25 Ending the Range Wars on the Last Frontier: Zoning the Sea

Elliott A. Norse

There's always been competition. Fishermen are competitive by nature, you know . . . they want to catch every last one. . . . So it's a fight for the fish.

PAUL PELLEGRINI,
*Eureka, California, commercial fisherman.**

Imagine that you're taking a drive in the country. You might leave your neighborhood, pass some ball fields and the airport, skirt the rail yard and warehouse district, stop and go through canyons of office buildings and retail businesses, go round a university campus, cut through a mosaic of residential and commercial areas, navigate a patchwork of farmland and tree plantations, and finally enter a magnificent national park, there to soothe your spirit.

Although such a journey might seem rather ordinary, something about it is truly remarkable: Despite the absence of color-coded labels, at every moment from start to finish you could discern the purposes to which people put each parcel of land, and what you and others could and could not do in them. As Orbach (2002) notes, "The last 10,000 years of human history have seen the complete carving up of terrestrial space and resources into property, some of which is held in trust for aggregates of people under institutions called governments, under the general term 'public trust.'"

Moreover, society has worked out elaborate and effective means to resolve conflicts over the use of these places. Through a variety of processes, diverse societies have concluded that there are circumstances when individuals gain more than they pay by surrendering some freedom. The result is hardly ideal for everyone (or even for anyone), but provides a predictable spatial framework that benefits enough people sufficiently that people generally abide by the rules. Of course, humans are a disorderly species, and social contracts over land use sometimes break down on scales from local disputes to world wars, but some degree of order prevails in most places at most times. This social contract mostly works.

A stark contrast is the situation in the sea. With few exceptions in industrialized nations (one, in Devon, UK, is discussed in Blyth et al. 2002; Acheson, Chapter 20, illustrates others in Maine, USA, and in Japan), people claim the "right" to go wherever they want, whenever they want, to do whatever they want. This unrestricted freedom produces a disorderly "free-for-all," a system where interests collide without a social contract. Perhaps the sharpest disparity lies in the fact that our approach to the land is more orderly than our approach to the sea, with the latter being character-

*Rough Seas, The NewsHour with Jim Lehrer (KCET-Television Broadcast, Los Angeles, California), June 13, 2001

ized by varying degrees of incessant conflict. In Seattle, for example, stories about the sea are far fewer in the newspapers, yet are more likely to concern conflicts among different interests. This is evident in headlines such as "Total fishing ban urged for heavily polluted fjord" (*Seattle Post-Intelligencer,* May 7, 2004) and "Powerful interests may clash in push to heal the oceans" (*Seattle Times,* February 16, 2004).

Of course, terrestrial and marine ecosystems (naturally and as affected by humankind), are both nonlinear (complex) systems with multiple components whose interactions produce systemic behaviors that cannot always be predicted from knowing how the individual components work. Moreover, these ecosystems sometimes undergo fundamental reorganization to new states. But on the timescale of human lives, terrestrial systems exhibit at least some signs of stability, while marine systems are exhibiting increasingly chaotic behavior indicating impending phase change. A fast-growing scientific literature indicates that marine systems are at what physicist and journalist Malcolm Gladwell (2000) calls a "tipping point."

One reason that countless indicators of marine "health" are declining is the still-widespread belief that the sea is an inexhaustible cornucopia, and that society, therefore, should give primacy to supporting consumptive users. As a result, marine user groups have dominated governments' actions (for US examples, see Eagle et al. 2003; Okey 2003; Rieser et al., Chapter 21). Officials charged with the protection of marine resources have on a number of occasions told me: "If both industry and environmental advocates are beating on me and hate what I do, I must be doing something right." There is undoubtedly both self-importance here and a legitimate point that government must navigate between user groups and public interest groups advocating environmental protection. But this ongoing practice undermines order by forcing ocean systems and all their components—including humankind—into the chaotic realm of shrinking biodiversity until the system enters a new stable state. Of course, some stable states are more desirable than others. Some stable states (e.g., a growing number of ecosystems dominated by bacterioplankton and jellyfishes, as described in Jackson et al. 2001) are ones that humankind would do well to avoid. It is as difficult to envision how governing in ways that cause marine ecosystem instability is a safe, wise, long-term management strategy, as it is difficult to see the wisdom in driving while drunk. If a growing variety of indicators of ocean health are declining and nobody thinks governance is doing what it's supposed to be doing, it is time to confront the possibility that something is fundamentally wrong.

From what I have seen of ocean governance in the last quarter century, any semblance of marine ecosystem stability is exceptional in the United States, Canada, and the European Union, and, quite probably, in other countries. Humans had little effect when the sea's resources were largely untouched and users were few. But now, much faster than we realized, that has changed. The sea is severely impacted, human use of almost every last cm^2 is contested within nations' waters, and it is difficult to find any sector happy with the way the sea is governed. This is true both for user groups that have long benefited from society's lack of governance and for environmental advocates trying to arrest the sea's decline. As an ever-greater diversity of interests fights over the fate of the shrinking ocean resource base, the great blue cornucopia fades into memory. Unfortunately, our system of ocean governance has not yet reconfigured to reflect this new reality.

Marine populations are vulnerable (for a troubling assessment of population vulnerability, see Hutchings and Reynolds 2004), but are also resilient to some degree, and there are at least some scattered indications that marine ecosystems, or at least populations, can move back toward something approximating less impacted states. Some of these come from studies of marine animal population changes following devastation of native people by European diseases (Broughton 1997), effects of wartime reduction in fishing pressure (Smith 1994), or establishment of marine reserves (Halpern 2003; Roberts 1995). Much has already been lost, and there are many impediments to

slowing and stopping impoverishment of the sea's biodiversity. But by moving away from practices that keep us in chaos and push us toward new stable states that we might not like, we can consciously decide to use our growing scientific understanding to facilitate reassembly of marine ecosystems. Doing so will require a much more sophisticated understanding of how marine life and humans interact, the disciplinary nexus at the core of marine conservation biology.

This concluding chapter considers an ecosystem-based management tool—ocean zoning—that has the potential to move humankind toward protection, recovery, and sustainable use of the sea's biodiversity, a state more desirable than the one toward which current practices are forcing the oceans and our species.

A General Theory of Frontier Systems

Zoning estuaries, enclosed seas, coastal waters, and the open oceans would be a marked departure from current marine management in the industrialized world. Having colonized and modified most of the land on our planet, modern society has turned to the sea as the last frontier on Earth (Lemonick 1995; NOAA 1999; US Commission on Ocean Policy 2004). Because the marine frontier has yet to be examined thoroughly and the canonical examples of frontiers are terrestrial—as illustrated in fascinating books by Crosby (1986), Diamond (1997), and Flannery (1994, 2001), and in countless fictionalized accounts such as William Wyler's 1958 classic film, *The Big Country*—it is essential to know whether insights gleaned about terrestrial frontier systems are relevant to the sea.

The patterns of discovery and overexploitation described by Haley (1980), Kurlansky (1997), and Lutjeharms and Heydorn (1981) are no different from those in terrestrial frontiers (Figure 25.1). One account (*South African Shipping News and Fishing Industry Review* 1981) concerning the rock lobster *Jasus tristani* so succinctly encapsulates this that I repeat it verbatim:

> Rock lobster reappeared on the Vema Sea Mount in commercial quantities but the population was quickly fished down to an uneconomic level at the end of last year.
>
> Two boats, the *Farandale* working for Hout Bay Fishing, and Manuel de Pao's *Stratus,* went to the area 500 miles west of Lamberts Bay for hand line fishing and put down a couple of test traps. The results were so good that the boats returned to Cape Town for more traps and then the stampede started. About 20 boats went to the sea mount. Some of them did not have refrigeration on board and transshipped their catches to those which did.
>
> By the time the catch rate had dropped to uneconomic levels, some 80 tons of tails had been caught and sold through SA Frozen Rock Lobster Packers.
>
> The Vema rock lobster stock was virtually wiped out in a little more than two years in the mid-1960s after the sea mount was discovered by the US research ship *Vema* in 1957.

Perhaps the most authoritative identification of marine frontier governance in the United States comes from the Pew Oceans Commission (2003), a blue-ribbon national commission of experts, who refer to the report of a national commission on ocean policy of an earlier generation:

> Driven by the need to ensure the "full and wise use of the marine environment," (the Stratton Commission of 1969) focused on oceans as a frontier with vast resources, and largely recommended policies to coordinate the development of ocean resources. Reflecting the understanding and values of this earlier era, we have continued to approach our oceans with a frontier mentality.

Traditionally, frontier areas have been defined as having low human population density (in the United States, fewer than two per mi^2). However, the essence of frontiers is not demographic but, rather, their coherent set of legal, economic, sociopsychological, and ecological attributes that come into being when people gain open access to resources, whether following initial discovery or conquest of indigenous peoples. Elucidating these attributes can form the basis of a general theory of frontier systems. If this theory is

FIGURE 25.1. Scramble competition (Oklahoma Land Rush, 1893) at the end of the American Frontier Era. Photo by P.A. Miller, Courtesy of Oklahoma Historical Society.

valid, it should apply across a broad range of frontier situations, whether the Maori colonization of New Zealand, European invasion of the Americas, czarist Russia's expansion of sea otter hunting in the North Pacific, or the present-day spread of trawling on the world's seamounts.

Legally, frontiers are areas having:

1. Open access to resources
2. Larger, less differentiated jurisdictions than non-frontier areas
3. Few laws that effectively constrain human activities

Economically, frontiers are places where people:

1. Scramble to exploit natural resources
2. Use natural resources extensively and wastefully rather than intensively and efficiently

Sociopsychologically, frontiers:

1. Attract persecuted, disenfranchised, impoverished, or entrepreneurial people seeking their fortunes
2. Are where people resolve disputes by unilateral action or force rather than by negotiation
3. Favor independence, physical courage, boldness, ruthlessness, unbridled optimism, and "black-and-white thinking" over social restraint, empathy, cooperation, adherence to laws, nuanced weighing of alternatives, and sifting among "shades of gray."

Ecologically, in frontier areas humans:

1. Decrease the diversity and abundance of higher trophic level animals
2. Decrease the diversity and abundance of high-biomass animal species

3. Decrease the diversity and abundance of structure-forming species
4. Increase the abundance of opportunistic or unusable species
5. Disrupt biogeochemical cycles

As historian Frederick Jackson Turner (1893) observed three years after the official closing of the US frontier, subduing the land was crucial in shaping the character of nations such as the United States. Although he found some frontier traits admirable, he also realized that, "the democracy born of free land, strong in selfishness and individualism, intolerant of administrative experience and education, and pressing individual liberty beyond its proper bounds, has its dangers as well as its benefits."

I would argue that even Turner understated the dangers. Frontier systems cannot be sustainable because free, open-access resources attract people until their interests collide, creating instability. Resource depletion and the resulting conflicts among resource users reduce opportunities for pioneers, thereby creating opportunities for those who develop nonfrontier ways of doing things. That is what happened in the American West as market hunting and prospecting gave way to farming and manufacturing. Pianka's (1970) dualistic theory of *r*- and *K*-selection may inadequately describe life histories of cod and sea turtles, as Heppell et al. (Chapter 13) thoughtfully point out, but it has intriguing relevance to human resource users: in some ways frontier exploiters resemble opportunistic *r*-selected species, while users of places that are no longer frontiers more closely resemble *K*-selected species.

Marine frontier expansion has continued at an accelerating pace since the Stratton Commission's report in 1969. In recent decades, as humans have depleted resources closer to population centers, fishing and offshore oil operations have pushed into the world's remotest waters and at increasing depths (as deep as 2,000 m for bottom trawling and exploratory oil drilling). Only since the 1990s have marine scientists comprehensively documented the ubiquitous, profound changes indicating impending conclusion of the sea's frontier era. Some of the clearest symptoms include:

1. Sharply decreased abundance of higher trophic level species (Myers and Worm 2003; Pauly et al. 1998; Steneck and Carlton 2001)
2. Serial depletion of fisheries (moving from one abundant species or biomass-rich place to the next as each is depleted (Fogarty and Murawski 1998; Orensanz et al. 1998)
3. Extensive elimination of structure-forming species (Roberts and Hirshfield 2004; Watling and Norse 1998)
4. Proliferation and spread of weedy unusable or nonnative species such as jellyfishes (Brodeur et al. 1999) and starfishes (Buttermore et. al. 1994)
5. Dramatic changes in biogeochemical functioning (Jackson et al. 2001; Peterson and Estes 2001)
6. Increasing calls for novel solutions such as individual fishery quotas (Fujita et al. 1998; National Research Council 1999), fishery comanagement (Rieser 1997; Sen and Nielsen 1996), and place-based ecosystem management methods such as marine reserves (Mooney 1998; NCEAS 2001)
7. Increasing control over marine species' reproduction and growth through aquaculture (Goldburg et al. 2001)

Frontier Processes That Drive Impoverishment in the Sea

When humans' perception of the oceans was dominated by the fear of sea monsters, there was little need for governance; few dared to venture out to sea. But when exploration and commerce increased, European nations began crafting principles that would govern ocean use. As Orbach (2002) explains,

> It was exactly this inability of any nation or group of nations to actually control ocean use or access that led, in 1609, to the treatise by the Dutchman Hugo de Grotius titled "Mare Liberium," or "freedom of the seas" (Wilder 1998). Under the commonly ac-

cepted doctrine that developed pursuant to this treatise, the world ocean remained "open access, common pool," with no nation or group of nations controlling use or access.

Widespread acceptance of this doctrine led to legal treatment of the sea as a frontier. Subsequent expansion of nations' territorial seas in the late 1700s and establishment of exclusive economic zones (EEZs) in the last decades of the 1900s (Wilder 1998) have not fundamentally altered that, either in the 64 percent of the sea outside EEZ boundaries or, for the most part, within nations' EEZs.

Why does treating the sea as a frontier lead to biotic impoverishment (Figure 25.2)? To begin, it is helpful to understand how ecologists think about competition. Lincoln et al. (1982) define competition as "the simultaneous demand by two or more organisms or species for an essential common resource that is actually in limited supply (exploitation competition), or the detrimental interaction between two or more organisms or species seeking a common resource that is not limiting (interference competition)."

Early in frontier exploitation, resources are abundant and users are too scarce to compete for them. But whenever resources are freely available to anyone who wants them, the number of exploiters increases through birth, immigration, or niche-switching. Exploitation and/or interference competition begins and increases until it becomes ceaseless. Open-access resources of frontiers are inevitably afflicted by what is most often called the "the tragedy of the commons" (Hardin 1968), a concept previously articulated in the marine literature by Gordon (1954). The tragedy occurs whenever resources are open to all because there is strong incentive for individuals or groups to acquire, use, and exhaust resources before someone else does, while there is weak incentive for conservation. However, as Stern et al. (2002) point out,

> The metaphor of a "tragedy of the commons" is only apt under very special conditions. When resource users cannot communicate and have no way of developing trust in each other or in the management regime, they will tend to overuse or destroy their resource as the model predicts. Under more typical circumstances of resource use, however, users can communicate and have ways of developing trust.

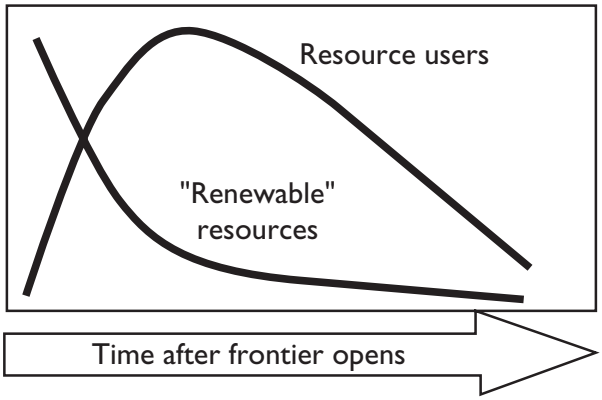

FIGURE 25.2. Frontier use of living resources. If frontier theory is correct, similar relationships should be true whether resource users are Maori moa hunters, Euro-American bison hunters, Russian sea otter hunters or fishermen who trawl for pelagic armourheads on seamounts.

As Feeny et al. (1996) and Acheson (Chapter 20) suggest, commons can be sustainably managed, at least as systems for catching some living resources (e.g., American lobsters, *Homarus americanus*), if not for biodiversity as a whole. This is most likely among small groups where access is limited, rules are agreed upon, and there is substantial social capital; that is, trust. In contrast, there is little reason to believe that frontiers where people have open access can be sustainably managed. Exceeding the productive capacity of the sea is far more prevalent (e.g., Myers and Ottensmeyer, Chapter 5; Heppell et al., Chapter 13) than the rare"successful" management examples provided by Hilborn (Chapter 15). Indeed, other than the examples in Blyth et al. (2002) and Acheson (Chapter 20), it is difficult to think of situations where commercial fisheries in modern industrialized societies have not overexploited target species, seriously harmed other species caught incidentally, or harmed the target species' habitat.

Unrelenting human competition for marine resources has pernicious effects on both resources and exploiters. The emphasis on beating competitors to resources (exploitation competition) rather than ensuring resource sustainability often proves economically ruinous because, as resources are depleted, cost per unit of production tends to rise and profitability tends to decline, so users bankrupt themselves as they exceed the capacity of nature to provide what they need. Moreover, as user groups act unilaterally to advance their own interests, they harm the interests of others, fostering intergroup hostility and bedeviling equitable and sustainable resource management that would benefit users in the long term. In frontier days of the American West, ranchers hired gunslingers to secure landownership and water rights (interference competition). Today, marine user groups pay what they candidly call "hired guns" (e.g., lobbyists, litigators) to maximize their share and minimize regulation by governments. Hence, in marine frontiers, just as Frederick Jackson Turner (1893) observed in terrestrial frontiers, "So long as free land exists . . . economic power secures political power." Or to paraphrase another, more recent Turner—Tina Turner—What's trust got to do with it?

The result of frontier exploitation is that, as fishing technologies improve while fishes' capacity to avoid overexploitation do not, biological diversity and fish productivity inevitably decline and user conflicts escalate except when governments can act effectively. The latter is a rare phenomenon, one reason being that, as on land, government agencies established to regulate ocean user groups cannot resist becoming captives of those they regulate, to the ultimate detriment of all. As Acheson (Chapter 20) notes, marine user groups facing the "collective action dilemma" are far more likely to use their political power to compel elected officials and government managers to maintain the regulatory status quo than to fashion new, more sustainable, and more profitable systems.

For fishes and fishermen alike, this is not a happy picture.

One consequence of user groups' and governments' inability to solve the collective action dilemma is the rise of advocates who speak for the resource itself. In a growing number of countries, public interest nongovernmental organizations (NGOs) have become strong advocates for protecting, restoring, and sustainably using marine life. Some have become sophisticated in incorporating natural science, economics, and law in their toolboxes, but user groups have three inherent advantages:

1. Lacking an income stream from the sale of resources or from taxes, environmental NGOs generally depend on voluntary contributions from concerned citizens or foundations, so scarcity of resources limits their capacity.
2. Environmentalists in democratic societies often find broad public support yet weak per capita commitment for conserving marine life. Few citizens are sufficiently motivated by marine management failures to push decision makers because everyone's interests are equally affected. In contrast, the fishing community has much narrower support—mainly fishermen, those who sell fish products, or those who sell products and services to fishermen and processors—but the impacts of management decisions on them are often stronger motivation.
3. Legal systems often give "rights" only to those who exploit resources, not to people who advocate conservation, who are hard-pressed to demonstrate their "standing."

As a result, public interest organizations have not yet achieved the political "critical mass" needed to transform the sea's frontier system into one that functions more sustainably. In most situations, they must secure cooperation from some resource users to win enough political support to facilitate this kind of transition. And as Acheson (Chapter 20) explains, resource users generally do not accept arguments for the public good unless they perceive that it is in their self-interest. To build more sustainable systems of resource exploitation, user groups must see and accept that they have a stake in changing the status quo.

Unending competition for every last fish is clearly inimical to everyone's interests, recalling an adage claimed by Kenyans, Indians, and Thais: "When elephants fight, it is the grass that suffers." (Sea)grass beds, mangrove forests, kelp forests, coral reefs, estuaries, continental shelves, continental slopes, deep-sea coral forests, seamounts, and the oceanic pelagic zone are all suffering as elephantine user groups fight over resources. Economic dislocation in fishing communities is increasing. The list of losers grows steadily. This almost universally unsatisfactory collective action dilemma has created the conditions that have people increasingly asking, Could there be a better way of managing the sea?

Widely Discussed Solutions

In recent years the worldwide collapse of fisheries and the less noticed worldwide loss of biodiversity (of which fishes are a part and on which fisheries depend) have spurred discussion of alternatives. Clearly, attempts to prolong open-access frontier exploitation—such as improving stock assessment–based management of fish populations one by one—cannot recover biodiversity and ensure that fisheries become sustainable. As physicist Albert Einstein is said to have stated, "The world we have created today as a result of our thinking thus far has problems which cannot be solved by thinking the way we thought when we created them." There is pressing need for a fundamentally different way of managing the sea, what Thomas Kuhn (1970) called a "paradigm shift."

Because inertia in human institutions favors the current (albeit collapsing) frontier system, any new system that replaces it will have to improve both biodiversity protection and fisheries. Trying to achieve the narrow goal of managing commercially targeted fish species without dealing effectively with broader biodiversity concerns—even incorporating some ecosystem-based principles and tools into fishery management—will not accomplish this. But three kinds of innovations have received considerable attention in recent years:

1. Conferring quotas to individuals and corporate users
2. Ceding management authority to fishing communities
3. Protecting places in the sea

Each of these ideas has both benefits and problems.

Individual Fishing Quotas

In recent years, a widely discussed means of addressing the tragedy of the commons has been giving commercial fishermen the privilege of catching a fixed proportion of the total allowable catch of certain fish populations each year. In the academic literature and in venues such as the Fishfolk e-mail Listserv, arguments about individual fishing quotas (IFQs) and similar methods have ebbed and flowed. The most important advantage of IFQs is that they limit effort by determining who may and may not fish. Another is that those who fish faster are not rewarded with larger catches. A third is that, unlike "command-and-control" regulation, which has sometimes set very brief open seasons in certain fisheries, IFQs allow people to fish when they want, allowing them to avoid dangerous weather and adjust for fluctuations in fish, labor, and fuel prices. These are important improvements for fishermen.

The most common objections to IFQs have been that they are both socially inequitable and unsustainable because the largest portions of the catch tend to be allocated to those who have exploited stocks fastest, an unpromising strategy for conserving resources. But there are at least two more reasons why IFQs cannot, by themselves, solve the problems of declining fisheries and biodiversity.

First, IFQs only reduce competition within groups. While a fisherman or a company might obtain the legal privilege to catch a portion of a fish population (let's call it A), the total size of that population is significantly affected by others. Fishermen who target other fish populations can reduce the allowable catch either by killing A as bycatch or by reducing the carrying capacity of the population A's habitat (for ex-

ample, by destroying seabed structures important for A's recruitment). Moreover, when certain gear groups, such as trawlers, fish in the same area as pot fishermen or longliners, it is almost inevitable that trawlers will destroy or damage the other groups' gear (Blyth et al. 2002). Some fishing methods are not compatible with others in the same places. IFQs, by themselves, do not deal with these "forbidden combinations."

A more fundamental problem is that IFQs only address the interests of commercial fishermen, not the larger problem of biodiversity loss or the interests of other users. IFQs give de facto management control over marine resources to people who might not appreciate the importance of conserving biodiversity and clearly have no mandate to conserve it. They do not address the needs of other user groups that depend on living resources (e.g., sportfishing, whale-watching, or scuba diving operations) or nonliving resources (oil and gas producers, fish-farmers, or fiber-optic cable operators). Hence, IFQs address some important problems concerning commercial fishing but do not address a host of others. When used alone they do not necessarily conserve marine biodiversity, improve the situation of other user groups, or even maintain fisheries.

Comanagement

Another response to the fisheries crisis is a growing wave of enthusiasm about "comanagement," a place-based method that gives representatives of fishing communities, cooperatives, companies, or other organizations substantial say over management of fisheries and, therefore, the marine ecosystems in which fisheries occur. Undoubtedly there is wisdom in giving people with an economic stake a voice in deciding the fate of the resources on which they depend because they have relevant knowledge of and—in some restricted circumstances (Acheson, Chapter 20)—incentive to sustain the source of their sustenance. As in other fishery management schemes, in theory, comanagement groups whose ideas fail will be unprofitable and will be forced from fishing, while those whose ideas work will be profitable and gain increasing market share. There are examples showing that there can be enough trust within local fishing communities that comanagement can work. However, there is a gulf between the benefits of comanagement in principle and in reality.

One reason is subsidies. Fishing interests often pressure governments to subsidize failing fisheries in ways that exacerbate their decline and harm biodiversity. Many a fishing community that pushed government regulators to set higher-than-sustainable catch quotas has subsequently sought government assistance (e.g., unemployment insurance or other forms of social welfare payments) when—unsurprisingly—the fisheries failed. This happens because fishermen, lawmakers, and managers seem to ignore a basic ecological principle of predator–prey relations: a predator population (e.g., fishermen) that reduces its prey population (e.g., fish) too much must undergo population reduction until the prey population recovers enough to support a predator population recovery. By not allowing fishing communities that have overexploited their resource base to shrink or disappear, government subsidies ensure that the fish populations and the ecosystems of which they are a part cannot recover.

Even if, by some miracle, comanagement systems could immunize themselves from subsidizing overfishing, a more fundamental problem with comanagement is the phrase "on which they depend." As ecologists know, specialized monophagous predators' populations rise and fall with that of their prey, but more generalized, polyphagous predators can switch from one prey to another, and can therefore be hard on their more vulnerable prey species—even to the point of extirpating them—so long as others nearly as rewarding are available.

Further, comanagement might work on a local level, but can it work on much larger scales? In the United States, fishing interests have had what amounts to a comanagement program with the federal government since the 1970s. Eight regional fishery management councils were established under the Magnuson-Stevens Fishery Conservation and Man-

agement Act to advise the federal government on fisheries. These councils are dominated by fishermen and fish processors (Eagle et al. 2003; Okey 2003; Rieser et al., Chapter 21) and their decisions are almost always accepted by the National Marine Fisheries Service. As the Pew Oceans Commission (2003) states:

> The Commission's investigation has identified no other publicly owned American natural resource managed through a process that allows resource users to decide how much of the public resource can be taken for private benefit. In the majority of fisheries examined by the Commission, this system has created nearly insurmountable obstacles to managing the resource for sustainable catches and for the broad public benefit over the long term.

Because fishing has a larger influence on marine biodiversity than any other human activity, these councils have, therefore, presided over the depletion of many targeted fish populations and countless other species in marine food webs. Weber (2002) gives a fascinating account of how this vast regional fishery comanagement effort has repeatedly failed to conserve marine biodiversity and sustain fisheries. And, as Pauly et al. (1998), Watson and Pauly (2001) and others have shown, this has led to serial depletion, major reductions in fish populations, and dramatically altered food web structure and dynamics. Yet comanagement bodies continue to operate as if there will always be more fish to overexploit.

The behavior of participants in the USA's national comanagement scheme is inexplicable if one thinks that the fishing industry depends on a continuing supply of fish. That may well be true in traditional fishing communities where people have deep roots and no economic alternatives. But as Colin Clark (1973) astutely observed about commercial whaling, commercial fishery management takes not only the "income" that fish populations could provide in perpetuity but also liquidates the "capital stocks" of fishes (this is the one place where the term fish *stocks,* as opposed to *populations,* is appropriate), converting them to financial capital that can then be switched into investments that bring higher rates of return. Fisheries often harm fish populations and the rest of biodiversity because it is economically sensible for fishermen to deplete populations to the point of economic extinction and then to switch. Only if fishermen do not have the option of switching from one fish "stock" to the next (Acheson, Chapter 20) or into other investments (e.g., other kinds of stocks) will they have strong incentive to fish sustainably. However, this subjects them to fish population fluctuations (Hilborn, Chapter 15).

As important as it is for fishery managers and legislators to hear what fishermen say about allocation of catches, the ruinous power of fishermen in determining total allowable catch quotas suggests that government legislators and managers need more distance from fishermen, not less. Both the Pew Oceans Commission and the US Commission on Ocean Policy (2004) have recommended the long-overdue fundamental change of separating conservation (how much gets to be caught) from allocation (who gets to catch it). Comanagement clearly has some genuine advantages under conditions of mutual trust that Acheson (Chapter 20) describes. But, by itself, comanagement is hardly a prescription for healthy oceans.

One intriguing implication of comanagement is acceptance of zoning. Because comanagement regimes are place based, they are, in effect, zones where fishing is the dominant use. That is true at any scale, from waters immediately seaward of fishing villages in Japan, New England, or old England to the $>10^5$ km^2 areas comanaged by US fishery management councils. Thus the question is not so much whether a substantial portion of the fishing community will accept zoning; they already do. Rather, it is whether nations can develop zoning schemes that demarcate places not only for fishing but also for maintaining biological diversity, nonconsumptive recreation, offshore oil extraction, pipeline corridors, cable corridors, shipping lanes, defense, scientific research, and other uses. To do this, nations must recognize fishing as one category of use among many, one that is not always compatible with other societal interests.

Marine Reserves

Marine protected areas (MPAs), which permanently protect areas of the sea from at least some threats, and, in particular, marine reserves, which permanently protect against all preventable threats, are place-based ecosystem management tools that are increasingly favored by many natural scientists (e.g., MCBI 1998; NCEAS 2001; Roberts, Chapter 16; Nowlis and Friedlander, Chapter 17), public interest advocates, and some social scientists and fishermen. If they are not just "paper parks," but have been designed or retrofitted to have effective means of ensuring compliance, MPAs are clearly an important tool for conserving biodiversity within them. The more threats they protect against, the better they will be for maintaining biodiversity. And the more they resemble the ecosystems before they experienced human impacts, the more useful they are to scientists who are studying the factors that underlie the diversity and productivity of the sea. Further, both ecological theory and a small but growing body of empirical evidence indicate that marine reserves also help to replenish areas outside them (e.g., Halpern 2003; Roberts et al. 2001; Roberts, Chapter 16; Sladek Nowlis and Friedlander, Chapter 17).

However, MPAs (including marine reserves) are not a panacea, as Ward (2003), Roberts (Chapter 16), and Lipcius et al. (Chapter 19) are careful to note. They reduce or eliminate competition for resources within them but do not, by themselves, alleviate competition for resources overall. Indeed, by decreasing the area available for exploiting resources, they might displace fishing effort, thereby increasing competition outside their boundaries, even into places that were previously unfished. Moreover, marine reserves are probably the best means of protecting against some threats, including overexploitation, habitat damage, and kinds of marine pollution that primarily affect biodiversity near the source. But they provide little or no protection against pollutants that have strong effects on marine life far from their source, against the spread of alien species, or against global climate change. Although they are a very promising tool for slowing the decline of marine biodiversity, they are unlikely to provide enough protection in some cases. As Allison et al. (1998), Crowder et al. (2000), and Lipcius et al. (Chapter 19) explain, effectiveness of marine reserves will be severely compromised without adequate management of species and ecosystems outside them, so marine reserves are best used as components of a more comprehensive scheme, rather than as fortresses or "megazoos" isolated from their surroundings.

In summary, IFQs, comanagement, and marine reserves can be important tools for protecting and restoring marine biodiversity and sustaining fisheries. None, by itself, is sufficient. They can, however, be integrated effectively into a larger, more comprehensive, place-based ecosystem management framework; namely, ocean zoning.

Zoning Principles, Benefits and Weaknesses

Zoning is a place-based framework for ecosystem-based management that reduces conflict, uncertainty, and costs by separating incompatible uses and specifying how particular areas may be used (Norse 2003; Pew Oceans Commission 2003). Lands virtually everywhere are partitioned among individuals, groups, and nations into customary or legal zones that are used and managed in different ways. Most coastal nations have begun to partition coastal waters by declaring EEZs, but differentiation of uses within EEZs is far less evolved than on land.

The central principle of zoning is that marine ecosystems and their users are heterogeneous. To be consistent with the overarching goal of maintaining the integrity of the living sea and its benefits to humankind, it is best to manage different places with different objectives and in different ways to reflect this heterogeneity. By offering an alternative to "one-size-fits-all" management approaches, zoning can address the distinctive needs of local biological and human communities in the context of oceanographic, biological, economic, and political processes operating over a range of spatial scales that can be quite different from traditional

jurisdictions. By addressing human and natural processes at both local and larger spatial scales, zoning allows those who govern to deal with crucial emergent needs in marine ecosystems—characteristics of the whole interacting ecosystem, rather than each of the individual parts—such as connectivity and redundancy.

The recognition that fishing is the most important threat to marine biodiversity brought fishing interests and conservation advocates into protracted conflict by the late 1990s, conflict that has worsened as the crisis has intensified. As a result, forward-thinking people and policy bodies are recommending zoning as a different way of managing marine ecosystems. Ogden (2001) recommends that the United States "institute a comprehensive program of ocean resource management and protection based on zoning within the U.S. exclusive economic zone (EEZ)." Pauly et al. (2002) state, "Zoning the oceans into unfished marine reserves and areas with limited levels of fishing effort would allow sustainable fisheries, based on resources embedded in functional, diverse ecosystems." Pikitch et al. (2004) say that ocean zoning "will be a critical element of EBFM" (ecosystem-based fishery management). Russ and Zeller (2003) recommend zoning both the world's EEZs and the high seas. The Pew Oceans Commission (2003) says:

> Regional councils should utilize ocean zoning to improve marine conservation, actively plan ocean use, and reduce user conflicts. . . . Regional ocean governance plans should consider a full range of zoning options. This includes marine protected areas; areas designated for fishing, oil, and gas development; as well as other commercial and recreational activities.

and

> Regulate the use of fishing gear that is destructive to marine habitats. Fishing gear should be approved for use subject to a zoning program. The program should designate specific areas for bottom trawling and dredging if scientific information indicates that these activities can be conducted without altering or destroying a significant amount of habitat or without reducing biodiversity.

Many who have spent decades advocating for establishment of marine protected areas have benefited from the insights of Graeme Kelleher, under whose aegis Great Barrier Reef Marine Park became what Agardy (1997) calls "without question the largest, most ambitiously planned and most highly praised multiple use marine protected area in the world." For example, Kelleher (2000) observes:

> There is a global debate about the relative merits of small, highly protected MPAs and large, multiple use MPAs. Much of this dispute appears to arise from the misconception that it must be one or the other. In fact, nearly all large, multiple use MPAs encapsulate highly protected zones that have been formally established by legislation or other effective means. These zones can function in the same way as individual highly protected MPAs. Conversely, a small, highly protected MPA in a larger area subject to integrated management, can be as effective as a large, multiple use MPA. This debate is another example of the either/or arguments in which we Westerners seem to excel. I have seen eminent Western scientists criticize very large, multiple-use MPAs on the grounds that they do not provide sufficient levels of protection, even though they do contain very substantial areas formally zoned as Category I or II in the IUCN Protected Area Categories and even though it would be inconceivable that society would ever contemplate closing the whole multiple-use area to human activity. These debates are destructive.

Zoning has the distinct advantage of creating stability by incorporating and reconciling the interests of both conservationists and fishing groups by creating a matrix that includes:

1. Networks of fully protected marine reserves encompassing a diversity of ecosystem types, each of which encompass sufficient area and connectivity with other areas via currents and movement of adults or larvae, that populations (including metapopulations) remain viable (Palumbi and Hedgecock, Chapter 3; Levitan and McGovern, Chapter 4; Lipcius et al., Chapter 19) and ecosystem processes continue

2. Other zones that give priority or permission to various kinds of commercial, recreational, and subsistence fisheries, in which fishermen may experience reduced competition through IFQs, comanagement, or other means.

Thus zoning offers a win–win alternative to the present open access frontier system that plagues both biodiversity and fisheries viability and puts fishermen in conflict with one another, with other users, and with conservationists.

Commercial, sport, and subsistence fisheries are not the only users of marine biodiversity. Any new system to replace the existing frontier system will need to benefit a broad range of legitimate users of the sea. Other users that depend on healthy oceans include aquaculture operations, recreational divers, whale-watchers and bird-watchers, surfers, beachgoers, ocean-related tourism and real estate interests, educators, and marine scientists. Other present or potential interests that are less dependent on marine biodiversity and fisheries, but which can have important effects on them, include oil and gas producers, miners, wind farms, tidal and ocean thermal energy conversion power producers, pipeline and fiber-optic cable companies, dredge spoil disposers, salvagers, shippers, cruise operators, navies, law enforcers, and recreational boaters.

Zoning can provide for the diverse and often conflicting needs of these interests in several ways:

1. It replaces "one-size-fits-all" command-and-control regulation with a diversity of management mechanisms that reflect the heterogeneity of marine ecosystems and users.
2. It reduces among-group competition by ensuring that all groups with a stake in the health of the sea are recognized, listened to, and have appropriate say in establishing, monitoring, and revising zone boundaries and uses.
3. It can offer greatly increased certainty, allowing economic interests to undertake long-term economic planning.
4. It minimizes regulation within zones, consistent with achieving zoning objectives.

By specifying places in which particular purposes have precedence, zoning provides assurance that those interests can operate with minimal or no competition from incompatible uses within their zones. Spatial separation of, say, shipping lanes, oil production facilities, pot fishing, trawling alleys, and marine biodiversity reserves gives different interests the unprecedented opportunity of avoiding intersectoral competition within their zones. It reduces costs from legal fees and damaged equipment that arise from conflicting uses. And, by reducing uncertainty, it provides a far more favorable environment for investors who seek to gauge risk and return on investment. Thus zoning uniquely provides substantial benefits for all sectors.

By fully protecting some places and allocating other places to various uses or groups of compatible uses, zoning also reduces conflicts within zones. It does not eliminate all such conflict; humans, after all, are human. But for a group that can build enough trust to create and comply with agreements about the resources within its zone (e.g., via IFQs or comanagement), its members will benefit from both reduced within-group and among-group competition. Acheson's Chapter 20 details the principles that allow the lobster fishing community in Maine, USA, and local Fishermens' Cooperative Associations in Japan to limit access, sustain economic returns, and reduce within-group competition, thereby assuring each accepted member of the community an opportunity to fish. This allows managers of zones to fashion local solutions that promote fairness, stability, and effectiveness and avoids the inevitable problems that arise when management fails to deal with differences among human and biological communities.

An essential element in making zoning biologically effective and socioeconomically equitable is determining which uses are compatible within and among zones. Some groups of uses, such as well-regulated oil production and sportfishing, seem to be quite compat-

ible within zones. Others are not. A crucial task in preparing any zoning scheme will be determining the "forbidden combinations" that must be separated to reduce intergroup conflict. Further, as poet Robert Frost (1914) wisely observed, "Good fences make good neighbors." Because activities within zones can have effects that cross zone boundaries, it is also essential to determine which kinds of zones make "good neighbors" for certain other zones and which do not. One of the most promising models, which builds on the biosphere reserve concept long advocated by the UN Man and the Biosphere Program, is surrounding fully protected marine reserves with buffer zones (Agardy 1997; Day 2002) that allow all or certain subsistence-, commercial- and/or recreational fishing and other activities so long as they do not damage benthic habitats. This has the conservation benefit of effectively increasing protected area size for those species that are not caught.

These consequences of zoning can arrest and reverse declining biodiversity and alleviate the pernicious effects of open-access competition, thereby increasing stability of the marine ecosystem and benefiting the humans who depend on its diversity and productivity. In view of these advantages, one might be tempted to see zoning as *the* answer to the growing list of ills in the oceans. But zoning is about people. The kinds of zones, their distribution in any zoning system, and their effectiveness will reflect the scientific understanding, economic principles, procedural efficiency, inclusiveness, transparency, fairness, and effectiveness of measures to ensure compliance. Undue influence by any sector, a poor zoning process, or corruption of officials deciding zoning patterns, could undermine the political viability of any zoning process. The success of any zoning process will also depend on the quality of information and its availability to different user groups and decision makers. As Day (2002) emphasizes, "zoning will not be perfect."

Replacing a familiar open access frontier system with a more orderly zoning system will not be easy, because the large number of interests and their conflicting needs will require specific understanding of the complexities, some shared vision, and Solomonic wisdom. But the largest stumbling block is an aspect of human nature, as encapsulated in the classic problem of game theory called "the prisoner's dilemma." In this case, for zoning to proceed, a broad range of interests will have to decide—each for their own reasons—that having the opportunity to use and exert substantial control over a portion of the sea is better than fighting incessantly for all of it while its resources continue to disappear. There is no inherent reason why we cannot manage the sea in a more orderly way. As Orbach (2002) states, all that is needed is political will. And that, in turn, comes from trust.

The history of enmity among and within interest groups and between them and governments suggests that assembling zoning systems will be anything but a simple task. One astute ocean policy analyst, Commission on Ocean Policy member Andrew Rosenberg of the University of New Hampshire, has said, "Anyone who thinks ocean zoning will be easy ought to participate in a local (land) zoning board meeting." Establishing zoning systems will require years for research, scoping of public attitudes, confidence-building processes, and equitable social and legal mechanisms to ensure compliance. Further, these processes will require adequate funding. However, the key question is not whether it will be easy, but whether there is any viable alternative at a time when the failure of the frontier paradigm has become undeniable. The clear-eyed question is, Which is worse: a new system with some unknown dynamics that is not guaranteed to work? or a familiar system that virtually everyone sees as a failure? In other words, is it better for us all to change course, with all the difficulties that entails? or to "go down with the ship"? Despite the caveats and questions that remain to be answered, zoning seems preferable to watching the life drain from the sea.

I suspect that the greatest impediment to zoning will be its unfamiliarity, the mind-set of, We can't do it because we've never done it that way. As most anyone involved in public processes has observed, there are always some people who will cling to something familiar, even while complaining bitterly about its fail-

ings, rather than daring to try something new. Acceptance of zoning might ultimately lie beyond the traditional boundaries of natural science and policy in the unfamiliar realm of marketing.

Toward Comprehensive Zoning

There are two ways to undertake ocean zoning: piecemeal, by assembling zones in certain places for certain purposes without much regard to other purposes, and comprehensively, by assembling a range of zones throughout a large area that accounts for the needs for achieving all recognized purposes. There are many place-based programs that would qualify as piecemeal zoning, including offshore oil and gas leasing programs, military security or ordnance disposal areas, leased shellfish beds, the Inshore Potting Agreement between trawlers and pot fishermen in Devon (UK), "no-go" buffers around seabird nesting islands, and marine reserves. In contrast, there are relatively few examples of comprehensive zoning efforts.

Small areas are relatively easy to zone, as they generally include a lower diversity of biota and of competing human interests. Lundy Marine Nature Reserve (www.lundy.org.uk/inf/mnr.html), southwest of Britain in the Bristol Channel between Devon and Wales, is a small (13.9 km^2) zoned area established by statute in 1986. Its simple zoning system now includes two very small no-go archaeological protection zones to protect shipwrecks, a much larger no-take (reserve) zone, a still larger refuge (limited-use buffer) zone in which potting and recreational angling are allowed, and a general-use zone that specifically excludes only spearfishing.

Florida Keys National Marine Sanctuary (USA) is 700+ times larger (9,845 km^2) than Lundy Marine Nature Reserve and is not yet comprehensively zoned. The majority of its area is unzoned, subject only to the Sanctuary's general rules. But it has far more kinds of de facto zones. Officially there are five major kinds of zones (Cowie-Haskell and Delaney 2003; Delaney 2001; www.floridakeys.noaa.gov/regs/zoning.html) but some kinds have a variety of purposes or management rules. Wildlife management areas designed to protect endangered or threatened species have various restrictions including no-access (no-go) and no-wake zones. Ecological reserves protect fairly large areas representing a diversity of habitat types and limit consumptive activities. Sanctuary preservation areas are heavily used shallow reefs that would otherwise have user conflicts. Existing management areas reflect other jurisdictions within the Sanctuary that are managed under a variety of regimes. For example, the Sanctuary surrounds the 259 km^2 Dry Tortugas National Park. Special use areas or research only areas protect areas important for scientific research, education, and other purposes. Among these zones are some two dozen no-take areas, with the largest, the Tortugas Ecological Reserve, encompassing 518 km^2. Moreover, to protect the values within the Sanctuary from risks of ship groundings and other kinds of shipping impacts, more than 10,000 km^2 surrounding the Sanctuary was designated as a particularly sensitive sea area (PSSA) by the International Maritime Organization in 2002. Ships longer than 50 m (164 ft) cannot anchor and cannot enter certain areas (www.floridakeys.noaa.gov/news/2003govcabreport.pdf). The addition of this protective PSSA buffer added a new zone and effectively doubled the size of the protected area.

The best-known and fullest expression of comprehensive zoning over a very large area is Australia's Great Barrier Reef Marine Park (GBRMP). Encompassing more than 344,000 km^2 of coral reefs and associated ecosystems, the Park is larger than the land area of Germany, Vietnam, or Ivory Coast, and is 35 times larger than Florida Keys National Marine Sanctuary. It is an integrated complex of different zones managed in different ways consistent with the overarching goal of conserving the natural values of the vast Great Barrier Reef (Day 2002).

The zoning system and other management approaches in the Great Barrier Reef Marine Park management approach is an instructive model for zoning that could be applied, with various modifications, in many other places, and, as Davey (2003) suggests, its

principle elements can be scaled up to the national level (for example, in Australia's National Representative System of Marine Protected Areas; www.deh.gov.au/coasts/mpa/nrsmpa/index.html).

The GBRMP was established in 1975, largely to prevent harm to the coral reefs from oil drilling and mining. Among many reasons, Norse (1993) noted that the following have been central to its success:

1. Its management agency, the Great Barrier Reef Marine Park Authority, is backed by legislation with real "teeth."
2. The park is managed as a complete marine ecosystem. This allows the Authority to create a mosaic of protected areas and multiple-use areas.
3. The Authority manages for a broad range of uses consistent with the GBR's essential ecological characteristics and processes. The many potential conflicts among park users require the Authority to consult with users and industries to fashion regulations and zoning decisions.
4. Continuing public awareness of and meaningful participation in the Authority's decisions have gained the public's support, which has translated to political support.
5. The Authority has remained adaptable to the park's changing patterns of use. Regulations and zoning plans have provided mechanisms for adapting management that responds to new understanding about the Great Barrier Reef ecosystem.

Other reasons for its success include the clarity of its zoning system (Day 2002); so long as people know where they are, they know what they can and cannot do.

In discussions about ocean zoning in the 1980s and '90s, I sometimes heard that the GBRMP is *not* an appropriate model for some place or other, but when I asked why, the answer was usually nothing more than "It is too large." I respect the challenges of scaling, but I suspect that the GBRMP zoning model, with some thoughtful modification, would apply as well in areas the size of Lundy Marine Nature Reserve as in areas such as the proposed Northwestern Hawaiian Islands National Marine Sanctuary (USA), which is about as large as the GBRMP, and in areas larger still.

If anything, the GBRMP has shown its flexibility by adding new areas and undertaking a dramatic, comprehensive new planning process: The Representative Areas Program (RAP) (www.gbrmpa.gov.au/corp_site/key_issues/conservation/rep_areas). One result of the RAP was to raise the no-take percentage of the Park from 4.7 percent to 33 percent starting in 2004. Another was to raise the area where bottom trawling is not allowed from about half to about two-thirds of the Park (MPA News 2003).

The Authority maintains a large, useful website (www.gbrmpa.gov.au) that is a virtual cookbook for zoning efforts. A print-out of this website, as well as copies of Day (2002) and Kelleher (1999, 2000), would make perfect gifts to officials responsible for ocean management in the USA and other countries.

Technological Advances That Can Help Zoning

In the not-too-distant past, there were fewer people and more fish, so zoning was not the imperative that it is now. Fortunately, in parallel with the increasing urgency, there are developments that have made the task much easier. A legal improvement is the establishment of EEZs in which there is clear national jurisdiction over resource use. A number of other improvements are technological.

One of them is improved maps. A variety of tools for surveying undersea topography have created higher-resolution information on undersea features than was available a decade ago. In some cases these are supplemented by remotely operated submersibles that can photograph the seafloor under a broader range of conditions and at much lower cost than manned submersibles. Earth observation satellite imagery has recently provided valuable information

about currents and patterns of productivity and can be beamed digitally to licensed receivers around the world. In combination, for those who can access them, these tools provide a much clearer picture of the physical setting for zoning.

Technologies can also help participants in zoning processes see options more clearly. Geographic information systems (GIS) let people superimpose layers of data in ways that allow rapid quantitative comparison of options. As an example, if someone wants to know how shipping lanes and seabirds could interact, GIS can show their coincidence if the data layers are available. Another technological advance that facilitates comprehensive zoning is the Internet. By allowing people to send text and images across vast distances at high speed, it facilitates communication, a key element in public participation processes.

Finally, technological advances can build trust by easing the task of ensuring compliance with zoning schemes. Global positioning systems (GPS) allow vessels to know precisely where they are in reference to zones. Vessel monitoring systems (VMS) allow officials to observe the positions and headings of boats in relation to various zones. Knowing that everyone is complying with mutually agreed upon rules removes disincentives for those who will benefit from the rules they have helped to fashion. In place-based systems such as ocean zoning, knowing where people are is half the battle.

Some of the aforementioned tools have helped to impoverish the marine realm by making the sea transparent and reducing chances that fishes can hide in the depths. It is comforting to know that these same tools can be used to protect marine life and encourage sustainable fisheries.

Beyond Denial and Inertia

No matter how desirable it might be for society to choose its new stable system state, it is not easy for individuals, sectors, or society as a whole to alter course. The greatest enemy of change is fear, and two common manifestations of fear are refusal to recognize evident truths and inertia or inaction even when the need to act is apparent. At a time when growing numbers of fishermen are lamenting *Empty Oceans, Empty Nets* (the title of a 2002 national television show in the United States), some still avow that the scientists are all wrong, that "there are plenty of fish out there." The evidence for the disappearance of marine life is ubiquitous and overwhelming, yet, as with scientific findings on cigarette smoking, pesticide impacts, and climate change, people in some industries steadfastly deny the validity of any research whose findings they do not like. There are no circumstances in which the evidence can win their trust.

As a society, we must decide whether to let those who will not trust science dictate our collective fate, and the fate of something even larger than we are: the sea. What is clear is that we now face a choice between an appalling certainty—that we are losing marine biodiversity and fisheries—and the worrisome uncertainties inherent in building a new system to replace one that has failed. And even when the need to act becomes clear, the will to do so is hardly universal. But, as Chinese philosopher Lao Tzu said 2,200 years ago in the *Tao Te Ching,* "A journey of a thousand miles must begin with a single step."

Fortunately, there is reason for hope. Societies and their institutions can consciously embrace fundamental change, as illustrated by dramatic social changes in nations where institutional barriers that long prevented women from making their fullest contributions to society have been dismantled. It has happened because so many people came to insist on change and then compelled decision makers to heed them. During the same period, US public attitudes about forests shifted from valuing them as biomass producers to valuing them as habitats for wildlife, and management of forests has shifted as a consequence. In some nations, the same transformation occurred in public attitudes and government actions concerning whales (Dallmeyer, Chapter 24). Attitudes and ways of acting can change.

Polls done for SeaWeb show that 63 percent of Americans believe that regulations protecting the

ocean are not strict enough (versus 2 percent who think they are too strict), and 75 percent favor limiting activities that harm marine biodiversity in MPAs (versus 10 percent who oppose limitations) (Dropkin 2002). Such widely held public attitudes could presage fundamental change in governance of waters under US jurisdiction, suggesting that the United States will eventually overcome denial and inertia on vital marine issues.

Conclusions

Since humankind entered the highly unstable (unsustainable) period punctuated by the closings of frontier after frontier, our history has been a struggle between freedom and order. I believe that the lack of freedom is damaging to the human spirit, and hence to all of the best areas of human endeavor. But freedom cannot mean that anyone can do anything anywhere at any time, especially as frontier eras draw to a close. It is important to recall the insight of Hannah Arendt (1951) in *The Origins of Totalitarianism:*

> To abolish the fences of laws between men—as tyranny does—means to take away man's liberties and destroy freedom as a living political reality; for the space between men as it is hedged in by laws, is the living space of freedom.

Or, as former US Supreme Court Justice Oliver Wendell Holmes put it, "The right to swing my fist ends where the other man's nose begins." The closing of the blue frontier requires that we temper the freedom of those who insist on continuing a ruinous course so that we can protect the freedoms of the billions of people and myriad other living things that owe their well-being and their very lives—past, present, and future—to the miraculous diversity of the marine realm.

There is no "silver bullet" that will instantly reverse decades or centuries of accumulated damage to the living sea. Some harm is already irreversible. Some options are forever foreclosed. The impediments to success are numerous and formidable. Until now, humankind's capacity to harm the sea has far exceeded our ability to protect it. But over the span of my career, and especially in the last few years, I have seen growing evidence that we are responding to the challenge of safeguarding the sea's integrity with new insight, values, and institutional change.

Assembling a workable system of marine stewardship that integrates scientific understanding, biodiversity conservation, and the needs and values of a growing world population is a challenge that we have not, as yet, come anywhere near achieving. Two things are clear: First, the insights generated by current and succeeding generations of marine conservation biologists will be indispensable for fashioning systems to protect and restore marine biodiversity. And second, thanks to the sea's resilience and to human ingenuity, we still have a chance to leave future generations biologically diverse oceans *if* we act quickly and effectively.

The challenge is vast, complex, difficult, and yet quite clear. I believe that we will meet it.

Acknowledgments

This chapter has benefited from the wisdom and information provided by scholars and practitioners around the world, including Fan Tsao, Katy Balatero, Bill Chandler, Hannah Gillelan, Lance Morgan, Jim Acheson, John Ogden, Gail Osherenko, Oran Young, Graeme Kelleher, Jon Day, Daniel Pauly, Callum Roberts, John Amos, Lisa Dropkin, Larry Crowder, Michael Soulé, John Twiss, Alison Rieser, Denis Hayes, Hooper Brooks, Beto Bedolfe, Josh Reichert, Angel Braestrup, Wool Henry, Mike Sutton, Jon Edwards, Sonia Baker, Steve Moore, Amy Lyons, Jim Sandler, Leslie Harroun, Conn Nugent, Wren Wirth, Karen Winnefeld, Gerald Rupp, Megan Weinstein Howard, Scott McVay, Timon Malloy, Ben Hammett, Sally Brown, Jennifer and Ted Stanley, Sharon and Mark Bloome, Malcolm Baldwin, Billy Causey, Imogen Zethoven, Robbin Peach, Amy Schick, Wendy Craik, Andy Rosenberg, Priscilla Brooks, Carl Safina, Rod Fujita, Bob Repetto, Erin Hannan, Biliana Cicin-Sain, Bud Ehler, John Mosher, William Wyler, Burl Ives,

Charles Bickford, Gregory Peck, and Jean Simmons. Finally I thank my wife and loving wife Irene Norse, who allowed me to pursue my desire to learn about ocean zoning even when it meant encouraging me to meet with officials of the Great Barrier Reef Marine Park Authority in the midst of our 1992 honeymoon in Queensland.

Literature Cited

Agardy, T.S. (1997). *Marine Protected Areas and Ocean Conservation*. R.G. Landes, Austin, Texas (USA)

Allison, G.W., J. Lubchenco, and M.H. Carr (1998). Marine reserves are necessary but not sufficient for marine conservation. *Ecological Applications* 8(1) Supplement: S79–S92

Arendt, H. (1951). *The Origins of Totalitarianism*. Harcourt Brace Jovanovich, New York, New York (USA)

Blyth, R.E., M.J. Kaiser, G. Edwards-Jones, and P.J.B. Hart (2002). Voluntary management in an inshore fishery has conservation benefits. *Environmental Conservation* 29 (4): 493–508

Brodeur, R.D., C.E. Mills, J.E. Overland, G.E. Walters, and J.D. Schumacher (1999). Evidence for a substantial increase in gelatinous zooplankton in the Bering Sea, with possible links to climate change. *Fisheries Oceanography* 8(4): 296–306

Broughton, J.M. (1997). Widening diet breadth, declining foraging efficiency, and prehistoric harvest pressure: Ichthyofaunal evidence from the Emeryville Shellmound, California. *Antiquity* 71 (274): 845–862

Buttermore, R.E., E. Turner, and M.G. Morrice (1994). The introduced northern Pacific seastar *Asterias amurensis* in Tasmania. *Memoirs of the Queensland Museum* 36: 21–25

Clark, C.W. (1973). Profit maximization and the extinction of animal species. *Journal of Political Economy* 81(4): 950–961

Cowie-Haskell, B.D. and J.M. Delaney (2003). Integrating science into the design of the Tortugas Ecological Reserve. *Marine Technology Society Journal* 37(1): 68–79

Crosby, A.W. (1986). *Ecological Imperialism : The Biological Expansion of Europe, 900–1900*. Cambridge University Press, Cambridge (UK)

Crowder, L.B., S.J. Lyman, W.F. Figueira, and J. Priddy (2000). Source–sink population dynamics and the problem of siting marine reserves. *Bulletin of Marine Science* 66: 799–820

Davey, K. (2003). Creating a National System of Marine Protected Areas—A conservation perspective. Pp. 103–015 in J.P. Beumer, A. Grant and D.C. Smith, eds., *Aquatic Protected Areas: What Works Best and How Do We Know?* Proceedings of the World Congress on Aquatic Protected Areas, 14–17 August, 2002, Cairns, Australia. University of Queensland Printery, St Lucia, Queensland (Australia)

Day, J.C. (2002). Zoning—lessons from the Great Barrier Reef Marine Park. *Ocean and Coastal Management* 45: 139–156

Delaney, J.M. (2001). Marine reserve design in Florida's Tortugas. *Earth System Monitor* 11(3): 12–13

Diamond, J. (1997). *Guns, Germs, and Steel: The Fates of Human Societies*. W.W. Norton & Company, New York, New York (USA)

Dropkin, Lisa (2002). Perceptions of ocean status and protection: New polling results. Presented at COMPASS conference on Marine Reserves Worldwide: Perceptions, Realities and Options, January 23, 2002, Monterey, California (USA)

Eagle, J, S. Newkirk, and B.H. Thompson Jr. (2003). *Taking Stock of the Regional Fishery Management Councils*. Island Press, Washington, DC (USA)

Feeny, D., S. Hanna, and A.F. McEvoy (1996). Questioning the assumptions of the "Tragedy of the Commons" model of fisheries. *Land Economics* 72 (2): 187–205

Flannery, T. (1994). *The Future Eaters: An Ecological History of the Australasian Lands and People*. Reed Books, Melbourne (Australia)

Flannery, T. (2001). *The Eternal Frontier: An Ecological History of North America and its Peoples*. Text Publishing, Melbourne (Australia)

Fogarty, M.J. and S.A. Murawski (1998). Large-scale disturbance and the structure of marine systems:

Fishery impacts on Georges Bank. *Ecological Applications* 8(1) Supplement: S6–S22

Frost, R. (1914). Mending Wall. *North of Boston*. 2nd ed. Henry Holt & Company, New York, New York (USA)

Fujita, R.M., T. Foran, and I. Zevos (1998). Innovative approaches for fostering conservation in marine fisheries. *Ecological Applications* 8(1) Supplement: S139–150

Gladwell, M. (2000). *The Tipping Point: How Little Things Can Make a Big Difference*. Little, Brown and Company, Boston, Massachusetts (USA)

Goldburg, R.J, M.S. Elliott, R.L. Naylor (2001). *Marine Aquaculture in the United States: Environmental Impacts and Policy Options*. Pew Oceans Commission, Arlington, Virginia (USA)

Gordon, H.S. (1954). The economic theory of a common-property resource: The fishery. *Journal of Political Economy* 62: 124–142

Haley, D. (1980). The great northern sea cow: Steller's gentle siren. Oceans 13(5): 7–11

Halpern, B. (2003). The impact of marine reserves: do reserves work and does reserve size matter? *Ecological Applications* 13: S117–S137

Hardin, Garrett (1968). The tragedy of the commons. *Science* 162(3859): 1243–1248

Hutchings, J.A. and J.D. Reynolds (2004). Marine fish population collapses: Consequences for recovery and extinction risk. *BioScience* 54(4): 297–309

Jackson, J.B.C., M.X. Kirby, W.H. Berger, K.A. Bjorndal, L.W. Botsford, B.J. Bourque, R.H. Bradbury, R. Cooke, J. Erlandson, J.A. Estes, T.P. Hughes, S. Kidwell, C.B. Lange, H.S. Lenihan, J.M. Pandolfi, C.H. Peterson, R.S. Steneck, M.J. Tegner, and R.R. Warner (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293: 629–638

Kelleher, G. (1999). *Guidelines for Marine Protected Areas*. IUCN, Gland (Switzerland)

Kelleher, G. (2000) The development and establishment of coral reef protected areas. Pp. 609–615 in M.K. Kasim Moosa, S. Soemodihardjo, A. Nontji, A. Soegiarto, K. Romimohtarto, Sukarno, and Suharsono, eds. *Proceedings of the Ninth International Coral Reef Symposium, Bali, Indonesia, October 23–27 2000*. Ministry of Environment, the Indonesian Institute of Sciences (Indonesia)

Kuhn, Thomas S. (1970). *The Structure of Scientific Revolutions*. University of Chicago Press, Chicago, Illinois (USA)

Kurlansky, M. (1997). *Cod, A Biography of the Fish That Changed the World*. Walker Publishing, New York, New York (USA)

Lemonick, Michael D. (1995). The last frontier. *Time Magazine* 146(7): 52–60

Lincoln, R.J., G.A. Boxshall, and P.F. Clark (1982). *A Dictionary of Ecology, Evolution and Systematics*. Cambridge University Press, Cambridge (UK)

Lutjeharms, J.R.E. and A.E.F. Heydorn (1981). Recruitment of rock lobster on Vema Seamount from the islands of Tristan da Cunha. *Deep-Sea Research* 28(10A): 1237

MCBI (1998). *Troubled Waters: A Call for Action*. Statement by 1,605 marine scientists and conservation biologists, Marine Conservation Biology Institute, Redmond, Washington (USA)

Mooney, Harold, ed. (1998). *Sustaining Marine Fisheries*. National Academy Press, Washington, DC (USA)

MPA News (2003). Australian Parliament passes rezoning bill for Great Barrier Reef, creating world's largest reserve system. *MPA News* 5(10): 1–3

Myers, R.A. and B.Worm (2003). Rapid worldwide depletion of predatory fish communities. Nature 423: 280–283

National Center for Ecological Analysis and Synthesis (NCEAS), University of California–Santa Barbara) 2001. Scientific consensus statement on marine reserves and marine protected areas. Issued at American Association for the Advancement of Science Annual Meeting, 17 February 2001, San Francisco, California (USA)

National Oceanic and Atmospheric Administration (NOAA) (1999). *Year of the Ocean Initiative, NOAA FY 2000 Budget Request Fact Sheet: Exploring the Last U.S. Frontier.* National Oceanic and Atmospheric Administration, Washington, DC (USA)

National Research Council (1999). *Sharing the Fish: Toward a National Policy on Individual Fishing Quotas*. National Academy Press, Washington, DC (USA)

Norse, E.A., ed. (1993). *Global Marine Biological Diversity: A Strategy for Building Conservation into Decision Making*. Island Press, Washington, DC (USA)

Norse, E.A. (2003). A zoning approach to managing marine ecosystems. Pp. 53–57 in B. Cicin-Sain, C. Ehler, and K. Goldstein, eds. *Workshop on Improving Regional Ocean Governance in the United States*. University of Delaware Center for the Study of Marine Policy, Newark, Delaware (USA)

Ogden, J.C. (2001). Maintaining diversity in the oceans. *Environment* 43(3): 28–37

Okey, A.T. (2003). Memberships of the eight regional fisheries management councils in the United States: Are special interests over-represented? *Marine Policy* 27: 193–206

Orbach, M. (2002). Beyond freedom of the seas. *Fourth Annual Roger Revelle Commemorative Lecture,* National Academy of Sciences Auditorium, Washington, DC (USA). Available at www.env.duke.edu/news/FreedomoftheSeas.pdf

Orensanz, J.M., J. Armstrong, D. Armstrong, and R. Hilborn (1998). Crustacean resources are vulnerable to serial depletion: The multifaceted decline of crab and shrimp fisheries in the Greater Gulf of Alaska. *Reviews in Fish Biology and Fisheries* 8: 117–176

Pauly, D., V. Christensen, J. Dalsgaard, R. Froese, and F. Torres Jr. (1998). Fishing down marine food webs. *Science* 279: 860–863

Pauly, D., V. Christensen, S. Guénette, T.J. Pitcher, U.R. Sumaila, C. J. Walters, R. Watson, and D. Zeller (2002). Towards sustainability in world fisheries. *Nature* 418: 689–695

Peterson, C.H. and J.A. Estes (2001). Conservation and management of marine communities. Pages 469–507 in M.D. Bertness, S.D. Gaines, and M.E. Hay, eds. *Marine Community Ecology*. Sinauer Associates, Sunderland, Massachusetts (USA)

Pew Oceans Commission (2003). *America's Living Oceans: Charting a Course for Sea Change*. Pew Oceans Commission, Arlington, Virginia (USA)

Pianka, E.R. (1970). On *r* and *K* selection. *American Naturalist* 104: 592–597

Pikitch, E.K., C. Santora, E.A. Babcock, A. Bakun, R. Bonfil, D.O. Conover, P. Dayton, P. Doukakis, D. Fluharty, B. Heneman, E.D. Houde, J. Link, P.A. Livingston, M. Mangel, M.K. McAllister, J. Pope, and K.J. Sainsbury (2004). Ecosystem-based fishery management. *Science* 305: 346–347

Rieser, A. (1997). Property rights and ecosystem management in U.S. fisheries: Contracting for the commons? *Ecology Law Quarterly* 24(4): 813–832

Roberts, C.M. (1995). Rapid build-up of fish biomass in a Caribbean marine reserve. *Conservation Biology* 9: 815–826

Roberts, S. and M. Hirshfield (2004). Deep-sea corals: Out of sight, but no longer out of mind. *Frontiers in Ecology and the Environment* 2(3): 123-130

Roberts, C.M., J.A. Bohnsack, F. Gell, J.P. Hawkins, and R. Goodridge (2001). Effects of marine reserves on adjacent fisheries. *Science* 294: 1920–23

Russ, G.R. and D.C. Zeller (2003). From *Mare Liberum* to *Mare Reservarum*. *Marine Policy* 27(1): 75–78

Sen, S. and J.R. Nielsen (1996). Fisheries comanagement: A comparative analysis. *Marine-Policy* 20: 405–418

Smith, T.D. (1994). *Scaling Fisheries: The Science of Measuring the Effects of Fishing, 1855–1955*. Cambridge University Press, Cambridge (UK)

South African Shipping News and Fishing Industry Review (1981). Vema yields 80 tons lobster. *South African Shipping News and Fishing Industry Review* 36: 21

Steneck, R.S., and J.T. Carlton (2001). Human alterations of marine communities: Students beware! Pages 445–468 in M.D. Bertness, S.D. Gaines, and M.E. Hay, eds. *Marine Community Ecology*. Sinauer Associates, Sunderland, Massachusetts (USA)

Stern, P.C., T. Dietz, N. Dolšak, E. Ostrom, and S. Stonich (2002). Knowledge and questions after 15 years of research. Pp. 445–489 in E. Ostrom, T. Dietz, N. Dolšak, P.C. Stern, S. Stonich, and E.U.

Weber, eds. *The Drama of the Commons*. National Academy Press, Washington, DC (USA)

Turner, F.J. (1893). The significance of the frontier in American history. Pp. 199–227 in *Report of the American Historical Association for 1893*

U.S. Commission on Ocean Policy (2004). *An Ocean Blueprint for the 21st Century: The Final Report of the U.S. Commission on Ocean Policy.* U.S. Commission on Ocean Policy, Washington, DC (USA)

Ward, T.J. (2003). Giving up fishing grounds to reserves: The costs and benefits. Pp. 19–29 in J.P. Beumer, A.Grant, and D.C. Smith, eds., *Aquatic Protected Areas: What Works Best and How Do We Know? Proceedings of the World Congress on Aquatic Protected Areas, 14–17 August, 2002, Cairns, Australia*. University of Queensland Printery, St. Lucia, Queensland (Australia)

Watling, L. and E.A. Norse (1998). Disturbance of the seabed by mobile fishing gear: A comparison with forest clearcutting. *Conservation Biology* 12(6): 1180–1197

Watson, R. and D. Pauly (2001). Systematic distortions in world fisheries catch trends. *Nature* 414: 534–36

Weber, M.L. (2002). *From Abundance to Scarcity: A History of US Fisheries Policy.* Island Press, Washington, DC (USA)

Wilder, R.J. (1998). *Listening to the Sea: The Politics of Improving Environmental Protection*. University of Pittsburgh Press, Pittsburgh, Pennsylvania (USA)