KEEPING OCEANS WILD

How Marine Reserves Protect Our Living Seas

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ABOUT NRDC

The Natural Resources Defense Council (NRDC) is a national nonprofit environmental organization dedicated to protecting the world's natural resources and ensuring a safe and healthy environment for all people. For over thirty years, NRDC's scientists and lawyers have fought for conservation on land and in the water. NRDC has offices in New York City, Washington, DC, Los Angeles, and San Francisco. For more information visit www.nrdc.org

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EXECUTIVE SUMMARY

The creation of marine reserves provides one of the most important and effective ways to protect the ocean. Like national parks and wilderness areas, marine reserves are areas where nothing can be taken out and only recreational and research activities are permitted. Marine reserves prohibit destructive activities like dredging and oil exploration, and they safeguard marine wildlife by excluding fishing. The result is a more diverse underwater realm, relative to exploited areas, with more large fish and pristine habitat. Hundreds of scientific articles have shown the benefits of marine reserves and other protected areas around the world. This report not only discusses the international scientific evidence in favor of reserves, it also presents success stories in the United States, the legal framework that governs reserve management, and general guidelines for creating new marine protected areas.

Five areas in the U.S. are highlighted, including:

- A dive park in Washington's Puget Sound where there are almost ten times more fish than in the neighboring waters open to fishing.
- Hawaii's Hanuama Bay, where protection means more corals, more fish, and more sightings of rare species that draw thousands of visitors each year.
- A controversial set of closed fishing areas in the Gulf of Maine that has led to dramatic increases in scallop harvests and the beginning of recovery for depleted groundfish.
- A reserve created by the Kennedy Space Center where record-sized fish are caught just outside the protected area.
- Newly protected spawning grounds in Alaskan waters thick with fish.

Drawing on the extensive research on marine reserves, this report offers general guidelines for creating and managing reserves. The designation of marine reserves should involve careful consideration of the ecology of an area, as well as input from local residents. Successful reserves need sound enforcement, community support, and scientific monitoring. Reserves are not a panacea for all the problems facing the ocean, and they need to be complemented by sound fisheries management outside the reserve as well as controls on water quality. However, the simple step of placing part of the ocean off limits can reap tremendous benefits. Creating a reserve is one of the few actions that actually increases the biomass in the ocean rather than simply minimizes how much is removed. By safeguarding ocean wilderness now, we save for a healthier ocean in the future.

CHAPTER 1

The Reasons for Reserves

We live in an ocean country. The United States controls the waters stretching out to 200 nautical miles from the shore, an area of sea as large as the total land in all fifty states. Inside the waters of this ocean country live some of the most extraordinary communities of plants and animals on earth. Because the United States stretches across latitudes from the arctic to the tropics, our oceans contain a greater amount of diversity than almost any other nation. Millions of Americans head to the sea each year to experience this marine biodiversity: in Alaskan bays filled with sea lions and salmon; along sandy beaches in the Gulf of Mexico; on delicate coral reefs around the Hawaiian Islands; and in the rocky tidepools of New England and Washington. There is tremendous wealth in our sea, and we draw on its resources every day. How can we make sure that these rich ocean ecosystems survive for future generations?

All too often the only news about the ocean is bad news. Fisheries are crashing as more boats chase increasingly fewer fish. Oil spills and sewage pollute the beaches. Heavy trawl fishing gear scrapes the ocean floor bare, disturbing underwater wildlife. Corals are shattered by boat anchors or die from disease and pollution. Last year, scientists working with the American Fisheries Society identified 82 marine fishes at risk of becoming extinct in the near future.[1] Years of treating the ocean as the last frontier—inexhaustible and open 24 hours a day—have taken their toll.

We rely on poor and incomplete information about the ocean's condition and we have erred on the side of taking more, not less. When the National Marine Fisheries Service published its most recent report on the status of fish populations, the most shocking figure was not the 106 populations considered to be overfished. It was the fact that over two-thirds of species that are actively fished are considered "unknown," meaning that the service has no idea of the condition of those stocks.[2] With such a poor understanding of the ocean, marine plants and animals can disappear completely unnoticed.[3]

On land, we safeguard our natural heritage with a system of protected areas. There are national and state parks, monuments, wilderness areas, and wildlife refuges, some over a hundred years old. We restrict what activities can occur in these places to protect our wildlife, and we make provisions so that the public can enjoy them. Below the high tide line, we are only beginning to protect wilderness. Currently, less than one-hundredth of 1

percent of U.S. waters is fully protected, i.e., closed to all extractive uses, such as oil drilling, mining, or fishing. Yet these few ocean wilderness areas, or marine reserves, produce a tremendous amount of good news. Inside marine reserves there are more fish, larger fish, and healthier habitat than outside, where the ocean is everyone's property and no one's responsibility. Marine reserves around the world have demonstrated their ability to preserve healthy ecosystems, protect biodiversity, and rebuild depleted fish populations.

In the United States, momentum is growing to increase the number and size of protected sites. One example is the enactment of California's Marine Life Protection Act to improve the state's network of marine reserves, expand ocean wilderness, and improve ocean management. President Clinton announced an Executive Order in May of 2000 to increase and strengthen the current system of marine protected areas in the United States.[4] The Executive Order calls for the establishment of a national system of marine reserves, a federal advisory committee to recommend ways to improve ocean conservation, and a new Marine Protected Area Center that will serve as a resource to people and organizations looking for ways to designate protected areas.

This report summarizes information about the value of marine reserves, using the evidence from studies of marine reserves in other countries and in the United States. This report also points out the strengths and weaknesses of different approaches to protecting marine areas by telling the stories of five protected areas in the United States: in Florida, Washington, Alaska, Hawaii, and the Gulf of Maine. Some of these are true "no-take" reserves and some are not. The small pieces of ocean wilderness that exist today have many names, but they all tell the same story. If vibrant parts of the sea are protected, if they are left undisturbed, they thrive.

USING OR ABUSING THE SEA

The oceans form the largest highway in the world, carrying thousands of cargo ships each day. Sailboats race across them, and kayakers meander along their coastlines. We mine them for gravel and sand, and we dump our waste into them. We fish in them, both for food and just for the thrill of a catch. The oceans hold dive sites, oil wells, fiber-optic cables, surfing grounds, and holy places. More than half the U.S. population lives within 50 miles of the coastline, increasing the development that spills pollution into the sea. Federal and state governments juggle all these uses simultaneously, trying to keep everyone from colliding. When they focus on avoiding conflicts among different uses, they can easily overlook the larger impact of allowing so much activity in any one place. Marine reserves are based on the simple idea of leaving parts of the sea undisturbed.

The cumulative impacts of constantly disturbing the ocean can have devastating effects in the long term. Fish diminish in size and number or disappear altogether.[5-7] Fishing gear can destroy sea grasses, corals, and other habitats.[8-10] Taking large numbers of a species not only impacts the population of that species, but also the populations of its prey and its

predators. Fishermen often target groups of fish with similar behavior or habitat preferences—such as all fish resting on an area of the sea floor, or all fish feeding in a certain area. This can include many different species that fill similar ecological roles. When this happens, overfishing can completely eliminate a level of the food chain and shift the dynamics of the entire system.[11,12] Where once there were schools of large predatory fish, now there may only be tiny fish feeding on plankton.

Atlantic cod

Dwindling catches do not usually signal the end of fishing effort. Far more common is the tendency to "fish down the food web" by first removing all the fish at the top of a system and then overfishing what remains. [13] For example, by the end of the 1900s, centuries of heavy cod fishing in New England led to an increase in many species that cod like to eat, such as sea urchins, herring, and mackerel.[14,15] As cod stocks began crashing, fishermen shifted to the herbivorous sea urchins—the next species down the food chain. Other former cod fishermen moved on to herring and mackerel, species that are key prey not just for cod but also for marine mammals. The spiny dogfish, formerly considered a "trash" fish with no value, had its image rehabilitated for the market once it was one of the few species left. Now it, too, is overfished. While marketing and consumer demand can dictate what fishermen will be able to sell, it is the ecology of the system that determines what will be alive to be caught.

Even when fishing is drastically reduced or stopped altogether, it may take fifty to one hundred years for a population of fish to recover to even half of its initial size. Mandatory plans to rebuild fish populations are a new part of U.S. law, but so far very few programs have been successful.[16] Fishing boats now have the skill and technology to catch in a few seasons what can take decades to replace. Fishing down the food chain is unsustainable, not only for fishermen but also for the ocean wildlife like seals and otters which subsist on fish. Combine heavy fishing pressure with other human activities, like pollution and dredging, and larger environmental changes, like shifting ocean temperature regimes, and you have a recipe for disaster.

Marine reserves offer insurance for marine ecosystems—insurance against natural changes and errors in judgement and management. Effective management policies, including sound fisheries management and pollution control, are essential for healthy oceans. Reserves cannot work without the support of these other policies. But too often agencies act after a problem is discovered. Marine reserves are precautionary; they are an action we can take now, before problems arise, rather than waiting until it is too late.

LOSING A SENSE OF PERSPECTIVE

Marine reserves also offer a frame of reference to compare against areas heavily impacted by people. In the past, areas out of the reach of fishing served as this sort of

scientific control. Now that protection lags far behind exploitation, it is almost impossible to measure the true state of an ecosystem.[17] In 1997, two researchers in Southern California tried to reconstruct historic data about the Point Loma kelp forests as a way to determine how current conditions compared with those a century ago.[18] They found that large, slow-growing fish like giant sea bass had disappeared completely from the area, and that the average lobster caught in 1980 was less than half the size of a lobster from 1887. Because fishery managers rarely have the chance to look back more than a decade or two, gradual changes slip by unnoticed until the tiny fish thrown back yesterday became today's biggest prizes. It is not always possible to reconstruct old data sets, and without a historic frame of reference it is easy to believe that today's conditions are the way things have always been. Marine reserves can act as this reference by demonstrating how things are in the absence of ongoing human disturbances. As another scientist recently remarked, without marine reserves "we've been conducting a giant, uncontrolled experiment over the entire ocean for years."[19]

WHAT IS A MARINE RESERVE?

California's 1999 Marine Life Protection Act defines a marine reserve as follows:

> Marine reserve means a marine protected area in which all extractive activities, including the taking of marine species, and other activities that upset the natural ecological functions of the area are prohibited. While, to the extent feasible, the area shall be open to the public for managed enjoyment and study, the area shall be maintained to the extent practicable in an undisturbed and unpolluted state.

MARINE PROTECTED AREAS INCLUDE MORE THAN JUST RESERVES

One way to think about MPAs is to think of a range of levels of protection in the ocean. Much like zoning on land, different MPAs allow and prohibit different actions, ranging from those where conservation is most important to sites where any type of use is allowed.

This definition of a marine reserve is used in this report. Marine reserves prohibit extractive activities and keep the area undisturbed. They provide permanent designations, like parks, not temporary closures. When this report refers to an area as a marine reserve, it refers to how the area functions in a practical sense, not what it is named or, necessarily, why it was established. Some people also use "ocean wilderness" to refer to marine reserves. Another common term is "marine protected area" or MPA. Like marine reserves, MPAs target a location, not a single activity or species. However, MPA is a blanket term covering all areas with any amount of protection. Marine reserves are one kind of MPA. Because MPA is a general term, it can and does have different meanings in different states. Just as with any marine reserve, park, or refuge it is important to review the details of an MPA to know what it actually protects.

The confusing array of terms attached to marine protected areas can make it difficult to tell what an area actually protects by its name alone or by looking at a map. A National Marine Sanctuary sounds like a marine reserve, but the Sanctuaries Act itself offers sites very little protection. Each sanctuary operates under a different series of rules. Most, but not all, sanctuaries prohibit oil development. Beyond that prohibition almost anything goes. Sanctuaries are dredged, trawled, mowed for kelp, crisscrossed with oil pipelines and fiber-optic cables, and swept through with fishing nets. Sanctuaries have the opportunity to designate marine reserves within their boundaries and some, such as the Florida Keys Sanctuary, have already done so. Unless a sanctuary takes additional steps to conserve its marine wildlife, it offers little more protection than the surrounding open waters. In contrast, the closed area in Cape Canaveral, Florida is a military designation but functions as a marine reserve by excluding boats and fishing. The marine protected areas discussed in this report's case studies were all created for different reasons, but they all demonstrate the benefits of marine reserves, regardless of their titles.

Marine reserves are just one of the many tools for managing the ocean. Their strength lies in protecting the biodiversity of a location, rather than trying to address each individual human impact separately. Imagine a series of ocean zones similar to zoning on land. At one end of the zoning spectrum are areas completely off-limits and at the other end is completely open access. In between sit different zones, managed for purposes such as improving recreational and commercial fishing, education, or use by native tribes. Some of these zones would have few restrictions and be heavily used, while others would limit certain activities. Marine reserves or wilderness areas—places that are strictly "look but don't touch"—offer a high level of protection while providing an opportunity for people to visit and explore the sea.

WHO CAN CREATE A MARINE RESERVE?

Both individual states and federal government agencies control the establishment of marine reserves. Ideally, they coordinate their efforts throughout a coastal area. Whether or not creating a reserve actually requires the consent of both depends on where the reserve is located. The ocean surrounding the United States is divided into federal and

CALIFORNIA'S MARINE LIFE PROTECTION ACT

In 1999 California enacted the Marine Life Protection Act (MLPA), an innovative law that requires the state to evaluate and improve its system of marine protected areas and reserves. The state currently has 104 protected sites, some of which overlap, and the actual level of protection varies widely from site to site. Some of the sites were created to protect special ecological features while others were selected in a more haphazard fashion. Only a tiny fraction of the sites prohibit all fishing and other extractive activities. As small as they are, these reserve sites have larger numbers of important commercial and sport fish like sheephead, kelp bass, and vermilion rockfish than the fished waters surrounding them. [20,21] In fact, these undisturbed sites may be some of the few locations left where rockfish actively spawn. [22]

The MLPA creates a two-year process whereby the state considers expanding or reducing existing marine reserves, creating new reserves, and changing the management of existing protected areas to improve them. At the end of the process, the goal is to have a plan for a comprehensive network of protected areas, including marine reserves, that encompasses the full range of ocean habitats along the California coast. The MLPA incorporates both the best available science and the views of interested local residents into this process. The California Department of Fish & Game has convened a team of scientists to assist them in reviewing current sites and evaluating other habitats and communities of species that could benefit from increased protection. The science team will draft a master plan recommending new sites and improvements to existing sites. Once the draft plan is prepared, the state will hold workshops along the coast so that local communities can help shape the recommendations in the plan. This revised plan will be submitted to scientific peer review and become the subject of public hearings. The California Fish & Game Commission is scheduled to adopt a final plan in the summer of 2002. By using science and community input to look at the California coast as a whole, the MLPA aims to provide better protection to the state's underwater habitats and the animals that use them.

state waters. State waters usually extend from the high tide line on land out three miles. Federal waters run from three miles out 200 miles, an area also known as the U.S. exclusive economic zone. Within state waters, state governments have broad authority to control any activity and may designate a marine reserve without federal approval. States may create marine reserves through legislation or through a designation by the appropriate natural resource agency. Some states, like California, can also create reserves by popular vote through a ballot initiative.

In federal waters, completely new protected areas usually have to be declared by Congress or the president. Within existing larger protected areas—such as national parks, seashores, and sanctuaries—federal agencies have the opportunity to create reserves through administrative action. Agencies can also coordinate their actions under existing laws, such as the Clean Water Act and the Sustainable Fisheries Act, to effectively create new reserves. Federal agencies have a new incentive to work on marine reserves under the Presidential Executive Order issued in May of 2000, which calls for the establishment of a a national system of marine reserves, a federal center on marine protected areas, and a federal advisory committee on marine protected areas.[4] Two branches of the federal government, the Department of Interior and the Department of Commerce, oversee the majority of protected ocean sites.

Under Commerce, the National Oceanic and Atmospheric Administration (NOAA) manages the thirteen existing national marine sanctuaries. Sanctuaries are required to publicly review their management plans every five years. During this review, a sanctuary may consider creating marine reserves along with other changes in their management policies. However, a sanctuary can work to add a reserve at any time, not just during a management plan review. Within Interior, the National Park Service oversees 12 national seashores and 34 other national parks that include marine areas.[23] The Park Service has the authority to ban commercial fishing in these parks and exclude other uses that are incompatible with the parks' conservation mission.

In the case where a national park or sanctuary includes both federal and state waters, the federal government generally defers to the state on decisions involving state waters. Thus, for consistency throughout a reserve, any actions taken to protect the federal portion of the area need to be matched with comparable measures by the state. Because managing many protected areas requires so much cooperation between the state and the federal governments, parks and sanctuaries often create standing advisory committees with members from each level of government. These advisory committees also include members of the local community.

The other groups that play an important role in creating marine reserves are the regional Fishery Management Councils. There are eight councils: New England, Mid-Atlantic, South Atlantic, Gulf of Mexico, Caribbean, North Pacific, Pacific, and Western Pacific. The councils consist of federally appointed members knowledgeable about a region's fisheries including active commercial and recreational fishermen, scientists, and state and federal officials. Councils make recommendations to the National Marine Fisheries Service (NMFS) and the secretary of commerce, who either chooses to enact them or sends them back. Although Councils are not empowered to take many actions beyond making recommendations, their recommendations carry great weight and are often adopted verbatim by the agency. Councils can become involved with marine reserves in two ways. First, they are consulted by sanctuary managers when a sanctuary proposes a

new rule that would restrict fishing. Second, councils can create permanent or temporary no-fishing zones to protect habitat or help rebuild fish populations. Councils have no authority over non-fishing activities, such as dredging or oil exploration, and thus would need regulations by other federal agencies to exclude those actions and make a closed fishing area into a true reserve. Over the last decade, several of the councils have begun examining marine reserves as a tool for enhancing and rebuilding fish populations. Two of the case studies in this report stem from council decisions: the North Pacific Council designated the Sitka Pinnacles Marine Reserve to protect groundfish, and the New England Council manages the three large closed areas on Georges Bank. In addition, the Carribean Council has Hind Bank near St. Thomas, the Gulf Council manages reserves at the Dry Tortugas and three other closed sites, and the South Atlantic Council maintains the Experimental Oculina Research Reserve on the Oculina Banks. The Pacific Council recently decided to develop marine reserves to help rebuild rockfish populations. Council meetings are open to everyone and public comment can play a significant role in getting a marine reserve created.

MARINE RESERVES AND FISHERIES

For too many years, the federal and state agencies that manage the oceans have focused on controlling separate, individual actions in the ecosystem. Managers developed programs to regulate a certain fishing gear, a single species of fish, or the number of recreational licenses. Now, scientists and fishermen alike are realizing that these traditional management tools have all too often been an unqualified failure.[24-27] Just reducing the allowable catch of a single species does not necessarily eliminate all impacts on that species: the fish could still be taken as bycatch in another fishery operating in the same area, or spawning habitat may be destroyed by a different type of fishing gear. Dozens of species around the country now face the long process of “rebuilding,” which reduces fishing effort to almost nothing in order to bring back the fish. Rebuilding can take decades, or even centuries depending on the plan’s design, the condition of the populations and habitat, and other environmental factors.[16] Fishing is unlike any other industry. Wild fish are not planted or fertilized, nor are they owned by any one person. Fish are captured and sold by whoever gets to them first. What sustains these populations, for both commercial and recreational fishing, is the common property of a healthy ocean. In taking an ecosystem view of rebuilding a fishery, managers must consider the impacts of pollution and habitat degradation on fish populations and the interactions among species within a fishery. Marine reserves support this ecosystem management approach by conserving multiple species and habitats.

Reserves work to complement other conservation measures and can perform as well as, if not better than, some common fisheries management techniques such as size limits and temporary reductions in the number of boats fishing.[28-30] With careful design, reserves may also supplement fish populations in surrounding areas.[31-33] Certainly a reserve alone cannot protect an entire fishery or keep pollution out of the ocean; reserves must be part of a larger suite of conservation measures.[34] Reserves can enhance the fisheries

around them, and in doing so may be able to reduce the need for other regulations on fishermen by centering the protection on a location, not on individuals.[35,36] Where fish populations are already depleted, reserves can contribute to their recovery; where populations still thrive, reserves offer a precautionary measure that helps ensure the fish will survive for years to come.

NOT A NEW IDEA

While marine reserves may sound like a new idea, they are, in fact, an age-old part of ocean use. Traditional fishing cultures recognized certain areas as essential to ocean protection and declared them off-limits to fishing. Natural marine reserves existed for centuries—they were those places in the ocean too far away, too deep, or just too difficult to access. As technology improved, trips that were once thought impossible became commonplace until now virtually all of the sea is within easy reach.

Today, fishery managers have attempted to recreate these historical reserves on a temporary basis by declaring fishing closures. Often these closures exist for a single season, on the order of months, or the closures cover a single species, allowing fishermen to target other fish in the same area. Closures rarely last for more than a few years, but during that time they offer a glimpse of the benefits of a marine reserve. However, a closure and a reserve are not the same. Once a closure is lifted, the area can quickly be decimated again. Marine reserves are not temporary or seasonal, they exist to offer an area long-term protection from disturbance. Reserves can be complemented by adjacent closures or restrictions on certain types of fishing activity. For example, one of the benefits of marine reserves is their ability to protect spawning habitat and increase the reproductive success of fish inside the reserve. This leads to benefits for fish populations outside the reserve as well. If it is not possible, for social reasons, to close a very large area then a smaller reserve encompassing key habitats could be coupled with temporary closures to effectively protect a large amount of marine wildlife.

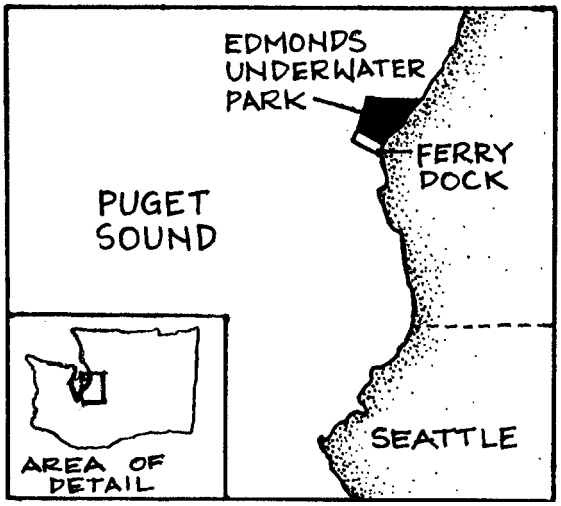
CHAPTER TWO

A Closer Look at Five Protected Sites

In discussions of marine reserves, one argument often presented against them is that there is no evidence that they work in the United States. This is false. While it is true that the majority of the research on reserves comes from sites in other countries, this simply reflects the lack of protection existing in U.S. waters, not a lack of evidence for success. The last decade brought increased attention to marine reserves domestically, and with that new research.[73] Even with the limited focus on reserves in the past, there still exist clear examples of successful reserves in the United States today.

NRDC selected these five locations to illustrate a variety of aspects of marine reserves. They are spread across the United States, including Hawaii and Alaska, and they were not created with similar goals in mind. The one thing uniting them all is that the areas were set aside and they have, for the most part, stayed closed to destructive activities. Keeping these reserves intact requires a combination of community support, enforcement, monitoring, and active management.

A THRIVING DIVE SITE: EDMONDS UNDERWATER PARK, WASHINGTON

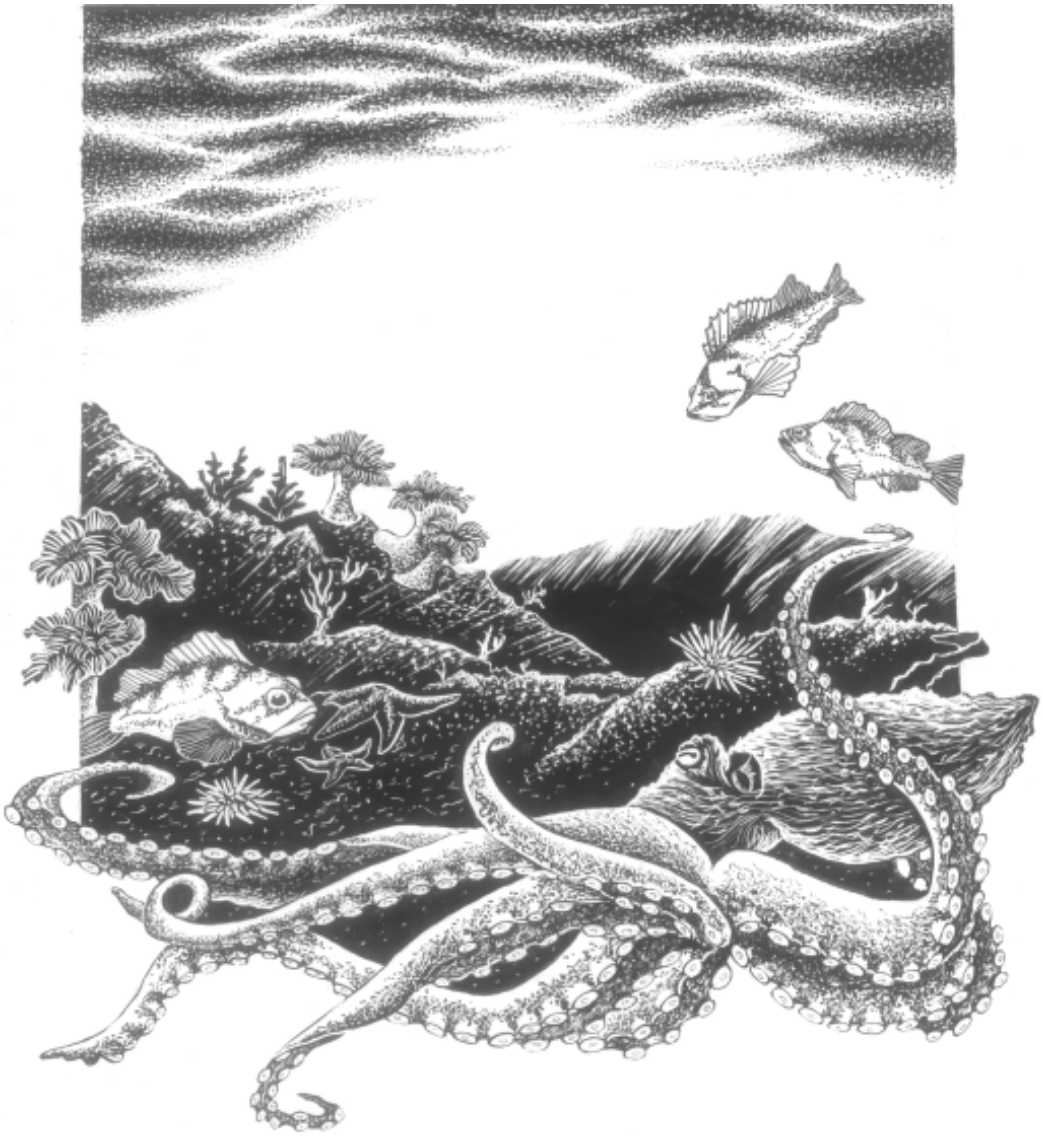


Cold water sweeps through Puget Sound, creating a highly productive estuary. Below the tidelines stretch large areas of hard bottom and rocky reefs—where piles of rocks shelter marine life. These formations harbor a diverse group of colorful fish collectively called rockfish (*Sebastes spp.*). Over seventy species of rockfish inhabit the Pacific coast, and many of them can live as long as one hundred years. Dungeness crabs also gather near the rocky reefs, alongside anemones, sponges, kelps, and sea cucumbers. On the edge of the sound, the craggy underwater coasts of the San Juan Islands hide Pacific octopi and wolf eels. The

diverse marine life and long ragged coastline of the area have long been an attraction for fishermen, kayakers, and divers.

One of the oldest dive parks in the United States, Edmonds Underwater Park, lies just north of Seattle. [37] Within its 27 acres of ocean property, the park has prohibited the taking of any marine life since its creation in 1970. Large signs at the park entrance warn visitors that disturbing the fish is illegal. The beaches leading to the dive park are also protected and patrolled by city Beach Rangers. These conservation measures make the park function as a marine reserve, but its primary purpose is to serve divers. Over 40,000 people visit the park each year.[37] A park manager, along with a dedicated group of volunteer divers, maintains "trails" and artificial habitat. The strong presence of volunteers, who educate visitors about protecting wildlife, means a high level of enforcement of the parks' protective rules.

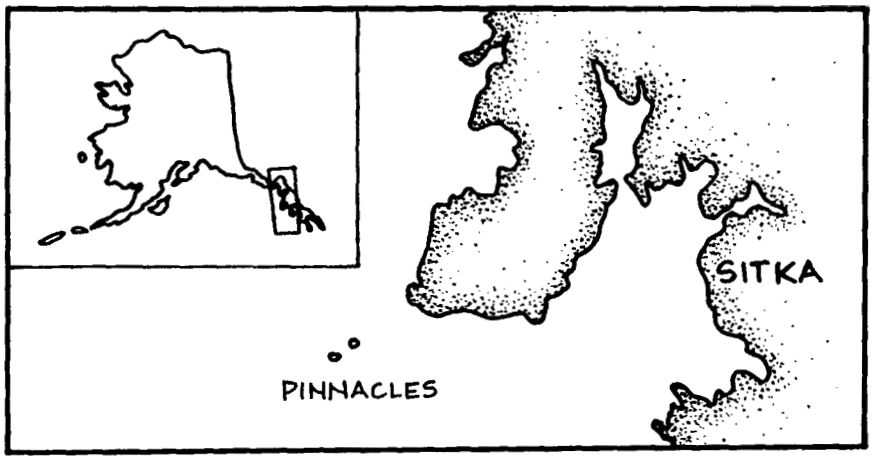
Some of the residents of Puget Sound.



In 1993 and 1994, scientists and volunteers working with the Washington Department of Fish & Wildlife surveyed fish populations in Edmonds Underwater Park, another small refuge area, and six other sites in Puget Sound where fishing was permitted.[38] They found significant differences between the fished sites and the protected sites, even when those areas had only been protected for a few years. At the 23 year-old Edmonds Underwater Park, the differences were most dramatic. Many more copper rockfish and lingcod lived inside the park, in some cases almost ten times as many fish as in the unprotected areas. Not only did more fish live in the park, but also the fish were much larger, a fact also true for another species, the quillback rockfish. These large fish can produce 50 times more eggs than the smaller fish in the depleted areas. Recent studies in Puget Sound[39] and near Monterey, California[40] show the same trends—the largest fish live in marine reserves.

SEEING IS BELIEVING: SITKA, ALASKA

Since 1990, The Alaska Department of Fish and Game has used a submersible to study bottomfish—rockfish, halibut, and other deep water species—in the eastern Gulf of Alaska. Through hundreds of dives, department staff identified two underwater pinnacles as important spawning and feeding grounds. These pinnacles rise sharply from the ocean floor off the coast of Cape Edgecumbe, where they provide ideal habitat for rockfish and lingcod. The dense aggregations of lingcod became subject to an intense fishery in the late 1980s, when fishermen found that targeting the pinnacles yielded three times as many lingcod per hour as fishing in the surrounding areas. [47] Because of concern about the increasing commercial pressure for these fish, the state of Alaska closed a 2.5-square mile area around the pinnacles in 1997. However, the state only has jurisdiction over lingcod and black rockfish, just two of the many species of groundfish living on the pinnacles, and recreational fishing in the area is managed by the federal government. When the state excluded commercial lingcod and black rockfish activity from the pinnacles, recreational fishing increased. To fully protect all the species on the pinnacles against overfishing and to prevent the habitat damage caused by boat anchors, the state also needed a rule from the National Marine Fisheries Service, by way of the North

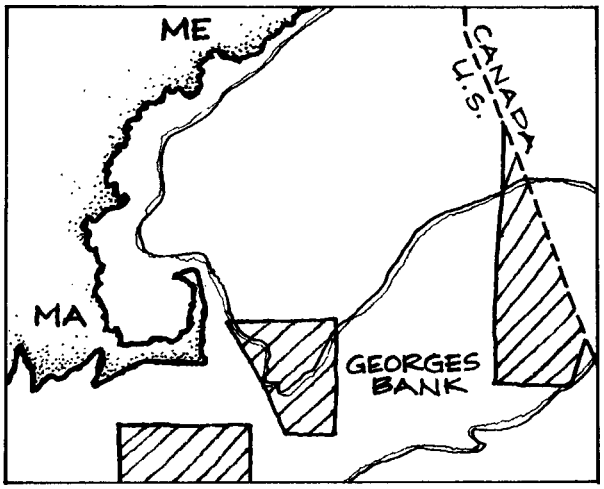


Pacific Fisheries Management Council. Both the federal government and the state of Alaska needed to agree to create the Sitka Pinnacles Marine Reserve, and that would not happen unless the government heard public support for the reserve.

The scientists at the Department of Fish and Game had a powerful tool available to them—a miniature submarine they used to study groundfish. As they began holding public meetings and gathering scientific input on the reserve, they also took people hundreds of feet underwater to see the pinnacles. There, people were able to see the unique habitat of the pinnacles, where, as one visitor described it, hundreds of big lingcod lay "on top of each other like cordwood" and schools of yellowtail rockfish fed along the pinnacle walls.[48] They videotaped these trips and showed them at public hearings. Once fishermen and local residents had the opportunity to see the remarkable size and abundance of fish in the area, they came to appreciate the need for protecting the pinnacles. Alaska's Board of Fisheries voted unanimously to designate the Sitka Pinnacles Marine Reserve in 1998, and the National Marine Fisheries Service concurred in the fall of 2000.

There are some exceptions to the rules of the Sitka reserve; essentially, the pinnacles reserve is a reserve only up to a certain depth in the ocean. Salmon fishing is permitted in the area, because it is thought that fishing lines cast for this species do not go deep enough to disturb the pinnacles. There has been some discussion about prohibiting salmon boats as well as non-fishing boats such as dive boats from anchoring at the pinnacles. These issues have yet to be resolved. It may be that these other activities can coexist in the reserve without destroying the thriving communities of fish on the pinnacles. Because the area was established for the purpose of protecting the pinnacles for years to come, not as a temporary fishing closure, there will be time to adjust the regulations and uses of the reserve in the future knowing that this habitat, and its fish, are secure.

CLOSING DOWN SPAWNING GROUNDS: GEORGES BANK



The Gulf of Maine is a large, rough ocean basin carved by glaciers and ancient rivers. The waters of the gulf hold some of the world's oldest fishing grounds that have fed countries on both sides of the Atlantic Ocean for centuries. Georges Bank rises up from the continental shelf, off the end of Massachusetts, to form one side of the Gulf of Maine. Once a

true island, Georges Bank gradually subsided nearly 6,000 years ago; now it serves as a gathering place for fish. [41]

In the past, Georges Bank was home to great schools of aquatic life: lobsters and flounders, great pods of whales, and the fish that often symbolizes New England—the cod. Unlike sections of the gulf close to shore, where bedrock outcroppings provide an anchor for kelp beds, Georges Bank is dominated by sand and gravel. This gravel pavement offers little vertical relief, so marine life creates its own structure from anemones, mussels, and scallops. Juvenile cod, flounder, and hake—collectively known as "groundfish"—feed on the microscopic invertebrates that grow in these areas.[42]

With so many desirable species, Georges Bank became a focus for heavy fishing pressure. Federal managers and fishermen alike grew concerned about the impacts of fishing gear. Both groundfish and scallops are taken from Georges Bank by trawls or dredges—heavy nets and frames that drag across the sea floor. Fishing gear used to target groundfish was taking scallops and vice versa, depleting both groups and possibly destroying the communities of invertebrates that sustained the groundfish.[8] By the early 1990s, New

Looking down at a healthy Georges Bank.

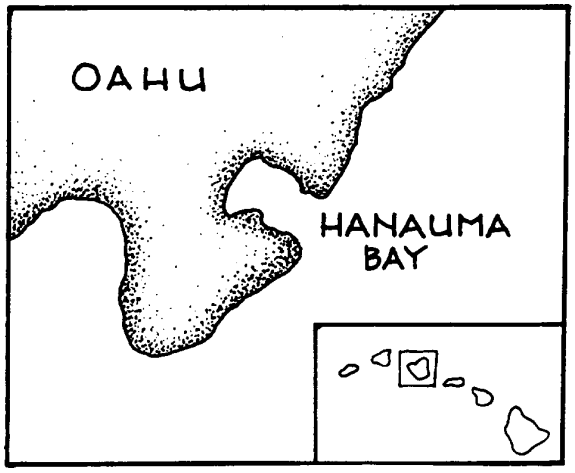
England cod and haddock stocks had plummeted. Federal managers tried a number of traditional fishing restrictions, but these failed to stop the decline. In December of 1994, the secretary of commerce used emergency authority to close three large areas of Georges Bank to all fishing except lobster traps.[43] For nearly five years, 6,500-square-miles of the sea floor were left undisturbed.

Sea scallops thrived once the dredging stopped, increasing to record sizes and densities. Researchers found 14 times more scallops inside the closed areas than in open areas.[43] Crabs, anemones, sea urchins, and other invertebrates also returned, and yellowtail flounder have begun to recover. It may be decades before flounder populations return to a healthy level, yet the pressure is already on to resume fishing in the closed areas. The New England Fishery Management Council now allows mid-water trawling for herring in the closed areas, since mid-water trawl gear does not touch the sea floor. In 1999, the council decided to open portions of the closed areas to scallop dredging because of the dense populations of the highly valuable shellfish. The council has since increased the total area open for scallop fishing, but this may not provide enough protection for groundfish, which recover more slowly than scallops. [43] As these closed areas become more and more open to specific fisheries, it will become difficult to resist the temptation to reopen them completely, but what took five years to rebuild could be destroyed in a single fishing season.

BALANCING ACCESS AND PROTECTION: HANAUMA BAY, HAWAII

Tucked into the southeastern corner of Oahu, Hanauma Bay is a picturesque stretch of sand and blue water. Waves crash in through the remains of the old volcanic crater that forms the mouth of the bay. A long coral reef starts within wading distance of the beach, and more than 300 species of fish swim through the corals. Hanauma Bay has been a popular site for centuries, since the first visits of Hawaiian royalty. Now, with Honolulu only 12 miles away, it attracts a million people each year.

In 1967, Hanauma Bay became Hawaii's first Marine Life Conservation District, a designation intended to protect nearshore areas by reducing or eliminating fishing. No fishing activity is allowed in Hanauma Bay, which has helped preserve both the fish and their reef habitat. A survey done in 1992 found the park had 27 percent more fish than nearby unprotected areas and twice as much coral cover.[45] Because of



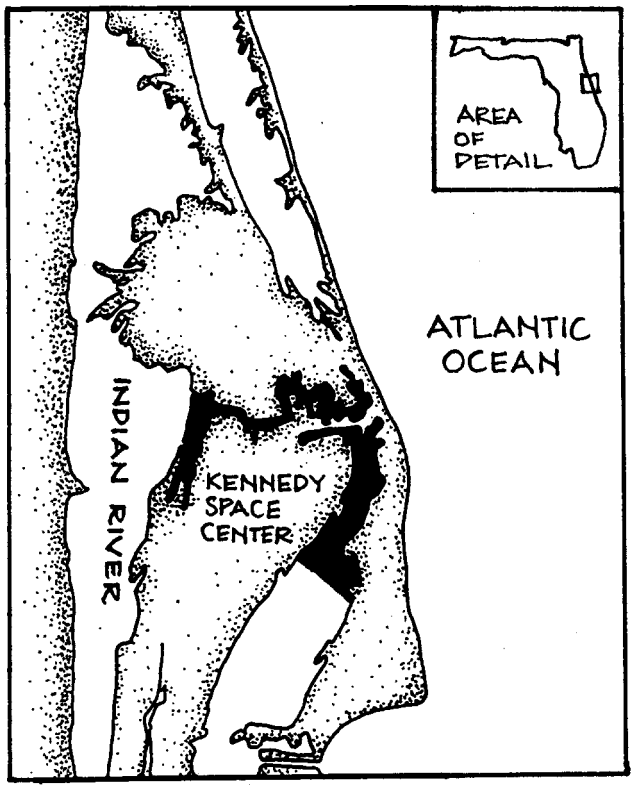
the park's protected status, it developed a reputation for being one of the best places to see rare species of Hawaiian fish. However, a steady increase in visitors made the bay a victim of its own success. Corals are easily damaged by people walking on them or kicking sand onto them, and the reefs started to suffer. Hanauma Bay needed protection not just against people taking things out, but against too many people coming in.

When the city and county government acquired the park in 1990, the tiny 0.15-square mile site was largely unmanaged and receiving nearly 8,000 visitors every day. Park managers sought ways to reduce the number of visitors to a level the bay could support. Instead of allowing thousands of cars to park haphazardly along the shore, managers installed a parking lot that closes after its 300 spaces are full. Commercial tour buses must obtain one of a limited number of permits. New restrooms mean that sewage goes to a treatment plant instead of contaminating the bay. In 1999, the city and county took a step towards restoring the bay's natural food chain by banning fish feeding. [45,46] A small parking fee and a $3 entry fee for non-residents is enough to pay for the park's management and education programs, including a study evaluating the impacts of tourism on the area. Managers also work with a large group of volunteers, who are trained to teach visitors how to treat the reef with care. By continuing to take precautions to safeguard the bay, the city and county help ensure that the reserve will continue to benefit and protect the ecosystem.

Underwater in Florida's lagoons.

AN ACCIDENTAL RESERVE: KENNEDY SPACE CENTER, FLORIDA

Most reserves are designed specifically to protect marine life, but sometimes successful protection comes when an area is set aside for other reasons. One such place is the estuary inside the Kennedy Space Center, which the federal government closed to all boat traffic in 1962. The Space Center closure had nothing to do with ecological concerns; it was instated to secure the shuttle launch site. However, by excluding boats, the closure also secured fish populations.



The Space Center sits in the middle of the Merritt Island National Wildlife Refuge on Cape Canaveral. Covering 218-square-miles of land and water, the refuge provides both a large buffer zone for the Space Center and a popular recreation spot. Within the Space Center's portion of the property, almost 15-square-miles of water prohibit all public access. In 1994, the refuge closed an adjoining 15-square-mile section to motor boats to protect the resident manatee population. Hundreds of endangered West Indian manatees live and breed in these areas, as do green sea turtles. Fishing and waterfowl hunting are still permitted in the manatee closure area, but only from rowboats or canoes. Thus, the reserve inside the Space Center's property is buffered by the large neighboring manatee closure that reduced boat traffic and fishing activity.

In 1999, scientists published a four-year study showing a greater diversity of fish inside the Space Center closed area than in the immediately adjacent fished areas.[32] At this point, the Space Center closure had been in effect for over thirty years. Seatrout, striped mullet, black drum, and red drum—all popular gamefish—were both more numerous and larger where they were protected. Only 6 black drum were found outside the reserve, as opposed to 169 fish found inside the reserve where the fish had an average length of 28 inches. The higher proportion of mature, large fish inside the reserve, along with other observations by researchers, indicates that the reserves are protecting spawning populations of these game fish. Fish were also migrating outside the reserve's borders, to the

benefit of fishermen. Recreational fishermen just outside the Space Center's boundaries reported catching record-sized fish.[44] One striped mullet tagged inside the reserve was caught 75 miles away.[32] Even though the reserve site was chosen without any regard to biological criteria, the Space Center provided both shelter for spawning populations and a supply of large fish for the surrounding waters.

CHAPTER THREE

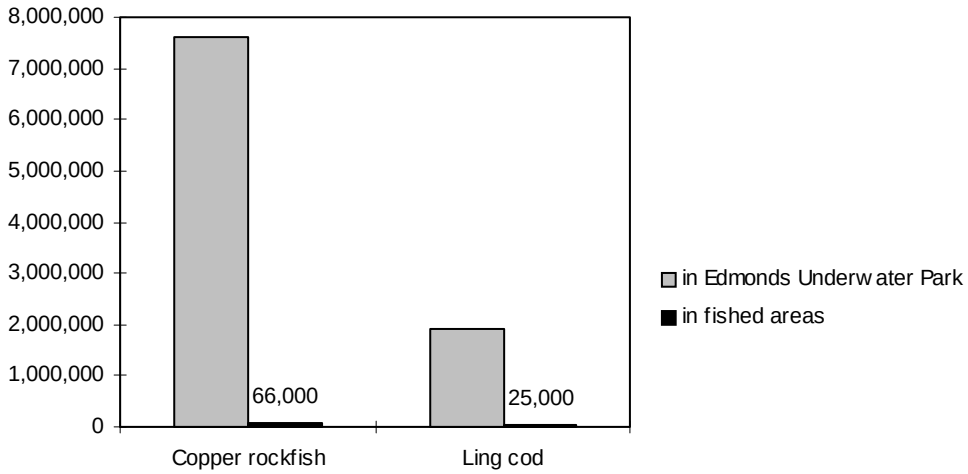
How Reserves Work and Why

There are hundreds of published scientific papers on marine reserves from around the world. [28,51-54] One recent summary paper compiled the results of over 80 studies. [55] Almost all of these studies found increased abundance and a higher density of fish in marine reserves. On average, reserves had twice as many fish overall and three times as many large fish as exploited areas.[55] These positive effects held true in temperate and tropical waters, for both fish and shellfish, and in a wide range of habitats. Reserves may be especially effective for fish that are highly dependent on particular habitats, such as rocky areas or coral reefs, and fish that are often taken as bycatch, but almost all species can benefit from the protection offered by a reserve, even if they are simply passing through.[56-57] New experiments tracking the movements of fish in marine reserves show some fish migrating outside the borders into fishing areas. [27,31,32,58]

The ability of reserves to shelter large fish is particularly critical to the ecosystem. Many fish take years to mature and reproduce—some begin spawning after only a couple of years, others require at least a decade. As fish grow larger, their ability to produce eggs increases exponentially so that in terms of making new fish, one big fish can equal nearly 100 smaller fish. In very long-lived species such as Pacific rockfish, large individuals (over 20 years old) produce the majority of eggs for the entire population of fish. There need to be enough large fish left in a population for those fish to find mates and reproduce.[22] Since most fish larvae are dispersed by currents, large fish inside a reserve can help populate other areas by releasing thousands of baby fish into the sea. Thus, reserves are functioning as ocean bank accounts—growing the living "capital" inside, and spilling "interest" into surrounding waters.

The graph on the following page illustrates the impact of protecting larger fish. In these two slow-growing species, a difference of a few centimeters in length can increase a fish's reproductive output by an order of magnitude. Lingcod in fished areas were, on average, only 59.4 cm long, while in the reserve they averaged 77.7 cm. Copper rockfish averaged 27 cm outside reserves and 34.6 cm inside. Those seemingly small differences mean that the potential egg production for a reserve site, such as Edmonds Underwater Park, can be as much as 50 times greater than that in fished areas.

MEAN EGG PRODUCTION FOR TWO SPECIES OF FISH IN PUGET SOUND[38]



INSURANCE IN A CHANGING OCEAN SYSTEM

For all that is known about the ocean, far more remains unknown. Our predictive power to estimate the consequences of our actions in the sea is low. New discoveries about long-term ocean processes only add to the uncertainty by demonstrating that the current status may reflect a short-term reality. New information appears all the time due to the efforts of scientists, volunteers, and fishermen, but there will never be enough data to answer every question. Considering that fishery managers may always be gambling on the ocean's renewable resources, marine reserves can provide a type of insurance against unforeseen disasters. Even when managers take the most precautionary approach, they always face the possibility that environmental changes or catastrophes like oil spills could compound management decisions and devastate an ecosystem. Fisheries management is an uncertain science at best, and marine reserves provide a margin for the inevitable errors.

PRESERVING HABITATS AND DIVERSITY

Vibrant underwater areas draw millions of visitors to the ocean each year; these are the most desirable sites for diving or watching wildlife. Well-managed marine reserves allow recreational visitors a glimpse of phenomenal diversity. Biodiversity inside reserves can be as much as 20 percent higher than in exploited areas.[55] This presents divers and snorkelers with a spectacular chance of seeing rare species. Because fishing is prohibited, fish in reserves may be less wary of humans and more approachable by photographers.[7,45] Without disturbance to the seafloor, corals and anemones grow into colorful underwater landscapes. Kelp forests, coral reefs, and areas of open sand and mud all support different suites of species, from the microscopic organisms at the bottom of the food chain to marine mammals and sharks. Marine reserves protect these habitats in a way that piecemeal regulations cannot.

FIVE MORE MARINE RESERVES

RESERVE	YEAR CREATED	SIZE (km^2)	RESULTS
Saba Island, Caribbean	1987	0.9	Studies in 1991 and 1993 found significant increases in predatory fish— groupers, snappers, and grunts. Groupers were extremely rare in fished areas. (49)
Apo Island, Phillipines	1982	0.11	A ten year study (1983-1993) showed that after nine years of protection, large predatory fish were more abundant not only inside the reserve, but also several hundred meters outside the reserve. Fishermen reported that their catch had doubled since 1985. (27)
Pt. Lobos State Reserve, California	Designated in 1963, closed to all fishing in 1973	3.14	A 1996 study of rockfish found twice as much biomass of black-and-yellow and kelp rockfish inside the reserve as in fished areas. The Pt. Lobos reserve also had significantly more mature adults of the copper rockfish, a slow growing species. (40)
Maria Island, Tasmania	1991	7	By 1997, the number of different fish species in this coastal reserve was 29% greater than unprotected areas. The reserve had nine times as many large fish and significantly larger abalone. (72)
Florida Keys National Marine Sanctuary	Network of reserves created in 1997	23 areas in total, ranging from less than 0.8 to 30	After a lengthy process established the reserve network, the Sanctuary instituted a five year monitoring program. Two years into the program, researchers found higher abundances of many game fish inside the reserves. In particular, spiny lobsters responded well to the additional protection and were much larger inside the reserves. (50)

HOW MUCH DOES RESERVE SIZE MATTER?

Because a primary reason for a marine reserve is the protection of ecological features and their associated wildlife, the best size for a reserve is one that covers all of those features. For example, if the reserve's goal is to protect one rare type of habitat or act as a site for scientific research, the reserve may only cover a small area. A reserve to restore fish populations may need to be much larger, depending on the species and their behavior. Estimates of adequate reserve size range from 10 to 70 percent of a target site, from reserves that can pinpoint a critical area of high biodiversity to reserves trying to cover highly mobile populations of fish.[33,34,58-60] Data show that in some ecological communities, even very small reserves (less than one mile-square) can increase the abundance of fishes and invertebrates.[27,61,62] Because of the way many marine organisms reproduce—by releasing their offspring into the water for broad dispersal—protecting even a small source population may have positive effects.[63] However, in most of the world these sources are poorly identified, if they exist at all, and it may be better to err on the side of more protection. With less than half of a percent of U.S. waters in marine reserves, every new addition, no matter what the size, is a significant contribution.

Small reserves can have problems, such as so called edge effects where so much activity is taking place around the edges of a tiny reserve that very little area is actually afforded any protection. Larger reserves may not only be more appropriate for such goals as protecting regional biodiversity, but also easier to enforce since the boundaries are simpler. Time is also a key factor determining the fate of a reserve.[40,65] Short-term closures can help species that grow quickly, but it may take at least a decade before increased fish populations within the reserve disperse into surrounding waters.[27,66] The total reserve can determine what species it will protect while the duration of the reserve controls the magnitude of the improvements.

Many countries have established networks of small reserves or reserves within a larger system of ocean zoning. [57,64] A network can target sites that are critical throughout one animal's life cycle, or connect a series of habitats important to many species or an over bioregion. In the Bahamas, the government has set an overall goal to protect 20 percent of the coastal habitat in network of marine reserves. More than 30 candidate areas were examined by government officials and scientists for both their ecological importance to the area as well as their cultural and economic value. In January of 2000, the Bahamanian government selected five new marine reserve sites, bringing the total reserve area up to 4 percent of the ocean under their jurisdiction. As the Bahamas expands its network to reach 20 percent, they hope to work with other island nations to create a series of reserves running down through the Dominican Republic.

CREATING A MARINE RESERVE

"A single citizen saying 'it isn't what it was' can carry more weight than any scientist."
Dr. Jim Bohnsack, National Marine Fisheries Service

Several key elements need to be considered at the early stages of designing a marine reserve to help make that reserve a success.

Make the process open. Oceans are a public resource, and ocean wilderness areas should reflect the desires of the public. There are costs and benefits associated with creating a reserve. Everyone, from fishermen to kayakers to scientists, should have the opportunity to participate in developing the goals for a reserve. Reserves need public support to thrive, and part of developing that support is listening to the needs of local residents. It also helps to bring people to any proposed reserve site to show them the underwater life. Diving and boating trips can help people visualize reserves. In Sitka, Alaska, when people could not travel to see the site itself, researchers made videotapes.

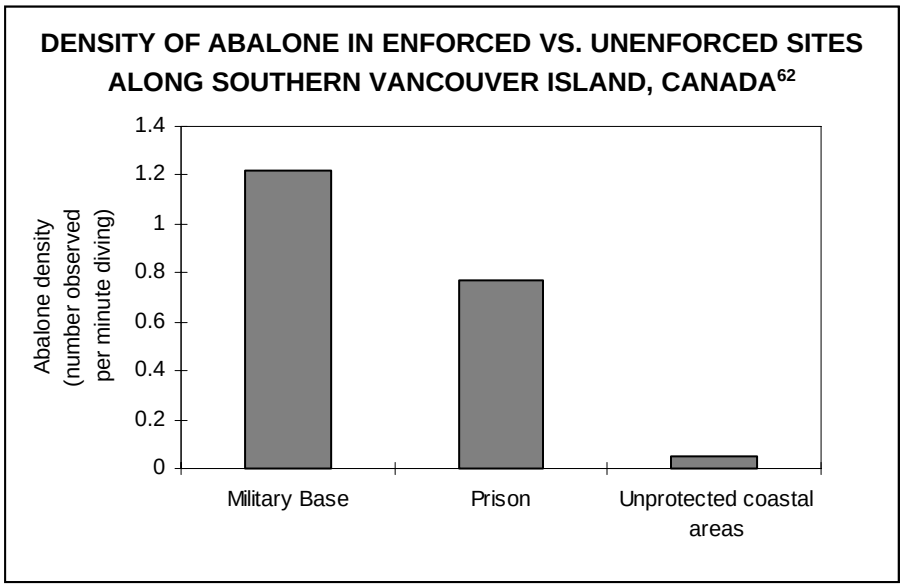
Define the goals of the reserve. A reserve created to increase the numbers of a coastal sportfish will have different needs than a reserve that seeks to protect a deepwater seamount. Clear goals are essential before siting a reserve because, without goals, it is

impossible to determine if a reserve is succeeding or failing. [68] Reserves should have a purpose in mind, such as safeguarding a type of habitat, rebuilding the stocks of a group of fish, or restoring a degraded area. The purpose of the reserve helps determine its location and management requirements.

Put ecological values first. Economic factors and political constraints play a significant role in designing reserves. These are critical concerns that must be taken into account, but, in the end, ecological characteristics should be the foundation for picking a site. If two locations have equal ecological value, then socioeconomic issues can drive the final decision. A site that does not have the ecological resources needed to achieve the goals of the reserve may not provide the desired benefits. A reserve may encompass areas of pristine, untouched habitat, or cover degraded areas that have the potential to rebound if fishing pressure is removed. Understanding the biology and dynamics of an area is key to siting a successful reserve.

Think of reserves as part of an overall management program. Reserves cannot be the only tool for ocean protection. They constitute a critical piece, but reserves alone will not address factors such as pollution, oil spills, or overfishing. Problems on land, such as poor septic systems and eroding sediments, must be solved or they will wash into the reserve. For marine reserves to work, and have broad support, there must also be areas where fishing activity is permitted and other disruptive activities are allowed. As long as society continues to demand fresh fish, or new communication cables, people will seek these resources in the ocean. Marine reserves can act like greenspaces and parks on land; they balance areas in use with areas protected for the future.

Keep the reserve closed. For a reserve to work, everyone needs to know the reserve's location and respect its boundaries.[69,70] In addition to controlling fishing activity, marine reserves will also need to restrict recreational activities and scientific observation to a level that does not disturb the habitat.[71] New technologies have made it easier to identify and enforce marine reserves, particularly those far offshore. Global Positioning Systems, or GPS, use satellites to determine the exact location of a boat anywhere in the ocean and are becoming standard equipment on fishing boats as navigational aids. One of the significant impacts of the fishery closure on Georges Bank was the introduction of a Vessel Monitoring System (VMS). Boats in the scallop fishery carry a VMS that reports their position every hour, allowing managers onshore to keep track of activity around the closed areas. VMS can also be configured to provide real-time information on how much the fishermen are catching, which is a major improvement in collecting fisheries data. VMS and other technologies can be extremely useful tools for enforcing marine reserves and for managing sustainable fisheries, but they are not yet widely used.



Closer to land, enforcement can be done with paid naturalists or park managers, or with groups of volunteers. Part of the importance of public participation in designing a reserve is that it helps create a site with broad support. The more people know about a reserve and its purposes, the more likely it is that they will respect the area. It may take years for the area within a reserve to rebuild itself, but it can easily be depleted if the site is reopened or threatened by poaching.

For example, Scott Wallace studied a closure for abalone populations in British Columbia and found poaching was so high that abalone only remained in places where fishing prohibitions were strictly enforced, albeit not for conservation purposes.[62] Even though abalone fishing along the entire coast had been prohibited for eight years, a search of five different coastal sites discovered a sum total of only nine abalone. However, two sites that were guarded and patrolled—one by the military and one by a neighboring prison—had enormous numbers of abalone. In order to make the reserve more than just a line on a map, it will need to both law enforcement and community education.

Marine reserves provide safe havens. In the wild and diverse world under water, they are the wilderness sites, the natural preserves where humans are transient visitors. Reserves complement and improve on the ways the United States currently tries to manage the oceans, and their benefits are tremendous. Marine wildlife thrives inside a reserve, a brilliant burst of color against the pale background of an ocean scraped bare. With marine reserves, we can protect habitats and creatures for generations to come. Without them, we can lose an entire world.

APPENDIX

FOR ADDITIONAL INFORMATION

NRDC has more information on marine protected areas at www.nrdc.org, including a report entitled, *Priority Oceans Areas for Protection in the Mid-Atlantic*.

"The Wild Sea," published by the Conservation Law Foundation (CLF), which targets the East Coast of the United States and includes a detailed description of the laws and regulations governing reserves. Copies can be ordered from CLF at www.clf.org.

The World Wildlife Foundation (www.wwf.org) produced *Fully-protected Marine Reserves: A Guide*, which includes both a comprehensive literature review and a set of slides showing reserves around the globe.

The National Academy of Sciences report *Marine Protected Areas: Tools for Sustaining Ocean Ecosystem*s, released in the fall of 2000, can be read online at www.nap.edu.

The University of Washington's School of Marine Affairs publishes MPA News, a free quarterly newsletter on MPAs, that can be delivered in print or electronically. Subscription requests should be sent to mpanews@u.washington.edu.

More information on the national marine sanctuaries can be found at the National Marine Protected Area website, www.mpa.gov, or by contacting one of the sanctuaries directly:

Channel Islands NMS
113 Harbor Way
Santa Barbara, CA 93109
(805) 966-7107

Cordell Bank NMS
Fort Mason, Building #201
San Francisco, CA 94123
(415) 561-6622

Fagatele Bay NMS
P.O. Box 4318
Pago Pago, AS 96799
011-684-633-7354

Florida Keys NMS (Administration)
P.O. Box 500368
Marathon, FL 33050
(305) 743-2437

Florida Keys NMS
(Lower Region)
216 Ann Street
Key West, FL 33040
(305) 292-0311

Florida Keys NMS
(Upper Region)
P.O. Box 1083
Key Largo, FL 33037
(305) 852-7717

Flower Garden Banks NMS
216 W. 26th Street
Suite 104
Bryan, TX 77803
(409) 779-2705

Gray's Reef NMS
10 Ocean Science Circle
Savannah, GA 31411
(912) 598-2345

Gulf of the Farallones NMS
Fort Mason, Building 201
San Francisco, CA 94123
(415) 561-6622

Hawaiian Islands
Humpback Whale NMS
726 South Kihei Road
Kihei, HI 96753
(808) 879-2818

Monitor NMS
The Mariners' Museum
100 Museum Drive
Newport News, VA
23606-3759
(757) 599-3122

Monterey Bay NMS
299 Foam Street, Suite D
Monterey, CA 93940
(408) 647-4201

Olympic Coast NMS
138 W. First Street
Port Angeles, WA 98362
(360) 457-6622

Stellwagen Bank NMS
14 Union Street
Plymouth, MA 02360
(508) 747-1691

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