Marine Reserves

A Guide to Science, Design, and Use

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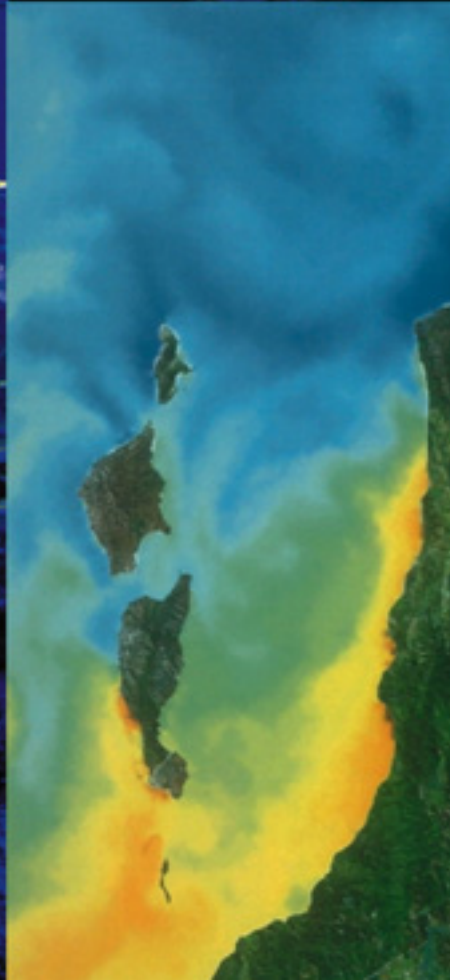

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Social Dimensions of Marine Reserves

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Social factors—not biological or physical variables—may be the primary determinants of marine reserve design and performance. While it may seem counterintuitive that the foremost influences on the emergence, evolution, and success of an *environmental* policy could be *social*, marine reserves result from *human* decision-making processes and require changes in *human* behavior to succeed. Thus, the social, cultural, political, and economic variables that mold individual choice and behavioral change ultimately shape the development, management, and performance of marine reserves and protected areas. For purposes of brevity, in this chapter the term *social* refers to social, cultural, political, and economic factors collectively, except where otherwise noted. Social factors, for example, fostered establishment and influenced the design of the Fagatele Bay National Marine Sanctuary in American Samoa. The participation of local authorities in the site selection process generated popular support for the sanctuary and, in recognition of Samoan cultural traditions, the proposed sanctuary boundary was revised to correspond with the bounds of the local marine tenure system (Fiske 1992).

Marine reserves are not only the product of social processes, but they also have social ramifications. Marine reserves, like other forms of resource management, allocate access to and use of marine resources among individuals and social groups and, thereby, directly and indirectly shape society. In Belize, for example, establishment of the Hol Chan Marine Reserve had far-reaching social impacts in the adjacent town of San Pedro. Reserve establishment catalyzed the transition of San Pedro from a fishing community to a tourism-based economy. Local men left the fishing industry for the higher wages they could

garner working as tour guides for snorkelers and scuba divers in the new marine reserve. The predominantly mestizo community diversified and grew rapidly, as newcomers from throughout Belize, North America, and Europe migrated to the area in search of economic opportunities. The standard of living in San Pedro continued to rise markedly following reserve establishment, as did levels of crime and drug abuse (Mascia 2000; unpublished data).

The relationship between marine reserve design and performance is complex and dynamic; just as reserve design influences performance, reserve performance influences design. This reciprocal relationship is seldom discussed in the scientific literature, but it is critical to understanding of reserve emergence and evolution and to the design of effective reserve policy. Following the early success of the Discovery Bay Fishery Reserve in Jamaica, for example, local fishermen successfully lobbied for expansion of the reserve (Woodley and Sary 2003). In Belize, the perceived socioeconomic success of the Hol Chan Marine Reserve not only prompted expansion of the reserve but also spurred nearby communities to initiate development of additional marine reserves. In Barbados, by contrast, widespread dissatisfaction with the social performance of the Barbados Marine Reserve (also known as the Folkestone Marine Park) contributed to the demise of a proposed network of marine reserves along the south and west coasts of the island.

An understanding of the relationship between marine reserve design and performance is essential to decision makers, who design reserves to achieve specific policy objectives. Though there has been a growing appreciation of the role of the social sciences in marine reserve design, social scientific research on reserve design and performance is limited. As a result, efforts to design marine reserves are still largely based on anecdotal evidence and individual experience rather than social scientific knowledge. Though conventional wisdom and trial-and-error have produced many marine reserve success stories, reserves designed in accordance with rigorous social science–based guidelines would be more likely to achieve social and environmental policy objectives.

This chapter reviews the social dimensions of reserve design and performance, the relationship between these two elements, and the implications of this relationship for marine reserve policy. The first section outlines the principal sociopolitical elements of marine reserve design: decision-making arrangements, resource use rules, monitoring and enforcement systems, and conflict resolution mechanisms. The role of cultural beliefs and values in marine reserve emergence, evolution, and performance is then discussed. The third section of this chapter reviews the social dimensions of reserve performance, with

particular attention to the effects of reserve establishment on resource users. After outlining the known relationships between reserve design and performance, the chapter concludes with a discussion of the implications of these design–performance relationships for marine reserve policy.

SOCIAL ASPECTS OF MARINE RESERVE DESIGN

A marine reserve is, in essence, a set of rules that collectively govern human interactions with a specified portion of the marine environment. Rules define reserve boundaries, the activities that may take place within these boundaries, and who may engage in reserve activities. Rules also specify protocols for monitoring and enforcing reserve rules governing resource use, as well as the mechanisms for resolving conflicts. Most importantly, rules govern the decision-making processes that establish marine reserve boundaries, resource use rights, monitoring and enforcement systems, and conflict resolution mechanisms. Thus, the design of a marine reserve is the specific configuration of rules that defines, explicitly or implicitly, *who* may do *what*—and *where*, *when*, and *how* they can do it—with respect to the portion of the marine environment designated as a reserve. The design of a marine reserve (i.e., reserve rules) directly and indirectly shapes human behavior, human interactions with the marine environment, and, ultimately, marine reserve performance.

There are four principal sociopolitical elements of marine reserve design: decision-making arrangements, resource use rules, monitoring and enforcement systems, and conflict resolution mechanisms. Each of these elements of reserve design may have formal and informal components with written or unwritten origins. Aspects of marine reserve design may be derived from legal statutes, policy statements, organizational practices, social norms, cultural traditions, or a combination of any or all of these. As a result, the de facto design that *actually* governs a marine reserve often differs sharply from the de jure system legally designated to do so. Commercial fishing continues in Glacier Bay National Park (Alaska, U.S.A.), for example, despite legal prohibitions dating to 1966 (NRC 2001, 156–157).

Decision-Making Arrangements

The design of decision-making arrangements determines the rights of individuals or groups to make choices regarding other aspects of marine reserve development and management. Decision-making rules determine, for example,

who may participate in making decisions and who may not (e.g., government officials, resource users), how decision makers are selected for their positions (e.g., elected or appointed), and how decisions are made (e.g., consensus or majority vote). These political variables are significant because policy preferences often vary among individuals or social groups; the structure of decision-making arrangements determines whose interests, beliefs, and values are represented in decision-making processes and thus manifest in policy and management decisions.

During the development of the Florida Keys National Marine Sanctuary management plan, for example, commercial fishermen shared limited decision-making authority with environmental groups and commercial dive operators, among others. Commercial fishermen generally opposed the establishment of marine reserves as part of the sanctuary management plan, whereas environmental groups and commercial dive operators generally supported widespread reserve establishment (Suman, Shivlani, and Milon 1999). If any of these groups had held exclusive decision-making authority, its policy preferences alone would likely have been reflected in the sanctuary management plan. In practice, the system of shared decision-making authority resulted in a policy compromise—immediate establishment of a system of nearly two dozen relatively small marine reserves and a commitment to develop a larger marine reserve in the Dry Tortugas within a defined time frame.

Marine reserve decision-making arrangements are usually complex. The responsibility and authority for decision making often rests with different (though sometime overlapping) sets of individuals or groups during the six sequential stages of the policy process: initiation, assessment, selection, implementation, evaluation, and termination (Brewer and deLeon 1983). Moreover, actors' decision-making rights are often limited to particular aspects of marine reserve development or management, such as enforcement or conflict resolution. Procedural rules that govern voting, decision-making criteria, and the use of scientific information also vary depending upon the stage in the policy process. At each stage, subtle differences in the rules that govern decision making may have significant impacts upon the design, implementation, evaluation, or reform of marine reserve rules governing resource use, monitoring, enforcement, and conflict resolution.

Marine reserve decision-making arrangements range along a continuum from highly centralized to highly participatory. Centralized decision-making arrangements limit decision-making responsibility and authority to a single individual or a small group, often specialists within a single government agency.

Participatory decision-making arrangements, by contrast, permit sharing of decision-making responsibility and authority among diverse groups: resource users; nongovernmental organizations; local, state, and national government officials; and other stakeholders.[1] Because the amount, diversity, and type of information brought to bear upon decisions depends upon who has the right to participate in decision-making processes (Healy and Ascher 1995), participatory decision-making arrangements generally increase the amount and diversity of information brought to bear upon decisions. Participatory decision-making arrangements thus increase the likelihood that policy decisions will be based upon accurate models of human behavior and environmental dynamics. Participatory decision-making arrangements also tend to enhance the perceived legitimacy of decisions that are made. The proposed boundaries of the Hol Chan Marine Reserve, for example, were revised prior to implementation at the request of local fishermen, which enhanced the legitimacy of the reserve in the eyes of affected individuals (Mascia 2000).

The procedural rules that govern how decision-makers make choices can shape the results of marine reserve decision-making processes. Voting rules shape the balance of power between majority and minority interests. Decision-making by consensus, for example, grants significantly more power to minority interests than decision-making by simple majority. Consensus-based voting rules, therefore, may preclude marine reserve designs acceptable to most decision-makers but strongly opposed by a few. Voting rules also shape perceptions of the legitimacy of decision-making processes among both minority and majority groups. Similarly, the rules and criteria established to govern decisions (e.g., requiring that a given percentage of the coastline must be designated as marine reserves) often shape the outcome of decision-making processes.

Resource Use Rules

Rules governing resource use are the second principal component of marine reserve design. Resource use rules—including laws, regulations, formal and informal policies, codes of conduct, and social norms—specify the rights (i.e., privileges) of individuals or groups to access and appropriate marine resources.

[1] In this chapter, the term *resource user* refers to individuals who derive consumptive or nonconsumptive benefits from their physical interactions with the marine environment. The term *stakeholder,* which includes but is not limited to resource users, refers to individuals and organizations with a significant interest in the marine environment or its management.

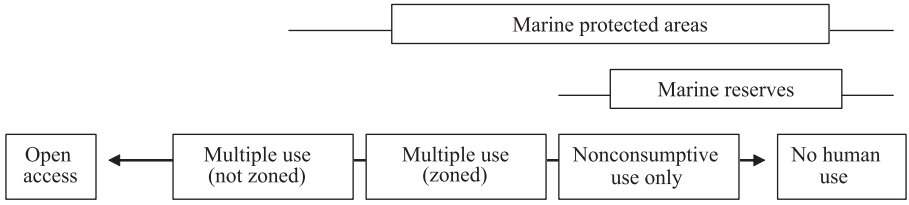

FIG. 6.1 Relationship of Marine Reserves to Other Systems of Marine Resource Governance, Including MPAs.

These rights may be held by individuals, groups, organizations, or the state, and are often shared among these actors. Moreover, resource use rights are seldom absolute. The U.S. government, for example, may alter the resource use rights of individuals without compensation when legitimately exercising its public trust authority. Though the right to change the rules governing resource use is generally held by governments, this decision-making authority may be shared with or delegated to resource users or other stakeholders. In the state of Maine, for example, lobster fishermen are governed by formal laws and informal codes of conduct that specify where, when, and how they may fish. The Maine state government recently granted lobstermen limited decision-making authority over resource use rules, including the right to specify trap limits, through the establishment of regional lobstermen-only "councils" (Acheson 2003).

Rules governing resource use thus specify how individuals may interact with each other and the marine environment. Infinite possible configurations of resource use rules exist, ranging along a continuum from "open access" (i.e., no rules) to a complete prohibition on human activities (Fig. 6.1). Marine reserves lie toward the latter end of this continuum but display a great deal of subtle variation in the rules governing resource use. Many reserves limit nonconsumptive recreational, commercial, or scientific activities, in addition to prohibiting all extractive activities (which are forbidden, by definition, in all marine reserves). Marine reserves are also frequently incorporated within larger marine protected areas with multiple regulatory zones, each of which may have a distinct set of rules governing resource use. The Florida Keys National Marine Sanctuary, for example, has several categories of regulatory zones, including three types of marine reserves: ecological reserves, sanctuary preservation areas, and research only special use areas.

Rules governing resource use shape marine reserve performance by establishing use rights that foster specific policy outcomes. Because it is often impos-

sible to maximize multiple policy objectives simultaneously, decision makers must frequently design marine reserve resource use rights that reflect tradeoffs among social, economic, and environmental goals. In designing the Tortugas Ecological Reserve (Florida, U.S.A.), for example, decision makers considered five policy alternatives. Alternative 1 emphasized short-term economic benefits over environmental sustainability by failing to establish a marine reserve in the Tortugas. By contrast, Alternative 5, the most expansive marine reserve proposal, emphasized environmental sustainability at the expense of short-term economic costs. Decision makers ultimately approved Alternative 3, a 151 nm^2 marine reserve (U.S. Department of Commerce 2000), which represented the middle-ground balance of economic and environmental outcomes.

The precision and stability of resource use rights mold individual behavior. Precise marine reserve rules specify clear use rights, minimizing conflict among resource users or between resource users and enforcement personnel. In some marine reserves, for example, dive operators may only use particular dive sites at assigned times; such arrangements prevent crowding and conflict among users. Rules foster conflicts when they fail to specify clear resource use rights, raising the costs of resource use and thus dissipating the benefits to resource users. Likewise, imprecise and unstable resource use rights create uncertainty over future opportunities, causing users to discount the future sharply and exploit resources more heavily than they otherwise would. Well-defined resource use rights—precise, stable, easily understood, and easily enforceable—enhance the economic benefits and environmental sustainability of marine reserves by reducing social conflict and creating greater certainty regarding future resource use.

Monitoring and Enforcement Systems

Marine reserve monitoring systems track changes in the state of reserve-associated social and environmental systems. Reserve monitoring systems vary in what they measure and who does the measuring, as well as where, when, and how measurements are made. Carefully designed monitoring systems—which generally include robust performance indicators, baseline data, and control sites—can provide insights into the changes in social and environmental systems due to reserve establishment. In practice, many marine reserves lack formal systems for monitoring environmental and, especially, social phenomena. As a result, resource users, managers, and other stakeholders often informally monitor environmental and social indicators to assess reserve performance. Monitoring-based assessments of performance can guide future re-

serve policy and management decisions, as well as enhance confidence in current policies and management practices. In Belize, for example, formal and informal assessment of the social and environmental performance of the Hol Chan Marine Reserve led to widespread support for expansion of the reserve (Mascia 2000; see chapter 10).

Enforcement systems attempt to increase compliance with rules governing resource use by monitoring individual behavior and sanctioning noncompliance. By increasing the severity and likelihood of sanctions and, thus, raising the opportunity cost of noncompliance, enforcement systems act directly upon resource users to foster adherence with established rules. Monitoring user behavior forces would-be poachers to engage in deceptive practices that diminish the benefits of engaging in prohibited activities. Sanctioning noncompliance further diminishes the benefits of engaging in prohibited activities and thus deters malfeasance. The role of enforcement systems has been demonstrated in the Bahamas, where aggressive enforcement of "no fishing" regulations at the Exuma Cays Land and Sea Park dramatically reduced the frequency and extent of fishing within the reserve (Mascia 2000).

Enforcement systems also shape compliance indirectly. By shaping perceptions of the efficacy of enforcement efforts, enforcement systems affect rates of "contingent compliance," where individuals base their decision to comply with rules governing resource use upon the (perceived) rate of compliance by others (Levi 1997). The theory of contingent compliance posits that, because individuals seek to avoid being a "sucker" by obeying the rules while others are not, individuals become increasingly likely to obey the rules as the perceived rate of compliance by others increases. Perceptions of the legitimacy of enforcement systems also shape compliance; both the design of sanction mechanisms and the perceived "fairness" of enforcers shape perceptions of legitimacy. Research suggests that meaningful but graduated and context-dependent sanctions, which ensure that punishment fits the crime, are generally perceived as more legitimate than draconian, one-size-fits-all penalties (Ostrom 1990).

Conflict Resolution Mechanisms

Conflict resolution mechanisms are formal and informal processes for resolving disputes. Conflict resolution mechanisms permit information exchange, clarification of resource use rights, and adjudication of disputes related to decision making, resource use, monitoring, and enforcement. Critical questions in the design of conflict resolution mechanisms include, Who may par-

ticipate? and Who adjudicates? Other important design issues include the frequency and location of conflict resolution activities. Readily accessible and low-cost conflict resolution mechanisms enhance regime performance directly by mitigating social conflict and thereby minimizing resource overexploitation and dissipation of reserve benefits (Ostrom 1990). Conflict resolution mechanisms also enhance marine reserve performance by giving voice to aggrieved parties and acknowledging their concerns, which increases the legitimacy of reserve rules and regulations.

BELIEFS AND VALUES

Underlying marine reserve design and, thus, reserve performance, are human beliefs and values. *Beliefs* are "what people think the world is like," whereas *values* are "guiding principles of what is moral, desirable, or just" (Kempton et al. 1995). Beliefs and values vary among individuals but often display consistent patterns of variation at the level of social or cultural groups. In a study of environmental beliefs and values in the United States, for example, Kempton et al. (1995), found that diverse social groups—loggers, environmentalists, small business owners, and policy makers—shared similar beliefs about the anthropogenic causes of global climate change but differed in the ways that they valued biodiversity. The converse is also possible, where groups may share values but diverge in their beliefs.

Beliefs shape the emergence and evolution of marine reserves. Most conservationists, for example, believe that fishing is the primary threat to marine biodiversity. Based on this shared belief, conservationists generally advocate the establishment of large marine reserves that prohibit fishing and focus less attention on other threats to marine biodiversity, such as land-based sources of pollution, habitat loss, or the introduction of exotic species. Many Caribbean fishermen, by contrast, believe that natural variability and habitat alteration induced by land-based pollution are the principal causes of fish population declines. Consistent with this belief, Caribbean fishermen often argue against the necessity of marine reserves and instead urge more effective coastal zone management (Mascia 2000; Robertson 2002, 197–198). These two belief systems suggest dramatically different approaches to marine conservation in the Caribbean; the policy manifestations of these divergent beliefs are shaped, in large part, by the design of decision-making arrangements.

Beliefs directly and indirectly shape marine reserve performance. Environmental policies based on faulty conceptual models of environmental dynamics or human behavior, for example, have little prospect of achieving their

specified objectives. Early efforts to conserve sea turtles through "headstart" programs were ineffective because conservationists believed, incorrectly, that increasing the survivorship of turtle hatchlings was the key to species recovery. In fact, more recent conservation science demonstrates that recovery of sea turtle populations is most sensitive to protection of juveniles, which are now protected from fisheries mortality through legally mandated gear modifications (Crowder et al. 1994; Heppell, Crowder, and Crouse 1996). The efficacy of the gear modification program, however, has been hindered by the belief among fishermen that the modified gear is not actually necessary to conserve turtles and, moreover, reduces catch (Margavio and Forsyth 1996; White 1989). These beliefs have reduced the legitimacy of the gear regulations in the eyes of fishermen and, as a result, have reduced compliance rates—to the detriment of sea turtle populations.

Values also shape marine reserve design. Organizational values (i.e., values shared among members of an organization or agency) shape the manner in which organizations set management priorities and undertake mandated activities. Similarly, decision makers' values limit the bounds of debate over both policy objectives (i.e., ends) and design (i.e., means). Policy objectives and designs that lie outside the bounds of what is considered "good, desirable, or just" are never raised in discussion or are rejected by decision makers. Based on his experience in East Africa, McClanahan (1999, 324) argues that, in any given country, "the types [of] and area in MPAs [marine protected areas, including marine reserves] will depend upon societal values." Similarly, Orbach (1995) notes that the United States has a two-track system of marine wildlife management rooted in American cultural values: U.S. fisheries policy *encourages* direct harvest of marine fishes (to generate "optimum yield"), whereas U.S. marine mammal policy generally *prohibits* direct harvest of all marine mammals (to foster "maximum sustainable populations"). Thus, American values clearly hold that what is "good, desirable, or just" for fish is very different from that which is good, desirable, or just for whales, seals, sea lions, and other marine mammals.

Values shape marine reserve performance through multiple indirect mechanisms. By defining the bounds of policy debate, decision makers' values may preclude consideration of policy approaches that would be effective but are perceived as "unjust," resulting in selection of less effective but more socially acceptable strategies. Differences between stakeholders and decision makers as to what actually constitutes socially acceptable policy can influence the perceived legitimacy of policies, which, in turn, may shape the rate and degree to which

agency personnel undertake mandated activities (Mascia 2000). Resource users' value-based perceptions of policy legitimacy also influence compliance rates. In the South Pacific, for example, the efficacy of traditional community-based marine reserves appears correlated with resource user values regarding local customs and traditions—particularly customary law and the authority of traditional village chiefs (Johannes 1978).

SOCIAL DIMENSIONS OF PERFORMANCE

The social and environmental changes induced by marine reserve establishment can be monitored over time to provide measures of reserve performance. Performance can be measured against implicit and explicit marine reserve policy objectives, as well as using generic standards and criteria for "good" policies, such as social equity, economic efficiency, and environmental sustainability. Evaluations of reserve performance foster accountability, promote social learning, and provide the impetus for replicating successful policies and reforming unsuccessful ones. Most analyses of marine reserve performance to date have focused upon environmental outcomes because these are the primary impetus for reserve establishment and perhaps simpler to measure. The social dimensions of reserve performance (Table 6.1), however, are generally of greater concern to most direct users of marine resources and often the source of contentious debate during reserve development and management. Unfortunately, the dearth of social scientific research on the social and economic performance of marine reserves frequently limits policy discussions to largely conceptual terms.

Economic

The economic performance of marine reserves can be measured according to both efficiency and equity criteria. The most complete indicator of reserve efficiency, and the most difficult to measure fully, is the relative change in the total economic value (TEV) that society derives from the marine environment following reserve establishment. Because of the difficulty associated with measuring TEV, researchers generally focus on its component parts: use values and nonuse values. Use values are the benefits and costs derived from direct use (e.g., fishery harvests, oil extraction, dive tourism) and indirect use (e.g., fisheries production, shoreline protection, nutrient cycling) of the marine environment. Nonuse values (also known as passive use values) include option, existence, and bequest values. The option value of a marine reserve is the value derived

Table 6.1 Select Social and Economic Performance Indicators[a] for Marine Reserves.

Economic Efficiency Indicators
Total economic value
Direct use value
Indirect use value
Option value
Existence value
Bequest value
Economic Equity Indicators
Income among social groups or subgroups
Wealth among social groups or subgroups
Wealth disparity among social groups or subgroups
Geographic distribution of costs and benefits
Sociocultural Indicators[b]
Employment levels
Crime, domestic violence, or alcoholism rates
Gender, ethnicity, age, religious affiliation, or other demographic attributes
Perceptions of individual, household, or community well-being

[a] These indicators may be measured for an affected population in its entirety or for particular groups or subgroups.

[b] Performance indicators measure relative changes in the state of social or environmental systems following reserve establishment.

from the potential future use of the reserve and its components. The existence value of a marine reserve is the value that individuals derive based solely upon the knowledge that the resource exists, whereas the bequest value of a reserve is the value that individuals derive based upon the knowledge that the marine reserve and its components will be available to future generations. Direct use values and some indirect use values accrue in monetary terms and may be directly measured; many indirect use values and all nonuse values provide nonmonetary benefits and costs and therefore cannot be measured directly (Bunce et al. 2000; NRC 2001).

The net effect of marine reserve establishment upon the total economic value of marine resources is not clear. The only study known by the author to measure the TEV of a marine reserve, a survey of the "willingness to pay" of tourists and local residents, estimated the total economic value of the Montego Bay Marine Park, Jamaica, at approximately $20 million (Spash et al. 2000). Clearly, one study is insufficient to make any definitive statements regarding the total economic value of marine reserves, though this research suggests that the total economic value of marine reserves may be quite significant.

The economic literature demonstrates that the direct use costs and benefits of marine reserves may be significant, varying dramatically in accordance with preexisting site-specific resource use patterns and reserve rules governing resource

use. Because consumptive direct uses are prohibited within marine reserves, there are usually clear costs associated with reserve establishment and the subsequent discontinuation of consumptive activities. Leeworthy and Wiley (2002) estimate that the "preferred alternative" marine reserve zoning system in the Channel Islands National Marine Sanctuary (California, U.S.A.) will result in maximum annual net costs of $902,000 in forgone benefits from consumptive recreational diving and fishing. Similarly, maximum annual net costs associated with loss of consumptive uses following establishment of the "preferred alternative" Tortugas Ecological Reserve in Florida are estimated at $880,000 in forgone commercial fishing benefits and $126,000 in forgone benefits from consumptive recreational activities (Leeworthy and Wiley 2000). It is worth noting, however, that the economic costs of forgone opportunities within marine reserves may not be incurred by resource users since these individuals may compensate for the loss of access to reserve resources by continuing their activities in nonreserve areas.

The net economic value of nonconsumptive direct uses of marine reserves varies in accordance with the rules governing resource use within reserve boundaries. If nonconsumptive uses such as scuba diving are prohibited, then the direct use costs of reserve establishment will be equivalent to the opportunity cost of forgone activities. If nonconsumptive uses are permitted, however, the net value of nonconsumptive direct uses is likely to be positive; that is, the value of nonconsumptive uses within reserves is likely to increase following marine reserve establishment with enhanced production of ecosystem goods and services. Dixon et al. (1993), and Vogt (1997) both suggest that the economic benefits from the nonconsumptive direct uses of marine reserves exceed the costs of forgone consumptive activities, but both studies' results are based on incomplete cost–benefit analyses. The net economic benefit of the Tortugas Ecological Reserve to nonconsumptive scuba divers at the time of reserve establishment was $25,000 annually (Leeworthy and Wiley 2000), a value that is expected to increase over time.

The indirect use value of marine reserves is not well documented either. Measuring the relative change in indirect use benefits and costs following reserve establishment is a significant challenge that economists have yet to overcome. The most obvious indirect use values of marine reserves, the "spillover" of fishery resources due to greater biological productivity of the protected marine environment, has been estimated using proxy measures in modeling and empirical studies. One bioeconomic fisheries model estimates that optimal establishment of marine reserves worldwide would increase the global harvest value of coral reef fisheries by approximately 5.5 percent ($1 billion) annually

(Pezzey et al. 2000). Using the relative change in catch per unit fishing effort (CPUE) outside marine reserves as a proxy for indirect consumptive use value, studies suggest that the indirect use values of marine reserves vary widely across sites and over time: published values range from no significant change in CPUE to increases of greater than 100 percent (Goodridge et al. 1996; McClanahan and Kaundra-Arara 1996; McClanahan and Mangi 2000; Roberts et al. 2001). In theory, CPUE values could be translated into estimates of the net indirect consumptive use values, though researchers have failed to do so as yet. Researchers comparing total fisheries yields before and after marine reserve establishment (an imperfect proxy for comparing the total direct and indirect use value of fishing) found total yields following reserve establishment to be 30 to 35 percent *less* than yields prior to reserve establishment (McClanahan and Kaunda-Arara 1996; McClanahan and Mangi 2000).

The indirect use value of marine reserves for nonconsumptive activities has not been well measured, though one would predict that the expected indirect value of reserve establishment should be positive. This prediction assumes that there is a positive relationship between the ecological integrity of marine ecosystems and the goods and services that these ecosystems provide to humans. Dive operators, for example, would presumably benefit from the enhanced production of ecosystem goods and services (e.g., spillover of fish) that results from marine reserve establishment. Similarly, coastal residents might benefit from enhanced shoreline protection in coastal areas adjacent to reserves.

The nonuse values of marine reserves appear to be positive, perhaps substantially so, but economists have not yet attempted to measure these costs and benefits directly. Research suggests that these values should vary depending upon the social significance of the marine reserve (Farrow 1996), though economic research has not explicitly tested this hypothesis. Using a thought experiment, Leeworthy and Wiley (2000) estimate the *nonuse value* of a marine reserve within the Florida Keys National Marine Sanctuary at between $3.39 million and $11.3 million annually. Scholz and Fujita (2001, 7), using virtually the same thought experiment, ascribe an identical value to solely the *existence value* of a marine reserve in the Channel Islands National Marine Sanctuary. Assuming a 3 percent discount rate and annual payments of $3 to $10 from 1 percent of U.S. households, the *total nonuse value* of a Florida Keys marine reserve is an estimated $113 to $377 million (Leeworthy and Wiley 2000). Because these estimated values are the product of thought experiments rather than scientific research based on measurement and observation, they must be viewed with caution—actual values could be substantially higher or lower than researchers predict.

The economic performance of marine reserves may also be measured using equity criteria. Indicators of economic equity track the relative changes in monetary and/or nonmonetary benefits and costs that accrue to different social groups as a result of reserve establishment. Measures of relative change in income, wealth, or wealth disparity among specific groups or subgroups (e.g., fishermen and divers, line fishermen and net fishermen), for example, represent useful indicators of the distributive economic effects of reserve establishment. The effect of marine reserves on economic equity may also be measured using indicators that track the net economic effect of reserves on populations of particular concern, such as women, minorities, the poor, the elderly, or traditional cultures. The geographic distribution (e.g., local versus national) of costs and benefits is also a useful indicator of the economic equity of a marine reserve.

The effects of marine reserve establishment on economic equity are perhaps even less well understood and less well studied than reserve effects on efficiency. Among those marine reserves that permit nonconsumptive uses, the general qualitative pattern that follows marine reserve establishment is a transfer of direct use benefits from consumptive resource users such as fishermen to nonconsumptive users such as dive operators and scientists. In Barbados, for example, establishment of the Barbados Marine Reserve shifted the local system of resource use rights from a virtual "open access" system that permitted both consumptive and nonconsumptive uses to an ecotourism and scientific use regime that allowed only nonconsumptive uses (Mascia 2000). Among marine reserves that prohibit both consumptive and nonconsumptive uses, all direct users incur costs associated with the loss of resource use rights within the reserve. In this instance, equity indicators include measures of the relative magnitude or significance of the costs incurred by user groups or populations of particular concern.

Among both consumptive and nonconsumptive users, the distributive economic effects of reserve establishment vary by subgroup. In St. Lucia, for example, establishment of the Soufriere Marine Management Area affected net fishermen and trap fishermen differently (Goodridge et al. 1996). In general, small-scale fishermen, especially those who use fixed gear or fish within informal fishing territories, are more vulnerable to the loss of fishing grounds than larger scale, transient fishermen employing mobile gear. Small-scale and territorial fishermen, when affected by reserve establishment, lose a larger percentage of their fishing grounds than large-scale or transient operators. The latter groups, however, may be more likely to lose a portion of their fishing grounds to marine reserves simply because they fish a larger geographic area. The distributive

economic impact of reserve establishment on nonconsumptive users appears correlated with users' degree of economic dependence upon the natural environment. Dive operators, for example, are more likely to benefit from reserve establishment than jet-ski businesses.

Sociocultural

The extent to which marine reserves achieve sociocultural policy objectives may also be measured and evaluated using performance indicators. Sociocultural performance indicators include relative changes in employment levels, crime rates, domestic violence rates, and alcoholism rates among specific groups, as well as shifts in household relations and modes of production. Demographic indicators include relative changes in the gender, ethnic, age, and religious profile of specific groups (e.g., resource users). Perceptions of individual, household, and community well-being provide measures of aggregate reserve performance—social, economic, and environmental.

The sociocultural dimensions of marine reserve performance have not been well studied. The limited data available suggest that small-scale fishermen may incur significant costs and be fully or partially displaced from the fishing industry by the establishment of marine reserves (Dobrzynski and Nicholson 2003; Goodridge et al. 1996; Mascia 2000; McClanahan and Mangi 2000). McClanahan and Mangi (2000), for example, report a 60 to 80 percent decline in the number of fishermen at the Jomo Kenyatta Beach fish landing site following establishment of the no-take Mombasa Marine Park in Kenya. Many displaced resource users gain full or partial employment in other sectors, such as construction or tourism, but older fishermen, in particular, appear less able to take advantage of alternative economic opportunities. Marine reserves may also induce new migration patterns by restructuring economic opportunities, drawing people to local communities in the case of some reserves and displacing them from adjacent communities in other situations. These shifting migration patterns frequently change the demographic profile of user groups and coastal communities, as was discussed previously with respect to the Hol Chan Marine Reserve. Perceptions of individual, household, and community well-being appear to vary by stakeholder group and depend largely upon the distributive economic impacts of reserves (Mascia 2000). No known research has examined the impact of marine reserve establishment upon social indicators such as rates of crime, domestic violence, or alcoholism, demonstrating the need for further study.

RELATIONSHIP BETWEEN DESIGN AND PERFORMANCE

The structure of marine reserve decision-making arrangements has a significant effect upon reserve performance. In marine reserves and analogous natural resource governance regimes, research demonstrates that the right of resource users to participate in the design and modification of rules governing resource use is correlated with regime performance—environmental and social (Christie and White 1997; Mascia 2000, 2001; Ostrom 1990; Pollnac et al. 2001). Research also suggests that resource user self-governance rights (i.e., the right to govern the behavior of one's group, independent of external authorities) are correlated with reserve establishment and performance (Mascia 2000; 2001). Selecting basic rules and criteria to govern decision making (i.e., process guidelines) before attempting to make substantive choices about reserve design may help to reduce conflict and facilitate informed decisions among stakeholders with diverse interests, beliefs, and values (Mascia 2001).

Research demonstrates that the clarity and congruence of rules governing resource use influence marine reserve performance. Clearly defined resource and reserve boundaries, as well as clearly defined individual resource use rights, tend to improve the social and environmental performance of marine reserves and other natural resource governance regimes (Ostrom 1990; Mascia 2000, 2001). Rules governing resource use that are explicitly linked to local conditions also tend to enhance reserve performance (Mascia 2000). Research also suggests that the presence of economically congruent resource use rights—where the resource users who benefit most from reserve establishment bear the greatest cost of sustaining reserve benefits, while those who derive the fewest benefits incur the least cost—foster marine reserve performance (Mascia 2000). Among effective marine reserves, research suggests that the rules governing resource use have sufficient scale and scope to address all threats that significantly affect the social or environmental systems of the reserve (Mascia 2000). Finally, the performance of legally designated marine reserves tends to be enhanced when reserve resource use rights are consistent with existing informal or culturally based resource use rights (Fiske 1992; Mascia 2000).

Research on the role of monitoring and enforcement systems in marine reserve performance highlights the importance of accountability, legitimacy, equity, and flexibility. Monitors who actively assess resource conditions and are accountable to resource users (or who are themselves resource users) tend to improve the performance of marine reserves and analogous resource governance regimes (Buhat 1994; Ostrom 1990; Woodley and Sary 2003). Likewise,

reserve performance is enhanced by the presence of active and accountable monitors of resource use behavior (Mascia 2000; Roberts 2000; Woodley and Sary 2003). Again, monitors may themselves be resource users. Sanctions for noncompliance must not only be likely and severe enough to raise the cost of noncompliance but also graduated and context-dependent to ensure that punishment fits the crime (Ostrom 1990; Mascia 2000).

The role of conflict resolution mechanisms in marine reserve performance is not yet clear. Available data suggest that low cost, local, and readily accessible conflict resolution mechanisms tend to enhance the performance of marine reserves and analogous natural resource governance regimes (Ostrom 1990; Mascia 2000). Additional research is clearly needed to understand better the role of conflict resolution mechanisms in reserve performance.

POLICY IMPLICATIONS

The relationships between marine reserve design and performance previously outlined have significant implications for marine reserve policy. Integrating these "lessons learned" into reserve design can contribute to the development of more effective marine reserves, as well as the reform of existing sites. Differences in goals and context make a rigid blueprint design for socially and environmentally effective marine reserves inappropriate, but policy guidelines composed of general principles for reserve design are possible and practical (Box 6.1). The policy guidelines outlined here should be viewed as working hypotheses that are based upon the best available social scientific knowledge, but subject to future revision.

First and foremost, resource users should share responsibility and authority for marine reserve development and management as part of a collaborative management (i.e., comanagement) system. Decision-making arrangements should grant relevant resource user groups "a seat at the table" and an equitable share of voting rights, and, where appropriate, should establish process guidelines that specify basic rules and criteria for decision-making. To ensure that resource user representatives advance group interests when participating in decision-making processes, formal and informal mechanisms (e.g., elections, consultative sessions) should be established to ensure that representatives are accountable to their constituents. As part of marine reserve management systems, mechanisms should be established to encourage and legitimize resource user self-governance initiatives that advance recognized policy objectives. Mechanisms should also be established to facilitate appropriate resource user

6.1 Principles for Marine Reserve Design

1. *Share responsibility and authority.* Bringing diverse stakeholder groups, including resource users, into marine reserve decision-making and management processes improves the substance and legitimacy of these decisions, increases management capacity, and enhances the legitimacy of management activities.
2. *Foster accountability.* Accountability mechanisms (e.g., elections, consultative sessions, or open meetings) increase the likelihood that decision makers will further constituents' interests rather than personal interests in decision-making processes. Accountability mechanisms also foster fair and active enforcement of rules governing resources use by enforcement personnel.
3. *Facilitate resource user self-governance.* Resource user self-governance initiatives that are consistent with reserve policy objectives can serve as effective complements to other management efforts.
4. *Clearly define reserve rules and boundaries.* Clear marine reserve boundaries and clear rules governing resource use within reserves foster compliance and simplify enforcement.
5. *Explicitly link rules governing resource use to social and environmental conditions.* Linking reserve rules to the state of social and environmental systems fosters adaptive (and more socially and environmentally sustainable) management of these systems.
6. *Structure reserve rules so that benefits of resource use are roughly proportional to costs of providing these resources.* Reserve rules that allocate resource use benefits to users in rough proportion to the costs that these users incur to provide the same marine reserve resources will likely be perceived as more legitimate, and thus enjoy greater compliance, than rules that allocate benefits disproportionate to their costs.
7. *Build upon informal resource use rights.* Building marine reserves on the foundation of existing systems of informal or customary resource use rights enhances reserve legitimacy and fosters compliance among resource users.
8. *Monitor reserve performance—environmental and social.* Tracking the environmental and social dimensions of marine reserve performance provides the basis for adaptive management.
9. *Make research and monitoring participatory.* Enlisting stakeholders, including resource users, in data collection and analysis educates participants, builds capacity, and fosters trust.
10. *Share monitoring results.* Sharing information regarding the environmental and social performance of marine reserves may enhance reserve legitimacy or provide the impetus for necessary policy reform.
11. *Make punishment fit the crime.* Graduated, context-dependent sanctions enhance compliance by raising the opportunity cost of noncompliance and enhancing the perceived legitimacy of the reserve.
12. *Share information regarding compliance rates and enforcement actions.* Broad dissemination of information regarding compliance rates and enforcement actions can enhance reserve legitimacy and foster contingent compliance.
13. *Establish highly accessible conflict resolution mechanisms.* Highly accessible conflict resolution mechanisms provide a vehicle for resolving disputes that would otherwise increase costs of resource use and, thus, diminish reserve benefits.

Source: Adapted from Mascia 2001.

and other stakeholder participation (formal and informal) in monitoring reserve performance and enforcing rules governing resource use.

Second, resource use rights should be clearly defined and congruent with the local social and environmental context. Reserve boundaries (internal and external) should be designated in a clear and culturally appropriate manner, such as using landmarks or buoys rather than global positioning system (GPS) coordinates. Similarly, resource use rights must be clearly specified (e.g., no-take zone rather than numerous species-specific size limits), so that users and enforcers know what is permissible and what is not. Rules governing resource use should be explicitly linked to and contingent upon the state of site-specific environmental and social conditions. Moreover, the scale and scope of rules governing resource use should be sufficient to address the anthropogenic activities that threaten reserve performance. Resource use rules should also be designed so that the benefits an individual derives from reserve establishment are roughly proportional to the costs he or she incurs to maintain provision of reserve benefits. Finally, rules governing resource use within marine reserves should build upon and reinforce existing informal or customary resource use rights that are consistent with reserve policy objectives.

Third, monitoring and enforcement systems should be active, accountable, and just. Monitoring systems should track the environmental and social aspects of reserve performance. Findings should be disseminated among stakeholders to enhance reserve legitimacy or provide impetus for necessary policy reform. Mechanisms (including the participation of resource users in monitoring efforts) should be established to ensure the accountability of monitors to resource users. Enforcement systems should also include accountability mechanisms, such as participation of resource users in formal and informal enforcement efforts. Information regarding enforcement efforts and compliance rates should be disseminated to increase user confidence in enforcement efforts and encourage contingent compliance with rules governing resource use. Sanctions for noncompliance should be graduated and based upon the seriousness of the offense (as well as other contextual factors) to ensure that punishment is just.

Finally, conflict resolution mechanisms should be established to resolve disputes among resource users, reserve officials, and other stakeholders. These mechanisms should minimize economic or logistical barriers to participation in order to foster rapid resolution of conflicts over resource use rights, enforcement actions, and decision-making processes. This suggests that conflict resolution should be a local, decentralized process that includes both formal and informal mechanisms. Though existing marine reserve research provides

little guidance on this point, informal conflict resolution mechanisms might include ad hoc "gripe sessions" (i.e., informal gatherings of stakeholders and reserve personnel to discuss issues of concern) and the informal designation of "elder" reserve personnel and resource users as unofficial arbitrators. More formal conflict resolution mechanisms might include regular consultations between resource users and reserve personnel, as well as nonbinding "stakeholder courts" designed to adjudicate disputes.

CONCLUSION

The social dimensions of marine reserve design and performance are as complex as the environmental dynamics that have been the focus of marine reserve research to date. More complete consideration of social criteria is critical to both defining and achieving "successful" marine reserves. Decision-making arrangements, resource use rights, monitoring and enforcement systems, and conflict resolution mechanisms all shape marine reserve design and performance by influencing individual choices and human behavior. Beliefs and values, too, shape reserve design and performance by molding individual choices. Reserve establishment impacts not only the state of environmental systems but also that of social, economic, and cultural systems as well. Comprehensive assessments of reserve performance, therefore, include not only measures of changes in fish abundance or species richness but also direct and indirect use values, the distribution of wealth, social relations, and perceptions of well-being. Social scientific research into the relationship between marine reserve design and performance has provided some valuable insights that can serve as working hypotheses for reserve policy, but further study is clearly necessary to enhance our understanding of this relationship and to improve our ability to design socially and environmentally effective marine reserves.

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