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Ocean & Coastal Management
Ocean & Coastal Management 46 (2003) 439–456
www.elsevier.com/locate/ocecoaman

Protected areas in marine resource management: another look at the economics and research issues

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Abstract

This paper reviews the research to date that relates to the economics of marine protected areas (MPAs). A special effort is made to examine the evidence on the benefits and costs of MPAs in terms of consumptive and nonconsumptive marine resource interests. General observations are made regarding the net effects of MPAs on these two stakeholder categories and the potential institutional costs of MPA implementation are highlighted. In general, the review finds that the empirical research on the economics of MPAs is limited and that there are several issues that might merit further investigation. The researchable topics are suggested as a way to better understand the socioeconomic impacts of MPAs and the potential response of stakeholders to proposed protected areas.
Published by Elsevier Science Ltd.

1. Introduction

Like catch quotas and seasonal closures of fishing grounds, marine protected areas (MPAs) are passive management strategies designed to allow time for an overexploited resource base to recover. However, the spatial orientation and permanency of MPAs often makes it easier to directly identify their beneficiaries than it is for other fisheries policies. This suggests that the scope of economic analysis for MPA policies should include considerations beyond the fishery [1]. Following Hoagland et al. [2] and the National Research Council's report on MPAs [3], this paper reviews the economics of MPAs in the general context of resource management in which fisheries management is subsumed. This is an important distinction, since most of the economic literature related to MPAs has focused on their potential role in fisheries management. As Sanchirico [4] has noted, the fisheries

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0964-5691/03/$ - see front matter Published by Elsevier Science Ltd.
doi:10.1016/S0964-5691(03)00017-6

focus is likely an effort to document the potential benefits of MPAs needed to gain the acceptance of fishers in the political economy. The broader scope of analysis allows for the possibility that a MPA could be a socially efficient use of marine resources, even if it were not able to generate net economic benefits for fisheries. This might be the case if portions of the resource have higher social value as a protected area for in situ purposes than they do in consumptive uses. The central policy issue here is a common one in modern resource management: how to encourage (second best) redistribution of marine resources from lower valued uses to higher valued ones [5].

This paper draws on others that have reviewed MPA economics [1,2,6,7]. First, we use the general framework presented in Milon [1] to present the evidence on MPA benefits and costs in the in terms of changes in "consumptive" and "nonconsumptive" values. This somewhat unconventional categorization[1] helps to highlight the general trade-offs inherent in a "no-take" MPA that benefits nonconsumptive stakeholders and imposes costs on consumptive users. A special effort is made to review the limited research that specifically relates to nonconsumptive values at MPAs. Second, using the consumptive/nonconsumptive characterization, we highlight the distributional effects of many MPA proposals and discuss a few directions for future research in this policy setting. The first part of this paper provides an economic definition of a MPA followed by a discussion of values related to marine resources. In the second section we consider how, based on the recent economic literature, a MPA could change these marine resource values (i.e., What are the potential social benefits and costs of MPAs?). The last section summarizes the findings, introduces the related policy implications and suggests some topics for future research.

2. Economic definition of a MPA

Marine resources are a type of natural capital that can be invested or used to generate a return to its owner [9]. Two main questions arise surrounding a marine resource investment decision: (1) who owns marine resources? and (2) in what ways can marine resources be invested? For the most part, marine resources are common property[2] whereby no one stakeholder has exclusive rights to the resource or its services. In the absence of clearly defined property rights, common pool problems arise as individuals competitively exploit the resource beyond its economically and biologically sustainable yield. As a result, there is a "rationale for governments to intervene as an advocate of proper management of environmental resources." [11, p. 25].

Recognizing that marine resources are owned and managed by the public we can turn to the second question of how to use or invest this natural capital. The efficiency

[1] There are numerous ways to characterize values for natural resources. The categorization here follows Johansson [8, Chapter 11].

[2] The term "common property" in this context refers to the regulated or restricted open access property regimes that characterize many of the world's fisheries since extended jurisdiction [10].

Table 1
Marine resource values

Value categories		Examples
Consumptive[a]		Commercial and recreational fishing, coral harvesting, pharmaceutical or mineral prospecting, and other extractive uses
Nonconsumptive	Onsite[a]	Recreational diving, nursery grounds, research
	Offsite	Value in simply knowing that marine biodiversity exists or that it will be preserved for future generations

[a] Consumptive and onsite values are "use" values and, as such, consist of the value of current use and the value assigned to the *option* of use in the future.

of a marine resource investment decision will effect and be affected by the relative values of the marine resources in different types of uses. Table 1 presents a listing of marine resource values according to consumptive and nonconsumptive categories. Consumptive values relate to any activities that "consume" (i.e., extract and remove) marine resources from their natural environment. Such values are derived from activities such as fishing or oil and gas development and from the opportunity to carry out such activities in the future. Nonconsumptive values are attributed to non-extractive activities, such as SCUBA diving. These values are derived onsite from direct experience with the resource and/or offsite from simply knowing that the resources exist or will be preserved for future generations to enjoy.

Increases in the values listed in Table 1 are *benefits,* whereas decreases are *opportunity costs,* so that the net return on any marine resource investment policy depends on the difference between the two. Therefore, by examining changes in marine resources values with and without a MPA we can measure it's net return over time and the distribution of the return (costs and benefits) among various stakeholders.

3. Benefits and opportunity costs of MPAs

Following Table 1, the benefits and opportunity costs of a MPA can be broadly categorized into those relating to consumptive and nonconsumptive values. This section reviews the economic literature for evidence on the benefits and costs for both categories and a third category related to the institutional aspects of MPA implementation. The discussion is meant to be an introductory review of the issues as they appear in the literature. No detailed attempt is made to catalog the estimates derived from the various studies or to describe the general methodologies applied in the studies.[3] Note that fishery interests are given relatively more coverage than other consumptive uses in the section on consumptive values. This reflects the fact that the

[3] See Hoagland et al. [2] for an excellent presentation in this regard for research prior to 1995. Other methodological reviews and introductions can be found in Thomson [12] or Crosby [13].

economic research on the effect of MPAs on consumptive values has focused primarily on expected net effect of protected areas on commercial fishers.

3.1. Consumptive

3.1.1. Fishing

The designation of a MPA can directly impose costs on fishers by closing off access to fishing grounds. For example, Leeworthy and Wiley [14] estimate that between US$0.3 to $1.2 million worth of commercial and recreational uses could be displaced with the creation of the Dry Tortugas Ecological Reserve in the Florida Keys. These losses could be "mitigated", though, if the displaced consumptive users can relocate to another productive area at little or no costs or if there are compensating "spillover" effects from the MPA to the remaining fishing grounds. If fishers choose to exploit areas with highest expected returns, then it would be costly for them to relocate their operations away from a (high return) protected area to some other (lower return) area of the fishing grounds [15]. More research is necessary, but we can assume that relocation after a MPA is not costless and that the mitigation of losses from forgone fishing grounds will depend primarily on the economic effects of biological spillovers.

Research has shown that MPAs can, in fact, provide biological spillover benefits to the remaining fishing grounds by protecting spawning stock biomass and genetic diversity, allowing for more natural population structures and providing new recruits to the fishery.[4] There have been several bioeconomic models developed to examine the expected net economic effects of MPA spillovers on fishing operations. These mathematical models are designed to predict the joint impact of a "no-take" MPA on various biological and economic indicators in a marine ecosystem. Fig. 1 shows the simple dynamics of the typical two-compartment dynamic model. As shown, the common approach is to divide the marine environment into an area or "patch" that is fished (fishing grounds) and another that is not (MPA). Spillover effects from the MPA to the fishing grounds area are depicted as a net transfer rate that depends on the relative fishery biomass densities in the two areas. In contrast to some of the more complex biological studies, the economic models usually model the biomass flow into and out of the two areas with a net growth function that represents intrinsic growth or recruitment rates less natural mortality rates. Some researchers have disaggregated the biological flow patterns to consider age-structured biomass [16–18] or predator-prey dynamics [19]. Others have modeled more than two patches to examine sink-source dynamics when one patch is closed to consumptive uses [4,20]. It should be noted that the bioeconomic models discussed here differ from strictly biological studies because they explicitly model effort in the fishing mortality calculations. This is shown in Fig. 1 where fishing effort is depicted as a function of market prices, harvest costs, and the preferences and technologies of fishers. The

[4] Sanchirico [4] provides an extensive discussion of the spillover effect issue in the context of a series of hypotheses about revenue and cost impacts of MPA implementations. We focus here on nature of the modeling exercises and present a more general treatment of the issues.

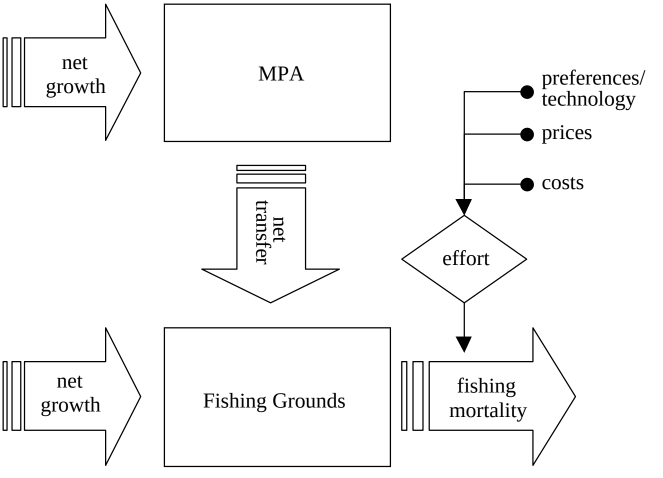

Fig. 1. Simple dynamics of bioeconomic models of MPAs.

explicit consideration of fisherman behavior in the bioeconomic models is necessary to get a complete picture of the social and biological responses to protected areas [21–23].

The modeling research consistently shows that MPAs by themselves are not likely to increase aggregate fisher welfare in a fishery characterized by (regulated or restricted) open access. This is expected because any additional net revenues or rents that are generated by a MPA in an open access system will tend attract entry and, thus be dissipated over time. Hannesson [15] suggests that fishers will actually be worse off due to increased harvesting costs experienced once the fishery has adjusted to new open access equilibrium, regardless of the spillover effects. What's more, since humans are not necessarily the only predator for species in an area to be protected, fishers would have to share any increases in productivity with natural predators [19]. This competition could also compromise any expected increases in harvest or stock levels both inside and outside of the MPA area. Consequently, without any incentives for fishers to control effort a MPA is likely to move a fishery from one open access equilibrium to another, leaving the welfare of the fishers unchanged at best.[5] Nevertheless, a protected area in an over-exploited system could provide an interim "double-dividend" by allowing both aggregate biomass and harvest levels to recover [20]. The promise of such near-term returns or "quasi-rents" to fishers have been shown to vary with the relative biomass densities in the MPA and fishing grounds prior to implementation, the net rate of biomass transfer between the MPA and fishing grounds, the type of connectivity between the MPA and fishing grounds, and the size/location of the MPA [15,20,22,23].

[5] This assumes that the fishers remain as fishers. There is some evidence, though, that fishers can be made at least as well off if they switch to nonconsumptive occupations related to a MPA [24].

As discussed above, the sustainability of any increased returns with a MPA is questionable in an active fishery where there are no regulations or incentives to control effort. However, there may be cases where effort is controlled internally by the structure of the fishing industry. For example, Leeworthy and Wiley [14] postulate that any increases in economic rents due to spillover effects from the Dry Tortugas Ecological Reserve may not be dissipated due to the "remoteness" of the proposed MPA location. This supposes that firms operating in a relatively remote location, like the Florida Keys, have a type of monopoly power that allows them to earn economic rents without attracting new industry entrants [25]. Thus, the structure of the fishing industry prior to MPA designation will also play a role in the ability of a harvesting community to sustain any long-term economic benefits from biological spillovers. Future research on the role of industry structure in protected area planning may help towards understanding the motivations of harvesters and the incentives necessary to enhance the acceptance of MPAs.

To the extent that fishers are risk adverse (i.e., concerned about fluctuations in their catch), the losses from forgone access to fishing grounds could also be offset if a MPA can reduce the variance of harvest levels over time [26]. Simulation analyses have shown that a MPA can reduce the variance in stock levels regardless of the degree of correlation between the net growth rates in the protected area and fishing grounds [17,27,28]. The same work has concluded that larger MPA sizes lead to relatively lower average variation in stock levels in both the protected area and the fishing grounds. These results are intuitive: the larger the buffer (MPA) against uncertainty, the smaller the average variation in the stock levels, and if stocks in the protected area and fishing grounds do not vary together, then the risk buffering effects of a MPA will be greater. In the end, however, the true economic benefit of the buffering effects of a MPA cannot be evaluated without knowing the extent to which fishers (or regulators) are risk adverse [27]. Holland and Sutinen [22] find evidence that fishers may actually not be risk adverse when it comes to the fishing location decision. That is, fishers in their study "did not seek to reduce risk by moving to areas where revenue rates are less variable" which, according to the authors, "may indicate that fishers are responding to news of a few highly successful trips rather than considering average revenue rates" (p. 259). This suggests that fishers may perceive that the risk buffering benefits of a MPA are not sufficient to offset the value of forgone harvesting privileges.

3.1.2. Other consumptive values

There are other valued consumptive uses of marine resources that might be given up when a MPA is implemented. Pharmaceutical bioprospecting is one consumptive use that has received attention recently [29]. A no-take MPA will likely eliminate the possibility of future revenues from pharmaceutical products developed from resources within its border. Thus, forgone returns from bioprospecting are another potential opportunity cost of MPAs. A study of a marine park in Jamaica suggests that this forgone expected value could be quite large, especially when unique environments, like coral reefs, are being considered for protection [30]. However, there is still not much research on the value of bioprospecting in marine environments and it is likely that range of possible values (opportunity costs) is wide and highly site specific. The same can be said for other resource extraction activities such as offshore oil and gas drilling that could be prohibited inside a MPA. There does not appear to be any published research on offshore energy reserves that relates specifically to MPAs, but studies on the value of oil and gas prospecting indicate that the opportunity cost of forgone drilling could be high [31,32].

3.1.3. Summary on consumptive values

So based on existing research, what is the expected net effect of a MPA on consumptive values? There is some indication that commercial and recreational fishers would be worse off with a MPA unless they place significant value on the ability of a MPA to buffer harvest fluctuations. Modeling analyses have shown that MPAs would be most effective in over-exploited fisheries by helping depleted fishery stocks recover. The resulting near-term benefits to fishers from the rebuilt stock will depend on the connectivity of the marine environment, the availability of substitutes for the forgone fishing grounds, and the presence of predators for protected biomass. In the long run, however, any gains to fishers will be dissipated if there continues to be no incentive for the harvesters to reduce effort. Bromley [33] sums up the predicament of investing in the presence of inadequate institutions and incentive structures for a common property resource:

> If it is determined that the resource will never be able to sustain the level of demands to be placed on it, then there must be some capital investment to augment it. But capital investment in the absence of a prior institutional fix will simply assure that the new asset is squandered as the old one was (p. 149).

As discussed above, MPAs are an investment of natural capital intended to "augment" fishery stocks by allowing them time to locally regenerate.[6] Note that, somewhat paradoxically, if fishing effort can be managed to economically sustainable levels with other policy tools, then protected areas are not the most efficient way to address problems of over-exploitation. Since MPAs effectively act to reduce the efficiency of nominal effort, other policy tools that can directly target effort levels and distribution more precisely may be a more cost-effective means than a MPA to remedy stock externalities [22,35]. In other words, if effort can otherwise be efficiently controlled, then MPAs may be too drastic a measure from a fisheries management perspective.

There may be other, less researched ways in which a protected area could provide benefits to fishing interests. First, if anglers place a value on species variety then they may receive benefits from MPA that is able to promote biodiversity. Further consideration of this issue would require more complex multi-species modeling efforts. Second, it may be possible for a MPA to change market prices by influencing the total supply and composition of harvested seafood [18]. A MPA that effectively increases the size and variety of seafood species could actually make consumers

[6] Daly [34] describes an investment in renewable resources, such as fish stocks, as a "waiting investment" that "simply means constraining annual offtake" (p. 31).

better off. On the other hand, a large no-take MPA could decrease seafood supply enough to make consumers worse off. The latter was shown to be unlikely under existing market conditions in the case of the proposed Dry Tortugas Ecological Reserve in the Florida Keys [14].

Less is known about the possible change in value that would result if other consumptive uses like pharmaceutical and energy prospecting are prohibited in a MPA area. It would appear, though, that the magnitude of trade-offs and potential for conflict should be investigated given the ever-growing interest in new drug and energy source development.

3.2. Nonconsumptive

Nonconsumptive values for a MPA are manifest in onsite experiences, such as SCUBA diving, or in offsite experiences by someone who will never visit the MPA (see Table 1). The latter types of values are pure "non-use" concepts because they relate to preferences for the existence of marine resource biodiversity, and/or the ability to bequest such resources to future generations.[7]

Very little empirical work has been done on the extent to which a MPA could directly affect nonconsumptive values. Many of the related studies have attempted to examine the economic impact of marine parks, a type of MPA, on neighboring areas [37,38] or tourist's willingness to pay for park entrance [39,40]. Unfortunately, as Pendleton [41] notes, these analyses sometimes inadvertently measured the total impacts or value of the resource and not the *marginal change* in impacts or value due to the existence of (i.e., protection provided by) a marine park.[8] In other words, some marine park valuation studies have implicitly assumed that all of the nonconsumptive-related revenues would disappear in absence of the park or MPA. This is clearly not likely, although, parks and MPAs have the potential to provide some *marginal protection* to the resource and resource users. It is the value of this marginal protection to nonconsumptive (and consumptive) activities that constitutes a true benefit of a MPA or park. A similar caution can be made about the user fee surveys. These studies suggest people would be willing to pay for access to an area of the ocean, which means that the government (public) could *charge* for the use of these resources. In this case, the information on willingness to pay user fees could be used to predict if the revenues collected from entrance fees would be sufficient to fund the costs of the park operation [39]. However, the values reported in the user fee studies cannot be used to evaluate the efficiency of a MPA investment unless the questionnaires were specially designed to elicit willingness-to-pay for specific MPA attributes or levels of protection [43,44].

[7] See Freeman [36, Chapter 5] for a complete discussion of non-use values for environmental goods.

[8] Pendleton [41] also points out that both returns and costs associated with a marine park investment accrue over time and not "overnight" as is implicitly assumed in some studies. Consequently, future annual benefit and cost streams should be discounted to the present value before comparisons are attempted. In all fairness, the shortcomings of some previous analyses were due to resource limitations admitted by the study authors (e.g., [42]).

3.2.1. Onsite

In the case of onsite nonconsumptive values, the marginal change in value associated with a MPA or park is measured by changes in welfare associated with activities in and around the MPA area (SCUBA diving, snorkeling, sightseeing, etc.). In effect, a MPA acts to increase (or prevent a decrease in) the demand for activities related to the protected area because more value can be obtained for the same visit if the resource is in better condition. Thus, for onsite nonconsumptive values, it is appropriate to ask whether a MPA will provide marginal improvements or prevent marginal damage in the perceived recreation experience, tourism revenues, and/or research opportunities.

Again, there is little research on the marginal value of MPAs to onsite nonconsumptive stakeholders. This is probably due to the general lack of socioeconomic data needed to perform a complete analysis of the relative values and costs *before and after* a MPA is implemented [1,45]. Consequently, like the analyses of consumptive values, the relevant valuation studies of nonconsumptive onsite values for MPAs have tended to be ex ante modeling or survey exercises. Leeworthy and Wiley [14] used benefits transfer to estimate the pre-protection value of nonconsumptive diving at the proposed Dry Tortugas Ecological Reserve in the Florida Keys. The authors speculated that the recreational diving community would benefit with a MPA, but they did not attempt to quantify the magnitude of the benefits. According to Leeworthy and Wiley [14], "as the (MPA) site improves in quality, we would expect that the demand for this site will increase and person days, consumer's surplus, business revenues and profits will all increase"(p. 14). An alternative approach by Murray et al. [43] examined SCUBA diver's preferences for marine life *attributes* (species abundance, size, etc.) that might be enhanced or protected by a MPA. The study found that, all else equal, an increase in grouper sightings or size could potentially increase the net revenues to the local dive-tourism market by more than ten percent. Thus, a MPA that can effectively enhance these attributes has the potential to enhance (and capture) nonconsumptive use values for local economies. It is important to note, however, that a MPA could also attract attention to an area and increase the potential for congestion. Increased congestion over time could actually decrease the value of nonconsumptive uses in the area [42]. Consequently, the ability of a protected area to sustain valued onsite recreational activities depends critically on the success of management in the area [46].

3.2.2. Offsite

There are those who will never physically experience a specific marine environment, but value its existence nonetheless. For example, someone who has not been to the Great Barrier Reef in Australia may value the existence of the area's unique attributes or they may want future generations to have the opportunity to enjoy the reef. Research has quantified these so-called existence and bequest values for marine resources in general,[9] but very little has been done to determine the extent to which they could be affected by MPAs. A few contingent valuation studies have

[9] A summary appears in Chapter 3 of [47].

been conducted to examine the willingness-to-pay donations to a fund that serves to maintain a MPA [39,40,44]. Spash et al. [44] found that locals and tourists would be willing to pay between US$1.17 and $4.26 annually for five years to a trust fund that would support strategies to *improve* marine biodiversity by 25% at coral reefs in Montego Bay, Jamaica.[10] The expected contribution levels reported depended on "whether respondents believed that marine systems possessed inherent rights, or that humans had inherent duties to protect marine systems" [44, p. 115]. Another study at Montego Bay Park found that a random sample of beach-goers would be willing to contribute US$1.45 a year on average to a non-governmental organization (NGO) entrusted with the management of the protected areas at the Park [39]. This second study did not, however, specify the change in the marine system expected from the NGO fund activities. Thus, the two studies were valuing somewhat different environmental "products" and cannot be directly compared. Taken with annual visitation and residency data, though, the results do give us an idea of the potential revenues available from "non-users" to fund MPA activities in the Montego Bay area. Spash et al. [44] put this figure on average at around US$20 million annually for five years for a total expected value of nearly US$100 million. Survey research in the Philippines finds similar potential annual revenues from donations for anchor buoy maintenance at popular scuba diving MPAs [40].

3.2.3. Summary on nonconsumptive values

A limited body of research indicates that nonconsumptive or "passive" values for marine resource protection can be a significant factor in the onsite and offsite demand for MPAs. However, the studies are relatively site specific and focus on the values held by local residents and visitors to the area. In most cases those surveyed had actually spent some time at the MPA or park and were asked to speculate what their "offsite" values would be if they were never to visit the site again. It may not be possible, however, to separate offsite values from onsite values for those who have onsite experience with the resource [48]. Consequently, the values reported in these studies may not be representative of the true "offsite" values held by individuals who have never actually experienced the resource. More research on the preferences of the general population may be necessary where larger MPAs are considered that are to be funded by national tax receipts. For reference, Leeworthy and Wiley [14] speculate that if one percent of US households were willing-to-pay US$3 to $10 annually for the Dry Tortugas Ecological Reserve, then it would have a total (passive) asset value of between US$13 to $376 million.

Despite the limited empirical evidence, MPAs will likely enhance nonconsumptive values. Accordingly, onsite nonconsumptive users are willing-to-pay fees for access to a MPA area and those offsite may be willing-to-pay for activities that help establish and maintain a MPA system. Taken together, these nonconsumptive stakeholders represent the demand for MPAs. The actual extent of the demand for any given MPA configuration is open to question, as is the ability of existing

[10] Spash et al. [44] also report similar results for a survey in Curacao.

institutions to supply the quantity demanded. The latter issue is considered further in the final section.

In closing we note that research and education have been cited as another potential nonconsumptive value for MPAs [49]. A MPA that enables scientists and/or students to observe pristine and/or recovery behavior of biomass stock could provide a valuable increase in knowledge about the marine environment. However, since education and research are typically public goods, MPA related changes in these values would be difficult to estimate and even more difficult to assign to specific stakeholders.

3.3. Institutional

MPAs require funding for planning, maintenance, and enforcement. These institutional costs include direct operation and maintenance expenditures as well as the capital required to set-up any MPA structures and governing institutions. The actual cost of maintaining a MPA is site specific, but figures from marine park operations suggest that set-up costs could run over US$500 thousand with annual costs well over US$100 thousand [40,50]. At larger operations, such as the 85 million acre park at the Great Barrier Reef, annual management expenditures can exceed US$5 million [51]. Fig. 2 shows the relationship between park size and annual expenditures per acre from published data [51] for the Great Barrier Reef Marine Park. Whereas the total costs of management increase with the park size, the average cost declines suggesting evidence of increasing returns to scale. This is encouraging if we can say that park size roughly approximates the "outputs" of the protected area. Modeling exercises have shown that (everything else equal) larger no-take MPA sizes provide greater biological benefits, but also lead to a greater loss in economic returns to a fishery [16,17]. Thus, the cost for producing the biological benefits with a MPA may also exhibit increasing returns to scale. This provides some direct support for

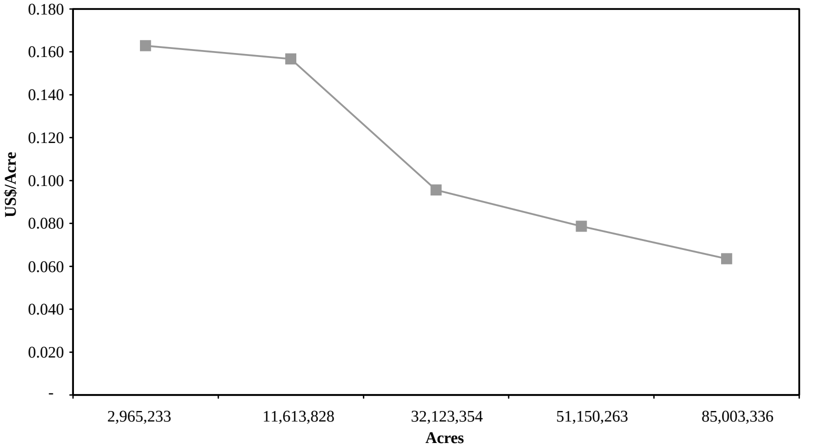

Fig. 2. Average cost per acre of management at the Great Barrier Reef Park, 1981–91.

Farrow's [6] claim that public investment to "concentrate" the benefits of stock protection in a MPA may be justified. However, a closer look at the costs of management and the related outputs at the Great Barrier Reef Marine Park and other MPAs would be necessary before any conclusions can be made.

Evidence from existing MPAs has shown that funding for enforcement activities is crucial [40,52], but that the level of enforcement may not be providing meaningful protection [53]. Fortunately, the costs of spatial enforcement in fisheries management have been declining due to new technologies like global positioning systems [54,55]. More research is necessary to document the costs of enforcing spatially oriented policies, such as MPAs, relative to the costs of other general tools in marine resource management (catch quotas, input taxes, etc.).

4. Discussion

This paper has reviewed the recent evidence from the literature related to the benefits and opportunity costs of MPAs. The discussion has focused on the expected net effect of a MPA on consumptive and nonconsumptive values for marine resources. This categorization was chosen because most MPA configurations, especially those with no-take components, will require trade-offs between consumptive and nonconsumptive stakeholder values. In this setting, values enhanced by a MPA are benefits whereas values that are given up become opportunity costs of a protected area. Taken with the potential institutional costs required to set-up and run a MPA, the net change in social values will determine the efficiency of a decision to invest marine resources in a MPA. A summary of the discussion appears in Table 2.[11]

Are MPAs competitive[12] investments of marine resources? If so, what mechanisms are available to help smooth the implementation of future MPAs? These questions should, of course, be answered on a case-by-case basis, but we can make some general observations in light of the evidence that might help guide decision-makers. First, a MPA may improve social welfare if it can make at least one stakeholder group better off, with out making another worse off.[13] Continuing with the categorization in Tables 1 and 2, a MPA is likely to make nonconsumptive stakeholders better off, but not without making consumptive users worse off. Recall that the latter was the main subject of review in Section 2.1 where we concluded that for fishers to be better off with a MPA they would have to place sufficient value on no-take areas as a way to minimize catch variation or enhance species variety. In absence of sufficient evidence regarding fisher's valuation of harvest risk or

[11] For reference, other tables of MPA benefits and costs appear in Hoagland et al. [2] and National Research Council [3].

[12] The term "competitive" is used to refer to an investment alternative that is at least as efficient as all other investment options. This means that the benefits an MPA investment are at least greater than the costs and that there is no other investment for the same marine resources that could generate greater net benefits to society.

[13] Also the value generated by the project must exceed the institutional costs of establishing the MPA.

Table 2
Potential economic benefits and opportunity costs of MPAs

Category		Benefits	Opportunity costs
Consumptive		Net revenue from harvest of spillover Reduction in harvest variance Greater benefits for any permitted uses Enhanced species variety	Foregone fishing income Crowding of displaced effort Higher search costs Foregone income from resource extraction (oil/gas, pharmaceuticals, etc.)
Nonconsumptive	Onsite	Enhanced recreational opportunities Research opportunities	Increased congestion
	Offsite	Support of existence values	
Institutional		Savings in enforcement costs over non-spatial management	Setup and maintenance expenditures

preferences for species variety, we continue the discussion assuming that they will not be any better off with a MPA. In any case, survey research and case studies suggest that fishers' generally perceive that any benefits offered by MPAs are less than the value of forgone harvesting privileges [56–58].

MPAs could potentially improve social welfare even if consumptive users are made worse off if their losses could be offset by the gains in nonconsumptive values. However, such a potential improvement can only be realized with the appropriate mechanisms to encourage the called for reallocation of marine resource access privileges. If there were well-defined property rights governing marine resource access, then the market would serve as the appropriate mechanism in this regard. To illustrate, consider that, for the most part, consumptive stakeholders' willingness-to-accept compensation for foregone fishing grounds characterizes the supply curve for a MPA. The supply curve reflects a notion of relative scarcity and can also be characterized as a schedule of increasing marginal willingness-to-pay for the consumptive use of marine resources as a larger percentage is devoted to a MPA. This indicates that consumptive users might be willing-to-pay increasingly more to prevent a MPA from being implemented. Alternatively, and perhaps more importantly, the supply relationship implies that consumptive users loose an increasingly greater amount of value with larger MPAs and thus, would have to be compensated increasingly more to accept larger MPAs. Continuing with the illustration, consider that the demand for MPAs is essentially a function of nonconsumptive stakeholder's willingness-to-pay for the right to MPA access exclusive of consumptive uses. This demand is characterized by a downward sloping schedule because nonconsumptive stakeholders value the resources in situ instead of in the marketplace.[14] Therefore, when a lower percentage of marine resources

[14] This characterization is overly simplistic in that nonconsumptive stakeholders may actually also have consumptive interests. For example, someone may enjoy both fishing and diving or someone who is otherwise a nonconsumptive stakeholder may also purchase seafood products.

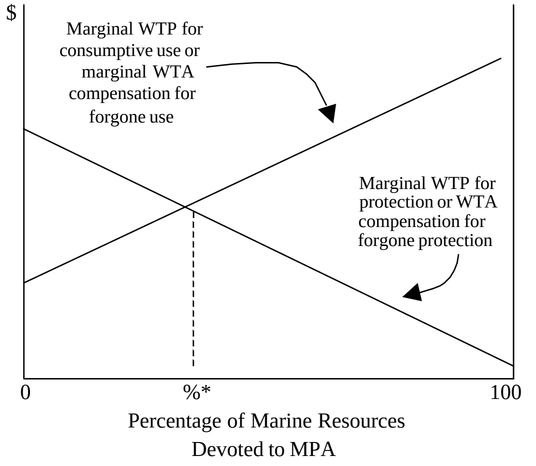

Fig. 3. Marginal valuation curves for direct users and MPA interests in relation to the percentage of marine resources devoted to a MPA.

are protected by a MPA, protection is scarce and nonconsumptive interests are willing-to-pay more for a MPA.

The "market" for MPAs is shown in Fig. 3 with hypothetical supply and demand curves for consumptive and nonconsumptive stakeholders in relation to the percentage of marine resources devoted to a MPA.[15] The intersection of the valuation schedules defines the efficient level of MPA designation for a given marine system. A market clearing "price" has two interpretations: (1) what nonconsumptive stakeholders would have to pay consumptive users for an additional percentage of MPA designation or (2) what consumptive users would have to pay nonconsumptive stakeholders to *avoid* an additional percentage of MPA designation. The first presumes that consumptive users have a property right to the marine resources in the MPA while the second presumes that it is the nonconsumptive stakeholders who have legal claim to marine resources. As with most (regulated) open access property regimes, though, these two groups have access privileges, but neither has an absolute claim to resource services [33]. Thus, no market can exist and a MPA that could potentially increase aggregate social welfare will not be implemented (efficiently) without some other institutional structure and incentives to facilitate the trade-off of values shown in Fig. 3.

As mentioned in Section 2 there is a role for government in the allocation of resources when a market failure exists due to lack of well-defined property rights. Clearly, the extent of the government's role can range from pure central planning to that of a support mechanism for stakeholders in MPA negotiations. It may be that a central planning perspective relying on formal benefit-cost analysis of MPAs is unrealistic given the complexity of some marine ecosystems [1]. In this case MPA

[15] The figure as drawn assumes that the marginal WTP and WTA are the same within each group, though this may not always be the case.

planning must proceed in the manner of recent cases in resource management that tend away from centralized decision-making and towards more participatory and negotiation-based solutions to resource allocation problems [59,60]. To this end, Milon [1] describes a "drama of marine system governance" in which the of scale and ecosystem attributes of the marine environment will determine the institutional arrangements and incentive structures necessary to encourage efficient cooperation among MPA stakeholders. The range of institutions and incentives for managing local commons is broad [61], so there is still considerable research to be done exploring the relative merits of different structures. A good discussion of the issues and some guidance on choosing MPA governance structures is presented in Milon [1]. We conclude our discussion with a few topics for future research that may be of use in governance design for future MPA proposals. Most of the topics are culled from the review of the benefits and opportunity costs of MPAs presented in Section 2. These topics will help in the understanding of the socioeconomic impacts of MPAs and the response of stakeholders to different proposals:

- What is the possible range of relocation costs for fishing effort displaced by a MPA?
- How does the structure of the local fishing industry affect harvesters' acceptance of MPA proposals?
- How much do harvesters value the ability of MPAs to reduce the variance of net revenues?
- How much do recreational angler's value species variety (if this attribute can be enhanced by a MPA)?
- To what extent would large MPA implementations affect the supply and market price of marine products?
- Are consumers willing to pay more for (a greater variety of) products from a "protected" marine environment?
- To what extent would energy and pharmaceutical prospecting be affected by MPAs?
- What are the typical costs and cost components of MPA set-up and management?
- Are there scale economies in MPA development?
- How do the costs of spatial management regimes compare with the costs of other strategies that directly attempt to control effort?

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