CHAPTER ELEVEN

Protecting Half the Ocean?

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One sustainable development goal specifically targets ocean conservation: SDG 14: to "conserve and sustainably use the oceans, seas and marine resources for sustainable development." However, there is no plan yet for achieving this goal. To date, only one underlying target has a quantitative objective, which is a target of the UN Convention on Biological Diversity (CBD): "conserve at least 10 percent of coastal and marine areas" by 2020 (SDG 14.5). Yet as of May 2018, 4 percent of the ocean was under some kind of protection, and only 2 percent was fully protected from extractive activities such as fishing, oil drilling, and mining. How will the goal of SDG 14 be achieved? What would stop us from getting there?

Here we argue that the driving vision of SDG 14 should be to protect half the ocean while truly managing activities sustainably in the other half. Most other subgoals fall within this overarching vision. In this chapter we review (1) the role of the ocean and ocean life in making earth an inhabitable planet, (2) how human activities are diminishing the ability of the ocean to provide for us, (3) why we should protect half the ocean, and (4) how that can be achieved along with sustainably managing the other half. Readers already familiar with what the ocean does for us and how we are destroying it might wish to jump directly to page 246.

What Does the Ocean Do for Us?

The living layer of our planet—the biosphere—is only about 15 kilometers thick. Although microbes have been found living a couple miles deep in rocks and floating ten miles high in the atmosphere, most of earth's biodiversity is concentrated around the surface. Ninety-eight percent of that critical living space's volume is in the ocean.

The earth's ocean-atmosphere dynamic is a feedback loop. While ocean life is affected by the physical environment—temperature, depth, currents—it in turn also affects the environment. For instance, bacteria and microscopic algae in the first 100 meters below the surface use the energy of sunlight to produce organic matter like terrestrial plants, which absorb carbon dioxide and release oxygen in the process. The oxygen released into seawater will eventually reach the atmosphere, providing more than half the oxygen in it. Ocean creatures unknown and unseen by most people give us every other breath we take. The other breath comes from our forests.

A recent study indicates that during 2002–11, the ocean absorbed a quarter of all the carbon dioxide released to the atmosphere by human activities (for example, fossil fuel burning, cement manufacture, deforestation) (Le Quére and others, 2012). That's about the same amount absorbed by all terrestrial plants during that period. The ocean also has an extraordinary capacity to store heat. Since 1955 the ocean has absorbed 90 percent of the extra heat generated by our atmospheric carbon pollution.[1] If the same amount of heat had gone into the lower 10 kilometers of the atmosphere, then the earth would have seen a warming of 36°C—eighteen times more heat than the mere 2°C we don't want to exceed to avoid catastrophic consequences for life on earth. Earth would be more like Venus: life as we know it would not be possible anymore.

The white cap on top of the world, the Arctic Ocean, is also essential for making life balmy in the northern hemisphere, through a conveyor belt of ocean currents. When seawater freezes in the Arctic, it releases salt at the surface. Then the surface water, very cold and salty, becomes very dense and sinks, creating a cold undersea waterfall moving southward. The sinking water is replaced by warmer water coming from the south. That forms a loop that includes the Gulf Stream, a relatively warm current that makes the British Isles and Scandinavia temperate and inhabitable year round.

The ocean also gives us about 100 million tons of seafood every year (Pauly and Zeller, 2016a), which is the main source of animal protein for more than a billion people worldwide, mostly in developing countries. An estimated 57 million people were engaged in the primary sector of capture fisheries and aquaculture in 2014 (FAO, 2016). The global first-sale value of seafood worldwide has been estimated at over $90 billion.

Intact ocean habitats also provide other invaluable services. For example, mangroves are trees that form forests on tropical coastlines; they are the only trees growing in seawater. The UN Environment Program estimated the global economic value that can be extracted nondestructively from mangrove forests at $1.6 billion per year (UNEP, 2006). Their complex root systems are nurseries for fish. In the Gulf of California, Mexico, the annual value of the services provided to the fish and blue crab fishery by mangroves averaged $37,500 per hectare

1. Baxter and Laffoley (2016), p. 456.

(Aburto-Oropeza and others, 2008). Over thirty years, the destruction of each hectare of mangrove would cost local economies approximately $605,000. Mangrove forests also provide a shield against storm waves and even tsunamis. The 2004 Indian Ocean earthquake and tsunami did the worst damage in places where the natural mangrove forests had been cut and replaced by tourist resorts, shrimp farms, and industrial facilities, whereas communities sheltered behind intact mangrove forests suffered less destruction.

Healthy coral reefs also form living barriers that protect 150,000 kilometers of coastline from the power of storm waves in more than 100 countries and territories. People have been able to live on low-lying islands for millennia because coral reefs have been growing and following the natural sea level rise that occurred after the end of the last ice age (about 11,000 years ago). But these reefs might not be able to cope with the accelerated sea level rise caused by human activities.

The ocean also provides opportunities for recreation, which contributes to job creation and economic growth. Marine and coastal tourism globally employed about 7 million people in 2010, with a direct added value of $390 billion (OECD, 2016). Europe alone had 480 million international tourist arrivals and 509 million international departures (Jackson and others, 2001). The Organization for Economic Cooperation and Development estimates a growth in marine tourism employment of 122 percent between 2010 and 2030.

The above are only a few examples of what the ocean provides for us. It is clear that a functioning and healthy ocean is essential for life on our planet. But because of the world's industrial activities and accelerated human footprint, we are diminishing the ocean's capacity to provide vital resources needed by the peoples of the world: food, oxygen, and climate regulation.

How We Are Killing the Ocean—and Harming Ourselves

We are inflicting many threats to ocean life, including overfishing, polluting, destroying habitats, and causing climate change. Humans have been fishing the ocean for millennia, depleting populations of large ocean wildlife—such as the extinct giant Steller sea cow and the Caribbean monk seal, as well as whales, sea turtles, and sharks (Jackson and others, 2001). It has been estimated that 90 percent of large ocean predators—sharks, tuna, groupers—has been fished out of the ocean in the last century.[2] Sharks are particularly threatened, with some species at less than 1 percent of their original abundance (before industrial fishing).

2. Baum and others (2003); Ferretti and others (2008); Myers and Worm (2003).

Overfishing

Since the end of Second World War, industrial fishing has expanded from the coastal waters off the North Atlantic and West Pacific to the waters in the Southern Hemisphere and into the high seas.[3] As fish populations were depleted near shore, fishing efforts had to expand farther and deeper offshore to satisfy people's growing demand for seafood (Morato and others, 2007). By the mid-1990s, only the least productive waters in the high seas, and relatively inaccessible waters in the Arctic and Antarctic, were left as "unfished" grounds. The decline of the global fishing catch since the mid-1990s and the rapidly diminishing number of untapped fishing grounds clearly show a limit to global fisheries growth (Pauly and Zeller, 2016b). Forty percent of the world's marine fisheries are overexploited or have already collapsed. Studies estimate that if the current trends continue, most fisheries will have collapsed by 2050 (Worm and others, 2006).

The removal of species by fishing also has indirect effects, in some cases unpredictable, with the potential to create ecosystem-wide changes. For example, fur hunters killed sea otters in Alaska to near extinction in the nineteenth century, thus removing the natural predator of sea urchins. Left to their own devices, sea urchins increased dramatically and devoured their seaweed home, turning former underwater forests of giant kelp into barrens (Estes and Duggins, 1995). Without the kelp, a variety of coastal fish and many other species disappeared. This is but one instance where removal of a single keystone species changed the entire landscape, the biodiversity it harbored, and the fisheries it supported (Estes and others, 2016).

Global industrial fishing affects not only the marine environment but also coastal populations in developing countries. In West Africa, for example, foreign fishing fleets—including from Spain and China—develop access agreements with local governments in exchange for meager fishing fees. This practice, alongside illegal fishing, has resulted in depletion of local resources, and local fishers are outcompeted, driving them to fish ever-declining fish stocks more intensively. Illegal fishing in West Africa is responsible for a loss of over $2.3 billion a year that could have benefited local economies (Doumbouya and others, 2017). Moreover, almost all of the fish caught by foreign fleets is consumed in industrialized countries, thus threatening food security and biodiversity in the developing world. Studies estimate that this "ocean-grabbing" worldwide costs between $10 billion and $24 billion, mostly to developing countries. And even legal fishing is vastly mismanaged. The World Bank estimates that wise management of fisheries

3. Swartz and others (2010). The "high seas" are marine waters beyond national jurisdictions, that is, beyond countries' 200-nautical mile Exclusive Economic Zones (EEZs), encompassing 60 percent of the ocean.

together with a conservation approach could result in an additional global fishing revenue of $83 billion annually (World Bank, 2008).

In addition, not only fish species are taken out of the ocean faster than they can reproduce, but fragile areas of the seafloor have been destroyed through destructive fishing methods. Bottom trawling, which drags heavy nets across the seafloor, destroys everything that grows there. Often, the target species—such as shrimp or deep fish—represent only 10 percent of the catch. Whatever else is caught in the nets—unwanted species including corals, sponges, starfish, and fish without commercial value—are discarded overboard, mostly dead. The worst damage is done on seamounts—deep underwater mountain peaks—where a single trawl can destroy thousands of years of growth of deep-sea corals (Althaus and others, 2009). Because isolated seamounts harbor many species found nowhere else, deep sea trawling may be driving many species extinct even before we discover them.

Ocean Warming and Acidification

Our fossil fuel economy amplifies the problems by making the ocean warmer and more acidic. Warmer temperatures have caused a decline in permanent Arctic sea ice at a rate of 13 percent loss per decade since we started observing with satellites in 1979, and models project an ice-free Arctic Ocean in the summer as soon as 2040 (Overland and Wang, 2013). The frozen Arctic Ocean has been a planetary air conditioner of sorts, helping to regulate the climate for thousands of years. But the white cap is turning dark blue as the sea ice melts and is replaced by open water. The darker ocean surface attracts more heat, melting more ice and in turn opening up more dark surface, and so on. Retreat of sea ice and warming seawater may also cause a massive release of methane that, to date, has remained frozen in the sea floor. Methane is a more potent greenhouse gas than carbon dioxide, thus potentially accelerating warming. These feedback loops are accelerating global warming and making the Arctic the fastest warming region in the world (Bitz and others, 2012). A 2° C average change in world temperature implies a 5° C change in the Arctic. The erosion of ice shelves will eventually remove the ice stopper that prevents Antarctic glaciers from flowing faster into the Southern Ocean, which will contribute to sea level rise. The consequences of melting of sea ice have already affected local communities in the Arctic region, forcing them to relocate because of the extensive damage caused by storm waves plus sea level rise (Banerjee, 2015), but these forces will also affect the entire planet (Serreze, Holland, and Stroeve, 2007).

Warming is also killing coral reefs across the tropics. Temperatures warmer than average have caused the bleaching of corals, whereby they lose their symbiotic single-cell algae. The number of bleached corals that die depends on the severity of the warming, among other factors. In 2016 the most severe warming event caused the largest coral bleaching episode in history, killing 67 percent of the coral in the northern part of the Great Barrier Reef in Australia within just nine months (Hughes and others, 2017). Already, more than a quarter of the coral reefs of the world are unrecognizable because of warming events, as well as pollution and overfishing. Under current trends, expected further warming and acidification will result in the collapse of coral reefs globally by 2050 (Hoegh-Guldberg and others, 2007). In other words, it is likely that corals will dissolve faster than they will grow.

Acidification of the ocean results from the extra carbon dioxide that human activities put in the atmosphere and is absorbed by the ocean. Acidification affects not only corals but also any organisms with a calcium carbonate skeleton, such as oysters, mussels, and small floating snails that are the main food source for juvenile salmon (Cheung and others, 2008). The ocean is helping take our carbon pollution from the atmosphere, killing life across the food chain in the process.

In addition, warming is changing the biological productivity of many ocean areas. Excessive warming creates a thick, warm surface layer that does not mix with colder waters below—like oil on water. That means that the necessary nutrients from the deeper ocean do not reach surface waters, therefore reducing their biological productivity. At the same time, the supply of surface oxygen to the deep ocean is significantly reduced, in turn affecting life in that realm. A study found a decline of more than 2 percent in ocean oxygen content worldwide between 1960 and 2010 (Schmidtko, Stramma, and Visbeck, 2017). Warming affects the entire ocean, from top to bottom.

Seawater warming may also lead to numerous local extinctions in the polar regions and semi-enclosed seas (Jones and Cheung, 2015). As the tropics become warmer, species can move to higher latitudes; however, species in the poles have nowhere to go and will be replaced by species coming from lower latitudes. Such species turnovers could affect over 60 percent of the present biodiversity. Climate change may also lead to large-scale redistribution of fisheries productivity, which is closely related to biological productivity of the waters where these fisheries occur. Under current scenarios, the maximum catch potential may show an average of 30–70 percent increase in high-latitude regions, and a decline of up to 40 percent in the tropics (Cheung and others, 2010). Highly impacted regions in the tropics and developing countries are especially vulnerable to these changes from a socioeconomic perspective.

Pollution

Pollution is another major threat to ocean life. Excessive agricultural fertilizer runoff reaches the ocean and threatens fragile ecosystems such as coral reefs. The most extreme case is the "dead zones," areas located typically off river mouths, where excess fertilizers enhance the explosive growth of microscopic plants in surface waters. This results in an accumulation of organic matter, which causes microbe populations to explode and consume all of the oxygen in bottom waters (Diaz and Rosenberg, 2008). Everything that cannot swim and escape dies, except for microbes. Currently there are more than 500 dead zones worldwide.

Another concern is the incidence of "red tides." harmful algal blooms that lead to toxicity in the environment. Although these may occur naturally, human activity can lead to their occurrence through increased coastal water pollution (for example, from untreated waste water including open sewers or fertilizer runoff) and seawater warming. Red tide toxins accumulate up the food chain, harming shellfish such as mussels and oysters. Eating contaminated seafood can produce illness and even death—in fish, birds, mammals, and humans. Impacts also include substantial economic losses to coastal communities and commercial fisheries.

Plastic trash—for example, bags, bottles, fishing gear—makes up 95 percent of trash in the ocean. Eight million tons of plastic—equivalent to dumping a garbage truck full of plastic every minute—enter the ocean annually (Jambeck and others, 2015). Some 88–95 percent of it comes from only ten rivers because of poor waste mismanagement (Schmidt, Krauth, and Wagner, 2017). Marine life—including squid, fishes, whales, and seabirds—eat pieces of plastic mistaken as food. For instance, along the coast of Brazil, 62 percent of king mackerel were found to have plastic pellets in their stomachs (Miranda and de Carvalho-Souza, 2016). Plastic contains and absorbs pollutants, including DDT, that people ingest as they eat polluted seafood. Nanoplastics are able to penetrate the blood-to-brain barrier in fish and cause behavioral disorders (Mattsson and others, 2017). We can expect similar effects on the human brain. If the rate of plastic waste continues, by 2050 plastic in the ocean may outweigh fish. The impacts on human health are obvious. We are eating the pollution that we throw in the air and the ocean, and our portions are increasing over time.

In summary, the loss of ocean biodiversity due to human activities, including exploitation, pollution, and climate change, is increasingly impairing the ocean's capacity to provide food, maintain water quality, recover from perturbations, capture carbon safely, and regulate the climate, among other stressors to the ocean environment. All of these have negative impacts on human well-being—from health issues to economic losses to human losses. Therefore, we cannot treat what happens to the ocean as an outcome independent of humanity. A healthy ocean is essential not only for sustainable development but also ultimately for human existence. This stresses the importance of connecting different SDGs. The question follows: Can we restore the former richness and productivity of the ocean, and what will be the benefits?

How to Restore the Ocean and the Services It Provides

To achieve the goals of SDG 14 and Agenda 2030, we must achieve a balance between protection and use. This is easily summarized in one simple approach: protect half the ocean and manage our activities in the other half smartly. This is the equivalent of building a giant ocean endowment that will produce compound interest that we can enjoy, instead of continuing on the current path where the ocean's natural capital is eroded, ever-decreasing its value, and its ability to produce returns degraded. We also need to dramatically reduce pollution and shift to an economy based on renewable energy—without which catastrophic climate change will hamper any gains achieved by reducing local threats to the ocean. Actions in the ocean are essential but insufficient unless the other SDGs create essential actions on land as well.

Protecting Half the Ocean

While protecting half sounds like an impossible task, steps can be taken to ensure that a good portion of the earth's water surface is safeguarded.

Marine Reserves as a Tool to Restore Ocean Biodiversity and Resilience. Better fisheries management to reduce exploitation rates of ocean life will not be enough. While reducing catch rates may help prevent the collapse of fish stocks, this does not encourage full recovery of biodiversity. No matter how well fisheries are run, biodiversity cannot be effectively restored when wildlife is removed at a commercial scale. Therefore, the world also needs strongly protected areas in the ocean, like national parks on the land.

No-take marine reserves—where fishing and other extractive activities such as mining and drilling are prohibited—can restore and preserve ocean biodiversity, from species abundance to the health of entire ecosystems (Sala and Giakoumi, 2017). On average, and typically within a decade, no-take marine reserves result in increases of 21 percent in the number of species, 28 percent in the size of organisms (Lester and others, 2009), and a remarkable 670 percent in biomass, relative to unprotected areas nearby (Sala and Giakoumi, 2017). The increase in biomass of predatory fish can be even greater. The increase in the biomass of predators has been shown to restore ocean habitats to a richer and more productive state. For example, in the Mediterranean and around New Zealand, efforts aimed at bringing back sea urchin predators reduced sea urchin density and consequently have shifted the ecosystem from a degraded state (sea urchin barren) to a complex, healthy state (algal forests with high biodiversity).[4]

4. Guidetti and Sala (2007); Shears and Babcock (2003).

These food web changes can also enhance the resilience of ocean ecosystems. For example, corals in the mid-Pacific Line Islands affected by the strong 1997–98 El Niño recovered in fully protected reefs within a decade, whereas they did not in unprotected islands (Sandin and others, 2008). In Baja California, Mexico, a mass mortality event caused by climate-driven oxygen depletion affected pink abalone populations, but they replenished faster within marine reserves because of large body size and high egg production of the protected adults (Micheli and others, 2012).

Marine Reserves Have Benefits Beyond Their Boundaries. One might worry that closing large areas to fishing will reduce the amount of food available for human consumption. But the opposite appears to be the case. Although marine reserves were not initially conceived to fix the problems of mismanagement of fisheries, they can help improve local fisheries around their boundaries.[5] The increase in the biomass of commercial species inside marine reserves increases reproductive output. Simply put, if we do not kill the fish, they grow larger and produce an exponentially greater amount of eggs and larvae. Areas outside reserves show a significant increase in biomass after the reserve is in place, through the spillover of adults or the export of larvae, or both (Lester and others, 2009). Well-enforced marine reserves can increase adjacent fishery catches. One study showed that local fisheries would not be sustainable without the reserves in some cases, while in other cases spillover offsets potential losses in catch (Halpern, Lester, and Kellner, 2009). In addition to enhancing or ensuring sustainable yield, well-designed marine reserves with proper business plans can start benefiting fishers in the short term and increase the long-term profitability of fisheries.[6] Recreational fishing outside reserves may also benefit from spillover. In Florida, the no-take areas in the Merritt Island National Wildlife Refuge have supplied increasing numbers of world record–sized fish to adjacent recreational fisheries since the 1970s (Roberts and others, 2001).

Some opponents to ocean protection argue that because creating marine reserves will displace fishing effort outside the reserves, unprotected areas would be depleted faster,[7] and fishers displaced by protection would suffer economic losses. As of May 2018, however, only 2 percent of the ocean was fully protected from fishing; thus, the displacement and the economic loss issues are currently insignificant. And as we'll see later, creating large fishing closures, reducing fishing effort, and reforming fisheries management can be a better solution for fisheries than the way they are managed currently (Barner and others, 2015).

5. Halpern, Lester, and Kellner (2009); Sala and others (2013); Sala and others (2016).
6. Sala and others (2013); Sala and others (2016).
7. Dinmore and others (2003); Hiddink and others (2006).

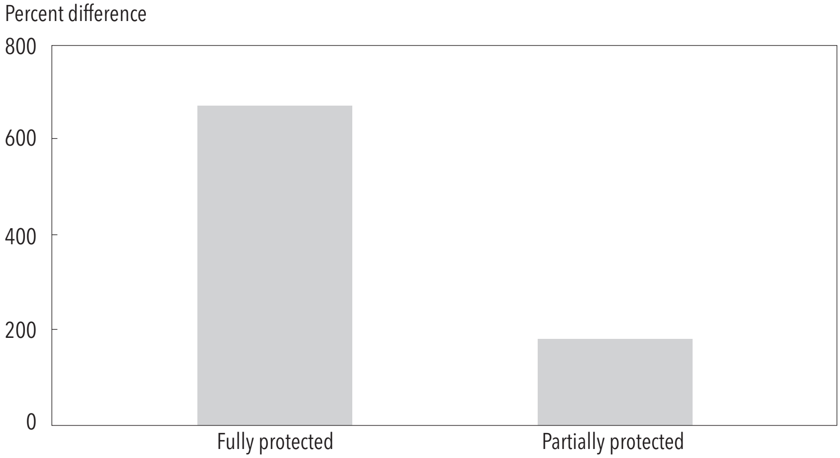
Marine reserves can also provide economic benefits through tourism and other services, some of which are difficult to quantify (for example, insurance value, local amenity value, storm protection, political value, and intangible capital such as spiritual beauty) (Sala and others, 2013). The increase in marine life inside marine reserves, in particular large fish, is the main attraction for divers and other tourists, which can bring revenue disproportionately higher than fishing. In the wider Caribbean and Pacific coast of Central America, for instance, 50 percent of all dives (7.5 million dives annually in 2003) took place within marine protected areas (Green and Donnelly, 2003). In the Galápagos Islands, a live shark brings in $5.4 million over its lifetime through "shark diving," whereas a shark killed for its fins brings only $200 (Lynham and others, 2015). Globally, almost 600,000 divers expend $314 million per year to dive with sharks (Cisneros-Montemayor and others, 2013). In contrast, the landed value of shark fisheries is $630 million and falling because of overexploitation. The number of shark watchers could more than double within the next twenty years, generating $780 million in tourism revenue annually. Sharks and other large fish are worth more alive than dead.

Why Do We Need to Protect Half the Ocean? The specific guidelines of SDG 14 include a target of setting aside 10 percent of the ocean into "protected areas" (without specifying the level of protection), but this target needs to be understood as only an interim milestone en route to more extensive and sustainable ocean conservation. A recent review of 144 studies indicated that, on average, at least 37 percent of the ocean should be protected in marine reserves to achieve, maximize, or optimize conservation and sustainability objectives (O'Leary and others, 2016). An analytical model also indicated that closing half the ocean to fishing would result in equivalent yields to those under good fisheries management (Hastings and Botsford, 1999). E. O. Wilson argues that to preserve 75 percent of species, half the planet (including the ocean) should be protected.[8] All of those studies recommend that between 40 and 50 percent of the ocean must be protected as a reasonable way to restore ocean biodiversity, its resilience, and all the services it provides to humanity—including helping to replenish fisheries in the half that would remain unprotected.

Currently, the world's 4 percent of protected ocean is spread across more than 10,000 marine protected areas (MPAs) of different sizes.[9] Their geography is highly skewed. Most protection occurs within a couple dozen very large MPAs, located within fewer than twenty countries' exclusive economic zones (EEZs).[10] Meanwhile, less than 1 percent of the high seas is protected.

8. Wilson (2016), p. 276.
9. Spalding, Fish, and Wood (2008). Also mpatlas.org.
10. Lubchenco and Grorud-Colvert (2015); Wood and others (2008).

Figure 11-1. Fish Biomass in Marine Protected Areas Relative to Nearby Unprotected Areas



Source: Sala and Giakoumi (2017).

It is important to note that there are many types of MPAs. At the most protective end of the spectrum are no-take "marine reserves"—areas where extractive activities are prohibited (reviewed above). The rest are partially protected MPAs that allow extractive activities to different degrees. Recent meta-analyses show that no-take marine reserves are far more effective than partially protected MPAs in protecting and restoring ocean biodiversity. See figure 11-1, which shows the total biomass of fish (a strong indicator of the maturity and health of the entire fish assemblage) is, on average, 670 percent greater within marine reserves than in unprotected areas, and 343 percent greater than in partially protected areas. The effectiveness of partially protected areas presented high variability, however, and often fish biomass was barely different from unprotected areas nearby. Partially protected MPAs are very useful for managing conflicting ocean uses in specific areas, but they are not truly protected.

Calling a marine area that allows fishing "protected" is like calling a logging concession (no matter how well managed) a "protected forest." Therefore, no-take marine reserves are the most appropriate and effective type of protected area in the ocean. This is no trivial clarification: little is accomplished if countries rush to label areas as simply "protected"—without implementing any real protective measures—before the 2020 United Nations deadline for protecting 10 percent of the ocean. The "Natura 2000" sites in the Mediterranean are a great example of how countries claim they have protected so much of their waters without actually protecting anything.[11]

Changing the Way We Obtain Food from the Ocean

To achieve ecological sustainability while providing food for more than 9 billion people by 2050 under the half-ocean-protected scenario, we will need to change the way we obtain food from the other half that is unprotected. Some even argue that the world need not increase the extraction of food from the ocean, because global food production globally could increase by a third just by reducing the current massive food waste (Shafiee-Jood and Cai, 2016). Regardless of how much food comes from the ocean, food production relying on the ocean must change, and that means basically reforming fisheries management and transforming aquaculture in a sustainable way.

Fixing Fisheries. Currently, fishing exploitation rates are not controlled in vast ocean areas, including the high seas. Only a small fraction of the fisheries of the world are managed and science-based, and they mostly concern single species targeted by industrial fleets in developed countries (Mora and others, 2009). Of those assessed fish stocks, 63 percent are overexploited and require rebuilding (Worm and others, 2009). Fisheries that target multiple species in developing countries are mostly unsustainable. Currently, there is overcapacity of fishing; too many vessels after too few fish—encouraged by government subsidies to the tune of $35 billion per year (Sumaila and others, 2016).

The fishing industry applies, at best, a disingenuous argument for the need to continue maximizing the catch to feed the world—one based largely on overcapacity of the global fishing fleet and inefficient use of resources. As mentioned earlier, the fisheries of the world have expanded farther offshore and into deeper waters because fish populations have collapsed in fishing grounds along the continental shelf.[12] Only a few select fisheries in a few countries such as the United States are sustainable (Worm and others, 2009). A World Bank report suggested that cutting fishing effort by 40 percent would increase the efficiency and profitability of fishing (World Bank, 2017).

11. UNEP-MAP-SPA/RAC M, “The 2016 Status of Marine Protected Areas in the Mediterranean,” 2017 (http://d2ouvy59p0dg6k.cloudfront.net/downloads/medpan_forum_mpa_2016___brochure_a4_en_web_1_.pdf). Natura 2000 is a network of nature protection areas in the territory of the European Union. It is made up of Special Areas of Conservation and Special Protection Areas designated respectively under the Habitats Directive and Birds Directive.

12. Swartz and others (2010); Morato and others (2007).

To effectively regulate fishing, end overfishing and illegal fishing, and make fisheries more sustainable and profitable while fishing in only half the ocean, the following must occur:

—A new regime of rights-based fisheries (RBF) management is required.[13] RBF assigns fishers and communities clearly defined rights to each fishery, as opposed to open access regimes that result in overfishing. If properly implemented, RBF gives fishers a vested interest in preventing overfishing and increasing compliance with catch limits (Barner and others, 2015).

—Fishing capacity needs to be reduced: boats need to be taken out of the water.[14] It would probably be self-regulated and reduced in a well-implemented RBF scheme. That would also reduce the issue of displacement of effort to unprotected areas after creation of large no-take marine reserves.

—Subsidies that perpetuate overcapacity and overfishing need to be eliminated. That would also save the world over $35 billion annually (Sumaila and others, 2016), which could be used to restore artisanal fisheries within countries' EEZs.

—National and global catch statistics need to be corrected. The Sea Around Us project at the University of British Columbia has reconstructed all catches reported to the Food and Agriculture Organization (FAO). The university researchers found that reconstructed global catches between 1950 and 2010 were 50 percent higher than reported to FAO and are declining more strongly since catches peaked in the 1990s (Pauly and Zeller, 2016b). FAO should not accept vastly underreported data anymore.

—Regional Fisheries Management Organizations (RFMOs) need to be reformed (Gjerde and others, 2013) and made accountable to a new independent global fisheries agency, one that oversees fisheries on the basis of science and sustainability rather than national interests. The high seas (over 60 percent of the ocean) are still largely unmanaged. Fishing of migratory species that migrate between countries, such as tuna and sharks, are managed by RFMOs, known, with some exceptions, to be ineffective in conserving the wildlife they exploit and driven by short-term gain and political pressure, while ignoring scientific advice on fishing quotas. Two-thirds of stocks fished on the high seas under RFMO management are either depleted or overexploited (Cullis-Suzuki and Pauly, 2010).

Farming Seafood the Right Way. As of 2017 aquaculture—fish and shellfish farming—provides about half the ocean food the world eats (FAO, 2016), and its yield is increasing fast, whereas the global wild fisheries catch has been declining since the mid-1990s and without hope of recovering anytime soon unless strong conservation measures are put in place (Pauly and Zeller, 2016b). Many view

13. Costello and others (2016); Worm (2016).
14. World Bank (2017); Barkin and DeSombre (2013).

aquaculture as the future of food production from the sea, but currently most aquaculture practices are not sustainable because, ironically, they depend on fish feed, which only exacerbates the pressure on wild fish populations (Diana, 2009).

Aquaculture also has enormous negative impacts by polluting the coastal environment, spreading disease, and depleting local fish populations through introduced farmed species (Diana, 2009). Therefore, aquaculture needs to (i) abandon its current dependence on fish feed, (ii) enhance the production of seaweed and filter feeders (for example, mussels and oysters), and (iii) close its production cycle as to avoid environmental impacts (Duarte and others, 2009). A recent study suggests that nearly every coastal country has large areas that are suitable for aquaculture and that those exceed the space required to meet forecasted seafood demand (Gentry and others, 2017). In fact, the current total catch from wild fisheries could be replaced totally by aquaculture, using less than 0.015 percent of the global ocean area. These results suggest that sustainable aquaculture alongside reduction of food waste could help feed the growing human population, thus eliminating the need for many industrial fisheries.

Let's Not Forget the Climate and Pollution

The only solution to reverse global warming and acidification of the ocean is to reduce our carbon emissions beyond the commitments of the 2016 Paris Climate Agreement. Even the commitment to limiting the average worldwide temperature increase to only 2° C by 2025 still will result in the loss of coral reefs and the melting of Arctic sea ice, among other ecological tragedies. To avert the worst disasters, rapid decarbonization of our human society is required (Rockström and others, 2017). Meanwhile, we can buy time by reducing local threats such as conserving fishing grounds and limiting pollution, to increase the resilience of ocean ecosystems.

To achieve the SDG target to "prevent and significantly reduce marine pollution" by 2025, the world needs to move from our current "linear economy" (make, use, dispose) to a circular economy in which resources do not become waste but instead are recovered and regenerated at the end of each service life.[15] Some companies are pioneering this approach. For example, Patagonia, a U.S. outdoor apparel company, has embedded the principles of the circular economy into its business strategy. By extending the usable life of its products, Patagonia can reduce the amount of carbon, waste, and water used by up to 20–30 percent per person, and it has diverted about 82 tons of gear from landfill in the United States.[16] But companies cannot be expected to voluntarily adopt such strategies.

15. Webster and MacArthur (2016), p. 210.
16. Chouinard and Stanley (2012), p. 160.

Government should embed the circular economy into national strategies. For instance, Scotland has already placed the circular economy at the core of its own economic strategy and manufacturing plan; China also has adopted a national circular economy strategy (Geng and others, 2013). In addition to current marine pollution regulations, governments should put a price on waste, including plastic, and use market incentives to foster innovation among businesses. Some enterprising companies, from carpet to sock manufacturers, are harvesting marine litter to upcycle for products.

How to Make Protection Happen?

To summarize the above proposition: in order to truly achieve global ocean sustainability goals, we need (a) a world where half the ocean is protected from direct human threats, while the other half is fished and farmed sustainably and (b) an economy based almost fully on renewable energies. The decarbonization needed to prevent catastrophic and irreversible climate change is detailed in Rockström and others (2017). The basic principles for fixing the way we fish are outlined above. But how to protect half the ocean? And what should be protected? We propose the following strategy.

The first step is to identify which areas to protect. Under the assumption that little of our ocean will be protected, what are the most critical areas for ensuring survival of as many species as possible? An example is the academic concept of "biodiversity hotspots," which aims to protect the smallest needed surface of the planet to preserve a large fraction of earth's biodiversity.[17] But such attempts to identify an optimal area are frequently overtaken by opportunities in the real world (such as the presence of an enlightened leader in a specific country), and hence not fruitful. Moreover, recent evidence suggests a need to think beyond species numbers, because entire ecosystems provide services key to our survival (Worm and others, 2006). Species numbers are key, of course, but the ecosystems they live in help us avert catastrophic climate change by capturing carbon from the atmosphere and seawater.

Through National Geographic's Pristine Seas project, which aims to save the wildest places in the ocean, we have learned that simply protecting as large an area as possible in as many places as possible is the most practical rule of thumb to ensure the protection of a representative sample of the ocean's major ecosystems and all the biodiversity within.[18] This broad approach to geographical representation would achieve goals for conservation of biodiversity and would also help

17. Roberts and others (2002); Myers and others (2000), p. 853.
18. See www.nationalgeographic.org/projects/pristine-seas/.

replenish local fisheries and help sequester some of our carbon pollution (Spalding and others, 2007).

How can we ensure that marine protected areas are evenly distributed so they will cover 50 percent of the ocean? If fishing were excluded from the high seas, about 60 percent of the ocean in spatial terms would form a giant savings account for those species that migrate between exclusive economic zones and the high seas, potentially increasing yield of these species by 30 percent (if caught only within EEZs) and aggregate profits by more than 100 percent.[19] A total high seas closure would also be easier to enforce than a mosaic of smaller protected areas. But it would not fulfill global conservation goals, because EEZs contain most of the biodiversity and currently account for 95 percent of the global fish catch.

Different approaches are required to create marine reserves in countries' exclusive economic zones, compared to the high seas. First, action can be more easily taken and is more practical within EEZs than in the high seas, because coastal countries have full jurisdiction to create protected areas within their 200-mile waters. How much of the economic exclusive zones of the world should be protected? Start with the 30 percent target as a milestone agreed on by most conservation groups worldwide.[20] While not every country can or will protect 30 percent of their own territory, several nations have already implemented no-take marine reserves covering more than 10 percent of their EEZs, including through large reserves as the most efficient path to protection: Palau (80 percent), United Kingdom (32 percent), Chile (24 percent), Gabon (26 percent), United States (23 percent), and Kiribati (12 percent). These examples show that the 30 percent EEZ target is politically feasible.

Not all coastal countries, as noted, have the ability or space to create large marine reserves. And not all reserves should be large. While reserves greater than 100,000 square kilometers, for example, are necessary to protect large ecosystems and have regional benefits, small reserves have local benefits for coastal communities too. Many governments do not have sufficient staff and resources to create and finance small marine reserves, so new business models are needed whereby a local enterprise could invest in the reserve and reap the economic benefits from increased tourism and better fishing around the reserve.[21] That will require governments to pass legislation empowering local communities to manage their local reserves.

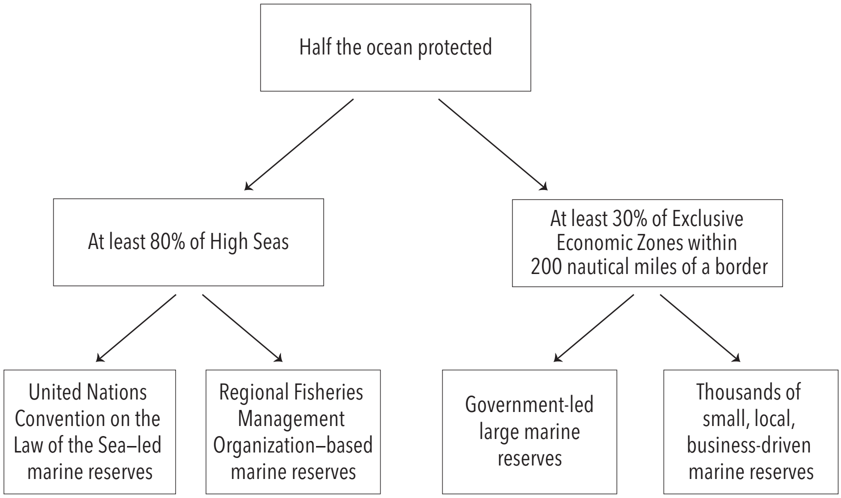
If 30 percent of the aggregate EEZs are protected, this translates to about 12 percent of the global ocean. In turn, to reach fully half the ocean under protection, at least 80 percent of the high seas need full protection, as shown in figure

19. Sumaila and others (2015); White and Costello (2014).

20. International Union for Conservation of Nature (2016).

21. Sala and others (2013); Sala and others (2016).

Figure 11-2. Schematic Representation of the Strategy to Protect Half the Ocean in Marine Reserves



11-2. This high seas target is consistent with a study that showed that the more of the high seas under protection, the greater the ecological and economic benefits (White and Costello, 2014).

For the high seas, the question is how to protect 80 percent of something that no country owns? They are governed by the UN Convention on the Law of the Sea (UNCLOS) but when the convention concluded in 1982, there was little concern about deep sea trawling or mining, and no attendees realized that Atlantic bluefin tuna was on its way to commercial extinction. The agreement reached by countries involved in UNCLOS dealt mostly with fishing, with only vague references to conservation in the high seas: "Necessary measures shall be taken . . . with respect to activities in the Area to ensure effective protection for the marine environment from harmful effects which may arise from such activities" (Article 145). But there were no specifics on what "effective protection" meant, and no mention of the need for marine protected areas or a mechanism to implement them. In other words, governance to ensure biodiversity conservation in the high seas is absent.

To remedy this, on June 21, 2017, 193 countries agreed at the United Nations to begin negotiations on a legally-binding instrument for on the conservation and sustainable use of biological diversity beyond national jurisdiction (BBNJ). This will likely be a slow process (formal negotiations are to commence only at an Intergovernmental Conference in September 2018) and will encounter resistance by the key countries conducting high seas fishing—China, Taiwan, Korea, Japan, and Spain (Sumaila and others, 2015). The BBNJ process is necessary to establish a mechanism for creation of MPAs in the high seas, but to be successful, it cannot be subordinated to the special interests within Regional Fisheries Management Organizations (RFMOs). It will also be essential that China, Taiwan, Korea, Japan, and Spain take a leadership role in high seas protection. They are taking more than 75 percent of the aggregate catch in the high seas and have a responsibility to ensure the integrity of the ecosystems they exploit.

Despite their shortcomings, regional organizations can be a solution to conservation of biodiversity in waters beyond national jurisdiction. A great example is the 2016 agreement to create the largest MPA in the ocean (at 1.5 million square kilometers) in the Ross Sea in Antarctica.[22] It required consensus among twenty-four nation states and the European Union and did not require a United Nations–led process. This shows that while the BBNJ instrument is developed, RFMOs could propose and implement marine protected areas on their own accord.

The final question is whether these large areas far from shore can be effectively enforced. The answer is yes, through a combination of remote surveillance and enforcement at port. Recent interest in the enforcement of marine protected areas has resulted in an unprecedented burst of innovation, including well-established satellite tracking and imagery, and drones, among other technologies.[23] Satellite technology is already being used by countries, or can be accessed at increasingly reduced costs through commercial applications. Citizens can also monitor illegal fishing using some of these tools through internet browsers.[24] The Food and Agriculture Organization of the United Nations promulgated in 2009 the Port State Measures Agreement to prevent, deter, and eliminate illegal, unreported, and unregulated (IUU) fishing. Once illegal fishing vessels are detected by competent government agencies, enforcement can be implemented at sea or at port with the aim "to prevent, deter and eliminate illegal, unreported and unregulated fishing." This means that parties to the agreement will apply it to foreign vessels when seeking entry to ports or while they are in port.[25] As of November 2017, fifty countries and the European Union had already joined the agreement.

What would be the timeline for protecting half the ocean? Currently there is no intergovernmental agreement beyond the CBD (adopted by SDG 14) target of 10 percent of the ocean to be protected by 2020. Because of the slow accretion of ocean protection to date, it might be impractical to expect 50 percent of the ocean protected by the SDG 2030 deadline. A more feasible timeline may be 30 percent

22. Commission for the Conservation of Antarctic Marine Living Resources (2016).
23. See secureoceans.org for more details.
24. See, for example, Global Fishing Watch at globalfishingwatch.org.
25. See www.fao.org/fishery/psm/agreement/en for details concerning this agreement.

by 2030—as recommended by the 2016 World Parks Congress[26]—and 50 percent by 2050.

Conclusion

Ocean protection and management require a radical new approach, a more ambitious scale of thinking based on science already available. Marine protection understood as a mosaic of small-scale uses seems appropriate in theory, but in practice it is much easier to enforce large no-take areas. Half the ocean needs to be protected from fishing, and the other half needs to be managed responsibly. In practical terms the protection requirement can only be achieved by protecting at least 80 percent of the high seas and 30 percent of countries' exclusive economic zones—by 2050 if not earlier.

It is key that countries that are leading in ocean conservation actively inspire other countries to follow suit. For example, high-level peer pressure at the "Our Ocean" conferences that U.S. Secretary of State John Kerry initiated in 2014 helped to double the total ocean area protected within three years. This is a clear example of how mutually reinforcing actions at the country level can facilitate a wave of action internationally.

Moreover, the challenges of protecting the ocean include integrating all the Sustainable Development Goals and not treating them within silos. For instance, industrial waste and agricultural runoff affect ocean life and end up polluting humans. And if the world does not shift away from fossil fuels soon, the ocean will be exceedingly warm and acidic, absorb less and less carbon, and could produce less oxygen. Without a healthy ocean, human life will suffer, through direct and indirect effects not always predictable. Let us imagine a day when the health of our ocean improves through better governance, and with this improvement come more business opportunities through sustainable tourism inside marine reserves; sustainable fisheries outside marine reserves; and other enterprises that restore our ocean, including sustainable aquaculture and agriculture, and management of waste, water, and energy. Our choice and path forward are clear.

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26. International Union for Conservation of Nature (2016).

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