# New Life for the Ocean

## How Marine Protections Keep Our Waters Wild

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Written by

James Horrox, Frontier Group

Steve Blackledge and Kelsey Lamp, Environment America Research & Policy Center

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# Contents

# Executive summary

The ocean drives the processes that make our planet capable of supporting life, and contains some of the world's most complex and diverse ecosystems.[1] But these ecosystems are increasingly under threat. Pollution, overfishing, offshore drilling and other human activities are destroying ocean habitat and threatening marine species, with profound consequences for the biodiversity on which the health of our ocean depends.[2]

A growing number of scientists and conservationists are coalescing around the goal of protecting at least 30 percent of the world's ocean by 2030 through networks of marine protected areas (MPAs) – protected zones of ocean where extractive and destructive human activity is limited.

**The experience of six MPAs in the United States and around the world shows that marine protected areas are effective tools to conserve and revive marine ecosystems. To restore our ocean to health, governments should take a strategic, science-based approach to planning and implementing MPAs and regional MPA networks.**

- **Highly to fully protected MPAs can protect and increase biodiversity, which in turn boosts overall ecosystem health.**[3] A 2006 meta-analysis showed that species richness in fully protected MPAs increased by an average of 23 percent after their designation, and fish numbers in surrounding areas also significantly increased as a result of spillover from the protected zones.[4]
- **MPAs create increased biomass, abundance and diversity of marine species.** A 2009 analysis synthesizing a range of studies of no-take marine reserves (fully protected MPAs) showed that full protection resulted in significant increases in average biomass (i.e., the total mass of living organisms in a specific area), size and density of organisms, and the number of species present.[5] In half of the reserves, total biomass of studied species was more than triple that of unprotected areas, and the density of those species more than 60 percent higher.[6]
- **Highly to fully protected MPAs can help mitigate the impacts of climate change.** Protected marine reserves have been found to increase the resilience of marine species to climate-induced impacts, such as shifts in species distribution, decreased ecosystem productivity and oxygen depletion, and to maintain the health of coral reefs and other features that protect coastlines from extreme weather events.[7] A 2017 study concluded that marine reserves are thus "a viable low-tech, cost-effective adaptation strategy that would yield multiple cobenefits from local to global scales."[8]

Marine protected areas have helped restore some of the world's most precious and unique ocean ecosystems – including several in the United States.

- **California's MPA network.** In America's first science-based, statewide MPA network, once-depleted populations of cabezon, lingcod, black rockfish, black abalone and other species have

experienced dramatic increases.[9] Within a decade of the implementation of a network of fully protected zones within the Channel Islands National Marine Sanctuary, the density of species targeted by fishing had risen in these zones by 50 percent, and biomass by 80 percent.[10]

- **Dry Tortugas National Park and Ecological Reserve, FL.** Protection of an "ecological crossroads" in the Gulf of Mexico has played a key role in the recovery of reef species including red grouper, mutton snapper, yellowtail snapper and hogfish.[11]
- **Papahānaumokuākea Marine National Monument, HI**. America's largest Marine National Monument, located in the Pacific Ocean off Hawaii, has helped rescue the endangered green turtle and Laysan duck from the brink of extinction and nurtured thriving populations of sharks, giant trevally and other species that have experienced massive population die-offs elsewhere.[12]
- **Cabo Pulmo, Mexico.** In one of the world's greatest marine protection success stories, protections enabled a reef to recover from near-total destruction by aggressive over-fishing. In the space of just 10 years, overall marine biomass in the protected area increased by 463 percent, and the biomass of top predators, including sharks and grouper, increased by more than 1,000 percent.[13]
- **Great Barrier Reef no-take marine reserves, Australia.** In the world's most famous reef, longstanding protections show the long-term benefits of MPAs for protecting biodiversity and enhancing ecosystem resilience. Protections have made reefs in no-take areas better able to rebound from coral bleaching, storms and coral disease than those in nearby areas with weaker protections and led to greater diversity, density and abundance of fish species, including coral trout, red emperor, redthroat emperor, stripey seaperch and sharks.[14]
- **Edmonds Underwater Park, WA.** In an artificial habitat in Puget Sound, protections have succeeded in restoring depleted local fish populations. Research has found the abundance of copper rockfish to be 15 times higher in Edmonds than in unprotected areas of the Puget Sound, and lingcod more than twice as abundant and significantly larger than in fished areas of the Sound.[15]

Marine reserves have also provided important research baselines to understand how marine ecosystems and individual organisms are being affected by local and global stressors, as well as important areas of reference for education and research on intact marine ecosystems.

## Policy recommendations

The health of our ocean is in crisis. Abuse and overexploitation of marine environments have led to ecosystem destruction and biodiversity decline on an unprecedented scale. And experts say the worst may be yet to come.

Federal and state governments must take urgent action to boost our ocean's resilience against the myriad threats it currently faces, and to ensure the maintenance of ocean ecosystems and conservation of marine life. Meeting these objectives will require action on numerous fronts, including sustainable fisheries management and global action on climate change.

Marine protected areas, if effectively implemented and properly managed, are a critical tool for protecting and enhancing the health of our ocean. Governments should take the following actions to expand marine protected areas and maximize their benefits for ocean health.

- **Governments should adopt the goal of protecting at least 30 percent of their countries' total ocean area, including 30 percent of the ocean area in each major geographic region and ecosystem.** Given the relative lack of highly and fully protected MPAs in United States waters outside of the remote Pacific region, U.S. policymakers' focus should be on ensuring that highly to fully protected MPAs are put in place across all key regions to ensure that representative examples of the diverse habitats and ecosystems in U.S. waters are protected.

- **State and federal governments should strengthen protections in near-shore areas**, especially by implementing highly to fully protected MPAs in these areas, in order to ensure adequate protections across all ecosystems and habitats and not just in remote areas of ocean.
- **MPAs should be ecologically linked in regional networks** to protect the full range of ecosystems and habitats in our oceans and ensure connectivity between fragmented habitats.
- **State and federal governments should take a comprehensive, strategic and science-based approach to planning, designing and designating MPAs and MPA networks,** integrating regional scientific knowledge, engaging local communities and other stakeholders, educating the public, and evaluating potential economic impacts.
- **State and federal authorities must ensure that implementation of MPAs and MPA networks is accompanied by a comprehensive management plan**, with a focus on scientific monitoring and robust efforts to ensure that protections are properly funded and enforced.
- **Policymakers should take measures to promote MPAs and disseminate research** carried out on MPAs to enable the public to better understand their value and support efforts to protect and enhance these areas.

# Introduction: The ocean under threat

Three quarters of the Earth's surface is covered by ocean. This vast, mysterious wilderness drives the processes that make our planet capable of supporting human life. It regulates our weather systems and climate. It provides us with water, food, and even the oxygen in our air. It helps protect us from the impacts of climate change, absorbing around a third of all the carbon dioxide we produce.[16] And it contains some of the most diverse ecosystems on the planet, home to a spectacular array of life – nearly 200,000 species that we know of, and potentially millions more.[17]

Photo: joakant, via Pixabay

The ocean does more than produce the things we need to survive. It has been a source of wonder to humans since the dawn of history; a staple of countless civilizations' literature, religion and mythology. We've been fascinated by it, marveled at it, and feared it.

And, too often in recent history, we've destroyed it.

The effects of unchecked human exploitation of marine environments are now clear. Pollution, overfishing and offshore oil and gas drilling are doing tremendous harm to sensitive wildlife habitats, contributing to population decline among marine flora and fauna with profound consequences for the biodiversity on which the health of our oceans depends.[18] Over the last half century, marine vertebrate populations have declined by nearly 50 percent, and the number of endangered marine species is growing.[19] Approximately one-fifth of the world's coral reefs have been effectively destroyed, and many of those that remain face imminent collapse.[20] Average acidity levels have risen by more than 25 percent since the dawn of the industrial era as the oceans have absorbed carbon dioxide emitted to the atmosphere, and are projected to more than double by the end of this century. This change in ocean chemistry may make the ocean uninhabitable for certain aquatic species and bring serious consequences for marine ecosystems and food webs.[21] Oxygen depletion, due to pollution from industry, agriculture and urbanization – as well as from warming, which increases oxygen demand and reduces oxygen solubility – has profound consequences for the plants and animals that depend on marine habitats.[22] Since the mid-20th century, the ocean's oxygen content has dropped by around 2 percent, and the volume of ocean entirely depleted of oxygen has quadrupled.[23]

So dire is the situation that some scientists believe we may already be witnessing the beginning of the next "major extinction event" in our oceans.[24]

The future of our planet and its people requires that we treat the ocean as the complex, awe-inspiring source of life that it is, and that we preserve ocean ecosystems not just in bits and pieces by protecting individual species and habitats, but as a coherent whole.

Marine protected areas (MPAs) – protected zones that limit extractive and destructive activities – are one of the most effective tools we have to ensure the continued health of our oceans. These protections can alleviate pressures on marine ecosystems by placing restrictions on fishing, drilling, shipping and other human stressors. Research shows that MPAs with the strongest protections, and especially fully protected "no-take" reserves in which all extractive and destructive activities are banned, have proven extremely effective in preserving biodiversity, strengthening the resilience of marine ecosystems, and helping to restore species habitats and populations.[25]

While the gravest threats to the health of the ocean are primarily driven by climate change, and thus require global action outside the control of local-level protections, research shows that MPAs and other management efforts are nonetheless an important part of the solution, with a role to play in helping to ameliorate stressors and giving the ocean a greater chance of recovery from disturbances.

A growing number of scientists and conservationists now argue that preventing the large-scale extinction of marine life will require us to conserve at least 30 percent of the world's ocean in strongly protected zones by 2030.[26] But despite the expansion of marine protections over the last decade, only 6.4 percent of the world's oceans is today protected in MPAs. And only 2.7 percent of it is in highly to fully protected zones.[27]

Until very recently, the United States had been a global leader in the push to implement MPAs. More than 40 percent of all U.S. waters are now covered by some form of protection, with upwards of 1,700 protected areas in total.[28] But while this figure may sound impressive, we still have a long way to go. MPAs focused specifically on the protection of ecosystems and biodiversity make up only a fraction of this total, and currently only around 3 percent of the country's waters are covered by fully protected zones.[29] Moreover, with the vast majority of highly to fully protected MPA area in tropical habitats in remote regions of the Pacific, many of the other ocean habitats in U.S. waters remain unprotected. Maintain-

ing biodiversity and protecting marine life will require us to take seriously the goal of conserving 30 percent of our ocean, and that means bringing 30 percent of all of America's marine habitats under the protection of highly to fully protected MPAs.

Recent years have shown that continued progress is by no means a given. Indeed, it has, at times, seemed as though we have been going backwards. On June 5, 2020, President Donald Trump signed an executive order opening up the Northeast Canyons and Seamounts Marine National Monument to commercial fishing.[30] Established as a Marine National Monument by President Obama in 2016, this 5,000-square mile protected area off the Massachusetts coast is the first and only marine monument in the Atlantic. Its monument designation prohibited all commercial extraction activities, providing critical protections for a stunning underwater habitat, home to vulnerable deep-sea ecosystems and an array of marine species, including ancient corals and endangered whales and sea turtles. In stripping protections from Northeast Canyons and Seamounts, Trump reduced the total protected area of ocean in United States waters outside of the western Pacific by almost 85 percent.[31]

The Biden administration has signaled its openness to reversing the rollbacks to Northeast Canyons and Seamounts, and at the time of writing it is possible that this unique area of ocean will once again come under federal protection. Indeed, the rollback of existing protections for marine ecosystems comes at a time when scientific consensus is telling us that we should be implementing more protections for our oceans, not stripping existing ones. While many of the world's MPAs have not yet been in existence long enough for us to see the full extent of their benefits, many others, where protections have been in place over a much longer period, show us very clearly that these protections work.[32] In this report, we survey six areas that have demonstrated that stringent, well-enforced MPAs are an effective means of protecting and restoring biodiversity, preventing species loss, and helping the ocean recover from human exploitation.[33] With fresh leadership in Washington D.C, these areas are examples that policymakers must look to and seek to emulate as part of a meaningful effort to protect our oceans, and to conserve the rich diversity of life they support.

# Ocean protections have come a long way, but not far enough

The idea of protecting areas of ocean is not new. In traditional fishing cultures, it has often been common practice to place certain particularly important areas of ocean off limits to fishing. Indigenous peoples of island nations in Oceania, for example, have employed measures to regulate and manage fisheries for centuries, including periodically closing off areas of ocean to allow them to recuperate from overfishing, or to protect important fish breeding grounds.[34] In the latter half of the 20th century, the practice of temporarily closing off areas of ocean to enhance the sustainability of fish stocks became a popular instrument of fisheries management, and as the benefits became clear, so too did the understanding that MPAs could deliver broader, ecosystem-wide conservation benefits.[35]

In 1975, the first conference on marine protected areas, sponsored by the International Union for the Conservation of Nature (IUCN), called for the establishment of a global system of MPAs to help mitigate the mounting damage being inflicted on the world's oceans by human activity. Over time, the focus shifted toward adopting MPAs to prevent habitat destruction caused by fishing and to preserve intact ecosystems and biodiversity, including enabling fished species to maintain their functional role in these ecosystems.[36] Protections came to extend beyond restrictions on fishing to include prohibitions on other human impacts, including pollution, aquaculture, seabed mining and oil and gas drilling.[37]

In 2010, the United Nations Convention on Biological Diversity set the goal of conserving 10 percent of the world's ocean in protected areas by 2020. But others have since argued that if these protections are to have the desired impact, this percentage should be much higher.[38] In 2014, the World Parks Congress called for 30 percent of the ocean to be highly protected by 2030. This target was adopted by the IUCN World Conservation Congress in 2016.

Governments have been taking notice. Over recent decades, countries all over the world have set aside vast expanses of ocean for protection. Since the 1960s, the total area of ocean covered by these protections has been increasing at a rate of more than 8 percent per year.[39] The past decade in particular has seen a marked increase in the establishment of MPAs, and especially of strongly protected areas in which all commercial fishing and other resource extraction are banned.[40] Since 2010, the area of the world's waters under national jurisdiction covered by some form of protection has almost doubled, to around 17 percent.[41]

Since the majority of the ocean is not under national jurisdiction, however, that 17 percent represents only

a tiny fraction of the total global ocean, and doesn't come close to meeting the 30 percent that many experts are now calling for. As of January 2021, according to the Marine Conservation Institute, only 6.4 percent of the global ocean is protected in MPAs, and only 2.7 percent is in highly to fully protected zones.[42]

## MPAs can offer varying levels of protection

Despite increasing recognition of the importance of marine protected areas, the definition of the concept is still a subject of some debate. The most commonly used is that of the International Union for Conservation of Nature, which characterizes a protected area as "a clearly defined geographical space, recognized, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values."[43] The United States' definition of MPAs is similarly broad. Executive Order 13158, signed by President Bill Clinton in May 2000, defines an MPA as "any area of the marine environment that has been reserved by Federal, State, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein."[44]

MPAs can be protected under a variety of legal designations, from national marine sanctuaries and marine national monuments to state parks and reserves. They can also encompass numerous habitats, from open ocean and coastal waters to wetlands and estuaries.[45]

Similarly wide-ranging are the purposes for which these areas are protected, and the levels of protection afforded to them. For example, some U.S. MPAs are set aside for scientific research, while others allow some level of fishing and recreational activity. Some are fully protected no-take reserves where all extractive activities are prohibited. Most are "multiple-use," incorporating zones with different levels of protection, including, in some cases, fully protected areas as well as zones where certain activities with low ecological impact are allowed.[46] The *Marine Protected Area Guide* – a collaboration between the U.N. Environment World Conservation Monitoring Centre and other organizations, designed to refine existing terminology and develop a shared vision for MPAs – classifies MPAs into four broad categories based on the degree to which they protect biodiversity and prohibit extractive activities:[47]

- **Minimally protected:** Areas designated as "protected" but within which either extensive extraction is permitted, or enforcement and effective management are lacking.[48]
- **Lightly protected:** Areas within which certain extractive activities, such as drilling and mining, are prohibited, but which permit some degree of commercial fishing. These areas provide a level of protection similar to fisheries management areas, which may protect certain species but still allow fishing (often with restrictions on, for example, the use of specific kinds of equipment).[49]
- **Highly protected:** Areas in which all industrial extractive activities, including drilling, mining and commercial fishing, are prohibited, but which may allow certain low impact extractive activities, such as subsistence and recreational fishing.
- **Fully protected** MPAs allow no extractive activities at all. These include "no-take" marine reserves.

By some metrics, the United States currently has upwards of 1,700 MPAs covering a little over 40 percent of the nation's marine waters.[50] However, this figure encompasses a wide range of different protections, including fisheries reserves and other area-based management tools that do not necessarily prioritize conservation objectives.[51] The Marine Conservation Institute puts the number of MPAs that meet the IUCN definition, are actively contributing to biodiversity conservation, and have regulations in force on the water at 901.[52] Currently, 23 percent of U.S. waters – around 1.3 percent of state waters and 23.9 percent of federal waters – qualify as highly to fully protected, and 3 percent are in no-take marine reserves.[53]

Relative to some other countries, these numbers are impressive. But they don't tell the whole story.

A 2019 analysis by the Center for American Progress found that the vast majority of the U.S. MPA system consists of a small number of very large, very remote marine monuments. Of the total area of all U.S. MPAs, 97 percent is located in the West Pacific, meaning that many ecosystems and habitat types elsewhere in U.S. waters remain unprotected.[54] This remote region also accounts for 99 percent of all highly to fully protected MPA area in U.S. waters. Most of the remaining 1 percent was concentrated in the Northeast Canyons and Seamounts Marine National Monument (which itself only covers a little over 1 percent of U.S. Atlantic Ocean territory). Maintaining representative, ecologically networked samples of the full variety of marine ecosystems, with the aim of enabling them to be self-sustaining and enhancing their resilience to changes in ocean climate, is vital if we are to ensure the preservation of marine species and interdependent, ecologically important areas and processes.[55]

Currently, of the country's 19 ecoregions (areas with generally similar ecosystems and environmental resources), only two – the South Florida/Bahamian Atlantic and the Hawaiian Archipelago – have more than 1 percent of their ocean area in fully protected MPAs that prohibit all extractive uses.[56] In addition, with few exceptions, most U.S. MPAs are relatively small: approximately three-quarters of them are less than 100 square kilometers in area, and only around 3 percent cover more than 1,000 square kilometers.[57]

# Marine protected areas safeguard wildlife and ecosystems

A growing body of scientific research indicates that MPAs that are at least highly protected – and fully protected ones in particular – consistently help to support larger, healthier and more diverse populations of fish and other marine animals.[58] No-take reserves currently make up only around 3 percent of U.S. waters,[59] but studies have shown that these areas can help protect the balance and integrity of marine ecosystems, lead to an increase in fish biomass and size and density of organisms, promote species diversity, and prevent species loss within their boundaries.[60] They can also have a positive effect on the ocean around them, increasing the abundance and diversity of marine life in adjacent areas.[61] MPAs have been found to yield the greatest benefits when they are large, highly protected, isolated by deep water or sand, well-enforced, and long-standing. According to a 2014 study published in the journal *Nature*, when all five of these criteria are met, benefits increase "exponentially."[62]

## MPAs promote increased biomass, abundance and density of marine species

Highly protected, well-managed and effectively enforced MPAs can lead to an increase in the density and abundance of marine species within their boundaries.[63] A 2009 analysis synthesizing a range of monitoring studies on the ecological effects of no-take marine reserves around the world showed that the protections afforded by these reserves result in significant average increases in biomass (the total mass of living organisms in a specific area), the size and density of organisms, and the number of species present within the reserves.[64] For example, in half of the reserves, total biomass of studied species was more than triple that of unprotected areas, and density more than 60 percent higher.[65]

In some cases, where the density and abundance of organisms is especially low outside of the reserves, the increases were even greater. One study, examining the Governor Island reserve in Australia, found that the biomass of rock lobsters was 2,300 percent higher in the protected area than outside it.[66] Across five studies measuring density of various marine species in the Las Cruces Reserve in Chile, the number of individuals of the species being studied was found to be on average 2,210 percent higher inside the reserve than outside it.[67] Of these studies, the two reporting the largest increases were both focused on the Chilean abalone, a species of sea snail that was "incredibly rare" prior to the creation of the reserve, and remained so everywhere except in the protected areas, where its population rebounded.[68]

Numerous other studies have documented the benefits of MPAs for marine life:[69]

- A 2017 analysis found that average biomass of fish in fully protected MPAs was 670 percent greater than in nearby unprotected areas and 343 percent greater than in partially protected MPAs.[70] The study also found that fish biomass was restored in fully protected marine reserves over time after the imple-

mentation of protections, whereas in partially protected MPAs it was not.[71]

- A study of marine reef fish in Tsitsikamma National Park off the coast of South Africa, one of the world's oldest fully protected MPAs, found that the density of certain fish species in the protected area is around 42 times higher than in unprotected areas.[72]
- Within five years of the implementation of protections on Georges Bank in the Gulf of Maine, the density of legal-sized scallops reached up to 14 times that of scallops in fished areas.[73] Crabs, anemones, sea urchins, and other invertebrates returned, and yellowtail flounder also began to recover.[74]
- MPAs can lead to larger fish populations beyond their boundaries, either through fish migrating from the protected area or the dispersal of larvae spawned within it.[75]
- In tropical environments, unfished reefs with large fish biomass tend to have greater coral coverage and lower levels of coral disease than unprotected reefs, with fewer bacteria, viruses and pathogens.[76]

Photo: U.S. National Park Service

*Kelp forests, like this one in the Channel Islands National Park off the coast of California, are important carbon sinks, and support a rich diversity of marine life.*

## MPAs protect and enhance biodiversity

Marine protected areas can protect biodiversity, strengthening ocean ecosystems by keeping natural processes intact and enhancing the resilience of their inhabitants. Highly to fully protected MPAs foster greater biodiversity, which in turn boosts overall ecosystem health.[77]

A 2006 meta-analysis of data from 44 fully protected MPAs showed that, post-designation, levels of biodiversity in these areas increased by an average of 23 percent, and fish numbers in surrounding areas also significantly increased as a result of spillover from the protected zones.[78] Increased biodiversity in turn increases degraded ecosystems' ability to recover from degradation.[79] For example, within two decades of its designation, a fully protected area in New Zealand's Leigh Marine Reserve recovered from destruction of kelp forests triggered by the unchecked growth of its sea urchin population, which thrived in the absence of heavily-fished predator species.[80] Restrictions on fishing within the MPA opened space for a rise in predator populations, including sea urchin-eating fish, resulting in an increase in overall biodiversity, a revival of the area's kelp forest, and a return of the local ecosystem to a complex, healthy condition.[81]

In addition to benefiting resident species, well-connected, ecologically coherent MPA networks that provide effective links across marine habitats have been shown to benefit highly mobile marine animals like whales and sea turtles by protecting important sites along their migratory routes, such as feeding and breeding grounds.[82] In the western Pacific, protection of the nesting beaches and foraging habitats of green turtles, including a significant portion of their migration routes to foraging grounds outside the protected area, has played a role in rescuing these populations from the brink of extinction.[83]

Since migratory species tend to have preferences for particular sets of conditions, such as temperature or oxygen concentrations, and often gravitate toward particular areas where these conditions lead to an abundance of prey, protecting such areas can benefit

these species.[84] This has been the case for certain kinds of seabirds, for example. A study of the distribution and foraging habitat use of three species of tropical booby in two MPAs in a network in the Central Pacific found that each MPA encapsulated more than 85 percent of foraging habitat for each species, suggesting that these areas are valuable to these highly mobile tropical species.[85]

## Highly and fully protected MPAs can help mitigate the impacts of climate change

Global warming is taking its toll on the ocean, with increasing acidification, oxygen depletion, changes in water temperature and currents, intensification of extreme weather events, and degradation of coral reefs and other critical wildlife habitats.[86] But the oceans themselves may be an important ally in combating this crisis.[87] For example, oceans and coastal habitats, such as mangroves and salt marshes, not only soak up huge quantities of carbon dioxide, but can also fortify our shorelines against rising sea level and extreme weather events that are all but guaranteed to become more frequent as the climate crisis escalates.[88] Research suggests that networks of MPAs that protect these coastal ecosystems can therefore help safeguard both human communities and ocean ecosystems against the impacts of climate change.[89]

Protected marine reserves have been shown to increase the resilience of marine species to climate-induced impacts. For example, when climate-driven oxygen depletion in Baja California devastated local populations of pink abalone, the protection these reserves provided for large adult mollusks with high egg production enabled abalone populations in the protected areas to recover more quickly than those outside the reserves, and moreover, helped to replenish non-protected surrounding areas through larval spillover across the reserves' borders.[90]

The increased complexity of ecosystems nurtured by MPAs in itself enhances the ability of protected areas to withstand climate-induced impacts. Research has shown that reserves with complex ecosystems are more resilient to the effects of climate change than unprotected areas.[91] Increased diversity in fish communities gives these communities greater resilience to variations in temperature, for example.[92] Similarly, studies have revealed that increased biodiversity enhances reef fish biomass and resilience against the climate change impact of rising temperatures.[93]

Photo: Timothy Kimon, via Unsplash

*Mangrove forests act as natural breakwaters, protecting against coastal erosion, as well as sequestering carbon and filtering pollution.*

MPAs can also help protect coastlines from the effects of climate change. Coral reefs, for example, are important natural breakwaters, absorbing the force of waves before they hit land. The same is true of mangrove forests, which also act as buffers against coastal erosion, as well as sequestering carbon and filtering pollution.[94] Ensuring natural features like these remain intact can help protect vulnerable coastal communities from flooding, tidal events and storms.[95]

Fully protected MPAs can also help protect ocean ecosystems from disease and damage. A 2015 study of Great Barrier Reef marine reserves, for example, found that coral disease levels were four times lower in no-take marine reserves than in other areas.[96] Other studies have shown that corals in fully protected reefs in the Line Islands in the central Pacific damaged by the violent El Niño events of 1997-1998 recovered within a decade, whereas in unprotected areas they did not.[97]

Like coral and mangroves, seagrasses can also be an important source of climate change mitigation.[98] Seagrass meadows – along with salt marshes, mangroves and kelp forests – are major carbon sinks. Coastal and marine habitats like these sequester carbon more efficiently than land-based ecosystems of equivalent area.[99] Seagrass alone is thought to be responsible for storing around 10 percent of the total organic carbon sequestered in the ocean.[100]

A 2017 study of how marine reserves can help marine ecosystems and humans adapt to five climate change impacts – acidification, rising sea levels, intensification of extreme weather events, shifts in species distribution, and decreased productivity and oxygen availability – concluded that marine reserves are "a viable low-tech, cost-effective adaptation strategy that would yield multiple cobenefits from local to global scales."[101]

# Marine protected areas: Six success stories

Recent years have seen a dramatic increase in designation and implementation of new or expanded MPAs.[102] While the full extent of the benefits of MPAs may only become clear over the longer term, a substantial number have been in place for several decades – long enough for scientists to be able to monitor the impact of these protections and understand just how effective they can be. Even some of those established over the last 10 or 15 years have already delivered remarkable results. The following case studies provide a cross section of these early successes.

## California

**After less than two decades, America's first science-based, statewide MPA network has shown what a strategically-planned, carefully-managed MPA system can achieve.[103]**

In 2004, following the adoption of California's 1999 Marine Life Protection Act, California began a consultation and planning process that would culminate in 2012 in the implementation of the country's first statewide MPA network.[104] Approximately 852 square miles of ocean off the California coast – a little over 16 percent of the state's waters – were placed under the protection of 124 MPAs.[105] Of this MPA area, approximately 60 percent (9 percent of state waters) is in no-take MPAs.[106] Early studies have shown that these MPAs are already delivering substantial benefits for fish and other wildlife and habitats.[107]

Map: CA.gov


*Marine Protected Areas off the coast of California.*

A 2013 study of MPAs off the state's Central Coast found a greater abundance of certain fish species, including cabezon, lingcod and black rockfish, in protected areas than in non-protected areas.[108] The endangered black abalone – a species of sea snail once numbering in the millions along California's coast but now harvested almost to extinction — increased in numbers and size inside MPAs within five years of these protections being implemented.[109] Similarly, within five years of the establishment of the North Central Coast's Sea Lion Cove State Marine Conservation Area (SMCA) – created in part to protect an important abalone nursery – populations of red abalone had experienced a "sharp increase."[110]

Research has also found evidence that California's MPAs are benefiting the ocean environment outside of their boundaries. A 2015 study looking at larval dispersal within and outside MPAs found "significant spillover" into surrounding areas, indicating that the protected areas are potentially important sources of new additions to the populations of a large percentage of resident species.[111] Similarly, a 2019 study revealed connectivity between populations of kelp rockfish in a number of Central Coast MPAs and in non-protected areas nearby.[112]

Photo: U.S. National Park Service

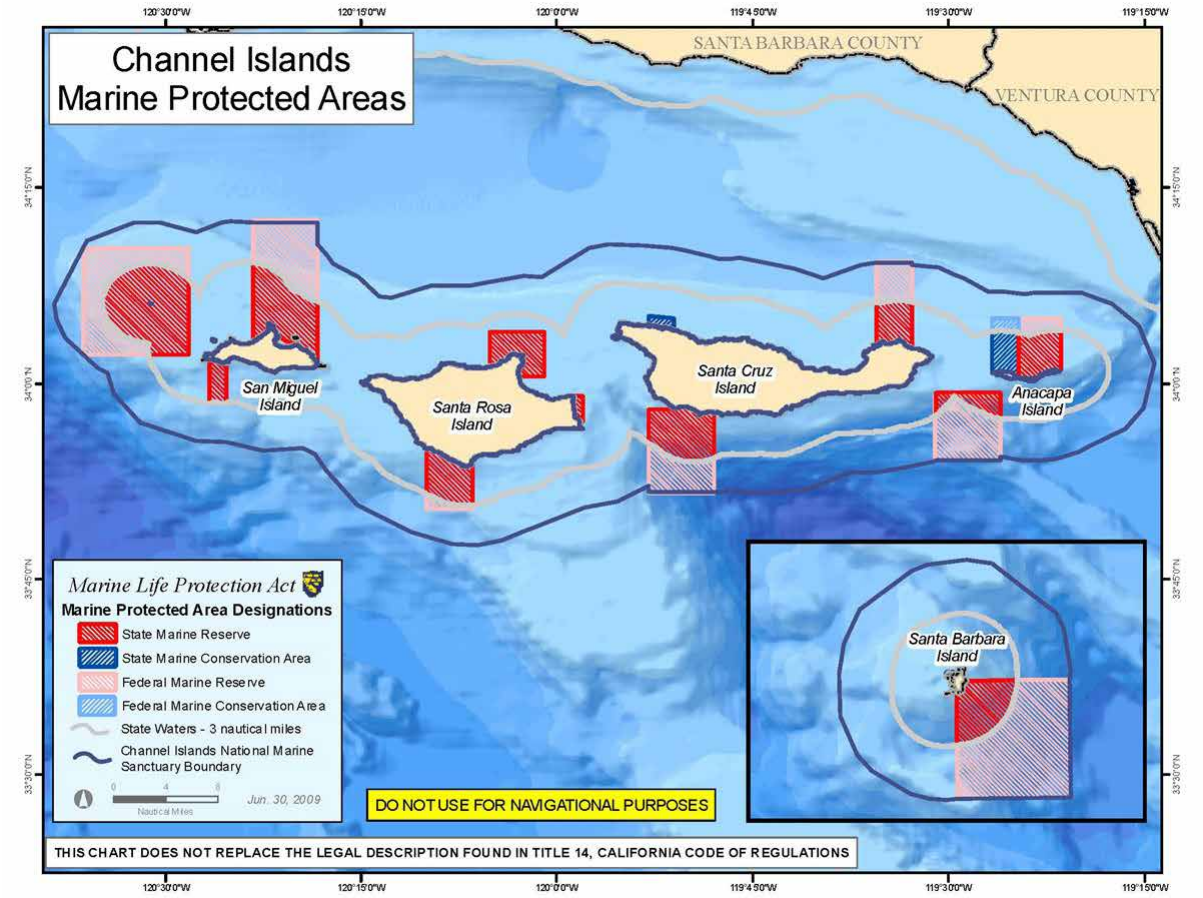
*The Channel Islands.*

## The Channel Islands MPAs

In 2003, the State of California designated 10 marine reserves and two marine conservation areas in state waters within the Channel Islands National Marine Sanctuary[113] – a 1,470 square mile area of ocean around Anacapa, Santa Cruz, Santa Rosa, San Miguel and Santa Barbara islands in the Santa Barbara Channel off the coast of Southern California.[114] In 2006 and 2007, the National Oceanic and Atmospheric Administration (NOAA) extended the protections into the sanctuary's deeper, federal waters, bringing the total number of marine reserves in the network to 11. Within these reserves, all fishing and other extractive activities are prohibited, while the two marine conservation areas allow limited take of lobster and pelagic fish.[115]

The Channel Islands sanctuary is the largest MPA network off the continental United States.[116] Within its boundaries exist numerous endangered species and a diverse patchwork of sensitive habitats, including rocky shorelines and sandy beaches, inshore kelp forests, soft bottom habitats and rocky reefs, and deep-sea coral gardens.

Map: U.S. National Park Service




Within just a few years of its designation, monitoring studies were already beginning to see the effects of the protection given to the area. A study published in 2010 found that the density of targeted (i.e., fished) fish species had increased inside the protected zones by 50 percent, and their biomass had increased by 80 percent, in the first five years of the reserves' existence. The biomass of predators inside the reserves was "significantly greater" than in unprotected areas, with 1.8 times more piscivores (animals that primarily eat fish) and 1.3 times more carnivores in these zones.[117] This is significant, since both of these groups play important roles in kelp forest ecosystems. California sheephead and spiny lobsters, for example, are important predators of sea urchins, and help prevent kelp beds – which support more diverse communities, complex food webs and healthy fish populations – from being destroyed through overgrazing by unchecked sea urchin populations.[118]

A 2015 study found that the average size of kelp bass and California sheephead was "significantly larger" in most of the older Northern Channel Islands marine

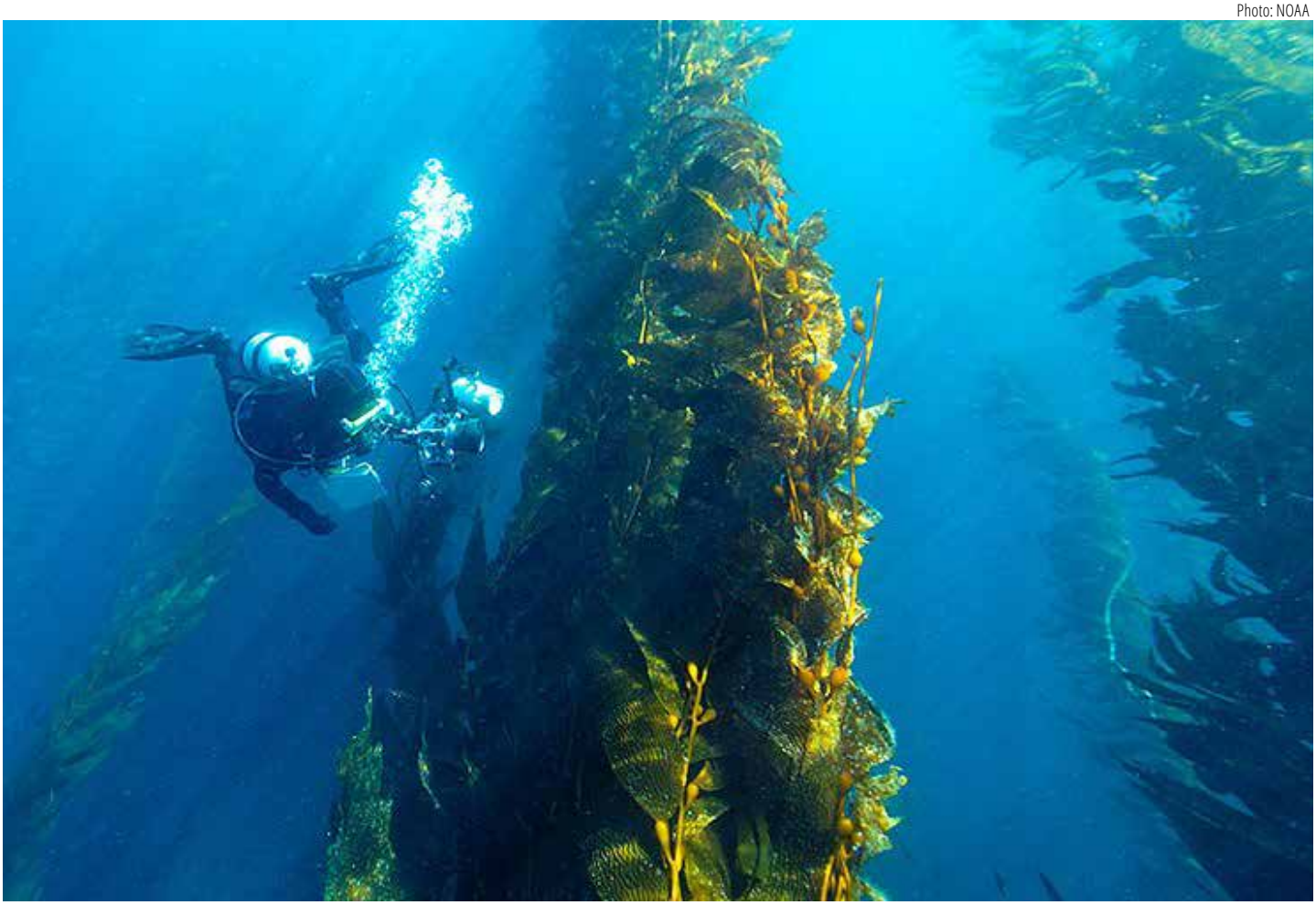
Photo: Tomarin via Wikimedia Commons, CC BY-SA 2.1 JP

*Kelp bass are among several species that have benefited from the protection afforded by California's MPAs.*

reserves than in non-protected areas.[119] The same study found that three of the five targeted invertebrate species in the Northern Channel Islands – California spiny lobster, red sea urchin and warty sea cucumber – were considerably more abundant in these protected areas.[120] Protections also had a significant impact on species' overall biomass. Between 2008 and 2013, average biomass for targeted fish species within the boundaries of the Northern Channel Islands reserves increased by 52 percent, whereas outside these MPAs it grew by just 23 percent over the same period.[121] A separate study, also published in 2015, also found that biomass of targeted fish "increased consistently inside all MPAs in the network."[122]

The success of California's MPAs has been attributed in part to the comprehensive, stakeholder-driven planning process that preceded their implementation. This process centered around integrating regional scientific knowledge, engaging local communities, and evaluating the potential economic impacts of marine protections off the California coast. California has also been recognized for its post-implementation management strategy. Since implementing its MPA network, the state has put in place a well-resourced MPA management program steered by a statewide, multi-agency leadership team, with a focus on "scientific monitoring, interagency coordination, public education and outreach, and enforcement,"[123] providing a valuable case study in how to plan, implement and manage a successful statewide network of marine protected areas.

Photo: NOAA



*A diver explores a kelp forest off Santa Cruz Island, CA.*

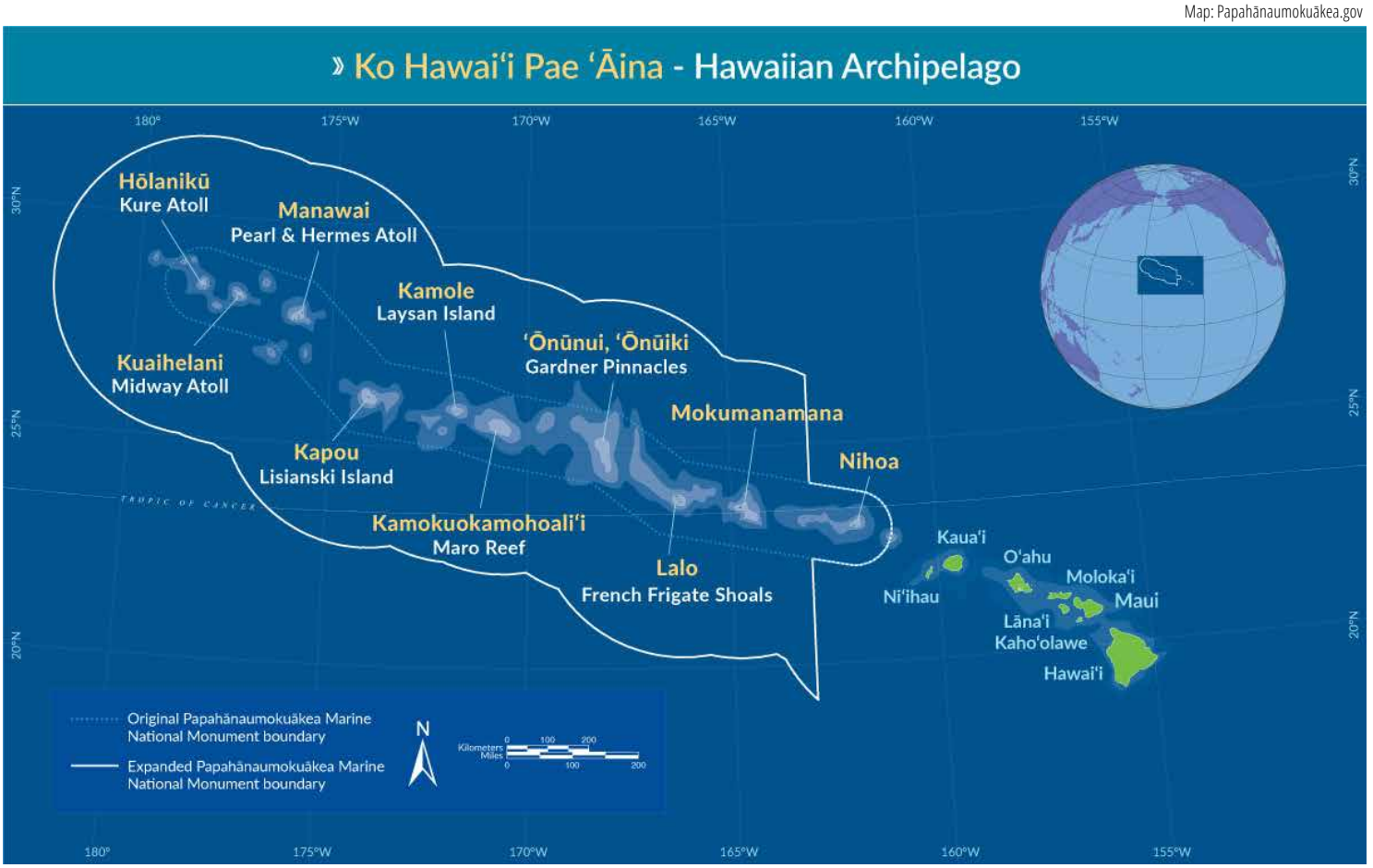
## Papahānaumokuākea Marine National Monument, HI

**In the Pacific Ocean, America's largest Marine National Monument has rescued some of the world's most endangered species from the brink of extinction.**

One of the world's largest marine protected areas, the Papahānaumokuākea Marine National Monument (PMNM) protects a large, pristine coral reef ecosystem and deep sea marine habitats across the waters of the Northwestern Hawaiian Islands.[124] Extending for 1,350 miles across the Pacific Ocean, the monument covers more than half a million square miles of ocean, including 10 islands and atolls, and is home to thousands of marine species, including mammals, fishes, sea turtles, birds and invertebrates, some of them found nowhere else in the world and several of them threatened or endangered.[125]

The Northwestern Hawaiian Islands are a place of huge spiritual significance in Native Hawaiian culture.[126] In 2006, President George W. Bush established the Northwestern Hawaiian Islands Marine National Monument – renamed Papahānaumokuākea shortly afterwards – in an effort to protect the extraordinary array of natural and cultural resources within its boundaries.[127] Parts of the area had had various protections in place since 1909, when President Theodore Roosevelt created the Hawaiian Islands Bird Reservation in response to the over-harvesting of seabirds. With national monument status, however, came a complete ban on all commercial resource extraction, including fishing and mineral extraction, across the entire region. Scientific research, some recreational fishing, and taking of fish for Native Hawaiian cultural practices are allowed with a permit.[128]

Map: Papahānaumokuākea.gov




*Papahānaumokuākea Marine National Monument.*

In 2010 the PMNM was designated a UNESCO World Heritage Site, and in 2016, under President Barack Obama, the monument was expanded to four times its original size, making it the largest land or marine preserve on earth at that time.[129] The expansion brought the total protected zone to its current 582,578 square miles – an area of ocean larger than the total land area of the state of Alaska.[130]

Of the 7,000 species that depend on the PMNM, around a quarter are only found in the Hawaiian archipelago.[131] The islands also play a major role in maintaining a number of endangered species.

The protected waters around the French Frigate Shoals, for example – the largest atoll in the Northwestern Hawaiian Islands – are home to a flourishing green turtle population.[132] Green turtles are found in coastal regions of more than 140 countries across the world, and all of the populations worldwide are currently listed as either Endangered or Threatened under the Endangered Species Act.[133] These turtles were once abundant in the Hawaiian Islands, but by the late 20th century their populations had been almost completely wiped out in the area. While the species continues to suffer elsewhere in the world as a result of hunting, coastal development, habitat destruction and destructive fishing practices, the protection of the French Frigate Shoals has fostered a "spectacular recovery" of their populations in Hawaiian waters.[134]

Protection of the turtles' nesting beaches and foraging habitats, coupled with prohibitions on hunting, has enabled successful reproduction cycles free from human disturbance and played a crucial role in their increased numbers.[135] The turtles also travel long distances to foraging grounds outside of the PMNM, such as seagrass beds around the Main Hawaiian Islands, and 30 percent of their migration route falls under the protection of the PMNM.[136] The growth of their population within the monument has been so significant that the IUCN now lists the Hawaiian green turtle as being a population of "least concern."[137]

Human activity, from overfishing and hunting to waste dumping, also had a hand in the near-complete disap-

Photo: John Burns/NOAA, 2017, via Flickr. Public Domain Mark 1.0

*A Hawaiian green sea turtle at Pearl and Hermes Atoll. Protection of their nesting beaches and foraging habitats has enabled these endangered turtles to flourish within the Papahānaumokuākea Marine National Monument.*

Photo: Naomi Worcester/Hawaii Department of Land and Natural Resources

*A Laysan duck with her offspring.*

pearance of the Laysan duck from the Main Hawaiian Islands (MHI). An extremely rare endangered species endemic to the region, by the end of the 19th century these birds had been all but wiped out everywhere except Laysan Island – part of the protected Hawaiian Islands National Wildlife Refuge and now the PMNM – where their population was barely into double figures.[138] Conservation efforts enabled by the protections of the PMNM have since enabled their population to rebound into the hundreds.[139] In the early 2000s, as part of an effort to aid their recovery, 42 of Laysan Island's ducks were relocated several hundred miles to Midway Atoll, where extensive habitat restoration enabled the establishment of a second population, lessening the risk of extinction from storms, disease or other disasters destroying their habitats on Laysan Island.[140]

Another startling feature of the PMNM, apparently spurred by the absence of human interference in the area, is the unusually high number of predators in the ecosystem. Populations of large predatory fishes have drastically diminished all over the world in recent decades, and "top predator dominated ecosystems" are increasingly rare.[141] Sharks, giant trevally, groupers and other predatory species that have experienced massive population die-offs elsewhere, however, are thriving in the pristine waters of Papahānaumokuākea.[142] The average biomass of fish in the monument is three times higher than in the Main Hawaiian Islands, and these apex predators account for more than 54 percent of the area's total biomass.[143] A 2016 study found up to an order of magnitude more giant trevally and amberjacks and five times more sharks in the protected waters of the Northwestern Hawaiian Islands than in the Main Hawaiian Islands.[144] Fish size, too, was markedly different between the two areas. Green jobfish (a kind of snapper) and bluefin trevally, for example, were significantly smaller in the Main Hawaiian Islands than in the protected area.[145]

Predators – especially apex predators like sharks – play a crucial role in marine ecosystems.[146] By feeding on species below them in the food chain they help control the populations of prey species, which in turn impacts the populations of prey species of those animals, and so on, triggering a cascade effect throughout the ecosystem.[147] Moreover, by reducing the impact of a species on a specific resource (e.g., through overgrazing), predators can increase the diversity of species in the ecosystem.[148] So, in many cases, greater numbers of predators is a good indicator of ecosystem health, including greater biodiversity and abundance of species in that ecosystem, a phenomenon that is on full display in Papahānaumokuākea.[149]

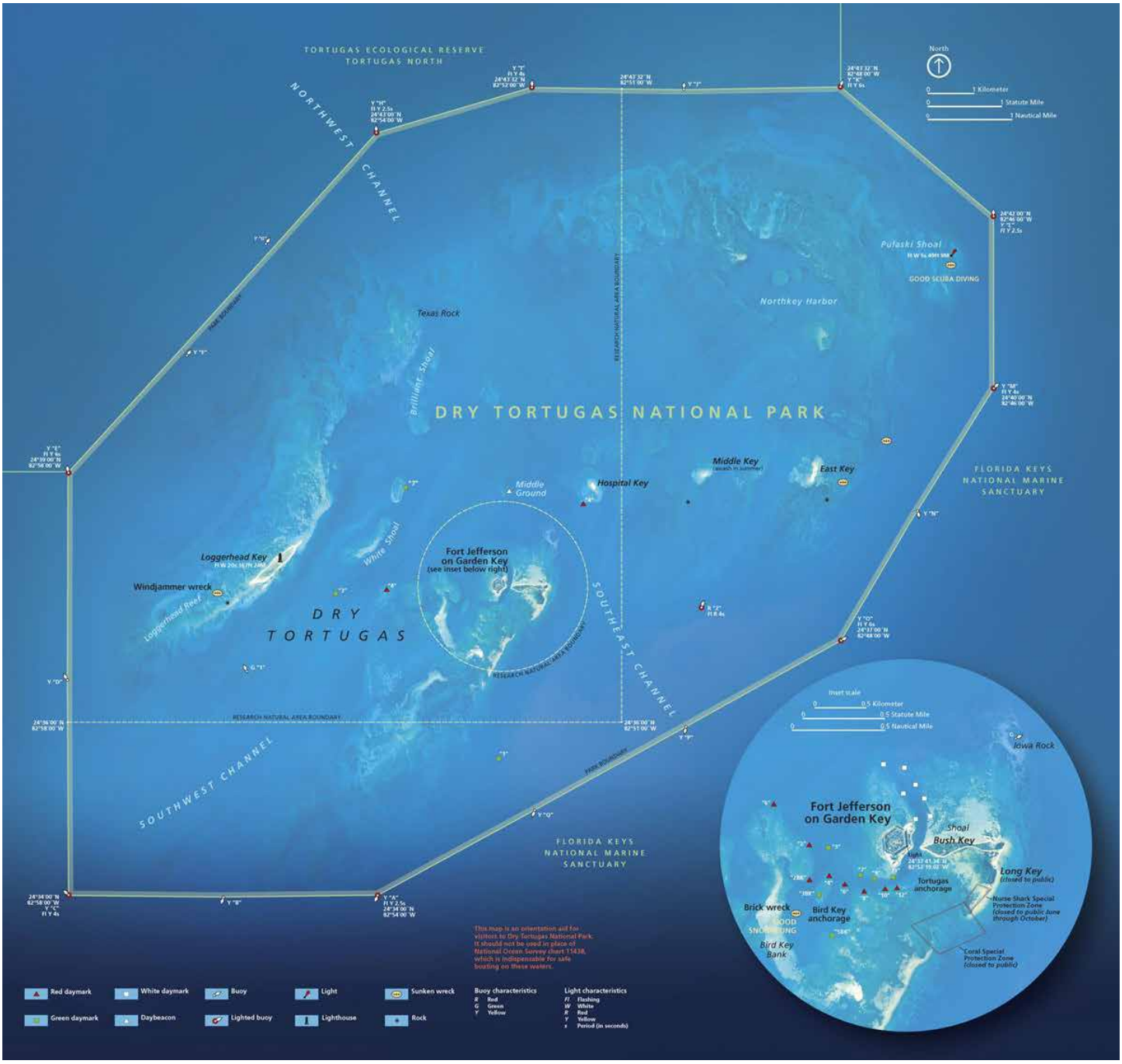
Photo: Yumi Yasutake/papahanaumokuakea.gov

*A Galapagos shark at Midway Atoll.*

## Dry Tortugas National Park, FL

**Protection of an "ecological crossroads" in the Gulf of Mexico has been instrumental in the recovery of reef species populations.**

In 1992, Congress created Dry Tortugas National Park, a multiple-zone, multiple-use MPA established "to protect and interpret a pristine subtropical marine ecosystem, including an intact coral reef community."[150] Located in the Gulf of Mexico at the southwestern end of the Florida coral reef ecosystem, about 70 miles west of the Florida Keys, the Dry Tortugas region provides breeding habitat for a vast range of marine species and is a major source of young coral and fish for the surround-




*Dry Tortugas National Park, with the Research Natural Area marked on the western side of the park.* Map: U.S. National Park Service

ing ocean ecosystem.[151] In all, the area is thought to be home to more than 700 species of fish, birds, mammals and corals, many of them threatened or endangered.[152]

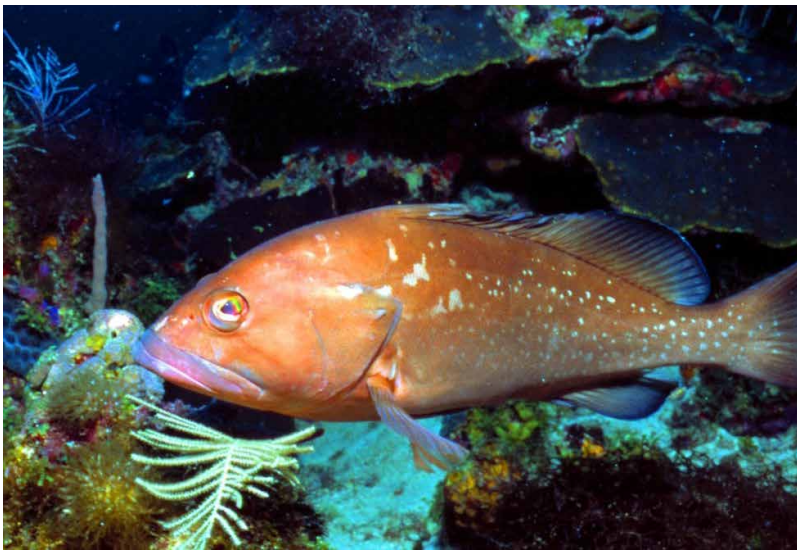
Like much of the ocean around South Florida, the Dry Tortugas area has been heavily impacted by human activity. Over the last several decades, overfishing and habitat loss have contributed to a decrease in the size and abundance of reef-associated game fish, including snapper, grouper and grunts.[153] Research initiated in 1999 concluded that almost half of all fish species in the park – and more than 70 percent of grouper and snapper species – were over-fished, and more than 60 percent experienced between two and six times the level of mortality recommended in federal targets.[154] Recent decades have also seen a severe deterioration of corals, particularly staghorn corals, which have declined by 99 percent since the late 1970s.[155]

In 2001, after a consultation process involving commercial fishermen, recreational anglers, scientists and others, the Tortugas Ecological Reserve (TER) of the Florida Keys National Marine Sanctuary was established by the National Oceanic and Atmospheric Administration (NOAA) and the state of Florida. Comprising two distinct areas of ocean adjacent to the Dry Tortugas National Park – the Tortugas Ecological Reserve North and the Tortugas Ecological Reserve South – the TER prohibits fishing and anchoring, with the aim of protecting marine life habitat and reef fish spawning grounds, preserving the region's biodiversity, and allowing the area to evolve undisturbed by human influences.[156]

In 2007, the establishment of the Research Natural Area (RNA) within the Dry Tortugas National Park closed off a further 46-square-mile area of ocean as a no-take marine reserve to provide a sanctuary for species that have suffered as a result of fishing and habitat loss, and to "restore ecological integrity and capacity for self-renewal by minimizing human disturbance."[157] Protecting shallow water habitats and reef fish species, the RNA complements the two existing no-take reserves of the TER.[158] The protection of these areas is intended to "ensure the success of both marine and terrestrial ecosystems while offering outstanding opportunities for scientific research and public education."[159]

Within five years of the implementation of the RNA, the ocean within its boundaries was already showing signs of recovery. A study published in 2012 found that species within the protected area were responding positively to protections. Bottom habitat previously damaged by fishing was supporting increased biomass and species diversity, and the number of spawning-sized adult fish within the RNA had increased relative to unprotected areas.[160] The number and size of several species, including red grouper, mutton snapper, yellowtail snapper and hogfish, have also increased in the nearby Tortugas North reserve and Dry Tortugas National Park, while in nearby non-protected areas of the Tortugas region they have either decreased or remained constant.[161] The protection the

Photo: U.S. National Park Service



*A red grouper under the coral in Dry Tortugas National Park.*

RNA provides for these species is thought to have been an important factor in this recovery.[162]

The marine reserves in the region are also working together as a network to increase the benefits they bring to the wider ecosystem. For example, researchers have identified a migratory corridor for adult mutton snapper between the RNA and these fishes' offshore spawning habitat at Riley's Hump – a reef in the Tortugas South reserve that provides an important spawning area for a variety of reef fish species. Research has found an increase in spawning aggregations (a grouping of a fish gathered together temporarily for the purpose of spawn-

ing) of mutton snapper at Riley's Hump since the establishment of the reserves, and observed a previously unknown migratory behavior where the fish would travel from the RNA to the southern slope of the reef to spawn up to four times in a single spawning season.[163] The latter study concluded that the RNA, in conjunction with the neighboring ecological reserves, provides "critical protection of essential reef fish habitat and important fish spawning habitat," and in the case of mutton snapper, has played a crucial role in the recovery of the spawning aggregations at Riley's Hump.[164]

The study of mutton snapper at Riley's Hump is one example of how the benefits of the RNA are not confined to the protected area itself, but are likely benefiting the surrounding region.[165] In another study, spillover benefits to areas outside the RNA were observed for all the various species of snapper and grouper monitored.[166] Research modeling the dispersal of fish eggs and larvae indicated that spawning in the Tortugas region is helping to replenish reef fish populations across the waters of south Florida, including in unprotected areas of the Dry Tortugas and Florida Keys reef tract, coastal bays along the West Florida Shelf, and along the state's east coast north of Miami.[167]

Photo: Pascal van de Vendel, via Unsplash

*A jackfish tornado at Cabo Pulmo.*

## Cabo Pulmo, Mexico

**In one of the greatest marine protection success stories worldwide, protections enabled an area to recover from near-total destruction by human exploitation.**

After decades of abusive overfishing had left the ocean off the Mexican town of Cabo Pulmo devoid of its once rich biodiversity, local activism culminating in the implementation of a no-take marine reserve transformed it into one of the most pristine areas of ocean in Mexico, now recognized by UNESCO as a World Heritage Site.

Cabo Pulmo, on the east coast of Mexico's Baja California Peninsula, has been called the jewel of the Gulf of California. This unique area of ocean lies in the transition zone between the tropical and temperate Pacific and supports a diverse array of marine life.[168] The shallow waters of Bahía de Cabo Pulmo contain the oldest of the three living reefs (and the only hard coral reef) on the west coast of North America.[169] Thought to be around 20,000 years old, the reef is home to more than 300 species of fish, around 70 species of invertebrates, and many of the approximately 6,000 other marine species found throughout the Gulf of California.[170]

Historically home to a vast array of marine species, including huge populations of giant sharks, groupers and other predators, the ocean off Cabo Pulmo has been a source of sustenance for the local community for centuries.[171] From the 1970s, the abundance and variety of species in the region made it a famous destination for sport and commercial fishing. By the 1980s, extreme overfishing and weak, poorly enforced regulations had led to a dramatic decline in local fish populations, with populations of top predators, such as sharks and marlin, and large reef species like grouper, radically depleted.[172]

In the early 1990s, concerned about the effects of human activity on the region's ocean ecosystem, residents of Cabo Pulmo joined forces with scientists from the local university to lobby the federal authorities to establish protections to safeguard the dwindling natural resources of this overexploited patch of ocean, and to give the reef ecosystem space to recover from decades of abuse.[173] In June 1995, the Mexican government

established *Parque Nacional Cabo Pulmo* – Cabo Pulmo National Park – protecting a little over 27 square miles of ocean between Pulmo Point and Los Frailes Cape. Initially, 35 percent of that area was placed off-limits to fishing. Further campaigning by local residents led to the expansion of the no-fishing area over the entire park.[174]

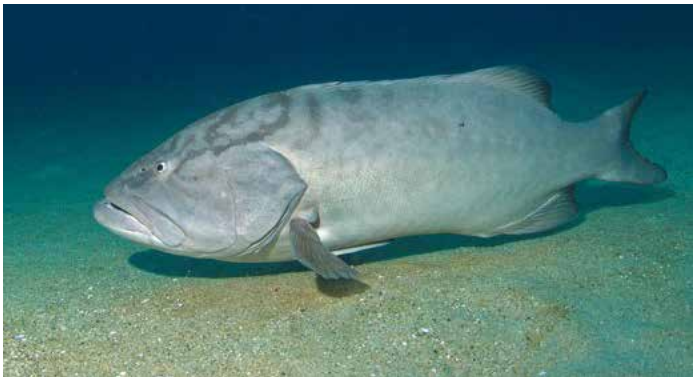
A 2011 study evaluating changes in marine biomass in the area between 1999 and 2009 revealed that in the space of just 10 years, overall biomass had increased by 463 percent, bringing the reef to a level comparable to that of unfished reefs.[175] The biomass of top predators, including sharks and grouper, had increased by 1,070 percent. Fish size and species richness had also increased, as had the diversity of top predators. The combination of higher densities and larger fish created an average biomass more than five times that of unprotected areas in the Gulf of California.[176]

In the space of just two decades, a heavily degraded patch of ocean had been transformed into a haven of biodiversity. Since the implementation of the protections, populations of numerous species, including whale sharks, manta rays, humpback whales and endangered sea turtles, have rallied.[177] A survey conducted in 2018 found 69 reef fish species that were not previously known to live in Cabo Pulmo, corresponding to 24 orders, 35 families and 51 genera, bringing the current checklist to 302 species (comprising 194 genera, 74 families, and 24 orders).[178]

Photo: clr_flickr via Flickr, CC BY-SA 2.0

*Reef fish at Cabo Pulmo.*

Photo: Octavio Aburto/NOAA Fisheries



*Research indicates that the protections at Cabo Pulmo are contributing to the return of the endangered gulf grouper.*

The reef has also become an important refuge and spawning site for at least one endangered species: the rare gulf grouper.[179] Historically, this was the most abundant predatory fish species to inhabit the rocky-reef ecosystems of the Gulf of California.[180] In 1960 these fish accounted for around 45 percent of local finfish catches in the region.[181] By the 1970s this number had decreased to 10 percent.[182] Today, gulf grouper make up less than 1 percent of total catches, and most of that consists of juveniles due to decline in the size of adult populations and fishing of spawning aggregations.[183] This precipitous decline has ramifications for the balance of predator and prey species in local reef ecosystems, and has led to the gulf grouper being classed as endangered on the IUCN Red List of Threatened Species and under the U.S. Endangered Species Act.[184]

Several studies have noted the presence of gulf grouper in the waters of Cabo Pulmo National Park, and there is evidence that the protections are contributing to the return of a growing population.[185] The area also provides an ideal setting for scientific study of the behavior of this previously under-researched species. Extensive studies of movement and residency patterns of gulf grouper within the park have revealed that these fish spend a great deal of time at specific sites within the protected area, suggesting that protection of rocky reef habitats like those of Cabo Pulmo can help restore the species to its pre-endangered status.[186]

*The Great Barrier Reef.* Photo: OECD

## The Great Barrier Reef, Australia

**After decades of protections, the world's most famous coral reef shows the long-term benefits of MPAs for protecting biodiversity and enhancing ecosystem resilience.**

The regulations governing activity on Australia's Great Barrier Reef are some of the most stringent and well-established of all of the world's coral reefs, and the fact that large portions of the Great Barrier Reef Marine Park have had these protections in place for several decades enables us to see very clearly how they enhance the health of coral reef ecosystems, support healthy fish populations both within and outside their own boundaries, and help marine ecosystems withstand and rebound from disturbances.[187]

The Great Barrier Reef is the world's largest living structure and one of the most complex and diverse ecosystems on the planet. Spanning almost 133,000 square miles of ocean off the northeast coast of Australia, this vast natural wonder is home to thousands of different species, including threatened, rare and endangered ones.

Its 70 distinct bioregions contain more than 2,900 individual coral reefs – including more than 450 species of hard coral – upwards of 700 square miles of mangroves and 2,000 square miles of seagrass beds.[188] These habi-

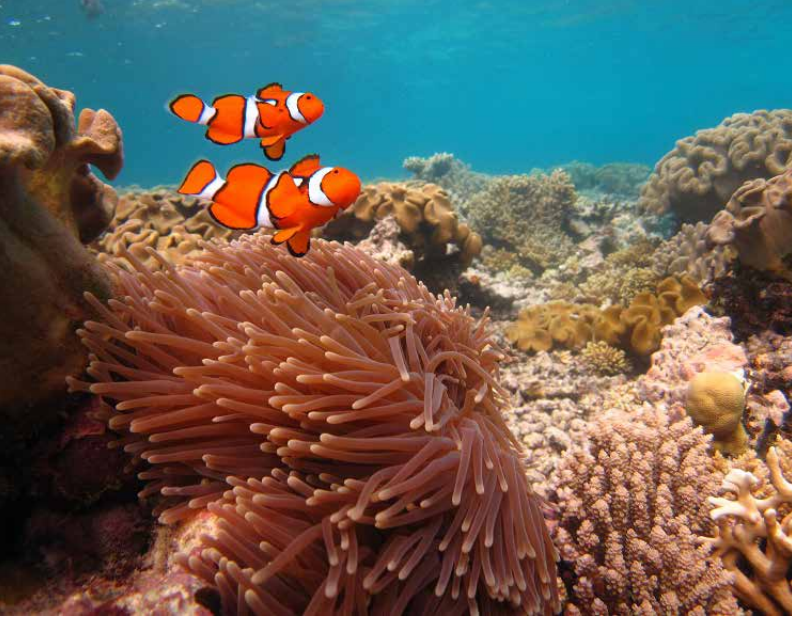
*Fish among the coral of the Great Barrier Reef.* Photo: Piqsels, CC0

*Pacific double-saddle butterflyfish among the corals of Flynn Reef.* Photo: Wise Hok Wai Lum via Wikimedia Commons, CC BY-SA 4.0

tats are home to more than 1,600 species of fish, 215 species of birds, six of the world's seven species of marine turtle, 30 species of whales and dolphins, 133 species of sharks and rays, and one of the world's most important populations of dugong, as well as a vast range of smaller but no less ecologically important species, like mollusks (3,000 species of them), sponges, marine algae, soft coral and a vast array of echinoderms, including starfish and sea urchins.[189] It's not for nothing that this kaleidoscope of biodiversity is known as one of the seven wonders of the natural world.

In an effort to safeguard this unique region from human pressures and protect the stunning plethora of life it supports, in 1975 the Australian government enacted the *Great Barrier Reef Marine Park Act*,[190] creating the Great Barrier Reef Marine Park Authority to "provide for the protection, wise use, understanding and enjoyment of the Great Barrier Reef in perpetuity through the care and development of the Great Barrier Reef Marine Park."[191]

Stretching 1,800 miles along the Queensland coast, the Great Barrier Reef Marine Park is a multiple-use protected area encompassing a huge range of habitats, including not only its famous coral reefs but also seagrass, mangroves, sand and sponge gardens in shallow inshore areas, and the deep-water habitats of the adjacent continental shelf.[192] Roughly 33 percent of the park is now fully protected in no-take zones – known as Marine



*Clownfishes.* Photo: Paul Arps, via Flickr, CC BY 2.0

National Park Zones – in which all extractive activities are prohibited.[193] A further 28 percent is covered by "Habitat Protection Zones," in which certain limited activities are permitted with a permit but which nonetheless provide relatively strong protections for sensitive wildlife habitats. The remainder is composed of a range of different management zones with varying levels of protection.[194]

A 2016 study surveying two decades of data showed that reefs in no-take areas of the park are better able to resist and rebound from natural disturbances, including coral bleaching, storms, coral disease and outbreaks of coral-eating starfish, than those in adjacent areas.[195] The study found that, on average, the size of disturbance impacts was 30 percent lower in reefs in protected zones, and these areas were able to recover 20 percent faster than unprotected areas.[196] In addition, the composition of the reef community was between 21 and 38 percent more stable in protected reefs than in unprotected areas.[197]

A 2015 study of fringing inshore coral reefs in the Whitsunday Islands, at the heart of the Great Barrier Reef, similarly found that the protections provided by no-take reserves had a major impact on coral health. Extensive surveys of hard coral colonies in a cross-section of management zones around the islands found that coral disease occurrence in the area was around four times lower in no-take reserves than in non-reserve areas.[198] Prevalence of three diseases in particular was "significantly decreased" within reserves, as were bleaching, coral damage and the quantities of derelict fishing line found.[199] The diversity of reef fish species, as well as the average densities of coral trout and plankton-eating pomacentrids – a family of ray-finned fish, including damselfishes and clownfishes – were also significantly higher within reserves than in non-reserve areas.[200] The authors concluded that a decreased abundance of derelict fishing line and less wounding and breakage of corals by fishing equipment were the major factors in the lower levels of coral disease in the protected zones.

Other studies have documented substantial increases in fish populations in no-take reserves in the park.[201] For example, a study published in 2004 examined the effect of no-take reserves on species abundance around the Palm, Whitsunday and Keppel Islands, looking at reserves that had been off limits to fishing for almost a decade and a half.[202] Densities of coral grouper and Spanish flag snapper (also known as the gold-banded sea perch) were significantly higher in protected areas than unprotected areas in two of the three island groups. Coral grouper were 3.6 and 2.3 times more abundant, respectively, in protected areas than in fished zones of the Palm and Whitsunday island groups, and Spanish flag snapper were 2.3 and 2.2 times more abundant in protected zones than fished zones of the Whitsunday and Keppel island groups, respectively. The biomass of both species was significantly greater in the protected zones than fished zones at all three island groups.[203]

This has been observed with a range of different species in certain locations within the park. Surveys have found, for example, that coral trout – heavily depleted on inshore reefs prior to protections – as well as red emperor, redthroat emperor and striped seaperch were generally more abundant in longstanding no-take zones than on fished reefs.[204] Sharks, too, have responded well to protections in certain areas. One study found that sharks were more than twice as abundant on reefs that had been off-limits to fishing for a period of decades than in areas where fishing is allowed.[205] In zones where

entry is prohibited altogether, whitetip and gray reef sharks have been found to be four and eight times more abundant, respectively, than on fished reefs, and gray reef sharks, in one study, up to 30 times more abundant.[206]

Fish size is also often found to be significantly higher in protected zones. The 2004 study of no-take reserves around the Palm, Whitsunday and Keppel islands, for example, found that density and biomass of Spanish flag snapper above the legal minimum size were 4.2 and 5.3 times greater, respectively, in protected zones than unprotected areas at all three island groups.[207] This is important for several reasons, not least of which being the fact that larger fish are disproportionately more prolific in terms of reproducing and thus make a significant contribution to replenishing local fish populations, both within the boundaries of the protected area itself and potentially also in adjacent waters.[208]

Indeed, there is evidence that protections of no-take reefs have had an influence on increases in fish populations across the wider ecosystem, including both in other no-take reserves within the network and in unprotected zones.[209] Studies have found evidence of "larval export" from no-take zones of the park, which is crucial both for linking up populations within the network of no-take zones itself and for replenishing populations in the wider area.[210] One study, looking at patterns of larval dispersal for coral trout and stripey snapper found that resident populations in no-take areas exported 83 percent and 55 percent of their offspring, respectively, to fished reefs.[211] The study's authors estimated that, despite accounting for only a little over one quarter of the local reef area, the no-take reserves produced roughly half of all new recruits to populations on both protected and fished reefs within a 30-kilometer radius.[212]

The experience of the Great Barrier Reef demonstrates that properly protected no-take MPA networks can play a major role in protecting ocean biodiversity and supporting ecosystem resilience, both by actively restoring the structure of these ecosystems and by slowing ongoing degradation.[213] Nowhere else has the extent of these benefits been demonstrated at this scale, and over such

*Protections have resulted in the growth of shark populations in parts of the Great Barrier Reef area.* Photo: Piqsels

a long time period, indicating vividly the restorative potential of fully protected marine reserve networks. At the same time, however, the reef also demonstrates that while protections can help ameliorate stressors and support greater chance of recovery from disturbances, they are by no means a panacea for the damage being done to the ocean by human activity.

As with MPAs elsewhere in the world, the major threats faced by the ocean at the Great Barrier Reef come from outside the reserves – primarily from climate change – and despite the benefits delivered by the protections in place, recent studies paint a bleak picture of the region's long-term outlook.[214] The 2019 *Great Barrier Reef Outlook Report* describes how an accumulation of stressors, primarily driven by climate change, have caused major deterioration of the overall health of the region, for example in the form of sea temperature increases and extremes, which have caused devastating mass bleaching events, leading to widespread coral loss, and in turn, impacting fish and invertebrate populations.[215] These events show that while MPAs and other management efforts are an important part of the solution, unless strong action is taken on a much wider scale to deal with the larger problem of global warming, they may only succeed in flattening a downward trajectory propelled by global forces outside the control of local-level protections.

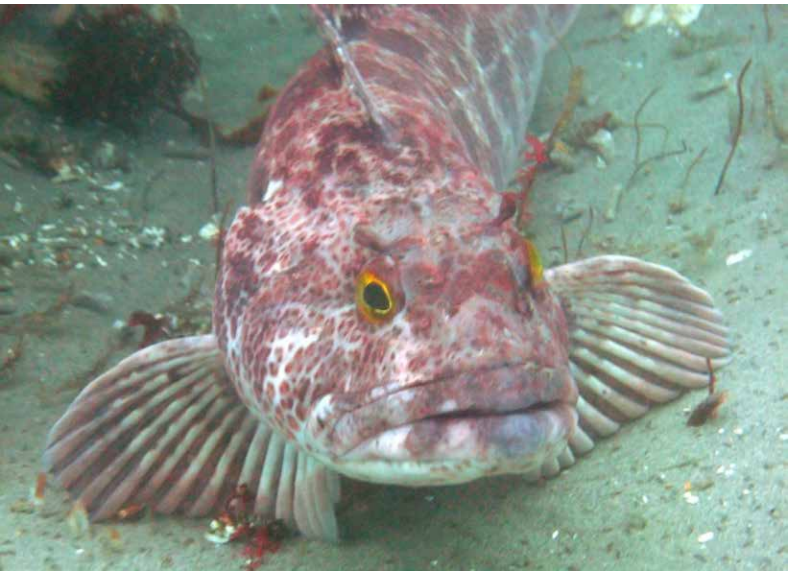
## Edmonds Underwater Park, WA

**In an artificial habitat in Puget Sound, protections have succeeded in restoring local fish populations.**

The large majority of the United States' MPAs in near-shore waters are situated in the ocean off the Pacific Coast.[216] Among the oldest of these lies off the eastern shore of Puget Sound, just north of the city of Edmonds in Washington state. A fully protected no-take zone, designated in 1970, Brackett's Landing Shoreline Sanctuary covers less than half a square mile area of ocean, but within this tiny area lie a range of different habitats teeming with diverse marine life.[217]

A wide sand flat makes up the majority of the reserve's subtidal habitat (the zone of shallow water extending about 200 meters from the low tide line) at the edge of which beds of eelgrass support a plethora of small fishes, including bay pipefish, juvenile codfishes and shiner perch. The sand and mud areas are home to flatfishes and salmon; tubesnouts and herring are common, as are marine mammals, including harbor seals and sea lions, and a rich variety of birdlife, including surf and white-winged scoters, red-breasted mergansers, various species of grebe, and seabirds like marbled murrelets.[218] Divers in the area have even spotted the occasional grey whale.[219]

Photo: Patrick Briggs via Flickr, CC BY 2.0



*Cabezon at Edmonds Underwater Park, WA.*

Much of the sanctuary, however, consists of an artificial habitat dominated by manmade features, including a sunken drydock, sunken boats, tires, concrete rubble, disused navigation buoys, and plastic pipes. This rather bleak-sounding underwater world is nonetheless a haven of biodiversity, with many of the submerged structures attracting species usually found in rocky habitats, including giant anemones, kelp greenling, painted greenling, surfperches, bladed kelp, bull kelp and black rockfish. The park also provides a refuge for certain species of fish, including, most notably, copper and quillback rockfish, lingcod and cabezon.[220]

This manmade reef falls within an area of the sanctuary known as Edmonds Underwater Park, just north of the Edmonds-Kingston Ferry Landing.[221] Established by the City of Edmonds in 1970 as a marine preserve and sanctuary, Edmonds Underwater Park is one of 10 such parks that make up Washington's underwater park system.[222] The park is a popular scuba diving destination, and around half of it has been developed specifically for divers, with a network of guide ropes forming trails linking up the various submerged features.[223] The area is protected by both the city and the Washington Department of Fish and Wildlife, which adopted the no-take restriction into state fishing regulations.[224] The taking of any fish or other marine life is strictly prohibited, as is the use of boats or other types of watercraft within 200 feet of its perimeter.[225]

Even though the protected area is relatively small, numerous studies carried out since the early 1990s suggest that the protections have been remarkably successful in providing a refuge for fish populations. Fish abundance in the area was low prior to the implementation of protections, and not significantly different from anywhere else in the surrounding region. Prior to 1970 the area was virtually barren of lingcod and rockfish, for example, but studies conducted in the 1990s indicate that these species rebounded after the implementation of protections.[226] Surveys of fish populations conducted in 1993 and 1994 comparing Edmonds Underwater Park and another small protected zone with six nearby areas that allowed fishing found striking differences between the fished areas

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*Quillback rockfish.*

and the protected zones.[227] At that point, Edmonds had had protections in place for almost two and a half decades, and it was here that the most striking differences were found, with populations of copper rockfish and lingcod inside the park in some cases almost 10 times those of populations in the unprotected zones.[228]

Subsequent research has found that the abundance of copper rockfish was 15 times higher in Edmonds than in areas of the Puget Sound with no restrictions in place.[229] The average size of these fish was also much higher at Edmonds, where 85 percent of them were found to measure 40 centimeters or more – lengths rarely found in outside the park.[230] Lingcod, too, were more than twice as abundant and significantly larger at Edmonds than in fished areas, with 95 percent measuring 70 cm or more.[231] Again, fish of these lengths were relatively uncommon in fished areas.[232]

The size and age of rockfish within Edmonds Underwater Park suggest that these fish will have higher reproductive potential than those in surrounding unprotected areas. Large quillback rockfish of the sizes found at Edmonds can produce substantially more eggs than the smaller fish in the depleted areas, potentially making them an important source for larval transport to replenish populations outside the reserve.[233] At Edmonds, rockfish reproduction potential has been found to exceed that of the average fished sites by a ratio of 55 to 1.[234]

The unusual artificial environment found at Edmonds Underwater Park provides good nesting and spawning habitat for lingcod and ideal conditions for juvenile rockfish to thrive.[235] The extent to which both species seem to have benefited from the protections while populations in Puget Sound more broadly are in decline is a testament to the effectiveness of the protections.[236] Moreover, in the case of lingcod – an important predator in the Puget Sound marine ecosystem – their success is also an indicator of how this tiny protected area has contributed to the health of the ecosystem as a whole.[237]

# Conclusion and recommendations

The health of our oceans is in crisis. Negligence and abusive overexploitation of marine environments have led to species loss, ecosystem destruction and biodiversity decline on an unprecedented scale.

Federal and state governments must take urgent action to boost our ocean's resilience against the myriad threats it currently faces, and to ensure the maintenance of ocean ecosystems and conservation of marine life. Meeting these objectives will require action on numerous fronts, including sustainable fisheries management and global action on climate change.

Marine protected areas, if effectively implemented and properly managed, are a critical tool for protecting and enhancing the health of our ocean. Governments should take the following actions to expand marine protected areas and maximize their benefits for ocean health.

- **Governments should adopt the goal of protecting at least 30 percent of their countries' total ocean area, including 30 percent of each major geographic region.** Given the relative lack of highly to fully protected MPAs in United States waters outside of the remote Pacific region, U.S. policymakers' focus should be on ensuring that protections are put in place across all key regions to ensure that representative examples of the diverse habitats and ecosystems in U.S. waters are protected.
- **State and federal governments should strengthen protections in near-shore areas**, especially by implementing fully protected MPAs in these areas, in order to ensure adequate protections across all ecosystems and habitats and not just in remote areas of ocean.
- **MPAs should be ecologically linked in regional networks** to protect the full range of ecosystems and habitats in our oceans and ensure connectivity between spatially fragmented habitats.
- **State and federal governments should take a comprehensive, strategic and science-based approach to planning, designing and designating MPAs and MPA networks**, integrating regional scientific knowledge, engaging and educating local communities and other stakeholders at the beginning of the process, and evaluating potential economic impacts or benefits.
- **State and federal authorities must ensure that implementation of MPAs and MPA networks is accompanied by a comprehensive management plan**, with a focus on scientific monitoring to enable active management, as well as sustainable financing and robust efforts to ensure that protections are properly enforced.
- **Policymakers should take measures to promote MPAs and disseminate research** carried out on MPAs to enable the public to better understand their value and support efforts to protect and enhance these areas.

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