CHAPTER 4
MARINE PROTECTED AREAS, MARINE SPATIAL PLANNING, AND THE RESILIENCE OF MARINE ECOSYSTEMS

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INTRODUCTION

At first blush, a concern for improving ocean resilience—or, more properly, the resilience of marine ecosystems—might seem misdirected. Oceans cover 71 percent of the Earth's surface and, because of their depth, provide 99 percent of the habitat available for life (Ogden 2001). Biological diversity in the oceans exceeds that on land (Craig 2005). In addition, the seas moderate and buffer the most fundamental physical and chemical processes of the planet, including temperature regulation, the hydrological cycle, and carbon sequestration. Changes in ocean temperature and ocean currents in one part of the world affect weather over a much greater area, as the La Niña/El Niña oscillation, or ENSO, demonstrates through its three-to-seven-year cycles, all driven by temperature and current changes in the eastern Pacific Ocean off the coast of South America. Barriers to dispersal are less prevalent in the sea than on land, promoting larval connectivity and migration over very large scales.

The oceans, therefore, maintain world-spanning, interconnected physical, chemical and biological processes that seem far too large and complex for mere humans to damage. Indeed, in terms of both effective governance and scientific research, "marine systems have been relatively neglected because they are 'out of sight, out of mind' to most people, including most scientists"

(Ray & Grassle 1991: 453). Until recently, a "paradigm of inexhaustibility" prevailed, a mindset that human managers did not need to worry about ocean health because marine ecosystems would always be resilient enough to absorb and recover from the multiple and interactive stresses—overfishing, pollution and now climate change—that humans impose on them (Craig 2005; Ogden 2001; Connor 1999).

Unfortunately, we now know that marine ecosystems often *cannot* in fact absorb the multitude of anthropogenic stressors imposed upon them, even before the accelerating impacts of climate change become more severe and add to existing drivers of change such as overfishing (Agardy 2010; Laffoley *et al.* 2008). Many marine ecosystems have lost their resilience to recurrent natural and man-made disturbances, and have undergone long-term shifts to new, degraded regimes (Hughes *et al*. 2005). In coastal regions in particular, fishing has substantially altered marine ecosystems for centuries (Jackson *et al.* 2001). For example, many coral reefs have undergone regime-shift to macro-algae following the over-exploitation of herbivores and the addition of land-based nutrients. A study published in *Science* in 2008 concluded that no area of the world's oceans is completed unaffected by human impacts, and 41 percent of the oceans are *strongly* affected by multiple human impacts (Halpern *et al*. 2008). In the face of additional climate change-induced stresses, marine governance systems and marine managers need to find mechanisms for increasing the resilience of ocean ecosystems. This chapter explores one set of those mechanisms—place-based marine management, especially marine protected areas (MPAs)—and the various legal regimes that encourage use of these tools in pursuit of increased marine ecosystem resilience.

THREATS TO MARINE ECOSYSTEM RESILIENCE

The main threat to marine ecosystem resilience is a loss of the ecosystem functions that marine biodiversity provides, leading to undesirable regime-shifts. From a resilience perspective, the number of species is less important than the functions that they perform (Bellwood *et al.* 2004). Depauperate regions are more vulnerable to human impacts because critical ecosystem functions may be performed by only one or two species. In this case, the loss of a top predator, or the only major herbivore, or a key structural, habitat-forming species can have profound ecological impacts. Biodiversity hotspots, on the other hand, typically have many species performing similar ecological roles, providing some insurance against modest losses of biodiversity (Bellwood et al. 2004). According to the United Nations Education, Scientific, and Cultural Organization (UNESCO), at least 43 of the 70 phyla of life—the second-most general classification of life on Earth, signaling broad genetic diversity—are found in the oceans, and 45 percent of known phyla exist only in the oceans; UNESCO also suggests that at least half, and probably more, of all species live in the seas (UNESCO 1996). Canadian scientists estimated in 2005 that there may be as many as 10 million undescribed species living in the seas (CMB 2011), although the recently completed international Census of Marine Life is starting to fill in some of those holes. By 2010, the Census had increased the number of known marine species from approximately 230,000 to approximately 250,000 (Ausubel, Crist & Waggoner 2010). However, the ecological roles of each of those species, and their contribution to ecosystem resilience, is very poorly understood.

Biodiversity contributes to the resilience of a given marine ecosystem by increasing the redundancy of structure and function within that ecosystem (Craig, 2005). As a result, marine biodiversity loss undermines marine ecosystem resilience. For example, the gradual depletion by overfishing of a suite of herbivore species in the Caribbean has eroded the resilience of coral reefs, leading to persistent regime-shifts from corals to ecosystems dominated by blooms of seaweed (Hughes, 1994). Nevertheless, significant concerns about loss of marine biodiversity did not emerge until the 1990s (Craig, 2005). As scientist Jeremy B.C. Jackson commented in 2001, "[t]he persistent myth of oceans as wilderness blinded ecologists to the massive loss of marine ecological diversity caused by overfishing and human inputs from the land over the past centuries" (Jackson 2001a: 5411).

The three principal drivers of change in marine ecosystems are land-based marine pollution, overfishing and climate change (e.g. Hughes *et al*. 2003; Jackson *et al.* 2001). Marine pollution takes many forms, but it is, critically, predominantly a land-based governance problem that cannot be addressed through the establishment of marine parks: Almost all marine pollution comes from land, the result of direct ocean dumping; direct and controlled discharge of pollutants from coastal facilities; indirect and largely uncontrolled runoff from agricultural and urban areas; and atmospheric deposition of pollutants initially emitted into the air. Deforestation, intensification of agriculture, urban sprawl, industrialization, population growth and migration to the coast have all contributed to increased near-shore pollution.

Offshore ocean dumping is now curtailed in the 80 or so countries that are parties to the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the London Convention). Nevertheless, for decades nations and individuals intentionally dumped wastes at sea, included nuclear and toxic chemical waste, and this legacy pollution from the ocean dumping remains a concern for marine ecosystem health. As the Millennium Ecosystem Assessment (MEA) noted in 2005, for example, "the estimated 313,000 containers of low-intermediate emission radioactive waste dumped in the Atlantic and Pacific Oceans since the 1970s pose a significant threat to deep-sea ecosystems should the containers leak, which seems likely over the long term" (MEA 2005: 483).

Coastal development directly spurs marine pollution problems, such as by increasing the amount of polluted runoff reaching the oceans and by promoting the discharge of sewage into the sea. According to the United Nations Environment Programme (UNEP), it would cost US$56 billion per year to adequately address discharges of untreated sewage from coastal communities, because "[a]round 60% of the wastewater discharged into the Caspian Sea is untreated, in Latin America and the Caribbean the figure is close to 80%, and in large parts of Africa and the Indo-Pacific the proportion is as high as 80-90%" (UNEP 2011). Certain kinds of land-based marine pollution, especially nutrient pollution from sewage, runoff of agricultural fertilizers, and atmospheric deposition of nitrogen and phosphorus compounds, is also linked to the proliferation of Harmful Algal Blooms (HABs)—the rapid reproduction and multiplication of small marine plants (phytoplankton and dinoflagellates) that then cause harmful effects on the environment. HABs, for example, can lead to "red tides," the release of neurotoxins and the contamination of shellfish, and eutrophication and coastal "dead zones."

The various forms of marine pollution can, unquestionably, impair the resilience of marine ecosystems, especially coastal ecosystems. Sedimentation from muddy runoff can smother and kill marine organisms, particularly juveniles, leading to recruitment failure. Without recruitment, ecosystems lose their capacity to absorb and recover from recurrent shocks such as hurricanes, leading to regime-shifts and long-term degradation. Turbid waters also have lower light penetration, affecting light-dependent species such as kelp and corals. Added nutrients from terrestrial sources, in combination with depleted herbivores from overfishing, promote the establishment and growth of phytoplankton and macroalgae. Often the gradual buildup of pollution goes unnoticed as a threshold level is approached, leading eventually to a regime-shift to a new, degraded system that is difficult to reverse. Nevertheless, resolving those pollution problems is predominantly a terrestrial rather than a marine governance issue, requiring improved management of land-use practices, protective control of air emissions, water discharges, plastic and other waste disposal, and better management of polluted runoff.

The newest major stressor to ocean ecosystems—climate change—is likewise predominantly a terrestrial governance issue: The ultimate "solution" to climate change is to reduce greenhouse gas concentrations in the global atmosphere, which in turn requires controlling greenhouse gas emissions from the various anthropogenic sources that are predominantly land-based. Nevertheless, until such controls are implemented and take effect, it is worth emphasizing that climate change poses new challenges to marine ecosystem resilience, making effective ocean governance that much more important. Climate change is affecting atmospheric, land, freshwater, and ocean temperatures—but not uniformly (IPCC 2007). Temperatures toward the poles are increasing faster than temperatures near the equator, and land temperatures are rising faster than temperatures in the ocean (IPCC 2007). Many of these climate change-driven ecological changes are likely to become worse in the coming decades, because global average changes of at least 0.1ºC to 0.2ºC *per decade* are expected for the rest of this century (IPCC 2007).

The oceans play a significant role in moderating climate change impacts, and understanding the interaction of the atmosphere and the oceans is widely acknowledged to be critical to understanding and modeling climate change. For the purposes of this chapter, however, the main point is that climate change alters the oceans themselves, decreasing the resilience of marine ecosystems and threatening to push those ecosystems over critical thresholds into new ecological states that function very differently. Generally, these alternate states are undesireable, because they deliver fewer ecosystem goods and services, such as income from fisheries and coastal tourism. Three climate change-related effects are particularly important for marine ecosystems: increasing ocean temperatures and consequent changes in ocean dynamics (e.g. current strengths and storms); sea-level rise; and ocean acidification.

Increasing surface sea temperatures and ocean heat content are two of the most direct impacts of increasing global average atmospheric temperatures. Increasing ocean temperatures have already changed important ecosystem functions and services. The IPCC in 2007 expressed "high confidence" "that observed changes in marine . . . biological systems are associated with rising sea temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation," including "shifts in ranges and changes in algal, plankton, and fish abundance in high-latitude oceans" (IPCC 2007: 3). In November 2009, researchers at NOAA reported that about half of the commercially important fish stocks in the western North Atlantic Ocean, such as cod and haddock, had been shifting poleward in response to rising sea temperatures. Similar shifts are underway in the southern hemisphere. Changes in ocean currents are also occurring, with the potential for major impacts on marine ecosystems. For example, "[e]vidence is starting to accumulate that global warming may contribute to—or even trigger—troubling ecological changes taking place in . . . key regions of coastal upwelling"—including areas off the coasts of northern California and Oregon—"where some of the world's richest fisheries exist," collectively accounting for 20% of the world's fish catch (Spotts 2007). In addition, the IPCC projected increasing coral bleaching events as current levels of sea surface temperature increase, and widespread coral mortality is likely to occur if SSTs increase by approximately 2.5 to 3.0 degrees Celsius (IPCC 2007). The largest coral bleaching event to date occurred in 1998 during one of the warmest years on record, killing approximately 16% or the world's corals (Hughes *et* *al*. 2003).

Increases in ocean temperature also contribute to increasingly violent storm events and to sea level rise, which in turn is expected to lead to coastal erosion and inundation of coastal wetlands (IPCC, 2007). Indeed, thermal expansion of ocean waters and melting ice contribute about equally to sea-level rise. According to NOAA in 2010, "[t]he rate of global mean sea level (GMSL) rise is estimated currently to be 3.1 ± 0.4 mm yr-1 (3.4 mm yr-1 with correction for global isostatic adjustment)" (Levy 2009). In the United States, the EPA estimated in a report to Congress that a two-foot (60 cm) increase in sea level could destroy 17 to 43 percent of the United States' coastal wetlands, with over 50 percent of that destruction occurring in Louisiana alone (EPA 2011), and the IPCC has "suggest[ed] that by 2080, sea level rise could convert as much as 33 percent of the world's coastal wetlands to open water" (IPCC 2007).

Finally, the most insidious side effect of climate change—"side effect" because it is not the result of atmospheric warming, but rather of the chemistry of increased atmospheric carbon dioxide concentrations—is ocean acidification. As the U.K. Royal Society reported in June 2005, increased carbon dioxide levels in the atmosphere are acidifying the oceans (Royal Society 2005). This acidification most directly puts coral reefs and pelagic plankton at risk because both of these important ecosystems rely on species that calcify carbonate skeletons or shells, a process with which acidification interferes (Royal Society 2005). The IPCC similarly concluded in 2007 that "[t]he progressive acidification of oceans due to increasing atmospheric carbon dioxide is expected to have negative impacts on marine shell forming organisms (e.g., corals) and their dependent species" (IPCC 2007: 8). As such, ocean acidification threatens the biodiversity and ecological functions that coral reefs and oceanic ecosystems support and maintain.

In contrast to both climate change and marine pollution, overfishing is decisively a *marine* governance issue—arguably, the most important marine governance issue for improving marine ecosystem resilience. Fishing threats to marine biodiversity and ecosystem resilience include the impacts on target species, the phenomenon of bycatch, and the destruction of important habitat. Harvesting of targeted species and bycatch changes the structure of food webs, and can tip marine ecosystems into a new regime. For example, in the Gulf of Maine, over-harvesting of groundfishes such as cod has led to population explosions of lobsters and sea urchins. In turn, hyper-abundances of herbivorous sea urchins have destroyed kelp beds, creating "urchin barrens"—low diversity ecosystems where recovery of kelp is prevented by continuous grazing due indirectly to overfishing (Steneck *et al*. 2011).

Despite greatly increased fishing effort world-wide, the annual catch of wild fish has leveled off, suggesting that humans have met—and probably exceeded—the sustainable yield of the world's fish stocks. As the U.N. Food and Agriculture Organization (FAO) reported in 2011, "Global capture fisheries production in 2008 was about 90 million tonnes, with an estimated first-sale value of US$93.9 billion, comprising about 80 million tonnes from marine waters and a record 10 million tonnes from inland waters . . . . World capture fisheries production has been relatively stable in the past decade" (UNFAO 2011: 5).

Nevertheless, even the normally taciturn FAO found the most recent marine fish stock statuses—and overall trends in stock status—to be cause for concern, and it emphasized the fact that bluefin tuna are now candidates for endangered species protection at the international level. Its 2011 summary of the status of world fish stocks is worth presenting in its entirety:

> The proportion of marine fish stocks estimated to be underexploited or moderately exploited declined from 40 percent in the mid-1970s to 15 percent in 2008, whereas the proportion of overexploited, depleted or recovering stocks increased from 10 percent in 1974 to 32 percent in 2008. The proportion of fully

exploited stocks has remained relatively stable at about 50 percent since the 1970s. In 2008, 15 percent of the stock groups monitored by FAO were estimated to be underexploited (3 percent) or moderately exploited (12 percent) and able to produce more than their current catches. *This is the lowest percentage recorded since the mid-1970s*. Slightly more than half of the stocks (53 percent) were estimated to be fully exploited and, therefore, their current catches are at or close to their maximum sustainable productions, with no room for further expansion. The remaining 32 percent were estimated to be either overexploited (28 percent), depleted (3 percent) or recovering from depletion (1 percent) and, thus, yielding less than their maximum potential production owing to excess fishing pressure, with a need for rebuilding plans. *This combined percentage is the highest in the time series. The increasing trend in the percentage of overexploited, depleted and recovering stocks and the decreasing trend in underexploited and moderately exploited stocks give cause for concern.*

Most of the stocks of the top ten species, which account in total for about 30 percent of the world marine capture fisheries production in terms of quantity, are fully exploited. The two main stocks of anchoveta (*Engraulis ringens*) in the Southeast Pacific and those of Alaska pollock (*Theragra chalcogramma*) in the North Pacific and blue whiting (*Micromesistius poutassou*) in the Atlantic are fully exploited. Several Atlantic herring (*Clupea harengus*) stocks are fully exploited, but some are depleted. Japanese anchovy (*Engraulis japonicus*) in the Northwest Pacific and Chilean jack mackerel (*Trachurus murphyi*) in the Southeast Pacific are considered to be fully exploited. Some limited possibilities for expansion may exist for a few stocks of chub mackerel (*Scomber japonicus*), which are moderately exploited in the Eastern Pacific, while the stock in the Northwest Pacific was estimated to be recovering. In 2008, the largehead hairtail (*Trichiurus lepturus*) was estimated to be overexploited in the main fishing area in the Northwest Pacific. *Of the 23 tuna stocks, most are more or less fully exploited (possibly up to 60 percent), some are overexploited or depleted (possibly up to 35 percent) and only a few appear to be underexploited (mainly skipjack). In the long term, because of the substantial demand for tuna and the significant overcapacity of tuna fishing fleets, the status of tuna stocks may deteriorate further if there is no improvement in their management.* Concern about the poor status of some bluefin stocks and the difficulties in managing them led to a proposal to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 2010 to ban the international trade of Atlantic bluefin. Although it was hardly in dispute that the stock status of this high-value food fish met the biological criteria for listing on CITES Appendix I, the proposal was ultimately rejected. Many parties that opposed the listing stated that in their view the International Commission for the Conservation of Atlantic Tunas (ICCAT) was the appropriate body for the management of such an important commercially exploited aquatic species. Despite continued reasons for concern in the overall situation, it is encouraging to note that good progress is being made in reducing exploitation rates and restoring overfished fish stocks and marine ecosystems through effective management actions in some areas such as off Australia, on the

> Newfoundland–Labrador Shelf, the Northeast United States Shelf, the Southern Australian Shelf, and in the California Current ecosystems (UNFAO 2011: 8 (emphasis added)).

Somewhat ironically, moreover, although the FAO characterized capture fishing overall as "stable," it also noted that total catch has declined in most oceans of the world and that several fish stocks have significantly decreasing yields (UNFAO 2011). Most particularly, "[t]he decline of the gadiformes ('cods, hakes, haddocks' . . .) seems relentless. In 2008, catches of this species group as a whole did not total 8 million tonnes, a level that had been until then consistently exceeded since 1967 and that reached a peak of almost 14 million tonnes in 1987. In the last decade, catches of Atlantic cod, the iconic species of this group, have been somewhat stable in the Northwest Atlantic at about 50 000 tonnes (very low by historical standards), but in the Northeast Atlantic catches have further decreased by 30 percent" (UNFAO 2011: 15). Total tonnage of marine fisheries captures peaked in 1996 (UNFAO 2011).

Commercial and artisanal fishing can undermine marine ecosystem resilience (e.g. Steneck et al 2010, Hughes et al. 2005, Bellwood et al. 2004), but so too can high levels of recreational fishing. A 2004 study in *Science*, for example, concluded that:

> Recreational landings in 2002 account for 4% of total marine fish landed in the United States. With large industrial fisheries excluded (e.g., menhaden and pollock), the recreational component rises to 10%. Among populations of concern, recreational landings in 2002 account for 23% of the total nationwide, rising to 38% in the South Atlantic and 64% in the Gulf of Mexico. Moreover, it affects many of the most-valued overfished species—including red drum, bocaccio, and red snapper—all of which are taken primarily in the recreational fishery (Coleman *et al*. 2004: 1958).

Moreover, the study emphasized that both commercial and recreational fishing "can cause cascading trophic effects that alter the structure, function, and productivity of marine ecosystems," and where recreational fishing actually outstrips commercial fishing, it "can have equally serious ecological and economic consequences on fished populations" (Coleman *et al*.

2004: 1959).

Fishers, quite naturally, prefer to catch the largest fish of the species they are targeting, and they often prefer to target large apex predators—tuna, swordfish—to begin with (Coleman *et al*. 2004). Both preferences have consequences for marine ecosystem function. First, by targeting large predators, fishers can wipe out (or nearly so) an entire trophic level of the relevant ecosystem's food web, changing the abundances of species, distorting foodwebs, and eroding the resilience of the ecosystem. In the heavily fished main Hawaiian Islands, for example, apex predators account for about three percent of the biomass of the coral reef ecosystems, while in the more isolated Northwest Hawaiian Islands, apex predators account for 54 percent of the biomass—a significant shift in food-web structure and ecosystem function. As apex predatory species become depleted, fishing effort typically expands or switches to large and then small herbivores, planktivores and detritivores, a phenomenon known as "fishing down the food chain." Second, by targeting the largest individuals of a species, fishers can change the species' reproduction dynamics. The biggest fish produce disproportionately more offspring—*i.e.*, the relationship between body size and fecundity is strongly non-linear (Roberts & Hawkins 2000). Moreover, in some heavily targeted species such as parrotfishes, individual fish undergo a sex change as they mature (Roberts & Hawkins 2000). Fishing can also exert strong evolutionary pressures on fishes, selecting for individuals that reach reproductive size earlier. Thus, by targeting the largest fish, fishers may alter sex ratios, puberty size, and reproductive capacity as well as overall abundances.

Fishers invariably catch non-target species, or bycatch. Very few fishing methods, especially at the commercial scale, can limit the kinds of species caught: long lines attract seabirds, marine mammals, and sharks as well as target fish; nets and traps capture species and juveniles that are too big to slip through the mesh. Improvements to gear, such as turtle exclusion devices on shrimp nets or escape slots on traps, can help to reduce bycatch. Banning netting in habitats where vulnerable species such as dugongs are prevalent can also reduce bycatch rates. Under most fisheries regimes, fishers throw the dead and dying bycatch back into the ocean, making accurate estimates of bycatch very difficult Moreover, "ghost fishing" by discarded or lost fishing nets and traps can continue to catch and kill fish and other marine creatures for years (UNFAO 2005).

Finally, certain fishing methods destroy the marine habitat necessary to support healthy ocean ecosystems. Blast fishing and fishing through cyanide poisoning on coral reefs are obvious examples (McClellan 2010). More controversially, perhaps, bottom trawling is recognized as an ecosystem-destroying fishing method. As the United States' National Research Council recognized in 2002, "[t]rawl gear can crush, bury, or expose marine flora and fauna and reduce structural diversity" (NRC 2002: 20). Bottom trawling and dredging have flattened the three-dimensional habitat formed by sponges, sea fans and deep-water corals in many of the world's fishing grounds.

The cumulative impacts of fishing on marine ecosystem structure and function (and hence overall resilience) are most obvious from an historical perspective. Many of the impacts of fishing are cumulative over long periods, making them easy to miss or ignore. In 1995, Daniel Pauly coined the phrase "shifting baseline syndrome" to describe a pervasive phenomenon in fisheries management:

> Essentially, this syndrome has arisen because each generation of fisheries scientists accepts as a baseline the stock size and species composition that occurred at the beginning of their careers, and uses this to evaluate changes. When the next generation starts its career, the stocks have further declined, but it is the stocks at that time that serve as a new baseline. The result obviously is a gradual shift of the baseline, a gradual accommodation of the creeping

> disappearance of resource species, and inappropriate reference points for evaluating economic losses resulting from overfishing, or for identifying targets for rehabilitation measures (Pauly 1995: 430).

An historical perspective on the status and trajectory of marine ecosystems is thus critical in assessing their resilience. Moreover, historical overfishing may be the key culprit in pushing these ecosystems towards a tipping point (Steneck et al. 2011, Hughes 1994). In 2001, after examining a variety of historical records and evidence, nineteen marine scientists jointly concluded that “[e]cological extinction caused by overfishing precedes all other pervasive human disturbance to coastal ecosystems, including pollution, degradation of water quality, and anthropogenic climate change” (Jackson *et al*. 2001b: 629). This study emphasized the significantly greater abundance of almost all fished marine species in historical times, and outlined the already-existing impacts of historical overfishing, theorizing that centuries of overfishing have set in motion processes that caused or contributed to current—and, the authors speculated—future collapses of marine ecosystems (Jackson *et al*. 2001b). For example, in the Pacific Northwest and Alaska, fur traders hunted sea otters “to the brink of extinction” by the 1800s in many kelp forest ecosystems, allowing sea urchins to multiply in the absence of their main predator; the sea urchins then ate the kelp itself, decimating the entire ecosystem (Jackson *et al*. 2001b: 631). This regime-shift persists today, except in areas were recovery of sea otters is underway.

Marine Protected Areas, Marine Reserves, and Marine Spatial Planning

While exact definitions can vary, *marine protected areas* (MPAs) are most essentially place-based legal protections for marine ecosystems—the ocean equivalent of terrestrial national and state parks. The International Union for the Conservation of Nature (IUCN), for example, defines an MPA to be "[a]ny area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (IUCN 2010).

When it comes to classification, lumpers will almost always come up with fewer categories than splitters, and the same is true with respect to classifying protected areas (Laffoley 2008). The IUCN, for example, delineates six kinds of protected areas and intends those categories to apply on both land and sea (Dudley 2008). For purposes of this chapter, however, only three distinctions are important: the basic concept of an MPA, the more specialized concept of a *marine reserve* or No-Take Area, and the comprehensive approach of *marine spatial planning* or *ocean zoning* that envisages a network of MPAs or NTAs.

All MPAs use the law or management authority to limit ocean uses in some respect. For example, many nations use MPAs to separate potentially conflicting uses of a marine ecosystem, such as recreational diving and commercial fishing. As Tundi Agardy has recently observed, "In planning marine protected areas, conservationists are able to root marine issues to a specific place, and in so doing, engage the public and decisionmakers in a concrete set of measures to protect that place" (Agardy 2010: x). However, when MPAs initially serve to separate uses, they can also function as part of a larger system of marine zoning, more formally known as *marine spatial planning*. Marine spatial planning is akin to land use planning for cities and suburbs, with the important distinction that marine spatial planning seeks to take the needs of the marine ecosystem into account in the planning, and to protect areas essential to ecosystem processes, productivity, and function (Agardy 2010; McLeod & Leslie 2009).

The most protective MPAs, generally known as *marine reserves*, prohibit all extractive uses of the marine ecosystem, including fishing (Craig 2005). The most protective marine reserves prohibit all access except for scientific research—and sometimes even severely restrict research—but most tourism-related marine reserves allow non-extractive recreational uses such as snorkeling, diving, and boating.

As one example of how authorities can employ multiple types of MPAs and marine reserves in a unified ocean zoning plan, is exemplified by the Great Barrier Reef (GBR) Marine Park in Australia, established in 1976. The Marine Park, which is the size of Italy, was initially zoned into areas that allowed or banned trawling, commercial and/or recreational line fishing, and other activities. The most protected areas, Preservation Zones, prohibited any accesses without a permit, and even scientific research was limited (GBRMPA 2004). Most of these no-go areas are small island rookeries for birds and turtles, where even a limited human presence could be damaging. Until 2004, less than 5% of the GBR Marine was zoned as no-take reserves where commercial and recreational fishing was prohibited. In 2004, the GBR Marine Park was rezoned in response to growing evidence and concerns about declining abundances of corals, fishes, turtles, and dugongs. In particular, the proportion of the Marine Park where fishing is banned was increased from 5% to 30%, and commercial fishing was prohibited in areas with high recreational use. Although all fishing is prohibited in these marine reserve zones (NTAs), users are free to enter for recreational activities (GBRMPA 2004), and recreational fishers can fish in the remaining two-thirds of the Marine Park. These changes in multi-zone use have been very effective: the number of targeted fish has already doubled inside the new marine reserves (McCook et al. 2010). Importantly, the 2004 rezoning was accompanied by additional changes in regulations (*e.g.*, on the number and sizes of fish that could be caught) and by a restructuring of the commercial fishing industry, interventions that are not spatially-explicit but which nonetheless reinforce the effectiveness of spatial planning.

PLACE-BASED MARINE GOVERNANCE AND MARINE ECOSYSTEM RESILIENCE

In terms of addressing threats to the resilience of marine ecosystems, marine reserves or NTAs most directly reduce the stresses caused by overfishing. In particular, research has demonstrated that MPAs and marine reserves that prohibit fishing and that are scientifically chosen to protect important fish habitats, such as breeding grounds or nurseries, can be quite effective in increasing both the numbers and size of targeted species of fish (e.g. McCook *et al*. 2010, Mumby and Harbone 2010, Craig 2002) and, more generally, in increasing biodiversity (Halpern 2003; Côté, Mosqueira & Reynolds 2001). In 2003, for example, Benjamin Halpern concluded that, "[o]n average, creating a reserve appears to double density, nearly triple biomass, and raises organism size and diversity by 20-30% relative to the values for unprotected areas" (Halpern 2003: S125). The biggest changes, as expected, are exhibited by harvested species. As their numbers increase, other species—their prey, predators and competitors—also change in abundance. Consequently, the recovery or preservation of targeted species has profound impacts on the structure of marine foodwebs and the resilience of marine ecosystems.

A broad and international consortium of entities—the World Commission for Protected Areas, the IUCN, the Great Barrier Reef Marine Park Authority, NOAA, Natural England, the World Wildlife Fund, and the Nature Conservancy—are advocating MPA networks as a means of increasing marine ecosystem resilience (Laffoley *et al*. 2008). MPA networks link smaller individual MPAs without necessarily zoning an entire contiguous range of ocean. As the consortium explains:

> When used in isolation, small MPAs may not support fish and invertebrate populations that are large enough to sustain themselves. To ensure that young marine organisms are available to replenish and sustain populations within MPAs, the area of protection must be fairly large. However, in many regions, economic,

> social and political constraints make it impractical to create one single large MPA of sufficient size to support viable, self-sustaining populations of all species. Establishing networks of several to many small to moderately sized MPAs may help to reduce socioeconomic impacts without compromising conservation and fisheries benefits. Furthermore, *well-planned networks* provide important spatial links needed to maintain ecosystem processes and connectivity, as well as *improve resilience by spreading risk in the case of localized disasters, climate change, failures in management or other hazards, and thus help to ensure the long-term sustainability of populations better than single sites* (Laffoley *et al*. 2008: 10 (citations omitted; emphasis added)).

In addition, the consortium identified four critical "components of a resilient MPA network": (1) "Effective management"; (2) "[r]isk spreading through inclusion of replicates of representative habitats"; (3) "[f]ull protection of critical areas that can serve as reliable sources of seed for replenishment [or] preserve ecological function"; and (4) "[m]aintenance of biological and ecologicall connectivity among and between habitats" (Laffoley *et al*. 2008: 16).

The consortium's advocacy is based on studies that indicate that marine reserves can increase the resilience of marine ecosystems to the impacts of climate change. In 2003, a group of 17 coral reef researchers stated that:

> Although climate change is by definition a global issue, local conservation efforts can greatly help in maintaining and enhancing resilience and in limiting the longer-term damage from (coral) bleaching and related human impacts. Managing coral reef resilience through a network of NTAs (marine reserves), integrated with management of surrounding areas, is clearly essential to any workable solution. This requires a strong focus on reducing pollution, protecting food webs, and managing key functional groups (such as reef constructors, herbivores, and bioeroders) as insurance for sustainability. (Hughes et al. 2003).

In 2003-2005, the critical role of herbivory in the recovery of corals following large-scale bleaching was examined experimentally on the Great Barrier Reef, by excluding grazing parrotfishes using large cages. In control areas, where grazing was uninterrupted, macroalgae were scarce and coral cover recovered quickly. In contrast, the exclusion of parrotfishes triggered a regime-shift to macroalgae, and coral recruitment was suppressed (Hughes et al.

2007). This study concluded that "management of fish stocks is a key component in preventing phase shifts and managing reef resilience. Importantly, local stewardship of fishing effort is a tractable goal for conservation of reefs, and this local action can also provide some insurance against larger-scale disturbances such as mass bleaching, which are impractical to manage directly."

January 2010, Peter Mumby and Alastair Harbone also observed that by "protecting large herbivorous fishes from fishing," marine reserves protecting Caribbean coral reefs would also "generate a trophic cascade that reduces the cover of macroalgae, which is a major competitor of corals," increasing the reefs' resilience to climate change (Mumby & Harbone 2010: 1). According to their research, after the severe coral bleaching event in 1998 in the Bahamas, coral recovery in marine reserves was significantly more extensive after two and a half years than in non-reserves, and macroalgae cover explained at least 43 percent of the variance in coral abundance (Mumby & Harbone 2010). They also concluded that "[m]arine reserves cannot protect corals from direct climate-induced disturbance, but they can increase the post-disturbance recovery rate of some corals providing that macroalgae have been depleted by more abundant communities of grazers that benefit from reduced fishing pressure" (Mumby & Harbone 2010: 4).

THE LAW OF PLACE-BASE MARINE PROTECTION AND MARINE ECOSYSTEM RESILIENCE

The oceans are a global resource, both legally and ecologically. Ocean currents connect vast regions of the seas to a much greater extent than on land, and no ocean ecosystem can ever be deemed to be completely insulated from the influence of events anywhere else on the globe. As a legal matter, this global scale of ocean dynamics suggests that governance efforts to improve the resilience of marine ecosystems must occur at multiple scales—international, regional, national, and, if national delineation of jurisdiction demands and allows, sub-national. Indeed, one of the greatest challenges for place-based approaches to marine governance is the acceptance of local communities—many attempts to establish networks of marine reserves or NTAs around the world have failed because of poor compliance and public support.

This section surveys some of the important governance mechanisms and trends currently established at these various scales that might encourage (or impede) ecosystem-based, placed-based governance of marine resources. This overview is necessarily brief, but it nevertheless provides a summary of both existing authority, and gaps in that authority regarding the increased and improved use of MPAs, marine reserves, and marine spatial planning to improve the resilience of ocean ecosystems, especially in the face of continuing global climate change.

Legal Jurisdiction Over the Oceans: The Basics

To establish an MPA, marine reserve, or marine zoning plan, the relevant authority must delineate a particular area of the ocean to be protected, then specify the activities that may and may not occur within one or multiple areas. As such, the use of place-based marine governance to improve the resilience of ocean ecosystems is intimately connected to the legal rules regarding jurisdiction over the seas.

International law—specifically, the United Nations Convention on the Law of the Sea (UNCLOS)—allows coastal nations to exercise control over fisheries and other ecological protections in a band of waters known as an Exclusive Economic Zone (EEZ), which extends up to 200 nautical miles out from shore. Almost all MPAs, marine reserves, and marine zoning areas are located within a specific nation's EEZ, and hence most such management areas are created through national or sub-national law. For example, in 2006 Portugal finished the designation process for the Lucky Strike Hydrothermal Vents MPA in the northeast Atlantic Ocean, within Portugal's EEZ, which protects 21 active hydrothermal "chimney" sites located at a depth of 1700 meters. This MPA promotes the biodiversity protection goals of both the OSPAR Convention, a 15-party treaty to protect the environment of the North Atlantic, and Natura 2000, a network of both terrestrial and marine protected areas designed to protect Europe's natural heritage.

Indeed, most place-based marine management areas are located far closer to shore than 200 nautical miles, to protect coastal habitats such as kelp forests and coral reefs. As a result, depending on a coastal nation's internal laws and customs, MPAs and marine reserves may be created through state, territory, or municipal laws. In the United States, for example, coastal states control a band of coastal waters three nautical miles wide (Florida and Texas have broader jurisdiction in the Gulf of Mexico) along their shores. Using this authority, and acting pursuant to its Marine Life Protection Act, the State of California is developing a network of MPAs along its 1100-mile coast, using a regional approach.

Under international law, the areas outside of any nation's EEZ are deemed the high seas, and a baseline assumption of freedom on the high seas prevails—although certain activities, such as piracy, have been illegal even on the high seas for centuries. Place-based management of the high seas is rare and generally requires nations to act through particularized treaties. Nevertheless, such efforts are not unheard of. For example, acting pursuant to the International Convention for the Regulation of Whaling, in 1994 the International Whaling Commission and the parties to the Convention established much of the Antarctic Ocean as an international whale sanctuary. Moreover, in November 2009, the Commission for the Conservation of Antarctic

Marine Living Resources, which implements the 1982 Convention on the Conservation of Antarctic Marine Living Resources, established its first, 90,000-square-kilometer MPA to protect the South Orkney Islands.

Marine resources on the continental shelf can trigger another set of international law jurisdictional rules, and the establishment of an MPA to protect the Rainbow hydrothermal vent field in the North Atlantic Ocean shows how complex international law can become. The vent field was discovered in 1997, and it is located outside the 200-nautical-mile limit of Portugal's EEZ. Moreover, it is deep—the vents range from 2270 to 2320 meters below the surface, sprouting from the continental shelf. Hydrothermal vents are unusual marine ecosystems that are quite valuable, both biologically and, potentially, economically:

> The organisms (including microorganisms) of the hydrothermal vent fields are not only adapted to complete darkness and extreme high pressure, but they also survive formidable levels of toxicity and acidity and inhabit the edges of or proximity to the vents, with water temperatures near boiling point. In these conditions, life would be impossible for most species currently living on Earth. However, hydrothermal vent fields shelter millions of animals, thus becoming what Lyle Glowka has called true "oases of life."
>
> Although observation and knowledge of the way hydrothermal vent fields function are still in their early stages, the scientific, ecological, and economic importance of these ecosystems is already undisputable. The wealth of the hydrothermal vent fields ranges from their singular biodiversity to the great and growing interest that such organisms have for medical science and for industry, to the mining of economically attractive minerals—particularly, polymetallic sulphides. In the near future, it is because of the unique life forms they shelter that hydrothermal vent fields may be seen to be "the next great prize in the global race for natural resources." The organisms of the hydrothermal vents open up a new world of possibilities in biotechnology, as well as commercial opportunities, that cannot be ignored. The race for 'biological gold', that is, for genetic resources, generated in marine depths is one of the obsessions of the beginning of the 21st century (Ribeiro 2010: 184-86 (citations omitted)).

To prevent uncontrolled exploitation of this marine ecosystem, in March 2005, the World Wildlife Fund sought to establish an MPA to protect the vent field under the auspices of Annex

V to the OSPAR Convention. At the same time, however, Portugal sought to establish national jurisdiction over the Rainbow hydrothermal vent field through UNCLOS's continental shelf provisions, which allow coastal nations to extend their jurisdiction over continental shelf resources beyond the 200-nautical-mile limit for ocean waters themselves. In the end, the two international law processes converged: In 2007 the parties to the OSPAR Convention recognized the designation of the Rainbow hydrothermal vent field as an MPA under Portugal's continental shelf jurisdiction and incorporated it into the OSPAR Convention MPA network for the North Atlantic (Ribeiro 2010).

International Treaties

Many international treaties protect marine living resources. Nevertheless, as is typical of ocean governance more generally, many such treaties focus on specific species or fisheries—not marine ecosystems or resilience more generally. Two examples are the International Convention for the Regulation of Whaling and the various treaties seeking to protect various stocks of tuna. Nations signed the International Convention for the Regulation of Whaling beginning in December 1946, and the treaty took effect in November 1948. The Convention's original purpose was to regulate the harvesting of whales, but in 1986, the parties imposed a world-wide moratorium on the killing of most of the large baleen whales. Although the International Whaling Commission has begun moving toward place-based protection for whales, such as through the 1994 establishment of the Southern Ocean Whale Sanctuary, the history of the Convention has been far more centered on species-specific protections (IWC 2011).

Treaties to protect tuna stocks have been even more focused, both in terms of species and in terms of geographic coverage. In 1966, for example, several countries—including the United

States, Canada, Japan, Spain, and France—signed the International Convention for the Conservation of Atlantic Tunas "'to specifically address the conservation issues facing the bluefin and other highly migratory species'" (Craig 2005: citation omitted). Australia, New Zealand, and Japan formalized the Convention for the Conservation of Southern Bluefin Tuna in 1994, focusing solely on maintaining the sustainability of the southern bluefin tuna fishery.

Nevertheless, more recent treaties do allow for—and, increasing, promote—increased use of place-based marine governance mechanisms. For example, the Convention Concerning the Protection of the World Cultural and Natural Heritage (the World Heritage Convention) came into force in December 1975. It encourages parties to accord both emergency and long-term legal protections to places of "outstanding universal value," and, while the treaty does not expressly target the ocean, a number of marine sites have been designated as World Heritage Sites, including the Great Barrier Reef (Australia), the Galapagos Islands (Ecuador), the Lagoons of New Caledonia (France), Belize Barrier Reef Reserve System (Belize), Sian Ka'an (Mexico), Islands and Protected Areas of the Gulf of California (Mexico), and the Papahanaumokuakea Marine National Monument in the United States.

In 1992, nations participating in the Rio Conference on Sustainable Development adopted Agenda 21, a global program for achieving sustainable development. Chapter 15 of Agenda 21 promotes conservation of biodiversity, including through "in situ conservation of ecosystems and natural habitats" (¶ 15.5). Chapter 17 more specifically addresses the "protection of the oceans, all kinds of seas, . . . and coastal areas" (¶ 17.1) and explicitly promotes integrated management of marine areas (¶ 17.5), "[c]onservation and restoration of critical marine habitats" (¶ 17.6(h)), and MPAs (¶ 17.7).

Rio Conference participants also adopted the United Nations Convention on Biological Diversity (the Biodiversity Convention), which entered into force in December 1993. Under article 6, parties to the Convention are supposed to develop national strategies to conserve and sustainably use their biodiversity, while article 8 explicitly promotes the use of protected areas. Since the second Conference of the Parties in 1995, these biodiversity goals have been explicitly extended to coastal and marine biodiversity through the Jakarta Mandate. In 2004, a decision of the Conference of the Parties implementing the Jakarta Mandate made it a high priority for party nations to establish marine and coastal management frameworks that incorporate MPAs. Moreover, at the very first conference of the Parties in 1994, the International Coral Reef Initiative was announced to increase knowledge about and protections for the world's coral reefs.

The third UN Convention on Law of the Sea came into effect in November 1994. As noted, its provisions allow coastal nations to assert jurisdiction over broad swaths of the ocean, supporting place-based marine management as a jurisdictional matter. Moreover, article 192 of the Convention establishes that parties "have the obligation to protect and preserve the marine environment," although that obligation is in tension with several other provisions that allow and even encourage use of the ocean's resources (Craig, 2005).

At the 2002 World Summit on Sustainable Development in Johannesburg, South Africa, participating nations adopted an implementation plan for achieving sustainable development—essentially, an update and refinement of Agenda 21. This implementation plan calls for the worldwide establishment of MPAs to restore overfished species and protect marine biodiversity—specifically, for a worldwide network of MPAs by 2012 (Laffoley *et al*. 2008).

Regional Approaches

The European Union is a party to the United Nations Convention on Biological Diversity and has committed to meeting that Convention's MPA goals by 2012. One important legal vehicle for pursuing this target is the EU Habitats Directive—or, more formally, Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. This directive created Natura 2000, a Europe-wide system of protected areas that includes MPAs and marine reserves. The stated goals of the marine aspects of Natura 2000 reflect international treaties, not a resilience goal: "The establishment of a marine network of conservation areas under Natura 2000 will significantly contribute, not only to the target of halting the loss of biodiversity in the EU, but also to broader marine conservation and sustainable use objectives" (Natura 2000 2007: 6). Nevertheless, in the face of climate change impacts, European efforts to create a system of MPAs and marine reserves are increasingly being linked to ecosystem resilience. As a 2011 news alert point out, "By protecting important habitats and ecosystem functions, such as storing carbon by the coast, MPAs can play a role in adaptation and mitigation strategies. They are also heavily influenced by climate change themselves. This could be addressed by creating 'climate-smart' MPAs. Much work has been done on ecosystem resilience and resilience toolkits in tropical regions, which could be applied to temperate and polar regions" (ENAS 2011).

MPAs are linked less formally in the Caribbean through the Caribbean Marine Protected Areas Management (CaMPAM) network and forum. The Caribbean Environment Programme, a subsidiary of UNEP, created CaMPAM in 1997, under the auspices of the Specially Protected Area and Wildlife Protocol of the Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (the Cartegena Convention), an umbrella treaty that covers all aspects of marine environmental protection in that region. Since 2008, with substantial financial and technical support from the Nature Conservancy, nations operating within CaMPAM—including the Bahamas, the Dominican Republic, Jamaica, Saint Vincent and the Grenadines, Saint Lucia, Grenada, Antigua, Barbuda, Saint Kitts, and Nevis—have been pursuing the “Caribbean Challenge,” aiming to protect 20 percent of the marine and coastal habitats of each nation within marine reserves (NTAs) in the Caribbean by 2020.

The Caribbean Challenge was the third such regional challenge aimed at increasing biodiversity and marine ecosystem health through the expanded use of MPAs and marine reserves. In the first, which began in 2006, the countries of Micronesia signed the Declaration of Commitment to the Micronesia Challenge. “The Micronesia Challenge is a commitment by the Federated States of Micronesia, the Republic of the Marshall Islands, the Republic of Palau, Guam, and the Commonwealth of the Northern Marianas Islands to preserve the natural resources that are crucial to the survival of Pacific traditions, cultures and livelihood. The overall goal of the Challenge is to effectively conserve at least 30% of the near-shore marine resources (within no-take reserves) and 20% of the terrestrial resources across Micronesia by 2020” (Micronesia Challenge 2011). A year later, similar aspirations began in the Coral Triangle through the efforts of Indonesia, East Timor, Papua New Guinea, the Philippines, Malaysia, and the Solomon Islands (Nature Conservancy 2011).

National Regimes

The 1993 United Nations Convention on Biological Diversity and the 2002 World Summit on Sustainable Development have encouraged several nations to pursue national systems of MPAs and NTAs (Craig 2005), and increasingly these systems are being linked to resilience goals. Australia, for example, has been pursuing a National Representative System of Marine

Protected Areas (NRSMPA) since 1991, building on its initial experimentation with the establishment of the Great Barrier Reef Marine Park in 1976. Australia currently protects about 10 percent of its EEZ through over 200 MPAs (DSEWPC 2011). While the NRSMPA as a whole is a mechanism for Australia to comply with its international obligations under the Biodiversity Convention and its Jakarta Mandate, including the 2012 MPA goal (DSEWPC 2011), the system consists of MPAs established through both the Commonwealth (national) and State or Territorial legal authority. Commonwealth reserves are established pursuant to the Great Barrier Reef Act 1975 (amended in 2003) and the Environment Protection and Biodiversity Conservation Act 1999.

The 1999 Strategic Plan for the NRSMPA does not explicitly mention resilience as a goal of the system—although the stated goals are certainly compatible with promoting resilience:

> The primary goal of the NRSMPA is to establish and manage a comprehensive, adequate and representative system of MPAs to contribute to the long-term ecological viability of marine and estuarine systems, maintain ecological processes and systems, and protect Australia's biological diversity at all levels.
>
> The NRSMPA also has secondary goals: to promote integrated ecosystem management; to manage human activities; to provide for the needs of species and ecological communities; and to provide for the recreational, aesthetic, cultural and economic needs of indigenous and non-indigenous people, where these are compatible with the primary goal (ANZECC 1999: 1).

However, by 2002-2003, when the Great Barrier Reef Marine Park Authority was planning the rezoning of the Park—which constitutes a large part of the NRSMPA—it adapted a resilience framework (Olssen et al. 2010). More recently, it promulgated a Climate Change Action Plan in 2007 that focused on increasing the resilience of the ecosystem protected through zoning (e.g. MPAs, marine reserves), reduced commercial fishing effort, and improvements in water-quality:

> To secure the future of the Reef it is essential for agencies responsible for managing the Marine Park and its adjacent catchment to do everything possible to restore and maintain the resilience of the ecosystem. It is critical that coordinated

> actions are taken to protect biodiversity, improve water quality and ensure sustainable fishing.
>
> Resilience-based management of the Reef is core business for the Great Barrier Reef Marine Park Authority. Major resilience-building actions already underway include the Reef Water Quality Protection Plan and the Great Barrier Reef Marine Park Zoning Plan. The emergence of climate change makes these efforts even more important, while also presenting new challenges and demanding further action. Without such action, the Reef faces a bleak future under almost all possible future climate scenarios (GBRMPA 2007: 3).

Moreover, in 2009, the Australian Government and the Queensland Government reached a new agreement to manage the Park for resilience, as a response to the threats that climate change poses for the ecosystem: “Even under the most optimistic scenarios for global reductions in greenhouse gas emissions, climate change will place substantial pressure on the Reef. What this means for the future health of the Reef will depend on its capacity to withstand and adapt to the impacts of climate change—referred to as its ‘resilience’ (Australian Government & Queensland Government 2009: 4).

In 1997, the Government of Canada enacted the federal Oceans Act, which (among other things) required the federal government to establish a Federal Marine Protected Areas Strategy (Government of Canada 2005), leading to a national system of representative marine protected areas. Three federal departments and agencies—Fisheries and Oceans Canada, Parks Canada Agency, and Environment Canada—implement the national system, creating three main types of MPAs (Government of Canada 2005). These include:

> **Oceans Act Marine Protected Areas** established to protect and conserve important fish and marine mammal habitats, endangered marine species, unique features and areas of high biological productivity or biodiversity.
>
> **Marine Wildlife Areas** established to protect and conserve habitat for a variety of wildlife including migratory birds and endangered species.

> **National Marine Conservation Areas** established to protect and conserve representative examples of Canada's natural and cultural marine heritage and provide opportunities for public education and enjoyment (Government of Canada, 2005: 4-5).

In 2003, a report called for the accelerated development of the federal networks of MPAs as a means to combat preserved degradation of Canada's marine resources. In response, the Canadian federal government issued a new Federal Marine Protected Areas Strategy in 2005 (Government of Canada 2005).

The 2005 strategy recognizes the more traditional biodiversity goals of MPAs. Thus:

> Around the world, marine protected areas have become increasingly regarded as a valuable conservation and protection tool. A new and innovative approach toward planning for a network of marine protected areas in Canada, including the effective use of an array of marine protected area instruments ranging from no-take marine reserves to multiple use areas, will contribute to the improved health, integrity and productivity of our ocean ecosystems (Government of Canada 2005: 6).

Among the expected benefits of the network was the expectation that "[t]he effects of localized catastrophes, either human or naturally induced, on marine species may be reduced by establishing networks of marine protected areas over multiple ecosystems and regions, providing a buffer against localized environmental change" (Government of Canada 2005: 8). By 2010, however, the Canadian government was beginning to explicitly connect its network of MPAs to climate change and to resilience concepts:

> Marine protected areas can contribute to climate change mitigation by protecting certain marine habitats that are especially good at absorbing carbon dioxide, emitted to the atmosphere from the burning of fossil fuels, deforestation, and other human activities. For example, coastal habitats such as salt marshes, sea grasses and mangroves account for less than 0.5% of the world's seabed, but studies have shown they can store up to 71% of the total amount of carbon found in ocean sediments. Marine protected areas can also facilitate adaptation to climate change impacts, through protection of ecologically significant habitats (e.g., sources of larval supply), as well as through protection of multiple sites of similar habitat type.
>
> This increases the likelihood that at least one sample of the habitat type and its

> associated biodiversity will remain intact, should a catastrophic event occur in the region; thus contributing to the overall resilience (ability to adapt to change) of the marine environment (Government of Canada 2010: 4).

Because of international law's allowance of an EEZ, "New Zealand's marine environment is more than 15 times larger than its terrestrial area" (NZDOC 2011). Pursuant to its 2000 Biodiversity Strategy, New Zealand sought to protect 10 percent of its marine environment in a network of MPAs and marine reserves by 2010. However, as is true of many coastal nations, this goal has a biodiversity focus driven by New Zealand's international treaty commitments, and the 2005 Marine Protected Areas Policy and Implementation Plan specifically states that its goal is to "[p]rotect marine biodiversity by establishing a network of MPAs that is comprehensive and representative of New Zealand's marine habitats and ecosystems" (NZDOC & NZMOF 2005: 6).

Nevertheless, the Biodiversity Strategy also recognized broader goals for New Zealand's marine ecosystems that resonate more strongly with a resilience focus. For example, the goal for 2020 is that "New Zealand's natural marine habitats and ecosystems are maintained in a healthy functioning state. Degraded marine habitats are recovering" (NZDOC & NZMOF 2005: 8). Moreover, in 2010 New Zealand released its new Coastal Policy Statement, which guides local authorities' day-to-day management of coastal resources. The first Objective of this policy is "[t]o safeguard the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems, including marine and intertidal areas, estuaries, dunes, and land" by, *inter alia*, "protecting representative or significant natural ecosystems and sites of biological importance" (Obj. 1).

New Zealand has a number of laws that allow for the creation of MPAs and marine reserves. These include the Marine Reserves Act 1971, which allows the Department of Conservation to establish marine reserves in New Zealand's territorial sea (the first twelve miles of ocean from the coast); the Marine Mammals Protection Act 1978, which allows the New Zealand Department of Conservation to create marine mammal sanctuaries, where fishing can be restricted; the Fisheries Act 1983, which allowed for the creation of mataitai reserves (permanent reserves important to the Maori for food gathering), taiapure (local fisheries subject to iwi or hapu (native restrictions)), and marine parks, although such use of the Act was cut off through the Fisheries Act 1996; and special MPA legislation, such as the Sugarloaf Loaf Islands Protected Areas Act 1991 and the Hauraki Gulf Marine Park Act 2000.

Since 2002, the New Zealand Parliament has been working on an update of the Marine Reserves Act 1971. The amendments, which fishers have strongly opposed, would allow for the creation of marine reserves throughout New Zealand's EEZ, and the parliament's latest report was due out in January 2011. The bill could also expand New Zealand's use of ocean zoning, which now focuses mainly on marine aquaculture (Agardy 2010).

According to NOAA's National Marine Protected Area Center, "[t]he U.S. has more than 1600 MPAs. These areas cover 36% of U.S. marine waters, and vary widely in efficacy, purpose, legal authorities, managing agencies, management approaches, level of protection, and restrictions on human uses" (NMPAC 2011). Moreover, the United States is pursuing a National System of Marine Protected Areas, which had its genesis in President Bill Clinton's May 26, 2000 Executive Order No. 13158. By design, this network includes MPAs and marine reserves designated at all levels of government (NMPAC 2008). To date, however, less than 1% of continental US waters are protected through marine reserves or NTAs.

The National Marine Protected Area Center finally published its framework for establishing the national system in 2008, stressing that "the national system will help to increase the efficient protection of important marine resources; contribute to the nation's overall social and economic health; support government agency cooperation and integration; and improve the public's access to scientific information and decision making about the nation's marine resources" (NMPAC 2008: 8). This 2008 framework document recognized a number of benefits to the nation from the representative network of MPAs, including enhanced conservation of marine resources and better ocean planning (NMPAC 2008). Overall, "[t]he purpose of the national system is to support the effective stewardship, conservation, restoration, sustainable use, and public understanding and appreciation of the nation's significant natural and cultural marine heritage and sustainable production marine resources, with due consideration of the interests of and implications for all who use, benefit from, and care about our marine environment" (NMPAC 2008: 13).

The National Marine Protected Area Center developed and published its framework document during the George W. Bush Administration, so it is perhaps unsurprising that the document does not mention climate change or emphasize resilience. However, in July 2010, President Barack Obama finally brought climate change, resilience, and ocean zoning into United States ocean policy through his Executive Order No. 13,547, "Stewardship of the Ocean, Our Coasts, and the Great Lakes." In this Executive Order, President Obama first recognized the pervasive importance of the oceans to Americans (§ 1). The Order then set out ten goals in protecting the United States's ocean ecosystems, including to: "protect, maintain, and restore the health and biological diversity of ocean, coastal, and Great Lakes ecosystems and resources;" "improve the resiliency of ocean, coastal, and Great Lakes ecosystems, communities, and economies;" and "improve our understanding and awareness of changing environmental conditions, trends, and their causes, and of human activities taking place in ocean, coastal, and Great Lakes waters" (§ 2(a)). The Ocean Stewardship Executive Order thus incorporates both climate change and improved resilience into its goals, a fact made clear as well in the order's purposes, which include "providing for adaptive management to enhance our understanding of and capacity to respond to climate change and ocean acidification" (§ 1). Finally, the Order creates a National Ocean Council with representatives from a wide variety of federal agencies and departments (§ 4), which is charged with approving and implementing marine spatial planning in U.S. waters (§§ 4, 6). It remains to be seen how exactly the United States will incorporate its existing network of MPAs and marine reserves into this new ocean zoning plan, but it is probable that the network will be deemed to contribute to ocean resilience and to provide one basis for more comprehensive marine governance and planning.

CONCLUSION

Improving the resilience of the oceans and avoiding the transgression of dangerous tipping-points has economic as well as ecological import. As John C. Ogden noted in 2001, "Marine ecosystems are major capital assets. In addition to providing valuable goods, such as fisheries and minerals, they provide critical life support services, such as diluting, dispersing, and metabolizing the effluents of society, thus purifying waters for recreation" (Ogden 2001: 31). Moreover, while Ogden concluded that "[t]he value of a healthy ocean is difficult to overestimate" (Ogden 2001: 31), other researchers have attempted to be more precise regarding the value of coastal and marine ecosystem services to humans. In 1997, for example, Robert Costanza and his team of ecological economists estimated that the open oceans provide ecosystem services worth $8.4 trillion per year, while coastal oceans provide ecosystem services worth $12.6 trillion per year (Costanza 1997). Some of these services, moreover, are irreplaceably life-sustaining for humans: marine phytoplankton, algae and other marine plants are responsible for 50 to 75 percent of the oxygen in the atmosphere, and fish, mollusks and crustaceans are an important source of protein for a large percentage of the world's population—according to the FAO, "[i]n 2007, fish accounted for 15.7 percent of the global population's intake of animal protein and 6.1 percent of all protein consumed. Globally, fish provides more than 1.5 billion people with almost 20 percent of their average per capita intake of animal protein, and 3.0 billion people with at least 15 percent of such protein" (UNFAO 2011: 3).

More and more governments are beginning to embrace place-based management of marine ecosystems and to expand single MPAs and marine reserves into representative systems of MPAs and comprehensive ocean zoning. In Australia, Chile, New Zealand and the Philippines, these efforts reflect legislative and political changes that began in the 1970s and 1980s (Babcock et al. 2010, Gelchich et al. 2009, Olsson et al. 2008, Russ and Ancala 2005). Moreover, many governments are also beginning to realize that these governance mechanisms can provide benefits that extend beyond "mere" restoration of fisheries and marine biodiversity, including increased resilience of ecosystems and coastal societies in the face of new climate change-cause stresses (Hughes et al. 2005).

While such evolution is all to the good, it nevertheless remains important to remember that place-based marine management must be grounded in good science; in particular, random assortments of small MPAs may do very little to improve ecosystem health or resilience. Nor is place-based management a panacea for what ails marine ecosystems; indeed, as marine governance mechanisms, MPAs, marine reserves, and ocean zoning can do little to improve land-based marine pollution or the root causes of climate change. Finally, in a climate change era, it may become increasingly important for marine management to become more flexible (Polaski et al. 2010, Hughes et al. 2007b), because the impacts of climate change are likely to fundamentally alter marine ecosystems in ways that exceed “normal” variability, even for these already highly dynamic assemblages.

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