE, POLICY, AND MANAGEMENT

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WILEY Blackwell

Registered office: John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial offices: 9600 Garsington Road, Oxford, OX4 2DQ, UK
The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK
111 River Street, Hoboken, NJ 07030-5774, USA

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Library of Congress Cataloging-in-Publication Data

Ray, G. Carleton.
Marine conservation : science, policy, and management / G. Carleton Ray and Jerry McCormick-Ray.
pages cm
Includes bibliographical references and index.
ISBN 978-1-118-71444-7 (cloth) – ISBN 978-1-4051-9347-4 (pbk.) 1. Marine resources conservation–Textbooks.
I. McCormick-Ray, Jerry. II. Title.
GC1018.R39 2014
333.91'6416–dc23
2013014734

A catalogue record for this book is available from the British Library.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Set in 9/11 pt Photina by Toppan Best-set Premedia Limited
Printed and bound in Malaysia by Vivar Printing Sdn Bhd

1 2014

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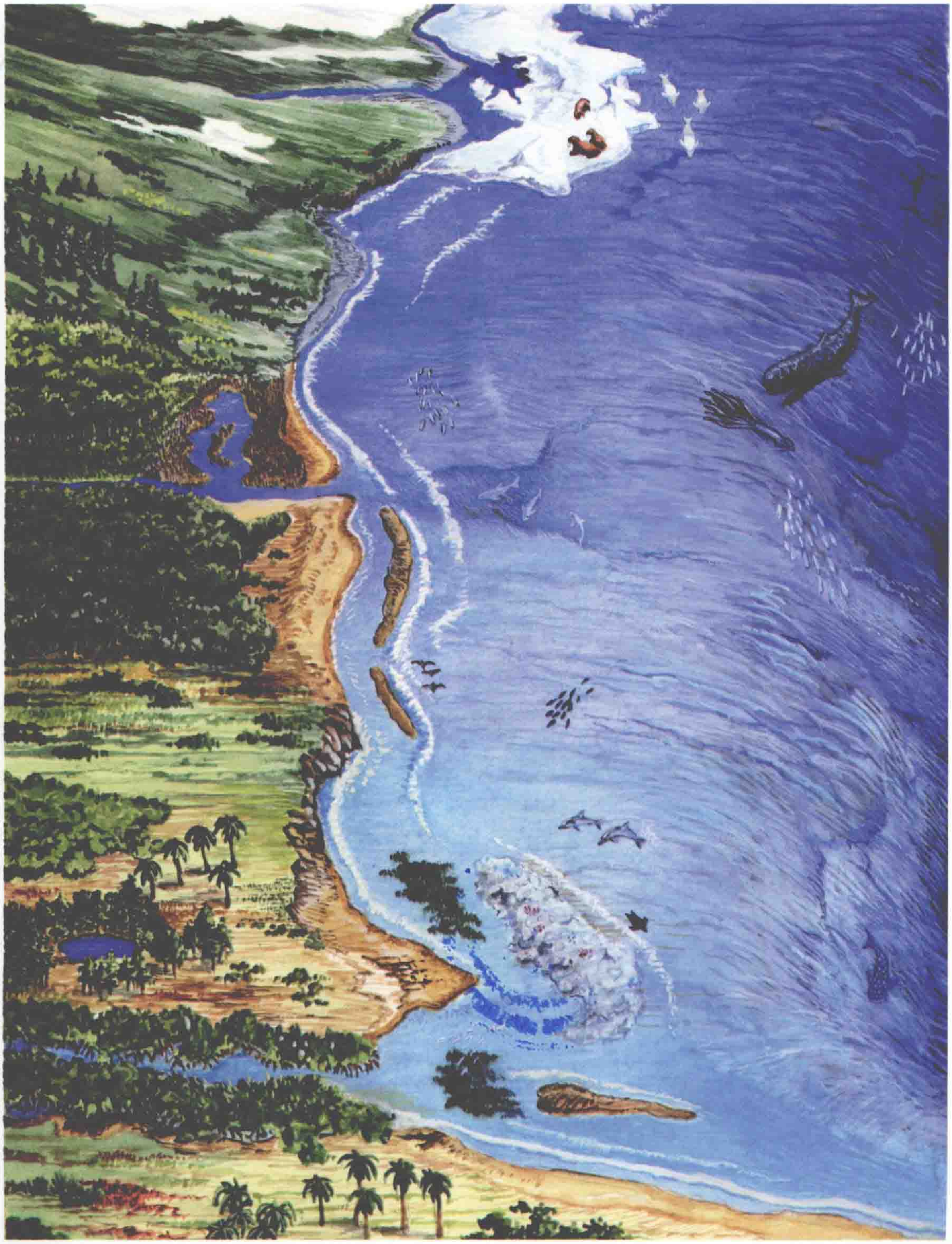

The land-sea coastal realm from the tropics to polar regions, where the majority of marine conservation issues lie. See Chapters 2 and 4 for physical and biological/ecological characterization. Illustration © Robert L. Smith, Jr.

Cover image: created in Photoshop by Robert L. Smith, Jr., from separate pictures of the walrus and the ice floe, Bering Sea. Photographs © Ray & McCormick-Ray.

To Sally Lyons Brown for her vision and support, and to Raymond F. Dasmann and F. Herbert Bormann who continue to inspire us.

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PREFACE

We are at a time in history when science allows us better to understand our global environment, and when human societies are beginning to recognize the urgency of marine conservation and the need for sustainable use of marine resources. As John A. Moore (1993) has put it: "We have reached a point in history when biological knowledge is the *sine qua non* for a viable human future . . . A critical subset of society will have to understand the nature of life, the interaction of living creatures with their environment, and the strengths and limitations of the data and procedures of science itself. The acquisition of biological knowledge, so long a luxury except for those concerned with agriculture and the health sciences, has now become a necessity for all."

During the past century, humans have acquired the ability to intrude, exploit, and better understand the last, previously unexplored portion of Earth—the contiguous global oceans. The rates and magnitude of change brought on by the Marine Revolution (Ray, 1970) followed 5–10,000 years of the Agricultural Revolution and two centuries of the Industrial Revolution, with dangers of repeating errors of the past. Observation of the quickening pace of change and the way that humans behave and manage themselves, and increasing knowledge of the way marine ecosystems function have made apparent major ecosystem instabilities and management incongruences. Approaches deemed feasible when marine conservation was emerging only a half-century ago no longer fulfill needs of the 21st century. That the world has become "hot, flat, and crowded" (Friedman, 2008) makes clear the need for new marine conservation approaches.

Our previous book, *Coastal-Marine Conservation: Science and Policy* (Blackwell Science, 2004) called attention to the fundamental role natural history and ecosystem-based science play in conservation policy and management planning. That is, conservation must be informed by the natural histories of organisms *together with* the hierarchy of scale-related linkages and ecosystem processes. This book continues that focus on a whole-systems approach to marine conservation, taking account of major advances in marine ecosystem understanding to guide marine conservation practice. Our objective is to expose students and other readers to the broad range of overlapping issues (Chapter 2) in the context of present conservation mechanisms that have been devised to achieve marine conservation goals (Chapter 3). Achieving these goals depends on understanding basic marine ecosystem science (Chapter 4) and the natural histories of marine organisms (Chapter 5), that is, how organisms make a living in dynamic and often stressful environments. In that process, we call attention to emergent and unexpected properties that are changing coastal and marine systems—climate change, ocean acidification, dead zones, and loss of biodiversity—that challenge the resilience of coast-ocean systems, hence also governance and human well-being. We present seven "real-world" case studies that exemplify coastal and marine conservation in action, each presenting a central issue or issues in the context of its biogeographic and social setting. Each combines theoretical ("pure") and applied science, and each concludes with challenges to governance that are not yet fully resolved.

A final synthesis chapter looks to the future, to transition coastal and marine conservation from the *being* of traditional, fragmented, protection, and management to the *becoming* of ecosystem-based approaches, intertwined in a social-ecological system, that propel marine biodiversity and society into the future. Overall, this book is an attempt to provide a framework for thoughtful, critical thinking in order to incite innovation in the new Anthropocene Era of the 21st century.

References, scientific terms, Latin names, and units. This book provides readers with a window into a massive literature on conservation science, policy, and management as a context for understanding the present state of knowledge of marine ecosystems, their life, and their current conservation and management. The language of science is enormous and similar terms often have different, even contradictory, meanings among disciplines. We have attempted to explain these terms by defining some of them in the text. We do not include a glossary, as definitions can be accessed in science dictionaries or through search engines on the Internet. We use the International System of Units (SI units) and metric measurements (e.g., m = meters, mt = tonnes, km = kilometers, nmi = nautical miles, etc.) throughout the text.

Species are referred to by their vernacular ("common") names (blue crab, herring, porpoise, etc.) with Latin names for proper identification. Care must be taken with vernacular names because for the great majority of species these names are not standardized (mammals, birds, and some fishes are notable exceptions). For example, "cod" is a common name for a valuable Atlantic fish of the cod family (Gadidae), but "cod" in Australia refers to groupers of the sea bass family (Serranidae), and for some species of the Southern Ocean "cod" refers to ice fishes of the family Nototheniidae; similarly, "rockfish" may refer to a number of fishes from a half dozen families of fishes; and, the "Dover sole" of the north eastern Pacific is not the highly valued Dover sole of the eastern Atlantic. Therefore, scientific names are essential for identification, and are given with the vernacular the first time the species is mentioned in each chapter, or if far separated.

Acknowledgements and permissions. We first wish to thank the Curtis and Edith Munson Foundation and The Henry Foundation of Washington, D.C., for generous support for the writing and publication of this book in full color, as well as other donors to the University of Virginia Global Biodiversity Fund. We remain deeply grateful to the late Sally Lyons Brown and the W. L. Lyons Brown Foundation for encouragement and support of the 2004 edition, without which the writing of the present book would have been far more arduous.

We especially wish to thank all co-authors and contributors of boxes for volunteering their time and expertise and for their patience during the four-year preparation of this book; these persons are identified accompanying their contributions, and their affiliations are given under Collaborating Authors following this Preface. Acknowledgements to persons and publications who provided photographs and figures are given as those materials appear. Chapters that list no authors, and photographs acknowledged as "the authors" are ours.

We are especially indebted to persons who have influenced our thinking during past decades: Frederick B. Bang, Raymond F. Dasmann, Francis H. Fay, J. Frederick Grassle, Starker Leopold, John A. Moore, Kenneth S. Norris, John C. Ogden, Fairfield Osborn, C. Richard Robins, William E. Schevill, William A. Watkins, and Sir Peter Scott. Others have been especially helpful by providing information specific to individual chapters: David Argument, Pat Bartier, Peter Berg, Charles Birkeland, Peter Boveng, Michael Braynen, Michael Cameron, Eric Carey, Mark H. Carr, Roger Covey, Jon Day, Terri Dionne, Catlyn Epners, D. Fedje, Lynn Gape, Robert Ginsburg, E. Gladstone, Samuel H. Gruber, Bruce P. Hayden, William J. Hargis, Nick Irving, Paula Jasinski, Victor S. Kennedy, Bjorn Kjerfve, Casuarina Lambert McKinney, Jeffrey Lape, Ian G. Macintyre, Dennis Madsen, Karen McGlathery, Pericles Maillis, John D. Milliman, Mary Morris, Roger Newell, Rick Parish, David Pollard, Cliff Robinson, Yvonne Sadovy, Rodney V. Salm, Neil E. Sealey, Kenneth Sherman, Herman H. Shugart, Richard Starke, Ann Swanson, Brent and Robin Symonette, Hillary Thorpe, Brian Walker, Douglas Wartzok, Maire Warwick, and Pat Wiberg. Mark Hixon, Mark Albins, and Mark Christie acknowledge support from the U. S. National Science Foundation for their research on reef-fish larval connectivity, as reviewed in Chapter 5 (grants OCE-00-93976 and OCE-05-50709), and the lionfish invasion in Chapter 6 (grants OCE-08-51162, OCE-12-33027, and a Graduate Research Fellowship). Norm Sloan (Ch. 10) also expresses thanks to those who contributed to the 2006 technical overview of Gwaii Haanas Marine: Pat Bartier, John Broadhead, Lyle Dick, Catlyn Epners, Daryl Fedje, Debby Gardiner, John Harper, Anna-Maria Husband, Greg Martin, Mary Morris, Trevor Orchard, Marlow Pellatt, Cliff Robinson, Ian Sumpter, and Ian Walker. Finally, we thank students who have taken our marine conservation courses at the University of Virginia for their often-insightful comments.

We also wish to thank the authors, illustrators, journals, and publishers who have given permission to use their work, as noted in captions to figures and tables.

We are grateful for the encouragement of funding organizations and agencies for which we have been granted support or have served an advisory or consultancy role, most particularly: ICSU (International Council for Science), IUCN (International Union for the Conservation of Nature and National Resources), NASA (National Aeronautics and Space Administration), National Geographic Society, National Oceanic and Atmospheric Administration, National Science Foundation, New York Aquarium (Wildlife Conservation Society), Office of Naval Research, UNESCO, U.S. Man and the Biosphere Program, Bahamas National Trust, U.S. Marine Mammal Commission, and U.S. National Park Service.

We are indebted to Ward Cooper, Izzy Canning, Kelvin Matthews, Delia Sandford, Carys Williams, Kenneth Chow and Audrie Tan of Wiley Blackwell for their efficiency and positive encouragement, as well as Ian Sherman and his co-workers who worked with us on the 2004 edition, without whom this new edition would not have been possible. We finally wish to thank Ruth Swan, project manager for Toppan Best-set, and Mark Ackerley, freelance copyeditor, for their diligent and thorough proofing, and freelancer Elizabeth Paul for her arduous permission seeking.

G. Carleton Ray and Jerry McCormick-Ray

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ABOUT THE COMPANION WEBSITE

This book is accompanied by a companion website:

www.wiley.com/go/ray/marineconservation

The website includes:
- Powerpoints of all figures from the book for downloading
- PDFs of tables from the book

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CHAPTER 1

IN PURSUIT OF MARINE CONSERVATION

There is a tide in the affairs of men
Which, when taken at the flood, leads on to fortune . . .
On such a full sea are we now afloat;
And we must take the current when it serves
Or lose our ventures.

William Shakespeare *Julius Caesar*

Open-ocean systems may seem not to be so disturbed at their surface, but signs of ecological disruption are apparent. The lone walrus on our cover is a metaphor for Planet Earth's fragmented habitats, disrupted ecosystems, and diminished biodiversity. As oceans change, tropical reefs die, polar regions lose sea ice, and marine life that we hardly know is increasingly becoming vulnerable to extinction. Nowhere is this change more apparent than in the land-sea coastal realm (Frontispiece), where the majority of humanity lives, ecosystems are most productive, and biodiversity is greatest.

During the rise of human civilizations, societies have inherited the economics of resource exploitation from an ocean perceived as "limitless." Fisheries, shipping, and coastal settlement as old as civilization, have increasingly expanded to force conservation into defense of species and spaces. And as the ecosystems upon which species depend have changed, scientists have become increasingly involved. Modern science, which had moved from studies in natural history to environmental modeling and statistics to better understand marine systems, is returning to natural history, recognizing that it forms the basis for environmental and evolutionary science itself (Box 1.1). The advancing state of knowledge and the increasing need for sustainable ecosystems are forcing marine conservation science to become more proactive and to expand its scope to encompass whole regional seas. Recognition of depleted fisheries, coastal catastrophes, and consequences of natural events tied to human activities have led to new ways of thinking about how marine conservation may modify society's relentless pursuit of ocean wealth.

The past decades' tendency to compartmentalize marine conservation issues has changed. Marine conservation is now forced to embrace the totality of issues together, because the oceans are interconnected, dynamic, and complex. Knowing how marine life makes a living is fundamental in the vast, bioenergetic marine environment undergoing continual change. And the dynamic features of the global ocean and of the coastal realm make the pursuit of marine conservation different from that for the land.

1.1 THE EMERGENCE OF MODERN MARINE CONSERVATION

Modern marine conservation arose after World War II when the oceans took on greater political, economic, and social importance. The oceans became viewed as a "supplier" to meet expanding human wants for food, resources, and wealth. Humans rapidly began to acquire the ability to explore and exploit this last, previously unavailable portion of Earth—the oceans—to fish and seek petroleum and minerals facilitated by new technology that allowed humans to invade, and also better to understand the oceans to their utmost depths. We call this era of emerging ocean importance the "Marine Revolution" (Ray, 1970). It followed the Industrial Revolution of about two centuries before, which had expanded the human footprint with the invention of the steam engine, electric power, industrialization, and urbanization. And the Industrial Revolution followed the Agricultural Revolution, circa 10,000 to 5000 BP, that transformed landscapes into patches of farmland on such massive scales as to alter Earth processes, including climate (Ruddiman, 2005). Each successive revolution promoted human well-being and population growth as it also depleted natural resources, and as land resources became depleted and consumption grew, societies looked to the oceans for food, energy, and economic benefits. Today, human activities are globally pervasive, marked by resource shortages and the need to conserve what remains in the new age of the Anthropocene (Crutzen and Stoermer, 2000; Steffen *et al.*, 2007).

The economic value that humans place on coastal and marine systems and their workings no doubt arose during the earliest of human cultures. The need for conservation that scientists and writers called attention to focused on overexploited commercial species as early as the 18th and 19th centuries with the squandering of Steller sea cows, fur seals, and others. George Perkins Marsh's *Man and Nature* (1864) was first to link culture with nature, science with society, and landscape with history, and spearheaded nature conservation by leading to forest conservation and establishment of the first

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Box 1.1 The importance of studying nature outdoors

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> The most basic rules of the world—the ones we all live by—are ecological rules. You can't study them or even perceive them very well in a classroom or laboratory. It is imperative to go out on the mountainside, watch the rain fall over a valley, dig into the earth beneath a fallen tree, or wade a creek for cobbles with sources upstream. The best work in the natural disciplines all starts with observations in nature.
>
> Kenneth S. Norris, in Dayton (2008)

Ken Norris wrote this, in late 1960, making a pitch to the University of California Regents to create a natural reserve system. He was successful and the UC Natural Reserve System has grown into the best such system in the world. But to what avail are patches of nature if people do not immerse themselves in those natural systems?

In the past few decades the powerful tools of molecular biology and capacity of modern computers have joined with technical advances that allow us to monitor and analyze the world around us with unprecedented precision. These new and powerful tools have seduced would-be ecologists into the comfortable idea that they can do good ecology in the laboratory or at a computer terminal without bothering to actually study nature. Indeed, the tools are so complicated that there has been strong selection for ecologists to become increasingly specialized with a laser-like focus. We have thus deprived ourselves of a sense of place of nature that comes from personal experiences, smelling, feeling, and seeing important if episodic relationships. Many ecologists and especially universities have lost respect for the broad view of nature, the understanding of the components and processes of the whole natural world or "natural history" of the systems we study. These specialists fail to perceive the critical relationships and ecosystem workings that their powerful machines were not designed to study. Deprived of personal experience in nature, many forget natural history and accept habitats and systems that are a pale shadow of their former selves and substitute simplistic models for understanding of nature.

Here we are concerned with the conservation of these habitats. We understand that we are reducing populations and losing species, and we are disrupting the important relationships that define our ecosystems. As populations decline, the relationships that define the ecosystems are lost long before the species go extinct, and it is precisely these relationships that we most need to protect. The damage to these relationships and ecosystems is often so persuasive that it may be impossible to understand what has been lost because generations of biologists have reduced expectations of what is natural. This sliding baseline of reality is exacerbated by the lack of personal experience in nature. Without a deep understanding of the history of their systems, ecologists can be beguiled by short-term events or introduced, inappropriate imposters that replace and mask the traces of the natural systems we hope to study and protect. The natural relationships simply disappear, leaving no conspicuous evidence of what has been lost. This loss is paralleled by the loss of human cultures and languages with the passing of elders; we, too, have lost the ecological cultural wisdom of the ages as well as the evolutionary wisdom found in intact ecosystems.

Conservation biologists face extremely difficult problems much more complex than most realize. For example, we need to understand ecosystem stability, recoverability, and resilience. How do we define stability, and what processes maintain it? What spatial and temporal scales are optimal for the analyses of trends? How do we define ecosystem stress? How can we understand when "natural" disturbances ratchet into new "stable states" that resist recovery? What relationships are most critical, what processes define strong and weak interactions, and how do we evaluate the most critical interactions? How do we define multispecies relationships important to ecosystem resilience? Can we predict thresholds in these relationships?

Sustainable ecosystem-based management is an ecological mantra, but how does "single-species management" morph into ecosystem-based management? What do we need to protect and how can we prioritize the relationships? People perturb all ecosystems, but how do we evaluate cumulative effects and understand how much is too much? That is, all ecological relationships have thresholds defined in the context of ongoing natural interactions, but which thresholds are most critical and how do we measure them?

The above questions focus on difficult science that cannot be done without a very deep sense of place that only comes from intimate familiarity with the natural world. But consider also the great importance of social values in addition to the natural sciences. The scientific focus is on important relationships critical for management, but how do we evaluate the value of species? Do we also need to protect weak interactions? Ecologists lose credibility when they claim that every species and interaction is critical to the ecosystem, because this assertion simply is not true. Most systems are comprised of many populations that can be altered without much ecosystem effect. There are many rare and very obscure species with no discernible interactions, and there are charismatic species such as pandas or leatherback sea turtles with roles that are hard to evaluate. Thus, we are asked whether some species are expendable, and we must learn to shift seamlessly from our scientific value systems to cultural value systems