Marine Protected Areas: Economic and Social Implications

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Abstract

This paper is a guide for citizens, scientists, resource managers, and policy makers, who are interested in understanding the economic and social value of marine protected areas (MPAs). We discuss the potential benefits and costs associated with MPAs as a means of illustrating the economic and social tradeoffs inherent in implementation decisions. In general, the effectiveness of a protected area depends on a complex set of interactions between biological, economic, and institutional factors. While MPAs might provide protection for critical habitats and cultural heritage sites and, in some cases, conserve biodiversity, as a tool to enhance fishery management their impact is less certain. The uncertainty stems from the fact that MPAs only treat the symptoms and not the fundamental causes of overfishing and waste in fisheries.

Key Words: Marine Protected Areas; Marine Reserves; Fisheries

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Contents

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Introduction

Among the nations of the world, the United States is unique for its huge and diverse endowment of living marine resources. As shown in Figure 1, the U.S. has about 95,000 miles of coastline and more than 3.4 million square miles of ocean in its domain (NOAA, 1998). Within these waters, a marine biodiversity rivaling that of some of our most treasured land-based systems exists. From coral reefs and sea grass beds to salt marshes and mangrove forests, the ocean and coastal areas surrounding the United States and its territories are teeming with marine life.

These habitats and the resources they support provide the public with a valuable and diverse set of goods and services, including seafood, recreational enjoyment, carbon sequestration, storm protection, and opportunities for pharmaceutical discoveries. For example, commercial fisheries alone add approximately $27 billion per year to U.S. gross domestic product (NOAA 2000). In addition, about 3.5 million acres of coastal wetlands, salt marshes, shrub wetlands, flats, and shoals provide many vital services and resources, such as nursery, feeding, breeding, and resting areas for fish, shrimp, crabs, mollusks, and birds. The coastal environment also supports many tourism and recreation activities that contribute, in total, about $595 billion annually to gross domestic product, making it the second largest contributor (NOAA 1999).

While the ocean is critical to society's economic and social well-being, scientific studies confirm that many of our marine resources are overexploited and face external environmental threats. In the United States, federal regulators report that 56 of 162 major fish stocks are overfished.[1] Furthermore, many fisheries are overcapitalized relative to the catch that would

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[1] This means that the rate of fishing mortality jeopardizes the capacity of the fishery to produce its "maximum sustainable yield" on a continuing basis (NMFS 2001).

maximize net economic returns to society. Too many boats chasing too few fish bring our ocean resources to the brink of collapse and sometimes beyond, as happened in the New England groundfish fishery in the early 1990s (NOAA 1999).

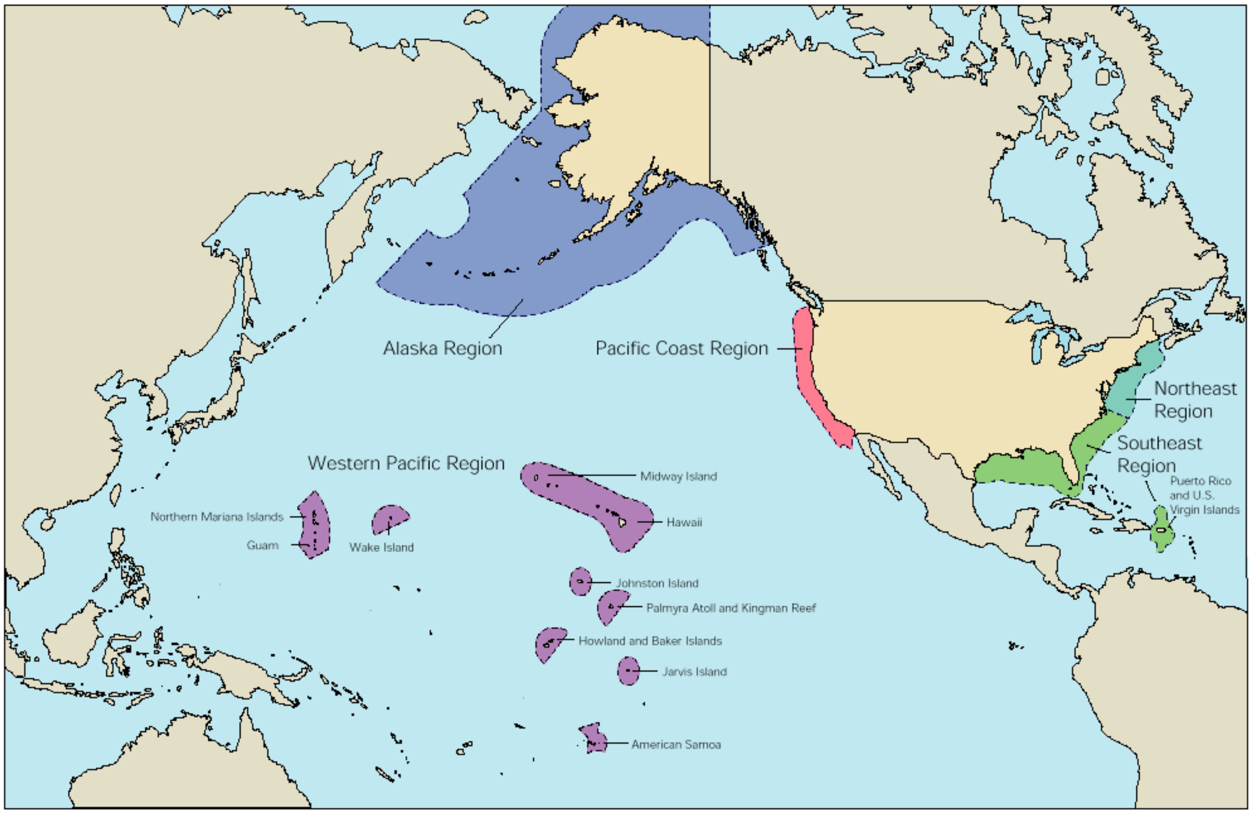

Figure 1: America's Ocean

Source: *Our Living Oceans 1999: A report on the status of the U.S. Living Marine Resources*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1999.

Although the threat of stock collapse is of great concern, the effect of overfishing extends beyond just that. Overfishing can exacerbate bycatch problems—such as the unwanted interaction with other fisheries, turtles, and even birds while fishing—which lead to waste and increased fish and marine life mortality as non-target species are caught and then discarded at sea. Also, fishing practices and gear can damage fragile ocean habitats. Bottom trawlers, for example, can severely alter the ocean floor and benthic ecosystems, which provide food and shelter for fish and other marine species. The loss or damage of these ocean ecosystems causes disturbances in food chains and, ultimately, the loss of unique marine-life communities (NRC 2000).

Our coastal resources are also coming under increasing stress, as more people move to the coast, which ultimately threatens marine biodiversity and productivity. For example, between 1986 and 1997, the United States experienced a net loss of 10,400 acres of estuarine and marine wetlands (Dahl 2000). Coastal development, including road construction, marina and port development, and dredging, accounted for most of this loss, and are most intense along the Gulf of Mexico and Atlantic coasts. Furthermore, runoff from urban streets, lawns, and agricultural areas, arising from greater development on the coast, delivers nutrients and chemicals to coastal estuaries and wetlands. These pollutants can cause fish kills and even stimulate algae blooms, which rob the water of oxygen and leave behind dead zones, such as the one found in the Gulf of Mexico that is the size of the state of New Jersey.

Sidebar I: Status of Protection in U.S. Waters

Unlike unique and irreplaceable land-based resources, very little of our national ocean treasure is protected. The nation has 300 specially designated marine areas managed by federal and state agencies and nongovernmental organizations (NOAA 1999). These include 12 marine sanctuaries in federal waters, national parks, seashores, monuments, and wildlife refuges, national estuarine research reserves, national estuary program areas, and areas designated for rebuilding stocks in federal fishery management plans. But together, these areas cover less than 1% of America's ocean, and less than 1% of this area is set aside as marine reserves, where fishing is prohibited (NOAA 1999). The status of marine resource protection contrasts sharply with land-based resources, where state and federal wilderness preservation systems protect about 5% of the nation's land resources from most human disturbances.

To help protect and restore fisheries, and to conserve biodiversity and cultural heritage sites (e.g., sunken ships), many fishery scientists and managers are promoting the use of marine protected areas (Scientific Consensus 2001, NRC 2000).[2] Historically, very little of the U.S. waters are protected (see Sidebar I). However, that could change with two executive orders by the Clinton administration that put political might behind the need for and use of marine

[2] MPAs can vary according to their management objectives and use restrictions. For example, the Florida Keys National Marine Sanctuary allows for multiple uses, including recreational fishing and diving. Some MPAs can even include both marine and onshore components, such as the Cape Cod National Seashore in Massachusetts (NOAA 2000). A "marine reserve," or no-take zone, is a special category of MPA. Inside a marine reserve, some or all resources are protected from extractive use. The Tortugas Ecological Reserve is an example of a no-take reserve where all marine life is protected. Finally, closed fishing areas that may provide spatial and temporal protection for spawning or juvenile stock are another type of MPA and have been used by fishery managers for many years.

protected areas (MPAs). The first order created the Coral Reef Task Force, whose mission is to strengthen the stewardship of the nation's coral reefs (Federal Register 1998). The task force recommended designating special areas, including "no-take zones, to protect and replenish coral reef ecosystems and prevent future harmful impacts" (Task Force 2000). The second and arguably more far-reaching effort came in 2000, when federal agencies were instructed to develop a national system of MPAs (Federal Register 2000).[3]

As fishery policy moves from recommendations to implementation, there will be an ever-increasing set of questions about how MPAs will affect local, regional, and national stakeholders that have come to depend on the oceans for their livelihood, recreation, and overall well-being. For example, commercial fishermen, who are displaced by a closure, surely will be concerned about how the set-aside will affect their ability to make a living. Recreational fishers might be concerned about their access to the protected area even if commercial fishing is excluded. And, finally, groups representing the well-being of current and future generations might ask what are the consequences if we do not set aside a significant amount of the near-shore habitat. Probably nowhere in the world is this more likely than in U.S. fishery management, where the stakeholders include commercial and recreational fishing interests, scientists, environmental organizations, and local, state, and national government agencies (see Sidebar II).

Given the recent momentum in both the public and scientific arena for creating MPAs, it appears that there is social value in creating areas free from exploitation within the marine environment. However, important questions remain on the goals and uses, location, size and number of MPAs (Walters 1999, Sanchirico 2000). To help shed light on the economic and social component of these questions, we highlight in this chapter the benefits and costs associated with setting aside areas of the marine habitat.

Before discussing the potential economic and social effects of MPAs, we discuss briefly the ecology of MPAs and the mechanisms that lead to the many stated benefits. We go on to describe the institutional environment where MPAs will be sited, because of its importance in determining the long-run effectiveness of MPAs and the potential support they will receive in the implementation process. In section 4, we discuss within a benefit-cost framework how these biological benefits might translate into economic and social benefits and how siting a MPA

[3] Also in 2000, the Clinton administration, by executive order, authorized an 84 million-acre MPA in the northwestern Hawaiian Islands (Federal Register 2000). The reserve encompasses nearly three-fourths of our coral reefs and a biological diversity that is unparalleled in U.S. waters.

entails costs. We employ a benefit-cost framework because it is a convenient structure to organize and classify potential outcomes, tradeoffs, and the risks associated with these choices (Freeman and Portney 1989). Its use does not imply that all potential benefits and costs are easily identified or even quantifiable. In fact, we address issues surrounding the calculation of benefits and costs in section 5. At the same time, we highlight some of the equity issues that are bound to arise during the debates about where to put MPAs. In the last section, we discuss where, when, and how MPAs might yield the greatest benefit to the public.

Sidebar II: Management Jurisdictions and Statutory Authority

Coastal States have jurisdiction out to 3 nautical miles (except for Texas and the west coast of Florida, where state waters extend out to 9) and the federal government has jurisdiction from 3 to 200 nautical miles. Beyond federal waters, international law and multilateral agreements between governments regulate marine resources.

Federal and state laws regulating the use of marine resources are implemented by government agencies subject to the public trust doctrine. This means that government managers are the exclusive public trustees and stewards of marine resources, which belong to every citizen. In this respect, access to and use of marine resources is different from other natural resources, like forest and rangelands, which are, in part, privately owned and managed.

At the federal level, there is no overarching federal statute that deals with the establishment and management of MPAs. The first set of MPAs came about under the National Marine Sanctuaries Act of 1972, which was passed to protect marine areas that contained resources of biological, historic, and economic significance. Today there are 12 national marine sanctuaries in federal waters. As for the use of MPAs in fisheries management, the Magnuson-Stevens Fishery Conservation and Management Act, the primary federal legislation governing U.S. fisheries, grants to eight regional councils the legal authority to consider and implement MPAs, including no-take marine reserves, within their fishery management plans. In recent years, several regional councils have established committees to evaluate the use of MPAs as a tool to restore fish stocks and to protect essential fish habitat.

In state waters, MPAs are subject to regulation by the individual states. Federal and state partnerships have resulted in the creation of marine protected areas that typically cover coastal waters, intertidal areas and land. NOAA has listed 39 candidate federal and state partnerships sites for consideration in its compilation of MPAs in the United States.

Ecology of Marine Protected Areas

A significant body of literature examines the theoretical and empirical biological effects of MPAs on habitats and the productivity of fish stocks (Dugan and Davis 1993; Roberts and Polunin 1991; Carr and Reed 1993; Allison et al. 1998; Carr and Raimondi 1998; Palumbi 1999; Boersma and Parrish 1999; Lindeman et al. 2000). This literature provides valuable information relating to the design, site selection, and implementation of MPAs. MPAs are found to be effective in protecting critical habitats, as spatial havens for intensely exploited species, as sources of stock for adjacent areas, and as potential buffers against management errors.

In general, the biological mechanisms that can make MPAs effective as fishery management tools are rather simple. When exploitation is ceased in an area, resident fish populations begin to recover. As the populations recover, the abundance of fish increases, including the number of older and larger fish that would have been caught if fishing were allowed to continue. In this way, MPAs provide direct protection to that fraction of the total fish stock residing within its boundaries. If these populations are mobile, then as the fish stocks recover, there will be spillover into other areas. The amount and range of the spillover depends on the dispersal characteristics of the populations that reside in the reserve. For example, if the population were rather sedentary (e.g., Red Sea urchin), then one would not expect any adult or juvenile dispersal. On the other hand, if the population is more mobile (e.g.for example, rockfish), then we might expect to see some spillover of adults and juveniles. Aside from adult and juvenile movements, spillover could occur if larvae from the closed area disperse to the open areas (Hastings and Botsford 1999; Pezzey et al. 2000). Further, if older and larger fish are more fecund, then the amount of larvae in the entire system might increase after a closure.

While the general principles are simple, measuring the magnitude and persistence of these benefits are not. First, existing MPAs were not designed as experiments to test for these factors, which means that disentangling the protected area effect and the effect due to heterogeneous habitats is empirically difficult (Garcia-Charton & Perez-Ruzafa 1999). Second, the marine environment is an extremely difficult arena in which to do empirical work; in part, because research to determine abundance and species diversity often relies on sampling techniques with high degrees of imprecision, such as visual sampling (Polunin and Roberts 1993). Finally, there exists uncertainty about the extent to which different areas in the marine system are connected by larval dispersal processes, adult and juvenile dispersal patterns, and/or seasonal migrations. This concern is raised not to diminish these benefits, but to point out that the magnitudes of these effects are uncertain and pose a major challenge in quantifying the benefits and costs of MPAs. Nevertheless, for our purposes, we operate under the premise that the ecological benefits within the protected area are realized and that there exists some spillover into the remaining fishable waters (Scientific Consensus, 2001).

Institutional Setting

In 1954, H.S. Gordon pointed out in a seminal article on the economics of fishery management that overfishing and overcapacity would plague open-access fisheries. His reasoning was that without any "sense of ownership" over a fish until it is on board their vessel, fishermen will engage in a race-to-fish. Further, both theory and historical record show that the race will continue until fish stocks are depleted and the number and types of vessels in a fishery exceed its viable capacity. Because of "rule of capture" incentives, fishermen neither take into account how their catches today will impact future catch levels nor the costs associated with excess fishing capacity (see Sidebar III). As many have noted since, if a policy intervention can directly address these incentives, then it would treat the fundamental causes of excess effort in fisheries and the symptoms, overfishing and overcapacity, would subside.

Today many fisheries throughout the world are no longer open-access, however, fishermen continue to operate under "rule of capture" incentives. In fact, current fishery management efforts have, for the most part, overlooked the role of incentives in shaping behavior and sought rather to focus on effort controls, such as trip limits, seasonal closures, and gear restrictions. Unfortunately, these regulations treat the symptoms of the problem and not the fundamental causes. A consequence is that signs of a recovery in fish populations can often attract additional fishing effort, as the perception of lower costs and greater-than-actual benefits entice new entrants and induce existing fishermen to apply more effort to sustain their enterprises. As a result, any short-run gains in stock levels and profits are not sustainable due to the policy-induced responses of the fishermen.

Sidebar III: Too Many Boats Chasing Too Few Fish

Ocean fisheries are a common property resource, which means that no one exercises complete control over them. Therefore, in the mind of a fisherman, a fish that is not caught today is someone else's fish tomorrow. Without exclusive harvest rights, no single fisherman can exclude others from exploiting the fish stock. As a result, individual fishermen act rationally to maximize their share of the catch by investing in bigger boats and more gear. This outcome, however, is ultimately destructive, as too many boats race to catch their share of a declining stock.

Depleted fisheries are often troubled by overcapitalization. In other words, more capital is invested in the fishery than is needed to harvest an optimal yield. This imposes a cost on society because the excess capital and labor that is employed in fishing could be employed in other sectors of the economy to produce goods and services whose net benefits exceed those generated by harvesting additional fish.

One way to address the causes of excess effort is a form of social control, or regulation, that turns "open" access to the fishery into "closed" access. Individual transferable quotas (ITQs), a property rights-based approach, is one possible form of regulation that is being used in many different fisheries and countries—including the United States—to regulate fishing efforts to the benefit of fishermen and the environment (NRC 1999).[4] Under ITQ management, the total

[4] There are many possible rights-based approaches to fishery management, such as cooperatives (e.g., Alaskan Pollock), community development quota (e.g., select Alaskan communities), and individual transferable quotas (e.g., Alaskan Halibut). As each of these approaches has advantages and disadvantages that are beyond the scope of this paper, we point the interested reader to the 1999 NRC report called *Sharing the Fish*

allowable catch is capped and the privilege of harvesting the catch is allocated to individual fishermen through quota shares that are secure and transferable with the objective of maximizing net economic returns.

How do incentives, property rights, and institutions affect the economic and social value derived from MPAs? In fact, the institutional setting where MPAs are being considered is a critical component in determining whether and how the benefits will persist over space and time and it has direct implications for the level of support MPAs could receive in the implementation process. For example, if fishermen believe that they will bear the costs of being displaced from an area and—due to the lack of exclusive harvesting rights—have no guarantee that they will capture the benefits of stock recovery, then it is likely their support will wane, everything else being equal. On the other hand, if the fishermen perceive that they will benefit from MPAs, then it is more likely they will support implementation. In an ITQ fishery, for example, fishermen no longer have an incentive to overcapitalize and race-to-fish, or take other actions that could dissipate some of the economic and social benefits of MPAs. In fact, if MPAs provide significant biological benefits, then these will be reflected in the long-run value of the fishery. As the fishermen hold shares of the total allowable catch , any increases in long-run value of the fishery make those shares more valuable and that provides fishermen with a tangible financial reason to care about the productivity of fish stocks and the essential marine habitats that support them.

Economic and Social Implications

The social sciences have contributed to a relatively small but steadily growing body of literature that examines the economic and social implications of MPAs (Farrow 1996; Hoagland et al. 1995; Milon 2000; Sanchirico 2000). The literature asks under what conditions might the conservation gains attributed to MPAs provide the largest benefit for the smallest cost. To answer this question, fishery managers will need to have a better understanding of how fishermen and other users choose the location of their efforts and how these choices will be affected by the MPA. In fact, displacement of effort both across the fishing grounds and into other fisheries is arguably a fundamental driver in determining the type and magnitude of the benefits from MPAs. Research into these questions will be helpful in guiding public-and private-sector decision making when it comes to determining the scale, scope, and siting of MPAs.

From society's perspective, MPAs are a public investment of marine resources (Sanchirico 2000, Zinn and Buck 2001). The decision to commit resources can be guided by a benefit-cost framework that measures whether the potential benefits of protection—adjusted to account for risks—outweigh the potential costs. Like other public investments, the potential benefits and costs of MPAs are realized both over the short and long run. For example, closing off an area that historically contributed a significant catch would probably reduce the total catch, at least in the short run. As population levels begin to recover in the MPA and spillover to the remaining fishable waters increases, total catch levels might increase (Sanchirico 1998). How long might it take this response to occur? The answer will depend, in part, on the biological characteristics of the fish (e.g., fast-growing or slow-growing stocks) and how responsive the fishermen are to the economic and biological conditions (Sanchirico 1998).

In what follows, we divide the potential benefits and costs of MPAs between extractive (e.g., commercial and recreational fishing) and non-extractive users (e.g., eco-tourists) and management.[5] Examples of the benefit and cost categories for this set of stakeholders are found in Table 1.

[5] Two potentially significant groups of stakeholders that we do not address are upstream polluters who could be affected by new water quality restrictions that accompany the siting of an MPA and offshore oil and natural gas interests who may find their options reduced.

Table 1: Potential Benefits and Costs of Marine Protected Areas

Categories	Benefits	Costs
Extractive Users (e.g., commercial and recreational fishermen)	increase in catch reduced variation in catch improved catch mix (i.e., greater frequency of older/larger fish)	decrease in catch congestion on the fishing grounds user conflicts higher costs associated with choice of fishing location increase in safety risks
Non-extractive Users (e.g., divers, eco-tourists, and existence value)	maintain species diversity greater habitat complexity and diversity higher density levels	damage to marine ecosystem loss of traditional fishing community
Management	scientific knowledge hedge against uncertain stock assessments educational opportunities	increase in monitoring and enforcement costs foregone economic opportunities (e.g., oil, gas, and mineral exploration and bio-prospecting)

Benefits to Extractive Users

MPAs that stabilize or increase fish populations inside their boundaries could provide a similar function outside the protected area if the spillover effect is significant. This, in turn, could result in reduced variations in aggregate catch levels (Lauck et al. 1998) or an increase in the long-run total catch. In the end, the net impact on catch depends on the relative importance of the area set-aside in the total catch before the closure and the status of the fish stock. For example, if the area contributed a significant share of total catch, it is less likely that total catch will increase, because the threshold level that the biological spillover effects must overcome is higher. On the other hand, if the catch level is an insignificant share of total catch, possibly because of over-exploitation before the closure, then the probability of increasing the total catch is higher. In an over-exploited system, and when fish stocks are neither too sessile nor too mobile, long-run total catch levels have been shown (theoretically) to increase after an area is set-aside from harvesting (Sanchirico and Wilen 1998).

MPAs can also increase the market value of a fishery by changing the composition of the catch. One of the uses of traditional area and time closures has been to provide protection to stocks to enhance market value by altering selectivity (OECD 1997). Selectivity could be altered, for example, if a closure is implemented in an area where a high proportion of the stock is young. In this case, fishing effort will be displaced to other areas, or to a different time period, resulting in a catch of larger fish and perhaps higher market prices. Another possible increase in revenues could occur if the changes in catch composition from smaller to larger fish are accompanied by a shift to a more valuable product form (such as frozen to fresh product).

Costs to Extractive Users

Although there is a considerable amount of literature investigating the biological benefits of MPAs, the potential costs have not received much attention. In general, fishing is a complex process that depends on many factors, including the type of vessel and gear used, target species, stock density, and time and areas fished. The inputs into this process affect the costs associated with fishing and, therefore, impact the activity level. One can imagine, for instance, that less congestion at a given fishing ground could lower the cost per unit of catch. Costs could also differ across fishing grounds due to oceanographic conditions, such as stronger currents that increase fuel use and/or geographic features that prohibit the use of certain gear types. Within the current debate, an important question is how could the introduction of MPAs affect these types of costs.

Reducing the amount of area open to fishing implies that, at least in the short-run, vessels could experience higher levels of congestion on the remaining grounds. Congestion effects could result in increases in fuel usage and higher capital costs (e.g., fish finding equipment). In addition, significantly reducing the amount of fishable waters could also lead to increased conflicts between users of the resource, such as allocation disputes and gear entanglements. A potential conflict could arise, for example, from a trawler displaced by an MPA venturing into an area traditionally occupied by fixed-gear fishermen only. In this example, the costs of harvesting increase not only for the displaced trawler, but also for the fixed-gear fishermen, who otherwise might not have been affected directly by the closures. Congestion effects might not only be concentrated in the fishery for which the closure was implemented, as establishment of an MPA could shift fishing pressure from one species to another, thereby increasing the competition for the catch of that second species (Sanchirico 2000).

A fisherman's decision of where to fish depends on many factors, including time of year, targeted species, expected time at sea, expected catch rates, transportation costs, search costs, location-specific costs, dock-side prices, and weather-related events. To understand how these factors might change after a closure, we discuss transportation costs—including time spent traveling and searching for fish. Following siting of an MPA, if vessels spend more time steaming to and from the fishing grounds, fuel use will be greater and the amount of time that vessels will spend with fishing gear in the water will be reduced. The increases in steam-time can create incentives for skippers to invest in additional capacity, such as larger hold size, improvements in fishing gear, and more horsepower. An MPA, therefore, can have the unintended consequence of increasing capital expenditures in the fishery at a time when fishery managers are trying to find ways to reduce capacity, perhaps with a vessel buy-back program.

In many fisheries, a significant component of total variable harvesting costs is the time and fuel spent searching for fish. In modeling harvesting costs, a basic assumption is that higher stock levels imply that search costs are lower, everything else being equal. This effect is commonly referred to as the "stock effect." If MPAs are used in a fishery where the stock effect is significant, then they could potentially reduce this component of harvesting costs. For instance, if the biological spillover effects are large and far-reaching, then there is a possibility that stock levels will increase throughout the fishery. In this case, one would expect searching costs to decrease. If the MPAs provide significant spillover, searching costs could also decrease if fishermen simply concentrate in the areas surrounding the MPAs. On the other hand, if the spillover effects are negligible, then searching costs might increase after MPAs are established. For example, displaced fishermen, who have local knowledge of fish concentrations, might need to spend additional time and effort learning about stock concentrations and oceanographic conditions that exist in the remaining non-protected areas.

Recognizing that fishing is one of the most dangerous occupations in the world, fishery managers should not discount the fact that certain types of regulations can increase occupational risks. Closing a near-shore environment, like a sheltered lagoon, could force fishermen to venture out to more distant waters. Operating further offshore will increase the time it would take to return to port, placing fishermen at greater risks from storms. These risks could be exacerbated if inshore fishermen, who are displaced by the MPA, are unable to secure the capital needed to make the necessary upgrades to their gear and vessels before heading offshore. The combination of inadequate vessels and lack of experience of the displaced fishermen "forced" to operate in new, riskier environments poses the potential for greater occupational risks and higher costs from increases in search and rescue missions.

Benefits to Non-extractive Users

Research shows that MPAs can increase biodiversity and allow a marine ecosystem to return to its "natural" state (e.g., Boersma and Parrish 1999). Non-extractive users may value these changes to the marine ecosystem. For example, designating a special marine area, like a park or sanctuary, to protect biodiversity may increase its usefulness; such an area could be used for diving and photography. Improving the health of the ocean may also appeal to individuals who might never intend to use the area, but who value its existence nonetheless. If a MPA does attract new visitors, this can lead to additional jobs, income, and tax revenues for the local community. It is even possible that potential increases in revenue from tourism could offset potential losses due to lower commercial or recreational catches because of the closure. Obviously, the location and setting of a particular MPA would play a critical role in the magnitude of these benefits and costs. For example, a protected area offshore that is mainly occupied by bottom-dwelling species will most likely not have a significant tourism potential, while a coral-reef closure might. In general, a MPA can offer protection and provide the possibility for economic returns to sectors of the economy not directly tied to commercial fishing. In fact, studies of marine parks in the Caribbean found that proper management could yield both (Dixon et al. 1993).

Costs to Non-extractive Users

The lack of understanding about the long-term carrying capacity of a designated area, such as a marine park, raises important questions about sustainable use. If tourism is left unchecked, for example, increased pressure on resources within the area could reduce the very biological benefits—such as abundant biodiversity and more fish—and cultural benefits that closing off the area to extractive users was supposed to protect. The utility derived by visitors could also be negatively impacted by the popularity of the site as more visitors result in higher levels of congestion within the site. If there is a direct relationship between the demand to visit a site and site quality (e.g., the probability of seeing large fauna and flora, or a special coral reef ecosystem) then congestion and the detrimental impacts associated with it could lead to fewer visitors and lower economic benefits. Ultimately, all values derived from the MPA could be reduced with unchecked tourism, implying that there is a need to couple siting decisions with management designed to limit the impact of non-extractive users.

People who value traditional coastal fishing communities may also be negatively affected by the potential changes induced by closing off a significant amount of economically viable fishable waters. An example might be a small and isolated fishing community that targets a fishery that inhabits a near-shore coral reef. If the goal of the MPA is to protect the *in situ* biodiversity of that near-shore reef, then a large area might be protected. Because of the closure, local fishermen who might not have the financial resources to operate in waters farther offshore could be forced out of the fishing business. In some communities, the next best opportunity could be working in the tourism trade, but as the economic base shifts from fishing to tourism, a traditional way of life could be lost.[6] Furthermore, local residents of the community who do not participate directly in fishing may feel that they are also deprived of their traditional way of life if greater tourism activities and negative impacts, such as congestion, are associated with the MPA (Hoagland et al. 1995).

Management Benefits

MPAs could provide "undisturbed" areas creating new opportunities for scientific research and offering a hedge against management errors. Scientists argue that these areas can be used as controls to monitor and study the recovery of fish populations that will improve estimates of population parameters (e.g., more reliable estimates of growth and natural mortality rates) and stock assessments, which currently rely too heavily on commercial catch data. Reducing the current level of uncertainty and improving the science in stock abundance forecasts can only improve the long-run management of fisheries. If poor stock assessments or inadequate political will to set total allowable catches at sustainable levels are the primary causes of overfishing, then MPAs might be a good hedge against such errors.

The effectiveness of MPAs in meeting their management objectives will be influenced by how fishermen respond to them and the presence of external threats, such as nutrient pollution and meteorological disturbances. In two studies, investigating the implications of MPAs—which include behavioral models of the fishing industry—the models predict that harvesting pressure outside and, particularly, along the boundaries of the MPA will increase (Sanchirico 1998; Walters 1999). There is some anecdotal evidence that this has occurred outside an MPA located

[6] It is important to note that many local fishing communities are on the brink of collapse because of historically low catches. If that is the case, then the shift of the economic base out of fishing into tourism could help sustain the local population. However, other fishery management policies, such as ITQs or community development quotas, could be used to benefit local residents while maintaining the traditional way of life.

off the coast of Kenya, where the number of traps increase dramatically in the immediate vicinity of the protected area (McClanahan and Kaunda-Arara 1996). This increase in effort along the edge of the MPA led the authors to conclude that the spillover benefits have been quickly dissipated. Additionally, the costs associated with increased competition could induce fishermen to adopt fishing practices that yield the highest private return subject to the new MPA constraint, but also could increase the amount of habitat destruction in the remaining fishable water.

With respect to the presence of external threats, the fact that a marine ecosystem is open and subject to broad oceanographic shocks may reduce the degree of protection and lower the value of an MPA as a hedge. MPAs are not protected from external threats, like nutrient pollution, coastal erosion, diversion of freshwater, and broad environmental shocks, such as those caused by El Nino. Environmental damage like the "dead zone" in the Gulf of Mexico is evidence of the threats from upstream nutrient runoff that can affect the health of a protected area. On the other hand, the existence of a special place, like the Flower Gardens National Marine Sanctuary off the Texas and Louisiana coast, may help create a constituency to work to reduce upstream nutrient pollution and other environmental damages.

When trying to manage complex, multispecies fisheries, some studies have shown that MPAs may be a feasible alternative to conventional fishery management tools (Holland and Brazee 1996; Lauck et al. 1998; Roberts 1997). Multispecies fisheries are often difficult to manage because regulations or market demand may shift effort from one species to another or result in greater discards. If designed and sited properly, MPAs may offer a second-best solution to stem overfishing in multispecies fisheries, such as the reef fishes in the Gulf of Mexico and the Southeastern United States.

Management Costs

In the absence of any changes in how the fishery is managed, MPAs will likely increase management costs because of the need for additional monitoring and enforcement. If there is little or no enforcement and monitoring of the protected area, then the expected biological benefits might not be realized. Some experienced fishermen believe that MPA boundaries simply cannot be enforced given the strong incentive to poach in protected areas, the remote nature of fishing grounds, and limited budgets for enforcement. On the other hand, monitoring and enforcement costs are likely to depend on factors such as the size, location, and use restrictions of MPAs, fishery management regulations, local fishing practices and customs, and the available technology. The increase in costs might not be significant if fishery managers employ new technology such as a global positioning satellite network that can automatically monitor the location of fishing vessels, or alert authorities if a fishing vessel enters a closed area. This technology is being used successfully around the Great Barrier Reef in Australia and the Georges Bank off the coast of Maine, and has reduced the need for fishery patrol vessels (The Economist 2001).

Political Economy of Implementation Decisions

When marine resources owned by all Americans and managed by federal and state governments are dedicated to a particular use, like a MPA, a public investment has been made. The desirability of such an investment can be found by weighing potential benefits and costs as described above, along with equally important moral, ethical, and cultural values. While the latter values are largely beyond the scope of this chapter, they often play a major role in shaping resource management decisions.

Benefit-Cost Analysis

The benefits and costs of MPAs can be systematically identified and described. However, a precise calculation of the expected net benefits obtained by expressing all benefits and costs in dollar terms is often not feasible. Like other public investments, the potential benefits of MPAs will often be realized at some future date, whereas many of the costs are incurred immediately, implying that closing off areas results in an inter-temporal tradeoff, perhaps even across generations (Holland and Brazee 1996; Sanchirico and Wilen 1998; Hannesson 1999; Pezzey et al. 2000). Difficulties also stem from the complexity and corresponding degree of imprecision when trying to predict the impact of a new management tool on biological and economic systems.

Another difficulty for managers is the task of predicting and quantifying the non-extractive use values associated with the closure. It is generally understood that these values are an important consideration in resource allocation decisions. In fact, many recent calls for MPAs have cited potentially large economic returns from ecotourism activities and conservation values associated with biodiversity preservation. Given the current lack of research on the magnitude of these benefits for marine resources, however, it will be difficult in the near future to fully incorporate them in decision making processes.

Equity and Fairness Concerns

Every public investment has equity or fairness implications and MPAs are no exception. Equity issues among the stakeholders in the process can easily arise because MPAs will most likely affect user groups disproportionately (Holland 2000). For example, if an MPA is sited within the near-shore environment, the inshore fleet could potentially incur the highest cost (such as the direct loss of fishable waters), while the offshore fleet could receive most of the benefits. Not surprisingly, distributional effects are very important in the political realm of decision making.

Commercial and recreational fishermen often fear they will bear the costs of closing areas but will not be the recipients of the benefits. Such a change in the distribution of benefits and costs—real or perceived—is inevitably the subject of considerable dispute. Better understanding of the benefits and costs may reveal ways to compensate the losers and allow the MPA proposal to go forward. Otherwise, one might reasonably expect political intervention aimed at restricting management options. For example, if recreational fishermen fear their interests will be harmed by arbitrary closures, one might expect a call for legislation requiring scientific evidence of damages before adopting MPAs (Murray 2001).

In some cases, changing the design of an MPA could address the equity issue. This is an option worth consideration. However, manipulating conservation tools may not be the best way to address inequities. Even though the public nature of marine resources implies that creating an MPA does not constitute a "taking" (although fishermen may not perceive it that way) requiring compensation, another possible option might be to provide direct payments to those who bear real costs when MPAs are implemented.

Concerns about fairness emphasize the importance of a public outreach strategy to identify who are the stakeholders that need to reach consensus on management objectives, location and design, and use of MPAs (Dobrzynski and Nicholson 2001). When deciding on MPAs, resource managers run the risk of placing too much emphasis in the beginning on where to site MPAs and how much of the resource to protect and too little emphasis on the socioeconomic considerations (NRC 2000). Therefore, those most affected by the decision are not given an opportunity to participate until a later stage when it may appear that important decisions have already been made. This approach can often stymie efforts to establish MPAs because those that have the most to lose will set out to undermine the effort. Rather than run this risk, resource managers ought to start the process by identifying all of the stakeholders, including commercial and recreational fishers, divers, environmentalists, and other concerned citizens, and involve them at each stage of the decisionmaking process. This way, the socioeconomic aspects of establishing MPAs, which often are the deciding factor in determining whether MPAs succeed or fail, can be considered in an integrated way along with the ecological factors.

Such an approach led to the successful establishment of the Tortugas Ecological Reserve, which is approximately 70 miles west of Key West in the Florida Keys National Marine Sanctuary. Once the idea was put forth, a working group was created as part of the Sanctuary Advisory Council, which is made up of stakeholders, to develop the boundary alternatives for the reserve and prepare a supplemental environmental impact statement. Technical advisory teams included a physical science (e.g., oceanographers and biologists) and a socioeconomics group (e.g., economists and sociologists) whose roles were to advise the working group during the process of developing boundary alternatives for the reserve. The socioeconomics team identified all the current users of the study area, quantified the spatial distribution of economic use and activity, provided maps of the commercial and recreational fisheries and drafted profiles of the various user groups (Leeworthy and Wiley 2000). After two years and many negotiations, the stakeholders agreed upon a preferred alternative for siting the ecological reserve (Leeworthy and Wiley 2000).

Conclusions

With many fisheries on the brink of collapse, fishery managers are looking to MPAs as critical tools in their recovery. In fact, there is strong scientific evidence that MPAs are effective at preserving unique marine habitats, restoring fish populations that reside within the protected area, and as a way of ensuring that special treasures are preserved. However, their roles in supplying biodiversity, providing a hedge against poor management and acts of nature, offering research opportunities, and as emigration sources for surrounding areas, depends on the scale, scope and location. For example, marine biodiversity might only be enhanced if a significant number of representative habitats are set aside. If fishery enhancement is the goal, then perhaps MPAs should be sited so the amount of spillover is maximized. Regardless of the goal, scientific research is needed to guide the design, siting, and implementation of MPAs. Careful planning and financial resources will also be needed to monitor MPAs for success or failure, alter their design as necessary, and enforce their boundaries.

One possible way to increase the probability of MPAs succeeding in fishery enhancement is to couple them with other complementary management tools that address the causes of overfishing, such as individual transferable quotas. Otherwise, the economic benefits, and perhaps the biological ones as well, might quickly disappear as fishing efforts expand in response to recovering fish stocks. Coupling MPAs with other more encompassing approaches that can address the causes of overfishing and overcapacity would certainly be a step forward in integrating the conservation of fish habitat with the prosperity of fishermen. Improving both the economic and biological health of the fishery should appeal not only to fishermen and help win their support for MPAs, but also to anyone who is interested in sustainable use of our ocean resources. Nevertheless, it is important to point out that protected areas do not address the causes of excess effort that trouble many fisheries. In general, whether the use of MPAs has any discernable effect on excess effort or on catch levels will depend on the particulars of the MPA under consideration, the behavioral response of the fishermen, the pre-existing biological and economic conditions, and the institutional environment.

Of course, in addition to fishery enhancement, MPAs will often provide important ancillary benefits. For example, protecting coral reefs that store carbon and provide unique recreation opportunities, such as scuba diving or underwater photography, will yield benefits independent of fishery enhancement. In addition, individuals who may never visit the site but benefit from knowing that rare habitats exist and endangered species are protected might value MPAs. Although difficult to measure, such non-extractive values may exceed the value of foregone fishing opportunities. But, until more data are collected and research is done on the magnitude of such values, weighing them against easier-to-quantify fishing impacts is difficult.

A natural question to ask is under what conditions might one expect the benefits of a MPA to outweigh its costs. Unfortunately, the answer depends in a nontrivial way on the goals, and the size and location of the area chosen for closure. For example, the greater benefits are to non-extractive users, the lower are the access costs to the site and the greater is the probability that an individual will see features of the "pristine" habitat that are important to them. One could imagine that coral reefs teeming with flora and fauna within the near-shore environment would have the highest non-extractive benefits. Areas set-aside to protect fish stocks where older and larger fish either receive a price premium in commercial markets or are more attractive to recreational participants might increase the potential for positive short-run benefits. Finally, if reducing potential costs to fishermen is important, then one might look to set-aside areas that contribute relatively less to their livelihood. Why might one potential MPA site contribute less than another? It could be because the species are widely dispersed throughout the fishing grounds or that the set-aside area is one of the least profitable areas to fish (Sanchirico and Wilen 1999). Another reason could be that the current scale of the MPA is such that it does not make any discernable impact on fishing profits.

Whatever the specifics of the current design, the benefit-cost framework allows decision-makers to examine the net economic benefits to society from investing in MPAs. If the analysis takes into consideration the likely intertemporal nature of the returns, it can provide information on the distribution and timing of benefits and costs that could help resolve issues of fairness among those affected by MPAs. However, political obstacles to adopting MPAs are likely to remain significant. Fishermen bear most of the costs in the short run when a protected area is set-aside, while improvements in catch size and composition may not be realized until the distant future. Because of the uncertainty surrounding the benefits and costs of MPAs and how they will be divided, fishermen—like many others—may be inclined to take political action to block the siting of an MPA, especially when there is a perception that the current management regime is sustainable.

A robust stakeholder process is likely to lead to better decisions concerning MPAs. Fishery managers need to engage fishermen, environmentalists, and other concerned citizens in setting goals for MPAs and in taking responsibility for achieving the goals. Fishermen, for example, could help fishery managers and biologists with decisions about where to site reserves that will have the greatest fishery benefit, but at the lowest cost to the fishermen. But for fishermen and others to participate effectively, the decision making process needs to be decentralized and information must be exchanged at the regional or local level. In this way, the values and beliefs of local resource users can shape an inherently scientific endeavor. It may also strengthen accountability for implementation and increase the likelihood that fishermen will benefit.

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