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Why Have No-Take Marine Protected Areas?

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Abstract.—Although the title of this symposium implied a focus on fully protected marine areas, most presentations actually dealt with a range of traditional "marine protected areas" or "marine managed areas" that offer less than "full" resource protection. Some presentations noted a backlash against establishing no-take reserves. Here we provide 17 reasons why there is a strong scientific, management, and public interest in using no-take marine reserves to build sustainable fisheries and protect marine ecosystems. We also discuss some underlying technical and philosophical issues involved in the opposition to their usage.

Introduction

Marine protected areas are used increasingly to manage marine resources, but they often mean different things to different people, based primarily on the level of protection they provide. The World Conservation Union defined marine protected areas (MPAs) as "any area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (IUCN 1994; Kelleher 1999). In the USA, Presidential Executive Order 13158 provided a similar definition: "any area of the marine environment that has been reserved by Federal, State, territorial, tribal or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." Under these broad definitions, a wide variety of sites could be considered as MPAs.

We focus on "marine reserves," here defined as marine protected areas permanently closed to all fishing and other extractive uses with limited exceptions for research and education by permit (Ballantine 1997). Because of the many different terms that have been used to describe marine reserves, the terminology is often confusing to both scientists and the public. Common terms used to describe marine reserves include no-take areas, nonconsumptive areas, fishery reserves (PDT 1990), marine ecological reserves, sanctuary preservation areas (USDOC 1996), research natural areas (Brock and Culhane 2004, this volume), fully protected areas (Roberts and Hawkins 2000), and sanctuary, outside the USA.

Closing areas to fishing has long been widely practiced in fishery management in historical and modern times to protect critical habitat, restore depleted species, and protect vulnerable stocks at spawning aggregation sites (e.g., Beverton and Holt 1957). Most closures, however, have been either seasonal, applied only to specific species, or have been limited to restrict certain destructive or wasteful fishing methods. Rarely have areas been permanently closed to all types of fishing. Modern fisheries interest in marine reserves began in the 1980s as a way to both protect marine ecosystem biodiversity and build sustainable fisheries (PDT 1990; Bohnsack 1996; Bohnsack and Ault

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1996). This interest has accelerated after failures of traditional fishery effort and size control measures to support sustainable fisheries and prevent collapses of fisheries and coastal ecosystems (Ludwig et al. 1993; Russ 1996; Botsford et al. 1997; Jackson 1997; Guénette et al. 1998; Pauly et al. 1998, 2002; Jackson et al. 2001; Christensen et al. 2003; Myers and Worm 2003; Rosenberg 2003).

Marine reserve implementation remains a rare and controversial measure despite support from numerous theoretical and empirical studies (Johnson et al. 1999; Murray et al. 1999; Fogarty et al. 2000; Roberts et al. 2001; Halpern and Warner 2002; Halpern 2003) and reviews that call for their expanded application in resource management (PDT 1990; NRC 1999, 2001; Roberts and Hawkins 2000; Ward et al. 2001; Pew Oceans Commission 2003; Pauly 2004, this volume). In response to the rare use of marine reserves, 161 academic scientists took the unusual step of issuing a signed consensus statement supporting the specific use of no-take marine reserves at the 2001 annual meeting of the American Association of Science (NCEAS 2001). Widespread concerns over marine resource protection in the USA resulted in Presidential Executive Order 13158, which seeks to inventory and assess existing MPAs (U.S. Office of the Federal Register 2000), and the adoption of a goal to protect 20% of U.S. coral reefs with marine reserves by 2010 by the U.S. Coral Reef Task Force (USCRTF 2000). The two largest U.S. marine reserve networks were established only recently in Florida and California. Two ecological reserves covering 280 km^2 (151 nautical mi^2) in the Tortugas region of the Florida Keys National Marine Sanctuary were established in 2001 (USDOC 2000). A contiguous 87-km^2 (47-nautical-mi^2) no-take research natural area was also approved for Dry Tortugas National Park but has not yet been implemented (Brock and Culhane 2004, this volume). Most recently, 10 reserves covering 244.5 km^2 (132 nautical mi^2) in the Channel Islands, California, were established in 2002 (McArdle et al. 2003).

Application of marine reserves has been controversial and has generated a backlash at times by those who favor continued use of other traditional fishery management actions (Shipp 2003) or multiple-use MPAs with only limited restrictions (Agardy et al. 2003; Clark 2003). Some concerns are that marine reserves may not be effective for biological (Carr and Reed 1993) or other reasons (Jameson et al. 2002); could be counter productive to conservation for social reasons (Agardy et al. 2003); and could threaten fishing "rights" of recreational anglers as expressed in the proposed Freedom to Fish Act (Lydecker 2004, this volume).

Here, we present reasons why there is a high degree of scientific, management, and public interest in using permanent no-take protection compared to using "multiple-use" zoning or other traditional fishery management measures. Our intent is to clarify the issues in the continuing debate on appropriate use of marine reserves and spatial management in marine fishery and conservation management.

Results

Permanent, no-take marine reserves have certain unique qualities with potential benefits that are not necessarily provided by other types of marine protected or managed areas. Below we describe 17 unique attributes of marine reserves roughly organized into categories under fundamental, scientific, and management considerations.

Fundamental Considerations

(1) High Level of Ecosystem Protection

Fishing is a known major threat to marine populations and ecosystems (Dayton et al. 1995; Pauly et al. 1998, 2002, 2003). By removing fishing, no-take reserves potentially provide a high level of resource protection by eliminating threats from directed take of targeted organisms, bycatch mortality of nontarget organisms, and habitat damage from fishing activities. In an endless gradation between totally open and completely closed, marine reserves provide a high level of protection but not total protection. They do not, for example, directly protect against regional pollution, climate change, natural disturbance, or human disasters (Jameson et al. 2002). Other provisions can be added that provide higher levels of resource protection, such as prohibiting touching, diving, research, or even human entry, but with potential social and economic costs in terms of reduced benefits from nonextractive activities.

(2) Potential Ecological Integrity

Because no-take marine reserves protect all species, habitats and populations impacted by previous fishing can eventually recover and restore ecological integrity to reflect "natural" ecosystem structure and function. Permanent protection allows ecological integrity to ultimately persist in reserves.

(3) Precautionary Approach
The precautionary approach can be stated simply: when in doubt, be cautious. In practice, if you don't have a complete understanding about the functioning and dynamics of natural systems or their management, then some resources should be withheld from exploitation until a complete understanding is obtained (Bohnsack 1999a). Lauck et al. (1998) demonstrated how marine reserves can mitigate the effects of uncertainty associated with fishery exploitation.

(4) Shifted Burden of Proof
Compared to other types of managed areas, marine reserves shift the burden of proof from proving that fishing causes an adverse impact to proving that it does not (Dayton 1998). The result is that, in reserves, management focus shifts from a risk-prone approach, in which actions are taken only after resource impacts are demonstrated, to a more risk-averse approach, in which resources are protected until it can be demonstrated that an activity is not harmful.

(5) Existence and Future Value
Marine reserves help protect existence value for people who do not directly use resources and for future generations. Aldo Leopold (1949) noted that we cannot prevent the alteration, management, and use of resources, but we need to affirm their right to continued existence, and in some places, their continued existence in a natural state. His biotic ethic requires human obligation, responsibility, and self-sacrifice to preserve ecosystems for present and future generations. This mantra needs to be adopted for effective management of marine ecosystems.

(6) Increased Public Understanding and Appreciation
Marine reserves provide opportunities for quality formal education at the primary, secondary, and graduate levels. With public access, they also provide better public understanding and appreciation of marine ecosystems and marine reserves and the importance of effective resource management. Pauly (1995) described the shifting baseline problem in which each generation develops lower expectations about natural resources based on its own direct experience with depleted resources. Marine reserves with public access offer an opportunity to reverse this trend by restoring areas with more natural and healthy ecosystems. They also provide citizens an opportunity to directly observe the effectiveness of resource management and understand its importance by comparing reserves to surrounding areas.

(7) Enhanced Nonextractive Human Uses
By separating incompatible activities and protecting some areas from fishing and depletion, no-take reserves can support nonextractive uses that have ecological, social, genetic, economic, educational, scientific, recreational, aesthetic, spiritual, and wilderness importance (Bohnsack 1998). They can diversify the economy by providing new social and economic opportunities. This is especially important for activities that require high resource quality. Otherwise, only those activities that depend on depleted or low quality resources can persist.

(8) Better Resource Protection
Unlike many other measures, there are no legal ways to avoid or circumvent the no-take provision which offers the possibility of better overall resource protection than do other measures. Trip limits and bag limits for a recreational fishery, for example, are popular conservation measures, but their effectiveness can be circumvented by making more fishing trips. Similarly, the effectiveness of gear restrictions and minimum size limits can be negated by increased fishing effort. Marine reserves also offer better resource protection because they buffer against changes in total effort or fishing practices in surrounding areas.

Scientific Considerations

(9) Objective Criterion
The no-extraction criterion prohibiting any activity that intentionally removes organisms or habitat is objective and easy to determine as compared to many other criteria that are subjective or difficult to define. Allowing "limited extraction" in a multiple-use MPA, for example, is problematic because there is no clear definition of what "limited" means. Accurately determining a level of extraction that is "not harmful" to a population or an ecosystem is difficult and mostly unknown. Also, monitoring or controlling the amount of take is not practical in most cases.

(10) Simplicity
Compared to other criteria, it is easy to determine whether an activity is extractive or not and fundamentally simpler to explain than why some users are allowed to remove resources and not others. Note, nonextractive, is not the same as, nor should it be confused with, nonconsumptive. Nonextractive recreational diving, for example, could be considered consumptive as the result of repeated contact and damage to the benthos. Allowing diving and other

nonextractive uses within marine reserves assumes that their impacts are either controllable or have much less significant impact than fishing. If not, additional protective measures may be necessary to confine, reduce, eliminate, or mitigate those nonextractive impacts. In the Florida Keys, for example, divers are also prohibited from touching coral as an added protection. One suggestion is to call these "kapu zones," after the Hawaiian word "kapu" (meaning "do not touch" or "forbidden"; Bohnsack 2000a). Kapu was historically used in Hawaii to protect marine areas.

(11) Control Sites

One of the most important tools in science is the experimental control, in which the influence of a variable is either controlled for or eliminated. By eliminating fishing, marine reserves provide control sites to objectively evaluate the effects of extractive impacts on marine ecosystems. They also provide a comparative basis for assessing the effectiveness of various fishery management measures in surrounding areas. Without control sites, it is almost impossible to scientifically address larger questions about how much resource can be removed from a marine ecosystem and still maintain the biological productivity, persistence, and ecological integrity.

(12) *Distinguish between Natural and Anthropogenic Disturbance*

Scientists and managers often need to distinguish between changes caused by natural versus anthropogenic events. Without marine reserves, environmental signals can become hopelessly confounded with fishing impacts. Observed higher abundance of exploited species in no-take reserves compared to similar habitats in surrounding areas, for example, indicates that fishing is the primary factor influencing the observed differences and has more impact on those species than other anthropogenic forcing factors such as regional pollution. In contrast, data showing no differences between reserves and surrounding areas may indicate that regional factors (either natural or anthropogenic) are more important influences on populations.

(13) Increased Scientific Knowledge and Understanding

Marine reserves can facilitate the elucidation of natural processes and enhance scientific knowledge and understanding of marine ecosystems by providing comparative areas with minimal human disturbances. Certain scientific experiments and observations involving biodiversity, behavior, and ecosystem processes can only be conducted in reserves.

Management Considerations

(14) Public Acceptance

Although large land areas in the United States have been protected from hunting and other extraction for well over a century, few aquatic areas have received similar protection. This fact that protected areas are widely used and accepted on land suggests that similar protections could be applied and accepted in the sea. The fact that they have not yet been widely applied in the ocean can be attributed in part to a historical lack of understanding and awareness of marine ecosystems, mistaken beliefs that marine resources are unlimited and impervious to human impacts, and what some consider inalienable rights to fish anywhere.

When high levels of protection are necessary, marine reserves may cause less social and economic disruption and receive better public acceptance than other measures that provide a similar level of resource protection (unless the closed area happens to be a predominantly favorite fishing area). Marine reserves, for example, become an attractive alternative when compared to closing down a fishery entirely or severely reducing bag limits, increasing minimum size limits, and restricting the number of participants. Potentially, reserves could allow more people to participate in a fishery than would otherwise be possible because total fishing mortality is less if some areas are highly protected (Bohnsack 2000b).

(15) Simplified Enforcement

As a management tool, reserves can potentially simplify enforcement by making violations easier to detect. Since the act of fishing is a violation, it is not necessary to obtain, identify, or measure catch. Violations can be detected by surface, aerial, or satellite surveillance, using a variety of technology and vessel monitoring systems. Because permanent no-take provisions apply to all species, there may be less public confusion and better compliance than if different closed areas were established for individual species in multiple-species fisheries. Establishing different seasons or closed areas with overlapping or conflicting boundaries for each species could be much more confusing and impractical.

The legal authority to close significant areas to fishing and technological means to monitor compliance and ensure enforcement have advanced in recent decades. The legal authority changed with the widespread expansion of national exclusive economic zones in 1977 (Bohnsack 1996). Technological advances in navigation, surveillance, and vessel tracking, as well as a new emphasis on homeland security,

make monitoring and enforcement of marine reserves more practical.

(16) Direct Fishery Benefits

Marine reserves potentially can provide many direct fishery benefits (Bohnsack 1998). The five most important benefits follow. Reserves can reduce the chances of overfishing by providing refuges from population exploitation. Compared to having all areas exploited under one set of regulations, reserves potentially can provide greater fishery yields in the long-term by having a larger and more dependable supply of eggs and larvae dispersed to fishing grounds. Reserves can also potentially increase yield from spillover, where animal emigration exports biomass from reserves through to surrounding fishing grounds (PDT 1990; Roberts et al. 2001). Reserves also can provide insurance to sustainable stocks by potentially accelerating stock recovery following natural disturbance, human accidents, management errors, or years of poor stock–recruitment (PDT 1990). Finally, they may be the only measure that can effectively preserve stock genetic structure from detrimental effects of selective fishing practices (Conover and Munch 2002).

(17) Indirect Fishery Benefits

Fishery stock assessment and management models depend on obtaining accurate estimates of critical population parameters of growth, natural mortality, and fecundity. If all areas are subjected to fishing, measuring these parameters and gaining an essential understanding of trophic and habitat relationships, recruitment variations, behavior, and population response to environmental variability are difficult, if not impossible, to obtain. Marine reserves can potentially benefit fisheries indirectly by allowing some critical population dynamic and fishery parameters to be estimated independent of fishery influences with a rigorous sampling design (Ault et al. 2002).

Discussion and Conclusions

The main priority of permanent no-take marine reserves is to protect biodiversity: ecological structure and function at the genetic, species, community, seascape, and ecosystems levels (NRC 2001). Their use has generated considerable scientific, management, and public interest because the no-extraction provision is simple and objective and offers a high level of resource protection that can potentially restore and maintain ecological integrity in areas with minimum human disturbance. Many scientific questions can best or only be examined using marine reserves. From a management perspective, marine reserves are attractive because they potentially provide a win–win conservation alternative that offers a high level of ecosystem protection while providing fishery benefits and enhancing and diversifying nonextractive human uses.

Much, however, remains to be learned because the science of marine reserves is new and most existing reserves are rare, small, recently established, limited to few habitats, or cover only very small portions of the total managed area (Pauly 2004, this volume). Because they are rare, more need to be implemented if they are to provide anything more than a token role in protecting marine biodiversity. Because marine reserves are rare and recently established, few scientific studies exist (Halpern and Warner 2002; Halpern 2003), leaving many questions and uncertainty concerning their application to biodiversity and fishery protection. More research is needed to address questions concerning individual reserve size, total number, location, total area, and habitats that need to be included to be truly effective. In addition, more replicated research is needed, especially at larger and more ecologically relevant spatial and temporal scales, to address questions of costs and benefits, effectiveness, and necessary design features for reserve networks. Many questions remain unresolved concerning social and ecological impacts of fishing displacement, applications to highly migratory species, and social acceptance, compliance, and enforcement. Thus, considerable scientific interest exists in establishing reserves in different regions and habitats and under different biological, oceanographic, and physical environments as well as in different social and economic environments.

Even though they prohibit fishing, marine reserves do not conflict with "multiple-use MPAs" because they create or enhance many kinds of activities within and outside their boundaries that conflict with fishing. When embedded in larger MPAs such as the Florida Keys National Marine Sanctuary, for example, they also support multiple human uses by separating incompatible activities and increasing total resource protection. A belief that fishing and other human activities can be practiced simultaneously in all areas without conflict is becoming far less realistic considering growing human population demands and the intensity of resource usage. Likewise, allowing all areas to be exploited with "limited restrictions" demands a high level of knowledge and human control that at present is essentially nonexistent.

Despite offering many potential benefits, marine reserves have generated considerable opposition (Norse et al. 2003; Shipp 2003). Most opposition has focused on technical issues about the applicability of reserves to different species and habitats, proof of fishery benefits, and the quantifying of design features (number, size, location, spacing, boundary configurations, and total area covered) for individual reserves and networks (Carr and Reed 1993; Botsford et al. 2001). Other issues involve enforcement, impacts of displacing fishing on people and resources outside of reserves (Bohnsack 2000b), and how to incorporate reserves into comprehensive management programs (Jameson et al. 2002). Some opposition simply reflects resistence to changing the status quo because it creates winners and losers. Fishers, who effectively have had historical access to the entire ocean, can be expected to aggressively oppose any changes that restrict that access (Lydecker 2004, this volume). Although this is not a scientific issue, such shifts are common and routinely handled by political and government institutions.

Philosophical opposition has received less attention but ultimately may be more important than the technical issues. While much attention has focused on economic costs and benefits, for example, relatively little attention has been paid to conflicts caused by wide differences in conservation ethics (Callicott 1992; Bohnsack 2003). As Leopold (1949) recognized, economics is not an ethic, and basing management decisions solely on economic self-interest is unwise. Inevitably, it leads to failure because elements without economic value eventually will be eliminated to the detriment of the economic parts. Leopold's biotic ethic led to a shift in management emphasis from "sustained production of resources or commodities, to a recognition that true sustained yield requires preservation of the health of the entire system" (Leopold 1949). Much of the current controversy over marine reserves appears to be a result of philosophical failures to recognize that people are part of marine ecosystems, that limits to human usage exist, and that human well-being is dependent on maintaining ecosystem health. Protecting marine biodiversity and maintaining sustainable fisheries are not mutually exclusive problems.

A key philosophical issue involves human dominance. Can marine ecosystems be manipulated and controlled at will and, if so, should all areas be exploited? Marine reserve application is based, in part, on a simple premise that if protected from human interference, nature has evolved to take care of itself. This premise conflicts with the top-down "command and control" engineering approaches that attempt to control complex human and ecological systems (Holling and Meffe 1996). This human control view is reflected in concerns that some resources may be underutilized in terms of total yield and, therefore, wasted by using marine reserves. An extreme example of this thinking is the position that marine reserves are not "management" tools because they do not involve active human manipulation.

Another issue is the philosophical dichotomy between fisheries and ecosystem management perspectives. In fisheries, marine reserves are usually considered a "tool" to be used independently of other fishery management options (Norse et al. 2003; Shipp 2003) and not as part of an integrated management system (Norse et al. 2003). The assumption is that fisheries are independent of biodiversity and ecosystem management. In an ecosystem perspective, fishery productivity is directly derived from ecosystem biodiversity, and the two must be managed together. Thus, much of the conflict between ecosystem and fishery management is an artifact of separating these two functions. We give three examples that elucidate this philosophical conflict: the amount of area needed for marine reserve networks, the displacement of fishing effort by marine reserves, and the current efforts to shift fisheries from single-species to ecosystem-based management.

First, considerable angst has been generated over questions concerning how much area should be included in marine reserve networks. Proponents of marine reserves usage argue that substantial portions of marine environments need reserve protection (Bohnsack et al. 2002; Pauly et al. 2003; Pew Oceans Commission 2003), but they generate considerable criticism when attempting to apply principals as guidelines using area percentages (Agardy et al. 2003; Norse et al. 2003; Shipp 2003). The critics are correct in that no one percentage will apply to all ecosystems or areas. However, the same critics ignore the fact that there is a need for a minimum percentage and that no biological, social, or economic theory exists showing that all areas should be exploited. Thus, while there should be agreement that fixed percentages of reserve area will not apply to all marine ecosystems, there should also be agreement that there is no support for zero as a percentage either. Ideally, adaptive management should be used to fine-tune protection to specific habitats and areas (Walters 1986; Murray et al. 1999).

Second, marine reserves are often criticized for not directly addressing human and environmental impacts of fishing effort displacement to areas outside reserve

boundaries (Norse et al. 2003). This problem is not a failure of marine reserves per se but a failure to include marine reserves as part of comprehensive resource management strategies. Despite claims by some opponents, we know of no statements that marine reserves alone will solve all fishery problems. If overfishing is a problem, effort controls and other traditional fishery measures are also needed, including size limits, bag limits, quotas, limited entry, closed seasons, gear restrictions, and closed areas for specific fisheries (Bohnsack 2000b). If these other fishery measures are not effective, larger proportions of habitats may need to be closed. Relying solely on no-take protection, however, may reduce options and flexibility for optimizing social and economic benefits (Murray et al. 1999).

Third, use of marine reserves represents a philosophical shift from single-species and reactive fishery management to a more precautionary approach using proactive spatial and ecosystem-based management (Bohnsack 1999b). Although many practical details still need to be worked out to make this shift operational, at the theoretical level it requires integrating fishery and ecosystem considerations.

In conclusion, no-take marine reserves are primarily intended to protect ecosystem biodiversity. They offer qualitative and quantitative qualities that are more than simply sequestering populations in no-take areas (Norse et al. 2003) or providing just another fishery management tool (Norse et al. 2003). Fundamentally, marine reserves use a simple, ecosystem-based, and precautionary approach to offer a high level of resource protection that benefits present human activities and future generations. Marine reserves increase human knowledge, understanding, and appreciation of marine ecosystems and their management by offering a high and objective level of protection and a scientific basis for assessing human impacts and management effectiveness. Reserves potentially can simplify enforcement, benefit fisheries, and eventually achieve wide public acceptance. We suggest that advancing the science of resource management requires considering people a fundamental part of marine ecosystems, shifting the focus of fishery management from resources as mere commodities to sustaining functional ecosystems, and incorporating marine reserve concepts and networks into comprehensive marine resource management.

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