Marine protected areas: Science, policy & management

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Abstract

Marine protected areas (MPAs) generate powerful interactions between social, economic and environmental interests, manifest at a circumscribed and often local scale. Consequently the designation and management of an individual MPA typically plays out in microcosm the general challenge of sustainable development in the marine environment. Some universally relevant questions relating to four commonly held defining attributes of MPAs are articulated. However, while many of the questions are universal, in practice the answers vary greatly. Consequently there are few MPAs which would not provide an informative case study elucidating the dynamics at the intersection between science, policy and management in the marine realm. The papers in this collection exemplify a range of key issues across this spectrum of disciplines. In practice most contentious issues relate to the balance within MPAs between environmental and socio-economic considerations, not least relating to fishing. In this respect greater attention in MPA management plans, to the economic benefits of MPAs for local communities is encouraged. However we also recognise that glib assertions that a secure sustainable balance between conservation and exploitation can be established in practice, typically with few resources in a largely unseen and often data-poor environment, may sometimes be politically expedient but scientifically questionable. Yet it is ultimately the work of all those involved directly with MPAs to collectively achieve the task of transforming the rhetoric of marine conservation policy into a successful reality on the ground and we commend the authors of this collection for their efforts to achieve that goal.

1. Introduction

It has recently been estimated that 87% of the world's oceans are already significantly impacted by human activity. (Jones et al., 2018). In 2010 the Strategic Plan of the Convention on Biological Diversity (CBD) established a 2020 target to the effect that 10% of the worlds coastal and high seas be conserved through systems of marine protected areas (MPAs) (CBD, 2010, Aichi target 11). Whether or not this MPA target is achieved it is true that their global extent has increased substantially in recent years to the point where they are now regarded as the "cornerstone" of marine conservation (Giakoumi et al., 2018). It has been estimated that in 2017 about 13% of the marine environment under national jurisdictions (up to 200 nautical miles from shore) was protected within an MPA, and 5.3% of the total ocean area (UN, 2017). However estimates of global coverage vary according to source and include an alternative lower figure of 3.6% of global ocean being reported as protected within actively managed MPAs. (Sala et al., 2018). Many definitions of marine protected area exist. Rather than add another to the literature, below we identify four recurring defining attributes for the MPA concept, which are consistent with most definitions which otherwise differ in detail:

• A geographical area of marine character or influence with defined boundaries, normally including both water column and underlying benthic components
• Which is protected through legal or other explicit means
• For the purpose of conservation of specified features or systems, and

• Managed with the intention of achieving a higher level of protection than that of the surrounding area

Although such defining attributes in themselves may seem innocuous, in fact, each represents an area of vigorous debate and contention played out at the intersection of three disciplines: science, policy and management. In a recent "clarification", the International Union for the Conservation of Nature (IUCN, 2018) elaborated six "essential characteristics" for MPAs including inter alia a priority focus on conservation and the availability of resources and capacity to effectively implement an explicit management plan. In fact variations in both coverage estimates and definition reveal differences in the priorities and motivations of the organisations and individuals concerned. Many opportunities for different policy and management approaches are created by differing responses to many difficult questions: Taking each defining attribute in turn common questions include:

Area
How large should an MPA be in order for it properly to capture the specified features? To what extent is the boundary arbitrary or scientifically rational? Does the boundary trigger changes to the surrounding system? What constitutes effective "connectivity" within
or between MPAs? How and to what extent can a circumscribed area conserve a highly motile species?

Protection
What level of protection should apply? Should an MPA or parts of it be "mixed use" or "no-take"? Is there an appropriate balance between conservation and livelihoods? What are the political implications of more or less protection? How do we measure success?

Features
What is the purpose of MPAs both in particular and in general? In what circumstances might they be effective as representative conserved environments, for the protection of focal species, or as a strategy to ensure wider marine ecosystem or economic benefits? Which conservation features should be specified and why? Does current status suggest maintain or recover objectives?

Management
Which management approaches are optimal in delivering the stated objectives? What constitutes effective stakeholder engagement? Where is the best balance between consensual and contentious management approaches? Are particular management plans adequate or achievable? In practice, with finite resources, to what extent can compliance be achieved? These four categories of question are of general and worldwide applicability and are being addressed in theory and in practice in a multiplicity of institutions ranging from international treaty organisations through national and provincial governments to non-governmental organisations (NGOs), research institutes and universities.

2. MPAs & sustainable development

In practice the most contentious issues relate to the balance within MPAs between environmental and socio-economic considerations. For some stakeholders the answers are inclined towards one approach or another. NGOs and fishers for example can be clear on their often contrasting preferences. Consequently the configurations and management regimes of MPAs can be highly political issues which for Governments and their local agencies can be challenging, and are fundamentally a question of how in practice to achieve "sustainable development" in the MPA context? The concept of sustainable development has been widely adopted since its introduction into the international policy arena by the World Commission on Environment and Development in 1987 (WCED, 1987), since when it has become ubiquitous. Therefore by implication sustainable development is ostensibly achievable. But sustainable development differs from environmental protection in that the central premise of the former is that there need not be a trade-off between economic growth and the environment (Carter, 2007 p171, Portney, 2015). Politically this idea has great appeal as it allows for economic growth as a legitimate component of conservation thinking. Consequently the general challenge of achieving both conservation and economic exploitation in the marine environment is set at all political levels from local and national governments to major international treaty organisations. Goal 14 of the United Nations Sustainable Development Goals is to "Conserve and sustainably use the oceans, seas and marine resources for sustainable development. While Goal 14 is frequently quoted as a powerful rationale for effective MPA designations, it is only one of a number of Goals which in practice interact in such a way as to leave open major policy and management interpretations. In particular Goal 1 seeks to end poverty in all its forms and Goal 10 to reduce inequality within and among countries (UN, 2017). Moreover these goals are manifest in similar policy aims at national and local levels. Ostensibly conservation or economic arguments can be accommodated in the short term, by prioritising one over the other. But with the fast growth in number and extent of designated MPAs, finding ways to demonstrably achieve both at the same time, hand in hand, can be both a technically challenging and politically contentious exercise, in which different moral and legal imperatives, encapsulated in concepts such as precaution and proportionality, must be resolved. And among the approaches to conservation, the designation of a protected area, most of all, generates strong local interactions between social, economic and ecological dynamics. Each individual MPA arguably plays out in microcosm the general challenge of sustainable development in the marine environment. Consequently, despite targets in favour of increasing the number and size of MPAs, controversy still surrounds their effectiveness and even legitimacy (Cormier Salem, 2014). The "triple bottom line" (Rees et al., 2018) of economic development, environmental sustainability and social inclusion can be illusory. Not least in coastal seas, for every legitimate critique of the "paper parks" genre which emphasises the importance of "no take zones" or "strongly protected MPAs" (SEASTATES, 2017), there is a relatively deprived coastal town in an otherwise affluent country, or a poor community at risk of absolute poverty for whom exploiting the sea is part of their livelihood or even subsistence.

In this context glib assertions that a secure sustainable balance between conservation and exploitation can be established in practice, with few resources in a largely unseen and often data-poor environment, may be politically expedient but scientifically questionable. Yet it is

ultimately in the interests of all those involved with MPAs to collectively achieve the task of transforming the rhetoric of marine conservation into a successful reality on the ground.

Therefore in practice there are relatively few if any MPAs which would not provide an informative case study illustrating the challenges of sustainable development and elucidating the dynamics at the intersections between science, policy and management in the marine realm.

3. The collected papers

This themed collection of papers exemplifies all four question categories established above. Although it seems self-evident that the location and boundaries of an MPA should be informed by solid scientific evidence, the marine environment is, for scientists, remote, complex and often volatile. This complexity is well illustrated in this volume by Uncles et al. who provide a detailed report on water and sediment quality in an English estuary MPA, whose specification requires that these features should be maintained, and Breda et al. who report biogeochemical and bioaccumulation dynamics in a Portuguese coastal lagoon MPA. While both these papers show the complexity inherent in how, what Breda et al. refer to as "multiple driving forces" interact to determine different site specific risks at a local scale, in doing so they also arguably show that acquiring a detailed and complete scientific evidence base sufficient in itself for decision making is a highly technical, lengthy and expensive enterprise. Such factors implicitly suggest why MPA designations often cannot wait to be established only on the basis of complete scientific evidence. In this respect Ferrari et al.'s examination of how, in data-poor ecosystems, MPA planning can be achieved, is relevant. In particular they compare the utility of two different approaches in which environmental "surrogates" are used to predict the distribution and abundance of species in the absence of biotic data. Breda et al. show that, once an MPA is established, the integration of biophysical data sets to establish the risk to individual species and ecosystem services within protected areas can be particularly valuable for fisheries. But large data sets from different sources are by nature complex and sometimes conflicting. Here Watson et al. demonstrate the application of statistical approaches to help unravel interactions between different environmental drivers and associated feedbacks that might precipitate ecosystem 'tipping points'. Establishing a thorough species inventory for MPAs is especially challenging, particularly as many taxa undergo considerable temporal changes in abundance due to natural cycles, migrations and episodic severe events. The review of marine mammals in Mexican waters (Muzquiz & Pompa-Mansil) and the study on horseshoe crabs by Martinez et al. also raise the question of how adequately spatial measures can protect species which undergo significant migrations. For non-migratory species at least, no-take zones have been shown to be valuable spatial tools in restoring target species abundance in exploited areas, particularly in shallow waters. Also in this issue Malcom et al. provide new data on the effectiveness of no-take zones on target and non-target species on rocky reefs within deeper waters over useful timescales. Reporting the incidence and frequency of disease outbreaks (Sisney et al.) within protected and unprotected areas is valuable to establish whether anthropogenic disturbances are raising background stress levels. Unsurprisingly, dealing with 'uncertainty' is a recurring theme in the contributions to this themed collection. This may relate to the nature of the species, features and interactions within the designated area itself, or concern the efficacy of

management interventions. Although precautionary approaches have been applied in many contexts, arguably 'uncertainty' can sometimes be born of a failure to communicate with individuals and groups who have local and expert knowledge and who, if not heard may resist policy measures, as communicated by Said et al. Indeed this latter stakeholder phenomenon has been shown to be of crucial importance for the success or failure of MPAs (Giakoumi et al., 2018). For data poor ecosystems, there are difficulties in establishing meaningful baseline species distribution models and the importance of utilising local knowledge within these regions is necessary to achieve conservation outcomes (Ferrari et al.). This is also exemplified by the contribution from Loseto et al. on the protection of Belgua whales in the first MPA to be established in the Arctic. Here, indigenous knowledge has been fundamentally important for interpreting environmental change in the region and understanding whale population dynamics.Where more data is available, tools developed utilising the expertise and opinions of both academic and non-academic stakeholders can facilitate communication and guidance on the management of MPA features (Hopkins et al.). Through collaboration, innovative solutions can emerge, as in the case study by Hall et al. where, on urban coastlines within a protected area, engineers, scientists, agencies, schools and the local community have created pilot ecological enhancements to vital sea defences that could be scaled up to mitigate habitat loss. Overall the papers in this collection illustrate a range of responses to the key categories of question identified above. In doing so they exemplify a commonality of challenges across different national jurisdictions and biogeographical regions, and the sort of substantial scientific, policy and management issues presented by Marine Protected Areas worldwide.

4. Conclusion

MPAs are undeniably now established as a key protection measure for the marine environment, yet they remain a source of contention, sometimes even within stakeholder groups, let alone between them. In principle sustainable development delivers both environmental and economic benefits, but in reality many stakeholders perceive MPAs only as a vehicle for closing down economic opportunities. A burgeoning knowledge of the science of marine protected areas will gradually elucidate many of the questions raised above, and increase our understanding of the utility of MPAs in marine conservation. Similarly increasingly sophisticated approaches to stakeholder consultation and active participation will also prove essential. Arguably however less progress is being made on how and to what extent MPAs in practice contribute to the sustainable exploitation of the seas, rather than just their conservation. This is not to say that good examples of such work do not exist, see for example Russi et al. (2016) for a European review of a range of socio-economic MPA benefits. Also various case studies have demonstrated the principle that MPAs can improve fishing. Roberts et al. (2001) and Gell and Roberts (2003) provided early examples of such benefits. However as Buxton et al. (2014) have shown, it cannot be assumed that even no take zones will always generate such benefit. In any event while such case studies elucidate the underlying science, they do not substitute for stock analyses as an integral feature of management plans for individual MPAs. With a small number of notable exceptions (e.g. Goss-Custard et al., 2018), few reports exist yet seeking to maximize the sustainable economic benefit from an MPA with the precision of fisheries concepts such as maximum

sustainable yield or total allowable catch. Where an MPA is generating improved population dynamics and ecosystem function such analyses could, particularly with shellfisheries, enable locally increased regulated exploitation. At the local levels at which most MPAs operate, such benefits are key to achieving greater consensus between interest groups, thereby expediting the acceptance of MPAs, not only by those already persuaded, but by those who remain unconvinced. However strong the moral arguments for sustainability, it is generally accepted that the attitude of stakeholders on the ground is essential to the success of an MPA. Moreover, those whose livelihoods are achieved at sea generally know enough to circumvent regulations should they wish to. In this context, even in the coastal seas of higher income countries, few if any MPA managers have the resources to fully enforce MPA restrictions where a community is not supportive. This is a reality that must be factored into MPA science, policy & management to an extent that goes beyond even sophisticated approaches to consultation.

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