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VIEWPOINT

Recasting shortfalls of marine protected areas as opportunities through adaptive management

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ABSTRACT

1. Many marine ecosystems are in critical decline.
2. Iterative assessments of the costs, benefits, and problems associated with conservation initiatives such as marine protected areas (MPAs) can help to improve their effectiveness.
3. The increasingly popular framework of marine spatial planning (MSP) provides opportunities for improving marine management but also needs to avoid similar shortfalls to those identified for MPAs.
4. There is a critical need for realistic presentation of the scope and capacity of MPAs to counteract biodiversity loss, both in isolation and as part of marine spatial planning or other approaches to complementary management.
5. The purpose of this viewpoint is to generate increased momentum to integrate MPAs with other strategies and to recognize the important advances that have been made in MPA planning, implementation and management.

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INTRODUCTION

Severe declines in marine systems mean that we face the prospect of losing species and entire ecosystems within a single generation (Rogers and Laffoley, 2011) and effective management of marine environments is urgently needed (Sala and Knowlton, 2006; Worm *et al.*, 2006). Much has been written about the effectiveness of marine protected areas (MPAs; 'an area of 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' (Kelleher and Kenchington, 1992)) as a tool for marine conservation (Halpern and Warner, 2002; Stewart *et al.*, 2009; McCook *et al.*, 2010). However, a recent review (Agardy *et al.*, 2011) gained profile in *Nature's* News section (Cressey, 2011) by highlighting the shortfalls of MPAs and pointing to marine spatial planning (MSP) as a complementary approach. Our Viewpoint was inspired by this review by Agardy and colleagues. Our purpose is to recast the real and perceived shortcoming of MPAs as opportunities for improvement through an adaptive management approach. The criticisms of MPAs made by Agardy and colleagues (2011) are used to highlight

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opportunities and work already underway to improve MPAs throughout the world (Table 1).

There are three key components to our Viewpoint. First, while there are some legitimate problems with MPAs which are a concern where they occur, we aim to identify additional solutions and examples of how shortfalls are already being addressed. Importantly, shortfalls or poor implementation should not be used as excuses to justify a lack of action. Instead, past challenges can serve to inform and improve future MPA design and management. Second, MSP is coming to the fore as a means of zoning the ocean, and it has been proposed that MSP addresses the failings of MPAs (Agardy *et al*., 2011). However, we think that there is danger in proposing a panacea for the oceans, because appropriate solutions – be they MPAs, MSP or something else – will be context-specific. Furthermore, MPAs are management tools, whereas MSP is a process, not an outcome. MSP might be more akin to MPA planning or design than MPAs. Third, the extent to which MPAs and MPA networks are designated on the basis of 'blind faith', 'careless processes' or 'invalid models' as argued by Agardy *et al*. (2011) is undocumented. Although examples of such problems exist, there is a risk of concluding that these are widespread or dominant without sufficient evidence.

MPA CHALLENGES AS OPPORTUNITIES

In this section, we examine key shortcomings of MPAs as outlined by Agardy and colleagues (2011), and reframe these as opportunities while highlighting some additional challenges. Our sub-headings parallel those of Agardy *et al*. (2011) but are reworded to focus on opportunities rather than shortfalls (Table 1). Our thinking is embedded in adaptive management because it provides a framework whereby past management successes and challenges can inform and improve current approaches (Gerber *et al*., 2007; McCook *et al*., 2010). Adaptive management is an iterative process of continuous improvement based on review, including identification of shortfalls, whereby management goals and methods will be expected to change over time as new information is obtained and new challenges develop (Walters and Hilborn, 1978). The adaptive management cycle includes the following general steps: plan, implement, monitor, review, learn, revise, repeat (Conservation Measures Partnership, 2007). In adaptive management, review and critique of existing management tools, such as MPAs, is a crucial first step. The shortfalls recently identified (Agardy *et al*., 2011) present such a first step, and here we take it further by reframing shortcomings as opportunities in order to maintain the current positive momentum of MPA establishment and to integrate MPAs with other strategies.

Matching MPA scale to issue and context

A criticism of MPAs is that many are too small or poorly designed to be ecologically effective (Agardy *et al*., 2011). This limitation has long been recognized, and has resulted in a move

Table 1. Key shortcomings of MPAs reframed as opportunities

Shortcoming of MPAs as outlined by Agardy *et al*. (2011)*	*Reformulation of shortcomings as opportunities*
Mismatch of MPA scale to issue and context	**Matching MPA scale to issue and context**
MPAs are too small or too poorly designed to be effective	Networks of MPAs, rather than only single MPAs, are being designed and established Integration of community-based opportunities with systematic conservation planning (scaling up and/or down) combines social and ecological considerations
Inappropriate planning or management processes	**Appropriate planning or management processes**
There is insufficient involvement of stakeholders and inadequate attention to compliance	Engaging stakeholders and incorporating their needs into MPA design can facilitate adaptive management and enhance compliance
Failure due to degradation of the unprotected surrounding ecosystem	**Management beyond MPAs**
MPAs are at risk when surrounding areas are degraded and may no longer be able to meet their objectives	Integrated management and land-sea planning, together with adaptive management approaches, can reduce some impacts originating beyond MPAs (e.g. 'ridges to reefs' approaches; (see Kool *et al*., 2010))
MPAs that cause damaging displacement and other unintended consequences	**Minimizing displacement and other unintended consequences**
MPAs result in displacement and thus impacts user groups and the surrounding environment	Design and management of MPAs can be improved if we enhance understanding of fisher responses to MPAs

*We omitted the last point by Agardy and colleagues, 'MPAs that create illusions of protection', because they provide the solution that the perception problems can be overcome by clarity and education.

towards networks of MPAs, i.e. linking them to each other so that there is connectivity (movement of adults and/or larvae) between them (Sala *et al.*, 2002; Leslie *et al.*, 2003). In some cases, such as for wide-ranging species (e.g. marine mammals), MPAs designed to protect them have been poorly designed and are unlikely to be effective (Agardy *et al.*, 2011). But there is hope for MPAs generally, because there is much current interest in scaling up small, community-based MPAs to networks of connected MPAs that also achieve regional goals (Lowry *et al.*, 2009; Rands *et al.*, 2010). Indeed, one of the emerging trends in MPA design is the desired integration of community-based opportunities with systematic conservation planning to leverage their benefits (Lowry *et al.*, 2009; Ban *et al.*, 2011). For example, in Fiji conservation planning software and habitat representation principles are being used to scale up community-based MPAs to an island scale (Wendt and Comley, 2011). Similarly, in a region of the Solomon Islands, a partnership of NGOs and communities is combining community selection of marine and terrestrial protected areas with conservation principles of representation and complementarity (Game *et al.*, 2011). In the Philippines, a social and governance network of small MPAs within Cebu Province is now being retooled to account for connectivity and habitat representation in its overall design at the Provincial scale (Eisma-Osorio *et al.*, 2009). Such scaling would allow issue and context to be matched to MPA scales through MPA networks.

The benefits and limitations of regional and local approaches to identifying MPAs have been discussed in the literature (Pressey, 1994; Pressey and Bottrill, 2008; Ban *et al.*, 2009), and we briefly outline them here. Regional approaches emphasize ecological principles of complementarity, representativeness and connectivity, and generally result in recommendations for relatively large (>10 km in diameter) MPAs. Local approaches generally emphasize practical considerations of governance, management and livelihood considerations, and usually result in small MPAs with fewer negative impacts on peoples' livelihoods. Regional, systematic approaches present implementation challenges, while community-based MPAs alone may not be sufficient to achieve ecological and social objectives (e.g. enhancement of fisheries, protection of biodiversity). Reconciling these two scales of operation requires regional designs to be scaled down (Mills *et al.*, 2010) and local actions to be scaled up (Lowry *et al.*, 2009; Mills *et al.*, 2010). Scaling down inevitably means integrating regional designs with local objectives and preferences (e.g. Papua New Guinea, Green *et al.*, 2009; and Indonesia, Wilson *et al.*, 2011) and evaluating priority areas at different scales (e.g. national, provincial and local governance units; South Africa, Lombard *et al.*, 2011), while building MPA networks from the bottom up without a regional perspective may fail to achieve regional goals (Weeks *et al.*, 2010). Therefore the integration of community and regional planning and implementation is an important avenue for improving the effectiveness of MPAs. The increasing discussion of these issues amongst conservation planners is an encouraging sign that there is progress towards such integration.

Appropriate planning or management processes

The criticism that MPAs have failed to sufficiently involve stakeholders is certainly valid in some cases (Agardy *et al.*, 2011). The opportunity, however, is that, as stakeholders are engaged by incorporating their socioeconomic needs into MPA design, they are more likely to be engaged in the monitoring and evaluation of management success, thus facilitating adaptive management when MPAs are failing to meet their stated objectives. Critical research is clearly needed on how MPA designs and planning processes can better reflect local socioeconomic conditions (Cinner, 2007), facilitate compliance by key stakeholders (Hauck, 2008; Pollnac *et al.*, 2010) and how marine conservation can be integrated with customary practices and preferences of local and indigenous peoples (Cinner and Aswani, 2007; Ban *et al.*, 2008). While additional research is helpful, diverse strategies already exist to engage multiple stakeholders. For example, public consultation of the rezoning of the Great Barrier Reef Marine Park involved over 30 000 submissions (Thompson *et al.*, 2004). Similarly, almost all successful MPAs in south-east Asia have invested heavily in stakeholder participation, which is often at the core of the planning and implementation strategy (White *et al.*, 2005). Furthermore, many tools exist that facilitate engagement of stakeholders, such as integrating community preferences into decision support tools (Ban *et al.*, 2009; Game *et al.*, 2011), mental models (Biggs *et al.*, 2011) and social network analyses (Vance-Borland and Holley, 2011).

Progress is being made to fully involve stakeholders in natural resource science, planning and management (Knight *et al.*, 2006; Pomeroy and Douvere, 2008; Almany *et al.*, 2010), and there is recognition that MPA design and implementation must account for critical linkages between social and ecological systems (Hughes *et al.*, 2010; Ban *et al.*, 2011). For example, the perspective on key stages of systematic conservation planning as discussed by Margules and Pressey (2000) is changing. These were originally biologically focused, and have been amended by Pressey and Bottrill (2009) to emphasize the social, economic and political context for planning. Furthermore, recognition of humans as part of the system has led to multi-disciplinary approaches to understanding interactions between social and ecological systems. For example, in response to different social–ecological conditions such as subsistence needs and high population densities in developing countries, MPAs are increasingly including management tools other than no-take areas (e.g. temporal closures, gear restrictions, and zoning schemes that allow for a range of controlled uses and limitations) (Cinner, 2005; McClanahan *et al.*, 2006; Game *et al.*, 2009). Thus planning and management processes are being adapted to more fully involve stakeholders, and consider social contexts and objectives, in the hope that this will lead to improved compliance.

Importantly, many MPA planning processes are not only improving how stakeholders are incorporated, they are becoming adaptive to changes in both social and ecological domains. Scaling up and down of MPAs, and the increasing focus on social–ecological systems, means that MPA design and management have to become more adaptive to incorporate these additional considerations (Grafton and Kompas, 2005; Gerber *et al.*, 2007; McCarthy and Possingham, 2007; McCook *et al.*, 2010). Adaptive management has a rich history in many coral reef developing nations (Cinner *et al.*, 2006), where traditional governance frameworks facilitate rapid responses to changing environmental or management conditions. In contrast, adaptive management has proven more difficult to achieve in developed countries because of a more formalized legislative system that tends to rely on top-down government actions (Walters, 2007). The small size of many MPAs in developing nations and the fact that they are frequently managed by a single community means that adaptive management decisions can be made and implemented rapidly. For example, coral reef areas are often managed adaptively through periodic closures, sometimes based on specific cultural triggers rather than ecological priorities (Cinner *et al.*, 2006). Social learning about MPA planning and management thus provides an opportunity to improve future practices.

Management beyond MPAs

The criticism that management is needed beyond MPAs has been well-recognized, but fortunately there is an emerging trend for marine management to be more integrative and holistic. Various peer-reviewed publications and some technical reports highlight that MPAs are not a panacea for all that ails the ocean, but rather are one tool that needs to be applied in conjunction with others (Allison *et al.*, 1998; Steneck *et al.*, 2009). Several studies highlight the need for planning across environmental realms and present conceptual frameworks for incorporating connectivity across marine, freshwater and terrestrial systems (Beger *et al.*, 2010; Alvarez-Romero *et al.*, 2011). This work has been complemented by several academic applications of planning across terrestrial and marine realms for specific regions (Tallis *et al.*, 2008; Klein *et al.*, 2010). These recent studies exemplify the trend in MPA planning to be more holistic rather than restricting management action to single MPAs, although challenges to such integration remain. In particular, the hurdle of coordination across multiple stakeholder groups, organizations and management agencies (including problems of overlapping jurisdiction) continues to be an impediment to integrated management.

Some practical examples highlight the shift towards more integrated, holistic management. The iconic example of the Great Barrier Reef Marine Park shows the success of an adaptive management approach (Olsson *et al.*, 2008; McCook *et al.*, 2010), and continues to address issues beyond the immediate scope of the management agency, such as land-based impacts (Great Barrier Reef Marine Park Authority, 2009). The Coral Triangle Initiative (CTI) which works across six countries for improved marine resource management has adopted an integrated approach that focuses on three primary strategies within an integrated EBM framework: ecosystem approach to fisheries management, MPAs/MPA networks and adaptation to climate change throughout the areas of concern (http://www.uscti.org/uscti/

default.aspx). Thus, while the CTI highlights the need for more and better MPAs, the overall thrust is to integrate MPAs with broader scale fisheries management and integrated coastal management (TNC *et al.*, 2008).

Minimizing displacement and other unintended consequences

MPAs can create physical, economic, and sociocultural displacement (Mascia and Claus, 2009; Valcic, 2009; Gaines *et al.*, 2010), but there is an opportunity to improve design and management of MPAs as our understanding of impacts improves. For example, key questions remain as to whether aspects of this displacement are offset by spillover of adult fish or larval subsidy that may increase fishers' catch or profitability (McClanahan, 2010; Graham *et al.*, 2011). This research gap, in combination with technological innovations such as vessel monitoring systems, is leading to an emerging research field that incorporates empirical and modelling studies to better understand the spatial behaviour of fishers and how they are affected by MPAs (Aswani, 1998; Holland and Sutinen, 2000; Wilen *et al.*, 2002; Branch *et al.*, 2006; Abernethy *et al.*, 2007; Daw, 2008). There has been increasing debate around displaced fishing effort programmes, providing insights into the greater effort to design such programmes and using lessons learned from Australia and the USA (Macintosh *et al.*, 2010; Sen, 2010). Improving our understanding of displacement, fisher behaviour, and compensation programmes should lead to better MPA design and management to minimize such impacts.

MARINE SPATIAL PLANNING

MSP is becoming a popular framework in which to embed MPAs (Crowder and Norse, 2008; Douvere, 2008; Foley *et al.*, 2010), and has been proposed as a solution to the shortfalls of MPAs (Agardy *et al.*, 2011). MSP provides the possibility of zoning the ocean for multiple uses, and thereby might more successfully engage stakeholders than conservation-only MPAs. The increasing interest in MSP is encouraging, as it will hopefully lead to additional efforts towards sustainable use of the oceans. On the other hand, MSP does not necessarily address many of the shortfalls of MPAs and cannot short-cut the hard work of engaging the range of stakeholders when scaling up to larger areas of concern or down to specific MPAs.

The processes of MSP and MPA network planning are not necessarily different, and MSP should be informed by the growing experience of systematic conservation planning and MPA network design. MPAs may involve a wide range of management regimes, from no-take zones to general use zones, and some large, multiple use MPAs can be considered outcomes of MSP (e.g. the Great Barrier Reef Marine Park; Day (2002)). Systematic conservation planning has a twenty-year history of developing theory and practice for management design, implementation and monitoring (Kirkpatrick and Harwood, 1983; Margules and Pressey, 2000; Knight *et al.*, 2006; Pressey and Bottrill, 2009). Indeed, many of the benefits of MSP (Agardy *et al.*, 2011) are the same as those afforded by a network approach to MPAs as implemented through conservation planning: having a larger vision, coordinating efforts, utilizing existing information, etc. (Margules and Pressey, 2000; Knight *et al.*, 2006; Possingham *et al.*, 2006). Like any planning exercise, MSP will focus within a particular region and on the representative stakeholders for that region. Outside of the planning region, there will likely be unintended consequences similar to those of MPAs (e.g. displacement of effort by fishers, crowding of fishing grounds, Agardy *et al.*, 2011), regional threats that will require additional management practices, and additional unforeseen issues (e.g. regarding migratory species) which still need to be addressed. For these and other reasons, MSP may encounter many of the problems seen in MPAs, if the issues we highlight are not considered: scaling up community-based efforts and scaling down regional plans; better incorporation of stakeholders into planning processes; recognizing and incorporating social–ecological linkages; implementing non-reserve actions; and developing an adaptive process.

Although the emerging framework of MSP may be useful for marine planners, its success will depend on the degree to which practitioners and scientists address the weaknesses of previous approaches by building and improving upon relevant theory and practice. Importantly, significant efforts will be required to ensure that MSP truly incorporates the full range of stakeholders' views, which may come from seemingly irreconcilable ideological positions about the nature of, and solutions to, problems (Pomeroy and Douvere, 2008). Marine spatial

planners may find valuable lessons in cultural theory and other social science frameworks that approach social problems in ways that acknowledge and incorporate contesting views (Verweij *et al.*, 2006). Furthermore, it is important to keep in mind that appropriate planning processes and solutions will be context-dependent, and that there are unlikely to be panaceas (Ostrom *et al.*, 2007).

The use of adaptive management in marine systems could be improved by moving from passive adaptive management (learning from past successes and failures) towards active adaptive management (deliberate experimentation and carefully designed monitoring to measure and improve management effectiveness) (Walters and Hilborn, 1978). For example, controlled, experimental manipulation of fishing effort could lead to sound guidelines on how much to reduce fishing effort by gear and fishery. While adaptive management has been called for frequently (Grafton and Kompas, 2005; Gerber *et al.*, 2007; McCarthy and Possingham, 2007; McCook *et al.*, 2010), use of the concept has been primarily passive (Walters, 2007). Admittedly, management agencies face real limitations on applying adaptive management because of the financial and other costs involved. In particular, active adaptive management implies experimentation that affects the livelihoods of stakeholders, and they may not be interested in participating. Nevertheless, management agencies can learn-by-doing, and continually improve management practices. Perhaps the interest in MSP provides an opportunity for a renewed call for active adaptive management, including the financial resources to do so, as a critical tool to improve management effectiveness.

HOW EXTENSIVE ARE THE PROBLEMS?

Although identification of shortfalls and successes is critical, perceptions about the extent of each can be critical to future implementation. Agardy *et al.* (2011) identify three potential problems with MPA implementation which may not be as critical as feared. First, they identify the problem of 'blind faith' in the ability of MPAs to counteract loss of biodiversity and services, but do not substantiate the extent of this problem. This has the potential to create the perception that 'blind faith' abounds, whereas there are also many examples of managers and scientists using the best available science to develop and manage MPAs, for example in the Philippines (White and Courtney, 2002), California (Airamé *et al.*, 2003), Australia (Fernandes *et al.*, 2005), South Africa (Lombard *et al.*, 2007) and the Solomon Islands (Game *et al.*, 2011). The interpretation that 'blind faith' is common risks undermining those efforts. It is widely acknowledged in the MPA literature that protected areas alone, without additional management, will be insufficient for ensuring the survival of species and recovery of overexploited stocks (see also section on 'Management beyond MPAs'). The work by Allison *et al.* (1998) emphasized this point, and much of the subsequent work on MPAs includes caveats about the necessity of management beyond the borders of MPAs (Sala *et al.*, 2002; Russ and Alcala, 1999; Alvarez-Romero *et al.*, 2011). For instance, it has been shown for the world's terrestrial and marine vertebrates that, while protected areas are insufficient to halt species declines, they have slowed the rate of deterioration by at least one-fifth (Hoffmann *et al.*, 2010), and evidence of the effectiveness of MPAs to recover depleted stocks is continually emerging (Russ and Alcala, 1996; McCook *et al.*, 2010). Awareness of the limitations and context of MPAs for species protection may be more widespread than "blind faith" in their effectiveness.

Second, the suggestion that MPAs are often designated 'carelessly' (Agardy *et al.*, 2011) seems subjective, and would require careful consideration of what constitutes carelessness. It is true that some MPAs may have been designated without employing a transparent, systematic, and participatory planning process, that some planning processes may have been insufficient due to lack of resources, and that some MPAs may have been designated as a result of unforseen opportunities; but these insufficiencies do not necessarily imply carelessness. Descriptions of risks inherent in 'careless' MPA designation need to be counterbalanced with any of the numerous examples of carefully planned MPAs, for example in the Philippines (White and Courtney, 2002), California (Airamé *et al.*, 2003), Australia (Fernandes *et al.*, 2005), South Africa (Lombard *et al.*, 2007) and the Solomon Islands (Game *et al.*, 2011). Further, the fields of MPA science and systematic conservation planning are making rapid advances towards more effective design and implementation (Margules and Pressey, 2000; Ban and Klein, 2009; McCook *et al.*, 2010; Adams *et al.*, 2011). Furthermore, some countries have policies and legislation that require rigorous processes involving the best science and stakeholder

involvement to establish MPAs (e.g. Australia, Great Barrier Reef Marine Park Act 1975, Marine Life Protection Act in California as amended in 2004). Even in developing countries such as Indonesia, which has a very large marine area under national protection, the process to locate and designate such areas has been systematic and based on the best scientific principles at the time of designation, even if much of this area is not yet effectively managed (TNC *et al.*, 2008). Finally, there is a trade-off between careful process and timeliness. For example, the implementation of the marine reserve on Apo Island in the Philippines predates most current thinking on careful design, yet the conservation and social benefits have been enormous (Russ and Alcala, 1999; Russ *et al.*, 2003). In 2009, both Philippines and Indonesia undertook a national MPA gap analysis based on habitat representation and key species criteria agreed to under the CBD. The results of these analyses are being factored into the planning for MPA networks for both countries and for prioritizing improved management in selected areas. Our main point of providing these counter-examples to careless establishment is that the amount of planning and science incorporated into MPAs design varies, and hence we caution against generalizing that MPAs are often designated carelessly.

Third, the argument that protected areas are 'bound to falter or fail' because of wholesale, 'uncritical application' of planning models designed for terrestrial systems that inadequately incorporate complexities of marine systems fails to recognize the numerous models created specifically for marine systems (Walters *et al.*, 2007; Ball *et al.*, 2009; Christensen *et al.*, 2009; Adams *et al.*, 2011). For example, Adams *et al.* (2011) developed a model for opportunity costs to fishers to allow for more sophisticated accountings of such costs in MPA design. In fact, one of the most widely used tools in protected area design, including for terrestrial biomes, is Marxan (Ball *et al.*, 2009), a software program that was created specifically for MPA design.

CONCLUSION

Discussion about MPAs, their shortfalls and opportunities, and moving towards MSP is important to improve the planning, implementation and management of the marine realm. Examples of (and opportunities for) improving the design and implementation of MPAs exist throughout the world. In particular, networks of MPAs, rather than discrete, isolated MPAs, are being designed and established to overcome the challenge of small or poorly designed MPAs; stakeholders are being more effectively engaged, which is leading to improved buy-in and can facilitate adaptive management; attention to management of threats originating beyond the borders of MPAs is reducing some of those impacts; and improvement in our understanding of displacement effects of MPAs can lead to improved MPA design. Because the implementation challenges for MPAs are largely the same as those for MPA network planning and MSP, the lessons learned from MPAs can help to improve future management of the oceans. The perspective we provide in this Viewpoint – seeing MPAs as opportunities – is aimed to encourage positive momentum to integrate MPAs with other strategies (e.g. fisheries interventions, MSP, integrated coastal management, etc.), and recognize the important advances that have been made in MPA planning, implementation and management. Of course challenges remain, for MPAs and MSP alike, but broadening the discussion of shortfalls towards consideration of the whole adaptive management cycle will hopefully lead to continual learning and improvement.

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