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Introduction

Debating the effectiveness of marine protected areas

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Increasing the size and number of marine protected areas (MPAs) is widely seen as a way to meet ambitious biodiversity and sustainable development goals. Yet, debate still exists on the effectiveness of MPAs in achieving ecological and societal objectives. Although the literature provides significant evidence of the ecological effects of MPAs within their boundaries, much remains to be learned about the ecological and social effects of MPAs on regional and seascape scales. Key to improving the effectiveness of MPAs, and ensuring that they achieve desired outcomes, will be better monitoring that includes ecological and social data collected inside and outside of MPAs. This can lead to more conclusive evidence about what is working, what is not, and why. Eight authors were asked to write about their experiences with MPA effectiveness. The authors were instructed to clearly define "effectiveness" and discuss the degree to which they felt MPAs had achieved or failed to be effective. Essays were exchanged among authors and each was invited to write a shorter "counterpoint." The exercise shows that, while experiences are diverse, many authors found common ground regarding the role of MPAs in achieving conservation targets. This exchange of perspectives is intended to promote reflection, analysis, and dialogue as a means for improving MPA design, assessment, and integration with other conservation tools.

Keywords: Aichi, benefits, conservation, monitoring, sustainable development goals, targets.

Introduction

Marine protected areas (MPAs) have been the subject of increasing policy attention during the last few years. They have been embraced by high level international bodies as being important for achieving biodiversity goals (e.g. the Convention on Biodiversity's Aichi Targets), as a key tool for meeting Sustainable Development Goals (U.N. Oceans Conference Voluntary Commitments), and to protect the natural heritage of humankind (UNESCO's World Heritage Program). Yet MPAs are not universally welcomed (e.g. Bennett and Dearden, 2014), in part because they do not always achieve the outcomes that are expected, hoped for, or intended (Chaigneau and Brown, 2016).

Proponents cite the maturity of the science supporting the effectiveness of certain types of MPAs in maintaining or restoring biodiversity (Lubchenco and Grorud-Colvert, 2015) and the potential for MPAs to make marine ecosystems more resilient to climate change (Roberts *et al.*, 2017). At the same time, there has been massive coral bleaching and death in iconic MPAs, including in the Great Barrier Reef Marine Park and Chagos MPA, revealing the limits of MPAs to protect against all main threats.

With more than 11 000 existing MPAs (www.mpaatlas.org), and many more proposed, it is not surprising that there are a variety of views and experiences about the effectiveness of MPAs. MPAs differ in many ways, including the objectives for which they were created, the ecological and human contexts in which they are situated, the degree to which they involve stakeholders, and how well their management and enforcement is resourced. This great diversity has led to a mix of outcomes that represents an opportunity to study the factors that lead to both successes and failures of MPAs, which in turn has created opportunities for learning about the potential promises and limitations of using MPAs to achieve conservation and social outcomes (Selig and Bruno, 2010; Edgar *et al.*, 2014; Gill *et al.*, 2017). If we are to get the most out of MPAs as a marine conservation and management tool, we need to make full use of this diversity of perspectives and experiences to understand when and where MPAs can be best used to achieve desired outcomes.

In this ICES Journal of Marine Science special feature, our objective was to explore this range of perspectives. To achieve this, we invited eight scientists and practitioners working with MPAs to write concise "point" essays about one key message from their experience. Each author was asked to clearly define "effectiveness" and discuss the degree to which they felt MPAs had achieved or failed to achieve the desired level of effectiveness. We then exchanged these essays among authors and asked that each write a shorter "counterpoint". Although the starting points were often divergent, most authors found common ground, and in some cases new insights, in the perspectives of their counterparts.

What is an effective MPA?

Part of the challenge in discussing the effectiveness of MPAs lies in precisely defining effectiveness. Ideally, objectives for MPAs should be defined clearly, explicitly, and in a way that allows progress to be measured. Most importantly, the stated goals of MPAs should be realistic and developed in consultation with stakeholders.

The potential ecological benefits of strongly protected MPAs (those that prohibit commercial activity and allow only light fishing) and fully protected MPAs that prohibit fishing are well documented (Sala and Giakoumi, 2017). Strongly protected MPAs increase fish biomass and diversity (Lester and Halpern, 2008, Edgar *et al.*, 2014; Gill *et al.*, 2017). MPAs can also promote the dispersal of larvae (Harrison *et al.*, 2012) and adults of target and non-target species to areas outside their borders, potentially benefiting both fisheries and biodiversity outside the MPA (Di Lorenzo *et al.*, 2016), although the extent to which this occurs and whether there is any net fisheries benefit, are unknown for most MPAs (Halpern *et al.*, 2009).

Although there are good examples where MPAs, especially when strongly protected, provide many ecological and economic benefits, not all MPAs achieve, or are intended to achieve, all of these beneficial outcomes. The vast majority of MPAs are not "strongly protected" (Lubchenco and Grorud-Colvert, 2017) nor were many designed to be. Many MPAs are explicitly intended for multiple uses. Of course, some MPAs are simply not effective. Even well-managed MPAs seem to be struggling to achieve their goals in the face of climate change (Hughes *et al.*, 2017; Rodgers *et al.*, 2017), but that does not mean MPAs are not beneficial. Day (2017) writes that the ecological status of the Great Barrier Reef would likely have been worse if the Marine Park had not been in place, but the monitoring data are insufficient to show that this is the case or whether the Marine Park was more effective than other conservation actions that could have been taken.

There is still much to learn about MPA effectiveness

Conservation professionals, faced with declining marine ecosystem health, are right to take action based on existing scientific evidence, reasoning, and modelling. MPA managers also need to continually collect evidence to determine whether management actions lead to the outcomes and targets that are set (Sandin *et al.*, 2008). To fully understand the effect of MPAs (both positive and negative), researchers need to construct and test the counterfactual—what would have been the state of ecological health without an MPA (Ahmadia *et al.*, 2015; Gill *et al.*, 2017)—which requires data before and after, with and without (BACI) MPAs. Although the BACI method appears in numerous studies (e.g. Kerwath *et al.*, 2013), MPA monitoring too frequently fails to include indicators and data that are conducive to this approach. As the goals of MPAs, especially multi-use MPAs, become more numerous and nuanced (e.g. climate resilience, ecosystem functioning, job creation, ecosystem services, and other societal benefits), identifying and collecting data on indicators that reflect the full suite of desired outcomes has become increasingly challenging.

More data and analysis are needed to understand the human and social impacts of MPAs. In the exchanges that follow, we see that the effects of "MPAs on people" and of "people on MPAs" are more complicated and far-reaching than previously acknowledged. Reduced access to resources, at least in the short-term, can create social and economic inequities (Halpern *et al.*, 2013), with unanticipated changes in human behavior. For example, the emergence of hyper-competitive behavior occurs in fishing communities that have been displaced by MPAs (Basurto *et al.*, 2016; Basurto, 2017). If this leads to decreased levels of cooperation among community members, it should be carefully considered in the evaluation of MPA effectiveness. Although poaching is known to be a problem within some MPAs, Bergseth et al. (2017) demonstrate that poachers in the Great Barrier Reef Marine Park are aware of the benefits of no take marine reserves and may even have been encouraged by the knowledge that catch will be better within the no take areas. Although the tradeoffs created by differing human responses to MPAs are acknowledged in the literature (Halpern *et al.*, 2013) they are seldom investigated empirically, nor are they placed in the context of other non-fisheries benefits of protection (e.g. shoreline protection, carbon storage, tourism, and recreation, etc.).

Of course, compliance matters for MPAs and there is increasing confirmation that "stronger protection" yields better results (Cinner *et al.*, 2014; Edgar *et al.*, 2014; Kaplan *et al.*, 2015; Gill *et al.*, 2017) but enforcement is often difficult and adds additional costs to effective marine protection (Mora *et al.*, 2006; Bergseth *et al.*, 2017). Claudet (2017) argues that by erroneously assuming no take areas are free from poaching, the true benefits of strongly protected marine reserves are underestimated because more could be done to improve compliance. When addressing compliance, enforcement and positive incentives go hand in hand. There is increasing evidence that a positive-incentive approach to MPA governance may lead to more effective MPAs (Kaplan *et al.* 2015). Obura (2017) hypothesizes that if significant expansion in MPA

coverage is to be effective, it will require special attention to MPA design that creates incentives for desirable behavioral outcomes.

Although the literature is replete with experimental and theoretical studies of the biological impacts of MPAs, we still have much more to learn about their societal, management, and policy dimensions. Beyond success stories for selected, well-managed MPAs (Woodcock *et al.*, 2016), we need to know more about how the more numerous, moderately resourced, and even failed MPAs affect people and whether the impacts of MPAs on human communities are, on balance, positive (Gill *et al.*, 2017).

Finally, while increasing evidence points to the ecological benefits of strongly protected MPAs within their boundaries, questions remain about how these benefits translate outside of MPAs, or to what extent MPAs provide positive net benefits for the wider social-ecological system, at the seascape scale (Karieva, 2006; Cinner *et al.*, 2014). More study is needed to address concerns about whether MPAs displace fishing effort to outside waters (Agardy, 2017; Hilborn, 2017) which, in turn, can simply displace impacts to other areas reducing biodiversity and fish abundance outside of the MPA. Collecting data to ascertain whether net benefits are being achieved, both inside and outside MPAs, will be needed if increases in the global coverage of MPAs is to achieve sustainable development goals (Pascual *et al.*, 2017). New methods will be needed to measure benefits and costs associated with remote MPAs, especially those that seek to prevent future impacts.

Why a healthy and ongoing debate about MPAs matters

A vigorous, scholarly debate about when and where MPAs are effective and appropriate, backed by more empirical scientific testing, will improve our ability to harness marine protection to improve ecological and social outcomes and help set realistic expectations about what MPAs can achieve, now and in the future.

As the global coverage of MPAs increases, research will be needed to determine how the trend towards larger and more multiple-use MPAs will influence their potential success and how this should best be measured. For both new and existing MPAs, managers should set realistic expectations regarding outcomes (Claudet, 2017), pay special attention to social and institutional contexts (Basurto *et al.*, 2016), work with stakeholders to achieve the best possible outcomes (Bergseth, 2017; Obura, 2017), and measure key indicators inside and outside of MPAs to assess MPA performance towards ecological and social goals (Agardy, 2017; Day, 2017). This requires integrating knowledge from multiple disciplines, as well as incorporating feedback from MPA planners, managers, and stakeholders. Implementing adaptive management processes that respond to new knowledge and data will further help to maximize the chances of achieving the stated goals of MPAs.

Gathering and analyzing new knowledge about MPAs, and debating the meaning of results, is necessary because:

- It is costly to invest in MPAs that cannot achieve their objectives, particularly when those funds could have been spent on other conservation actions.
- The failure to achieve MPA objectives can lead to an erosion of credibility and a loss of trust in management and conservation (Agardy, 2017).
- Over-reliance on MPAs can reduce creativity in finding new approaches to marine conservation and the best mix of approaches.

The exchange of perspectives presented in this initiative is intended to promote reflection, analysis, dialogue, and debate as a means for improving MPA design, assessment, and integration into the portfolio of available conservation tools. We encourage more scientific study, especially social science, economics, and interdisciplinary research to ensure that we:

- promote MPAs in situations where they are an appropriate conservation tool,
- do not oversell their benefits and undersell their potential risks,
- continue to improve the effectiveness of MPAs during the implementation process and after establishment (Ban *et al.*, 2012; Agardy, 2017; Obura, 2017), and
- understand the relative costs and benefits of MPA establishment, compared with or in conjunction with other approaches (including but not limited to watershed management, fisheries management, and pollution reduction) across multiple stakeholder groups and at the seascape scale.

We close with a call to expand the debate and discussion beyond the admittedly non-representative group of authors featured in this series to include a broader spectrum of MPA professionals and conservation scientists. The articles in this series will be linked to https://mpanews.openchannels.org where we invite the reader to continue the discussion on MPA effectiveness, outcomes, and experiences.

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