ONE

# Managing Human Legacies in a Changing Sea

## An Introduction

JOHN N. KITTINGER, LOUISE K. BLIGHT,
KERYN B. GEDAN, and LOREN MCCLENACHAN

In 1938, Howard Granville Sharpe was working on his small ranch, 13 miles south of Carmel on the Big Sur coast in California, when he spied something strange in the kelp beds offshore. A longtime native of the area, Mr. Sharpe was no stranger to the Big Sur coast, yet he and his ranch hands were perplexed to find a group of sleek animals lazing around the kelp beds offshore of Bixby Creek. Two days later, he drove north to Stanford University's Hopkins Marine Station, where he was politely rebuffed after reporting to the marine scientists there that he had discovered a species of sea otter. Entreaties to the local press and scientists at the California Fish and Game Commission were met with similar amusement and skepticism.

A few days later, Fish and Game officials agreed to travel south to Sharpe's Rainbow Headlands ranch, where they were amazed to find the first family of sea otters observed in nearly a century in California. Professor Harold Heath from the Hopkins Marine Station later remarked, "Had you reported dinosaurs or ichthyosaurs running down your canyon, swimming about, we couldn't have been more utterly dumbfounded" (Sharpe 1989).

With this observation, a new chapter of natural history was written on the California coast. Sea otters had occasionally been observed since the late 1800s but were widely believed to be regionally extinct after 200 years of hunting for the lucrative fur industry. Within a few decades of their rediscovery, however, otter populations spread northward up the coast, repopulating their previous range.

The recovery of otters was not met with universal enthusiasm. In an early case of shifted baselines, sea otters were viewed as a new arrival by coastal California residents whose perspectives of the coast were formed over a shorter period of time than the otters' history of

decline and recovery (see Box 2.1 by Jim Estes, in chapter 2). Urchin and abalone fishermen viewed the animals as competitors, which led to conflicts between otter-friendly coastal residents and those who viewed the species as a threat to their livelihood (Cicin-Sain et al. 1982). However, their return also heralded the regrowth of kelp forests, as dense aggregations of kelp-eating urchins fed the otters' voracious appetites. Protection and active management fostered growth of both otter populations and kelp forests, ecosystems that today support a diversity of species and provide social benefits in the form of fisheries and tourism. Indeed, the iconic kelp forests now common along northern California shores can be almost entirely attributed to the recovery of otters (Estes and Palmisano 1974).

This story of the return of the sea otter mirrors other emerging stories of recovery in marine environments around the globe (Figure 1.1). In the Pacific Ocean, egg and feather hunters reduced the short-tailed albatross to near extinction by the early twentieth century, with an estimated 5 million birds taken from one colony alone. As with sea otters in California, it was thought that the species had been eradicated until a small breeding colony of about 10 birds was discovered on the Japanese island of Torishima in 1951. Because albatrosses spend the first several years of their life at sea, these few individuals had escaped the final depredations of the feather hunters and formed the core of a population that continues to grow to this day. Other examples of recovery include the striped bass along the east coast of the United States, which demonstrates that the effects of overfishing can be reversed. In some cases, human actions have aided recovery; for example, coastal marshes, which are fundamental to estuarine ecosystems and were badly abused in centuries past, are now the focus of intensive restoration efforts, revealing the value that society has begun to place on the important functions and benefits these systems convey. Across the Pacific, the renaissance of traditional management systems based on historical practices has increased the biomass of target reef fish populations and provided social benefits to the communities that rely on these fisheries resources.

If there are universal lessons to be learned in these recovery stories, they are that the seeds of recovery and resilience can be found in surprising places and that *we have choices about the future of the oceans*. The lessons embedded in these historical recoveries also empower our generation of conservation scientists and ocean enthusiasts with the means (and perhaps the responsibility) to create an alternative future—one with healthy ocean ecosystems and resilient coastal communities. As Peter Sale writes in Box 1.1, nature is indifferent to the path we choose to take, but people care deeply about the state of nature; the abundance of marine species and the services provided by intact ecosystems greatly affect our quality of life and, indeed, our long-term survival.

These examples also teach us that history matters. There have been great losses in the global oceans, but as societies change the way they interact with marine ecosystems, so too do we change the environmental outcomes of these interactions. Species that were former targets of hunters and fishers have gained protection. Habitats that were once dredged and filled have become recognized for their role in coastal defense and fisheries production. Historical information sources that were once ignored have gained new life as data sources to

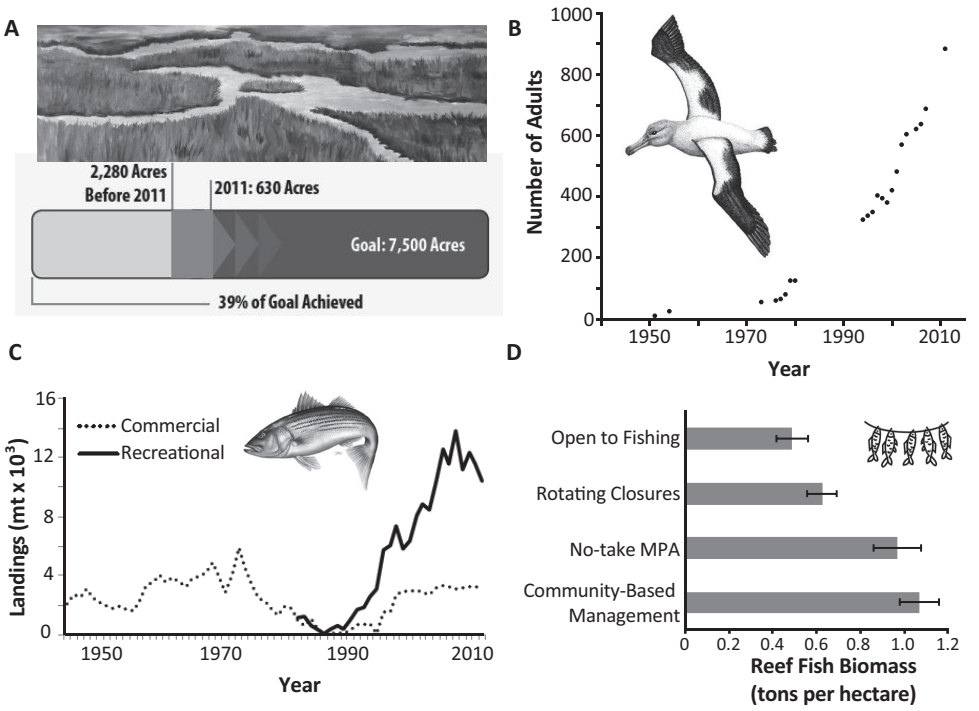


FIGURE 1.1 Four emerging stories of recovery in marine environments around the globe. (A) Progress toward salt pond restoration in San Francisco's South Bay (from South Bay Salt Pond Restoration Project Annual Report 2012). (B) Counts of breeding short-tailed albatross at Torishima Island, Japan, 1951–2011, following rediscovery (figure based on unpublished data from H. Hasegawa, Toho University, Japan; U.S. Fish and Wildlife Service 2008, Agreement on the Conservation of Albatrosses and Petrels 2009). (C) Increased striped bass landings demonstrate population recovery along the U.S. Atlantic coast (from Atlantic States Marine Fisheries Commission 2014). (D) Fish biomass under community-based management is not statistically different ($P > 0.05$) from no-take marine protected areas (MPAs) and is more effective than open-access areas and zones managed with rotating annual closures (partial protection) (data from Friedlander et al. 2013; based on 1,344 surveys at 143 locations: open to fishing, $n = 94$; no-take MPA, $n = 9$; community-based, $n = 18$; partial protection, $n = 22$).

understand baselines and make well-informed conservation decisions. Active management of species and habitats has certainly not always guaranteed recovery, but increasing attention to the historical dynamics of decline and recovery continues to reveal how we can use the past to better manage for the future.

In this volume, we define marine historical ecology broadly as the study of past human–environmental interactions in coastal and marine ecosystems and the ecological and social outcomes associated with these interactions. Marine historical ecology developed out of the growing realization that humans have altered marine ecosystems over very long time scales, and that historical data often are needed to understand the true magnitude of human-induced

## BOX 1.1 Viewpoint: Coral Reefs, Conservation, and Historical Ecology

Peter F. Sale

Ecologists who study coral reefs should be predisposed to the importance of history because they study a built ecosystem, one entirely assembled by its resident species as they build their skeletons from basic chemical building blocks. That reef ecologists mingle with reef geologists should aid this predisposition because geologists are far more aware of deep time than are ecologists. We should have been predisposed, but in the early days we mostly did not think of history at all. Coral reef ecology is very young, only beginning in the 1950s. At that time, the ecological paradigm was that enough time had usually passed to ensure that ecosystems were at or near an equilibrium state and, therefore, that history did not matter. I know I began my PhD research in the mid-1960s confident in my knowledge of the evolutionary history of coral reefs, but I did not view reef ecology from a historical perspective. Reefs were the way they were, and my job was to figure out how these amazing ecosystems functioned now. My colleagues mostly thought the same way. Within a decade, strongly influenced by that giant, Joseph H. Connell, who approached the challenges of both reef and rainforest by monitoring individual organisms' struggles to survive, grow, and reproduce over many years, I was using the monitoring of individual assemblages of reef fishes over as much as a 10-year span, as a major tool in my efforts to understand coral reefs.

Ten years is a very short time in the life of a coral reef, and long-term monitoring studies are difficult to sustain, but one learns that each year can be different (even in the tropics), and there are other ways to extend knowledge into the past. However, the recent history of coral reefs can be depressing. Long before we started to learn about their ecology, coral reefs were being degraded by human activities, first in some places, then in more, and now, through our releases of $CO_2$, throughout the tropics. If we do not alter our behavior significantly, the reefs I knew in the 1960s will have disappeared completely by midcentury. Most students today study human impacts on reefs, something my generation did not think about, yet I worry that they still do not always appreciate the extent and speed of historical change.

Conservation science is a challenging field, with immense, unspoken value judgments. Nature does not care if a coral reef becomes an algae-covered bench; it is people who care, and conservation science struggles to make this caring suitably objective, focusing on loss of ecosystem goods and services or loss of ecological function. We also seem to have decided that sustainable use must be compatible with ecosystem sustainability and with the economic, cultural, and societal success of people who do the using, because we want it to be so. In fact, historical ecology seems to be telling us that humans, in any numbers at all, making any substantial use of coral reefs, routinely overharvest fisheries and cause substantial destruction to the reefs themselves. And yet, history also sometimes reveals success stories where reefs are managed sustainably over long periods of time. These are the stories which give hope for a future, changed but still livable, and with a few coral reefs still present.

Peter F. Sale is Assistant Director at United Nations University, Institute for Water, Environment and Health. He is also University Professor Emeritus at University of Windsor.

changes. People working in marine historical ecology (and the authors who contributed to this book) come from a variety of fields, including marine biology, fisheries science, archaeology, geography, history, and more. These researchers also use information from diverse sources. Shell middens, oral histories, climate records, log books, restaurant menus, and handwritten letters in dusty museum basements all have had stories to tell about human–ocean relationships. Some marine historical studies stretch back a few decades, while others span millennia or longer (Box 1.2). All research in this area has a common goal of establishing a deeper understanding of how human societies have affected marine ecosystems through time.

While ecologists and biologists were instrumental in first describing many of the long-term anthropogenic changes to marine ecosystems, marine historical ecology has become increasingly more interdisciplinary in scope, and it will require an even greater collaborative effort to apply these findings to conservation and management. The interdisciplinary nature of this field has attracted numerous researchers and fostered cross-disciplinary collaborations, leading to more integrative approaches. For example, in the Gulf of Maine, fisheries scientists worked together with historians to estimate cod abundances in the 1850s (Rosenberg et al. 2005). In Hawaii, geographers, ecologists, and archaeologists collaborated to reconstruct the history of coral reef ecosystems and identify key social drivers associated with these changes (Kittinger et al. 2011). And a panel at the 2011 International Marine Conservation Congress brought together marine biologists, fisheries scientists, archaeologists, geographers, and others to explore ways in which history can help shape the management of marine ecosystems, launching this collaboration and edited volume. These multidisciplinary collaborations are increasingly common because they embody the potential for innovative ways of understanding long-term change, but also because interdisciplinary analyses can reframe these problems in new ways and offer new solutions to restore degraded ocean ecosystems and rebuild depleted resources.

Fueled by recognition of innovative scholarship and increased engagement by researchers and institutions, the past few decades have seen tremendous growth in this field. Marine historical ecology research now spans a growing variety of disciplines and has been published in the highest-impact scientific journals. In the past decade, scholars have also developed major initiatives in historical ecology that have significantly advanced the field, including the History of Marine Animal Populations (HMAP) project in the Census of Marine Life, the Integrated History and Future of People on Earth (IHOPE) project, and a series of working groups organized by Jeremy Jackson and others at the National Center for Ecological Analysis and Synthesis. Large-scale regional initiatives have also been developed, such as the San Francisco Estuary Institute's historical ecology project and the Mannahatta project in New York. This growth in the field demonstrates broad appeal, due in part to recognition that despite the limitations of historical data, discounting the long-term perspectives they provide can lead to inappropriate conservation actions and unintended negative consequences for ocean environments and coastal communities.

Increased interest in marine historical ecology in the research community corresponds with increased attention from the general public. Findings from marine historical ecology

BOX 1.2 Viewpoint: Why History Matters

Geerat J. Vermeij

In this age when change is so rapid that most of us have detected it in our lifetimes, it is tempting to think that no amount of historical understanding can help illuminate Earth's current unique transformation. Confronted with the reality that our own species dominates the biosphere as no species before us has ever done, most conservationists and policymakers have sought to comprehend and manage our relations with the rest of the living world by considering only the present and the immediate future. If history enters the picture at all (Willis and Birks 2006), it is limited to the postglacial period, when humans were already affecting our planet's climate and biota. With this short-term perspective, the primary application of history is to recreate ecosystems that existed before the advent of human hegemony.

Just as the history of civilization can inform present-day human affairs, so the history of life as chronicled by fossils offers us a long time scale as we grapple with the crisis of our planet-wide ecological monopoly (Vermeij and Leigh 2011). The Earth has withstood catastrophes and periods of rapid change before, and our deepening understanding of the circumstances of life in the past and of mechanisms of evolution not only expands insights into how the modern biosphere works, but often alters conceptions that were founded only on the world as it is today.

Ecologists were not alone in being slow to recognize this potential. For centuries, paleontology was a descriptive science, whose practitioners were content to name species, infer evolutionary lines of descent, and, beginning in the 1950s, describe the composition of ancient communities. It was not until the 1970s that these accounts were complemented by a more analytical approach, in which processes and interactions affecting living systems were traced back to the distant past. It soon became clear that the types and intensities of competition, consumption, production, extinction, nutrient cycling, mutualistic association, species movements, and the regulation of atmospheric and oceanic chemistry have changed dramatically over time, in accordance with previously underappreciated evolutionary innovations set against a backdrop of ceaseless mountain building, erosion, and tectonic rearrangements of land masses.

projects continue to gain a strong following at national and global scales. Nonfiction works in marine historical ecology have become popular books—for example, Jared Diamond's *Collapse,* Mark Kurlansky's *Cod,* Callum Roberts's *The Unnatural History of the Sea,* and James MacKinnon's *The Once and Future World*)—and environmental reporting and journalism has turned its attention to historical topics (Weiss et al. 2006). Marine education and outreach programs have also started including historical content, such as the Sant Ocean Hall at the Smithsonian Institution in Washington, D.C., which features an exhibit on long-term changes to marine fish populations, and the U.S. National Marine Sanctuaries Program, which has brought historical ecology into its programmatic goals. Collectively, these examples point to a broad public interest in the ocean's past and what it can tell us about current challenges in environmental sustainability.

How can this knowledge help all of us who seek to protect Earth's living resources? The fossil record offers the only long-term insights about how ecosystems recover and reassemble after great crises, what are the enduring effects of warming and ocean acidification, what happens when species from different parts of the world come together, how ecosystems create and accommodate tipping points in composition and organization, how natural systems have resolved tragedies of the commons that stem from the inner workings of the system itself, and how the biosphere's chemical environment is affected by innovations and disruptions. It documents economic trends in life's history, which strikingly parallel developments in our own short history (Vermeij and Leigh 2011). Knowledge of the past reminds us that the courses of evolution and the history of ecosystems exhibit predictable properties, all of which indicate the universality of change. Whatever equilibrium is achievable in the short run, it is upended by evolution from within and by disruptions that emanate from outside the realm of organisms. New species and ecosystems complement or supplant older ones, novel ecological relationships and criteria for natural selection become established, and systems collapse and recover, all thanks to adaptation or its absence.

And adaptation is, of course, the key to coping with change. The ability of living things to respond to and cause change in ways that benefit them is central to the persistence and evolution of life on Earth. It is this capacity to adapt that human dominance has all but eliminated from most species. History teaches that providing species everywhere with the resources, space, and time to adapt is the single most important condition for maintaining a viable, productive, and responsive biosphere.

The American historian Gordon Wood (2008:14) cautioned that "history tends to inculcate skepticism about our ability to manipulate and control purposefully our destinies." In the present context of our stranglehold over the world's ecosystems, it may be better to enable millions of species to adapt to change than to manage the world's affairs all on our own.

Geerat J. Vermeij is Distinguished Professor in the Department of Geology, University of California, Davis.

## FOUR CRITICAL CHALLENGES IN MARINE CONSERVATION

Marine historical ecology is increasingly oriented toward real-world applications, and researchers and practitioners are exploring tangible policy, management, and conservation strategies based on knowledge of the past. At the same time, marine conservation programs and practitioners worldwide struggle to meet the immense challenges of safeguarding biological diversity and maintaining the ecosystem services upon which society depends.

In this book, we focus on four key challenges that confront marine conservation: (1) recovering endangered species, (2) conserving fisheries, (3) restoring ecosystems, and (4) engaging the public. These four distinct areas represent specific challenges and opportunities, where marine historical ecology is distinctly poised to help address the implementation gap—or the

distance between conservation and policy actions and desired social and environmental outcomes. By providing real-world examples of applied approaches, as well as options for potential use and application, each of these sections advances concepts and tools that can be implemented in management and policy. Taken together, the sections offer a blueprint for using marine historical ecology to confront the challenges of ocean conservation in a rapidly changing world.

### Recovering Endangered Species

Endangered species protection and recovery has always been a central part of modern efforts to conserve and manage nature, in terms of public perception, science, and on-the-ground action. Similarly, estimating historical baselines for endangered species has long been a focus of marine historical ecology. These efforts have demonstrated that human exploitation has reduced the population abundance of many large marine animals over long time scales and has compromised the role of top predators and keystone species in ocean ecosystems. Some species, such as the great auk and Steller's sea cow, are now gone forever, while others, such as the northern elephant seal, have dramatically recovered from near extinction. The fate of some species, such as certain whales, still hangs in the balance. In this section, authors examine ways in which historical ecological research can contribute to modern efforts to recover marine species, many of which have endured centuries of exploitation. These authors go beyond documenting decline and show how historical reconstructions can help set realistic recovery targets, highlighting actions that have aided species in need of protection, or even helped turn endangered species back from the brink of extinction.

### Conserving Fisheries

Fisheries worldwide face critical challenges in sustainability, and marine historical ecology has played an important role in defining the extent of changes in fish populations worldwide. Daniel Pauly's now famous concept of "shifting baselines" was first conceived in the context of fisheries, and since that time considerable historical evidence has helped define the current status of, and trends in, fisheries. Fisheries sustainability, however, means moving beyond quantifying impacts and scales of loss and toward developing a portfolio of potential solutions. In this section, authors advance novel ways to apply historical data to the challenge of managing fisheries and describe a series of cases where these nonconventional datasets and approaches are resulting in real-world successes. For example, coastal and island communities are integrating historically based management practices into place-based resource stewardship efforts, preserving fish populations and ensuring ecological benefits from marine ecosystems. Additionally, stock assessment practices, which are difficult in data-poor fisheries contexts across the globe, are being modified to include historical data, providing more accurate baselines of fish populations and historically based recovery targets. These examples and others in this section point to a broad range of applied roles for marine historical ecology in fisheries conservation and management.

### Restoring Ecosystems

Restoring ecosystems to a healthy and resilient state is a fundamental goal of marine conservation, and marine historical ecology has played an important role in helping scholars and practitioners understand the nature of healthy ecosystems as they existed in the past. Authors in this section show us how historical information on the distribution and condition of habitats, as well as the historical production of social benefits from these systems (known as ecosystem services), can guide modern restoration efforts. For example, historical reconstructions can illuminate past ecosystem states and current population trends, highlighting the key drivers or processes (such as predation) that may be acted on to achieve positive change. Historical studies can also provide environmental baselines against which to measure the effectiveness of conservation actions. Finally, this section also examines how marine historical ecology can reveal the dynamic nature of marine ecosystems and ecosystem responses to past eras of environmental change (especially in studies over evolutionary and geologic timescales; Box 1.2). Such efforts are increasingly relevant to restoration efforts striving to protect ecosystem integrity and resilience in the face of a globally changing environment.

### Engaging the Public

The real-world application of results from marine historical ecology would be impossible without public engagement, because decisions about endangered-species recovery, fisheries conservation, and ecosystem restoration ultimately play out in a public sphere. Stories about the historical abundance of marine animals, the past bounty of fisheries, and the healthy functioning of intact ecosystems inspire wonder about the potential of the natural world to sustain and support humans and other life and, in doing so, influence policy debates. However, challenges also exist in this realm—for example, the uptake of conservation messages by a media-saturated public can be limited, and stakeholders can respond in a range of ways (and sometimes unpredictably) to historical information. As authors in this section discuss, historical ecology can provide competing narratives about the past and can also inspire alternative visions for the future. A diversity of stories may lead to conflict over desired outcomes of conservation and management, but they can also empower communities to effect change or advance potential solutions. Engaging the public around the history of people and life in the sea enriches these important discussions and is essential to developing and implementing conservation actions.

## GOALS FOR THIS VOLUME

We have two overarching goals for this volume. First, we hope to provide impetus for a vibrant, transdisciplinary discussion on using insights from historical ecology to improve the management and conservation of marine ecosystems and species. In essence, we hope to show—through tangible examples—how the research community can develop better, more viable science-based solutions, and highlight practical ways to enable their uptake in

the policy and conservation realm. Second, it is our intention to showcase practical examples of how historical data can be used in the conservation of marine ecosystems. Throughout the book, authors provide real-world and hypothetical examples of management strategies, policy levers, and conservation actions and perspectives, drawing on a diverse set of case studies from around the globe. Additionally, we have supplemented each chapter with "Viewpoint" boxes that contain reflections from policymakers, managers, and leading scientists about how the concepts presented can be engaged in real-world applications.

We hope this book will be of interest to a broad range of stakeholders working in the multidisciplinary fields of marine science and conservation, including academic researchers, educators, students, policy specialists, environmental managers, marine protection organizations, and others. We developed this book with this diverse ocean-minded community in mind, knowing that strong and diverse knowledge-to-action partnerships are necessary to work collectively toward a promising future for the ocean.

## GOING BEYOND THE SCIENCE: LINKING KNOWLEDGE TO ACTION

Understanding how to move beyond the science and to real-world results is increasingly important in a world where the integrity of marine environments is challenged by a growing number and intensity of human drivers. The future of these systems is as much about the plants, animals, and habitats that compose these ecosystems as it is about us. As historian David McCullough has eloquently written, "History is a guide to navigation in perilous times. History is who we are and why we are the way we are" (McCullough 1984).

Our generation of marine scientists does not have the benefit of seeing firsthand the intact ecosystems of the past—we work in highly altered environments. The changes to these systems were first described in detail by the generation of scientists who came before us, many of whom witnessed these changes over a lifetime of work. These groundbreaking researchers—some of whom contributed to this volume (including Boxes 1.1 and 1.2)—inspired us and prompted our initial interest in and commitment to the field of marine historical ecology. In science, it is often said that one stands on the shoulders of giants, and we gratefully acknowledge the important and transformative work of these scholars.

Along with altered ecosystems, we inherited the knowledge and skills to understand the long history of change in marine environments. The majority of the initial work in marine historical ecology focused on quantifying, reconstructing, and characterizing long-term change. The task now is to take marine historical ecology beyond the initial step of reconstructing and understanding change and apply it toward the significant conservation questions of the future. For example, how can long-term baselines best be used to plan for and recover depleted and endangered marine species? Can fisheries be productive enough to support growing populations and also be environmentally sustainable? What do we stand to gain by recovering coastal ecosystems? How can the vision of past ecosystems be used to inspire the public toward conservation action? And how does a historical understanding of past changes shape a collective vision for a sustainable future and the options for getting there?

These questions place us at a critical juncture of applying an amassed knowledge base to problems facing the real world. The central challenge is clear: it is one of going beyond the descriptive science of marine historical ecology and toward identifying tangible solutions. With that in mind, we strived to create not a volume *of* baselines, but rather a volume on *how to use them*. We sincerely hope the findings presented herein embolden readers with new ideas and tools to restore healthy ocean environments and build resilient coastal communities. After all, it is in this century that we must learn from the past to secure the future of our blue planet.

## REFERENCES


Agreement on the Conservation of Albatrosses and Petrels (2009) ACAP species assessment: short-tailed albatross *Phoebastria albatrus*. Available at www.acap.aq.

Atlantic States Marine Fisheries Commission (2014) Atlantic striped bass. www.asmfc.org/species/atlantic-striped-bass.

Cicin-Sain, B., Grifman, P. M., and Richards, J. B. (1982) Social science perspectives on managing conflicts between marine mammals and fisheries. Marine Policy Program, University of California at Santa Barbara and University of California Cooperative Extension, Santa Barbara and San Luis Obispo, CA.

Estes, J. A., and Palmisano, J. F. (1974) Sea otters: their role in structuring nearshore communities. *Science* 185, 1058–1060.

Friedlander, A. M., Shackeroff, J. M., and Kittinger, J. N. (2013) Customary marine resource knowledge and use in contemporary Hawaii. *Pacific Science* 67, 441–460.

Kittinger, J. N., Pandolfi, J. M., Blodgett, J. H., et al. (2011) Historical reconstruction reveals recovery in Hawaiian coral reefs. *PLoS ONE* 6, e25460.

MacKinnon, J. B. (2013) *The Once and Future World: Nature As It Was, As It Is, As It Could Be*. Random House Canada, Toronto, ON.

McCullough, D. (1984) Commencement address at Wesleyan University, June 3.

Rosenberg, A. A., Bolster, W. J., Alexander, K. E., et al. (2005) The history of ocean resources: modeling cod biomass using historical records. *Frontiers in Ecology and the Environment* 3, 78–84.

Sharpe, H. G. (1989) The discovery of the "extinct" sea otters. In *A Wild Coast & Lonely—Big Sur Pioneers* (R. S. Wall, Ed.). Wide World Publishing/Tetra, San Carlos, CA.

South Bay Salt Pond Restoration Project (2012) Annual Report 2011. www.southbayrestoration.org/documents/technical/2011sbspannualreport.FINAL.pdf.

U.S. Fish and Wildlife Service (2008) Short-tailed albatross recovery plan. Anchorage, AK.

Vermeij, G. J., and Leigh, E. G., Jr. (2011) Natural and human economies compared. *Ecosphere* 2, Article 39.

Weiss, K. R., McFarling, U. L., and Loomis, R. (2006) Altered oceans [article series]. *Los Angeles Times,* July 30–August 3.

Willis, K. J., and Birks, H. J. B. (2006) The need for a long-term perspective in biodiversity conservation. *Science* 315, 1261–1265.

Wood, G. S. (2008) *The Purpose of the Past: Reflections on the Uses of History*. Penguin, New York, NY.