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 that define human values. It is very hard to argue for aesthetic or cultural values for nature without having an intimate understanding of the natural world. If you have not experienced first hand the awe and wonder of nature, it is very hard to communicate it!

Finally, you went into biology because you love nature, and this involves regular contact with nature. The intuitive sense of place so very important to ecological understanding must come from personal experience—smelling, feeling, and seeing the important lessons nature offers an open and prepared mind. It is easy to be seduced by the demands of everyday life and to forget to visit nature and fuel your passion and sense of self as well as a sense of place necessary for your science.

U.S. Commissioner of Fish and Fisheries. But only since the 1940s did conservation become an ethic among the wider public. Aldo Leopold's *Sand County Almanac* (1960), Fairfield Osborn's *Our Plundered Planet* (1947) and *Limits of the Earth* (1953), Raymond Dasmann's *A Different Kind of Country* (1968) and *No Further Retreat* (1971), and others inspired a conservation movement that saw the founding of governmental agencies and non-governmental organizations dedicated to wildlife management and environmental protection. Rachel Carson's *Silent Spring* (1962)—on the *New York Times'* bestseller list for 31 weeks—served as an indictment of the pesticide industry and helped to catalyze ecological awareness and action. However, opposition to ocean abuse—a major feature of the Marine Revolution—has been relatively new.

Little had been said for the marine world until Rachel Carson's *The Sea Around Us* (1951) and, especially, Jacques-Yves Cousteau and Frédéric Dumas' The *Silent World* (1953) made the oceans and their life familiar to the public. Cousteau and Dumas' invention of the "Aqualung" (self-contained underwater breathing apparatus or scuba) allowed anyone in reasonably good health to explore and find value in the sea and marine life "up-close and personal." This self-conscious awareness of the sea's value, beyond only "resources," had immense, global impact. Under a new sense of urgency, Marine Protected Areas began to be established and charismatic species to be protected. Whales, sea turtles, and others that had suffered from over-exploitation, and dolphins and killer whales that were displayed in oceanaria became icons of the ocean's value.

The immediate responses for ocean protection were based on practices that had long proved appropriate for terrestrial environments, namely protection of *species*—overwhelmingly charismatic ones deemed threatened or endangered—and protection of *spaces* that served as habitats for unique, endemic, or threatened plants and animals, or as scenic inspirations. Marine conservation had finally joined an era of environmental concern that reached a climax, fervently expressed on Earth Day, 1970, that aroused the necessary social and political will to make transformational change (Graham, 1999): "In 1965 the environment was not a leading issue. Five years later it was the national problem Americans said they worried about most, second only to crime. Earth Day 1970, celebrated just as that crescendo in public concern was reaching its peak, became the lasting symbol of past frustrations and future hopes." Increased awareness of coastal impacts and recognition of failures to conserve marine resources brought on a quickening pace of change. The public opposed the ruthless slaughter of marine mammals, impacts of polluted water, and shores tarnished by oil spills. The result was a suite of environmental legislation, particularly in the U.S., that set standards that became adopted globally. U.S. legislation centered on species protection, coastal zone management, fisheries management, curbing ocean dumping, and establishment of marine sanctuaries. Marine Protected Areas became institutionalized, albeit operationally stalled by difficulties of designating environmentally or legally defensible boundaries, sizes, and locations, compounded by jurisdictional conflicts, established national priorities, and deficiencies of international ocean law. Internationally, the first effort (mid-1970s) specifically directed towards marine conservation became the *Marine Programme* of the *International Union for the Conservation of Nature and Natural Resources* (IUCN), which persists to this day. This program helped direct efforts towards regional-seas agreements organized and promoted by the United Nations Environmental Program (UNEP). Conservation focus remained on charismatic marine species—whales, seals, walruses, albatrosses, sea turtles, etc.—and natural areas of high biodiversity (coral reefs) and/or scenic beauty, which served to promote marine conservation to the vast majority of humankind that had little direct experience *in* the sea.

However, these programs lacked appropriate mechanisms for addressing new and emergent issues, which made obvious the enormity of the task confronting marine conservation. A cadre of non-governmental organizations (NGOs) began to expand, each with its own interests and goals. At this same time, marine ecology was advancing, generated by new technologies for undersea exploration; satellites allowed "world views" of the coasts and oceans, computers analyzed large data sets, and models revealed insights into system-level phenomena. A principal finding was that change is a fundamental property of ecosystems, at all scales from local to global, and that such change responds to ecological and social domains beyond protected-area boundaries. That is, "protection" of valued or threatened species and spaces—presumably isolated from harm—would not suffice. Marine boundaries are continuously on the move.

From about 1980 to the turn of the 21st century, human-caused ocean change deepened, grew wider, and became more complex, along with the public recognition that "biodiversity" was seriously under threat (Wilson and Peter, 1988). Conservation gradually began to take on a new role—that of protecting biodiversity "hot spots" and restoring diminished natural systems in a shrinking world dominated by human needs.

Additionally, a host of independent initiatives arose, but too many individually directed and often-conflicting laws, regulations, agreements, and treaties added up to challenge conservation—a "tyranny of small decisions" (Odum, 1982). By protecting one part of a whole system, another part unexpectedly reacts, often resulting in consequences that no one wanted or intended, including species depletion and ecological degradation.

We are now at a time in history when science allows better opportunities to understand our global environment and to more clearly recognize the limits of the oceans and the urgency of marine conservation. The need for a comprehensive "systems" approach to protect species and spaces has become increasingly apparent. Coherent national ocean policies are being called for, and international policies are being formulated, but the challenge of implementing comprehensive conservation policy remains. But as Graham (1999) warned: "A generation later, the political and economic ground has shifted . . . The public's sense of crisis has been replaced with enduring support for improving pollution control and conservation, but also with a frequent reluctance to pay the public costs of increased protection or to change everyday habits."

1.2 DEFINING "MARINE CONSERVATION"

Marine conservation is an elusive concept to grasp. What exactly is it? "Conservation," as defined in *Webster's Third New International Dictionary*, is "deliberate, planned, or thoughtful preserving, guarding, or protecting . . . planned management of a natural resource to prevent exploitation, destruction, or neglect . . . wise utilization of a natural product . . . a field of knowledge concerned with coordination and plans for the practical application of data from ecology, limnology, pedology, or other sciences that are significant to preservation of natural resources." These definitions presume a basic understanding of natural-resource science and illustrate that conservation is an issue-directed activity towards which science can provide a guide to inform decision-makers at all levels. However, solutions to sector-based conservation problems have proved elusive for reasons that are not always straightforward, not for want of a plethora of laws, regulations, agreements, organizations, and procedures that have been adopted, but for their applications in a society divided by priorities. Many difficulties also relate to recognizing the differences between land and sea and their respective conservation needs.

The oceans are not like the land. Physically, the three-dimensional ocean is driven by interactions of fluid dynamics, light, nutrients, and temperature. Biologically, ocean volume exceeds the land by almost two orders of magnitude, being dominated by small, non-charismatic microbes and plankton that support larger invertebrates and fishes and a few highly developed, charismatic air-breathing reptiles, birds, and mammals. Phyletic diversity and total biomass in the sea far exceeds that of the land, although large plants are few and restricted to shallow, nearshore waters. Functionally, marine ecosystems are continuous and connected across huge spatial extents, as exhibited by planktonic larvae, billfishes, sharks, sea turtles, and whales. Yet the ocean has boundaries to which species respond. Many widely distributed species exhibit taxonomic and genetic differences in biogeographic patterns and in metapopulations (Ch. 5). Ocean boundaries can move, and can change unexpectedly and unpredictably over decadal time scales or less, and at spatial scales rarely known for terrestrial environments. Such boundary changes are difficult to know, often being observed through natural history and genetic studies of species. Furthermore, the distributions and behaviors of species depend not only on the physical environment, but also on species that can affect and change environments. Species–environment feedbacks modify ecosystems and create conditions that support many other species. Many marine species are opportunistic, depending on chance or changes in response to highly dynamic marine systems. Furthermore, species and environments are interdependent and may coevolve. Such relationships are particularly difficult to observe in the moving fluid of the marine environment. Thus, defining species–environmental interdependencies under conditions of continual change and lack of natural-history knowledge for most of them remains a critical conservation arena. As Levin (2011) put it: "Sustainable management requires that we relate the macroscopic features of communities and ecosystems to the microscopic details of individuals and populations." But how?

1.3 MARINE CONSERVATION'S SCOPE

The rise of ecology, globalization, and the ubiquity of human activities makes obvious the fact that by the later 20th century humans had so altered global ecosystems that the rapidly decreasing number of natural spaces on Earth left to defend may soon be few. This raises the ambiguous issue of "scope." Does scope simply mean size, as established through spatially designated protected or managed areas, i.e., that the larger the boundaries or percentage of protected areas designated means that *more* is protected? Conversely, should preference be given to those species that we believe to be "charismatic"? Or does scope imply a greater suite of procedures, regulatory or otherwise, which translates to *how* conservation is conducted? Answers are not as simple as they may seem.

Currently, marine conservation draws public support and legislative action more from emotional and personal preferences and less from scientifically based information on marine system processes. Hardly anyone would not wish to save a whale, but what about its food supply of very small copepods and krill? And how do ocean processes operating over huge scales support those foods? Clearly, marine conservation is drawn into a large spatial context, as well as being subject to socio-economic conflicts. If marine conservation is to be about biodiversity maintenance, resource sustainability, and human well-being—and all at once—it should become fundamentally hierarchical, from protecting the rarest and most valued (in human and ecological terms) species and spaces, to sustainable use, and to enable the resilience of ecosystems; that is, conservation needs to become "systemic" in its approaches. The crisis is this: as the increasing human population demands ever more marine natural resources, the environmental deficit also grows (Ch. 13; Bormann, 1990). The objective of marine conservation, then, is to slow and eventually stop the ecological cascades resulting from social/ecological imbalances by protecting, restoring, and sustainably using resilient ocean systems and their living components as Earth's last frontier. This objective requires a better understanding of the living and physical components that marine conservation aims to address holistically. As Franklin (1993) has said in another context: "We must see the larger task—stewardship of all the species on all of the landscape with every activity we undertake as human beings—a task without temporal and spatial boundaries."

1.4 ADAPTING MARINE CONSERVATION TO THE 21ST CENTURY

The 21st century is much different from preceding centuries. The Earth is now "hot, flat, and crowded" (Friedman, 2008) and marine issues are converging, thus requiring new approaches. As this century advances, a systems approach is needed for improving society's ability to take effective action through improved understanding of the physical and biological worlds under an accelerating pace of environmental change (Forrester, 1991). Such an approach requires identifying and understanding the components in the system, and how system behavior arises from their interactions over time (Sweeney and Sterman, 2000).

Marine management institutions that arose in the 20th century are today challenged by the interactions among resources, the environment, critical habitats, and conflicts among institutions that undermine their mandated goals. The organisms that institutions aim to protect inhabit a dynamic world in which feedbacks and complex interdependencies sustain them. While the history of ecology is firmly grounded in natural history, understanding ecological patterns and being able to conserve resources requires understanding dynamics (Levin, 2011). This understanding requires a process that starts with a problem to be solved, and advances with better knowledge about the situation and the wealth of information available (Forrester, 1991). For conservation to advance, this wealth of information needs to: (i) place conservation issues in the context of environmental-social systems; (ii) connect species natural history to interconnected natural and human systems; and (iii) place ecosystem resilience in the forefront of conservation action (Walker and Salt, 2012). These goals relate to the art of systems thinking, which involves the ability to represent and assess dynamic complexity. Implicit in thinking about systems is the ability to have good science and quantitative data in order to see relationships between the issue to be addressed and the conservation tools to address it.

Marine conservation is confronted by an overwhelming array of complex issues and an astonishing amount of information. Categories of issues confronting marine conservation are introduced in Chapter 2 to help sort out this complexity. While solutions to many issues are being sought (Ch. 3), most of them have been addressed singly, as if in isolation. Yet some issues are emergent, have arisen suddenly and unexpectedly to catch both science and society unprepared, notably climate change, ocean acidification, and anoxia. Such issues relate to the nature and properties of the ocean's ecological systems, the natural histories of marine species, and their interactions, which requires relating dynamics and linkages of organisms to each other and to their environment. A conceptual level of ecosystem understanding helps make these connections real (Chs. 4, 5).

The book introduces seven case studies that exemplify pursuit of marine conservation. They illustrate an array of attempts to address specific conservation issues in geo-social-ecological contexts. Implicit in each case study is the relationship of social and ecologic systems to each other and to the task of conservation.

Some questions to consider along the way:

- How can marine conservation be framed to protect, restore, and accommodate both a dynamic marine environment and expanding human needs?
- How does systems thinking relate the environmental debt to social well-being and economics?
- How can a focus on "charismatic" iconic species be expanded to encompass biodiversity protection?
- How big, how many, and where should Marine Protected Areas be placed to maximize benefits for marine conservation?
- What lessons can be learned from real-world cases that can be extrapolated to other situations?
- How do 21st century needs fit within 20th century mandates?

Ecosystem approaches to marine conservation focus on issues holistically, rather than repeating fragmented approaches that fail to account for unexpected changes that arise from complex system behavior. Maintaining the status quo through sector-based decisions (e.g., fishing, coastal development, water quality, and energy) needs reconsideration, which requires thinking differently about solutions in order to better fit future policies with procedures. Successful alternatives are being sought (Ch. 13) to protect and sustain biodiversity and the species that both serve society's needs and refresh human minds. As complex systems defy intuitive solutions, it is time to explore new frontiers for marine conservation practice.

Marine conservation itself is now at a crossroads, transitioning from "protection" and sector-based regulations to a wider context. That marine conservation has lagged behind its terrestrial counterpart gives it the potential to be innovative by devising a "best mix" of old ways to new ones, taking historic successes and failures into account. Aware that the oceans are no longer "out of sight, out of mind" to most people, as in the recent past, and armed with "science as a way of knowing," as John Moore put in the title of his seminal book (1993), marine conservation should be capable of avoiding future pitfalls. Humans are not to be faulted for lack of caring. Rather, future progress lies in perceiving connectedness and feedbacks to and from the environment and human societies, leading to the hopeful well-being of both.

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