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Viewpoint

One size does not fit all: The emerging frontier in large-scale marine conservation

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ABSTRACT

On the 20th anniversary of the Convention on Biological Diversity, a network of very large marine protected areas (the Big Ocean network) has emerged as a key strategy in the move to arrest marine decline and conserve some of the last remaining relatively undisturbed marine areas on the globe. Here we outline the ecological, economic and policy benefits of very large-scale MPAs and show their disproportionate value to global marine conservation targets. In particular we point out that very large-scale MPAs are a critical component of reaching the Aichi targets of protecting 10% of global marine habitats by 2020, because in addition to encompassing entire ecosystems, they will bring forward the expected date of achievement by nearly three decades (2025 as opposed to 2054). While the need for small MPAs remains critical, large MPAs will complement and enhance these conservation efforts. Big Ocean sites currently contain more than 80% of managed area in the sea, and provide our best hope for arresting the global decline in marine biodiversity.

In 1992 the Convention on Biological Diversity (CBD) was opened for signature at the United Nations Conference on Environment and Development (the Rio "Earth Summit"). Recognizing the global crisis of dwindling biodiversity and extinction, the convention was eventually signed by 193 nations and territories. In 2010, at the 10th Meeting of the Conference of the Parties to the Convention on Biological Diversity in Nagoya, Japan, the Parties ratified the Aichi Biodiversity Targets, a broad set of initiatives including the following goal as part of Target 11: by 2020 at least 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, would be conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures that are integrated into the wider seascapes.

Many believed that this target was ambitious, because marine protected areas at that time encompassed only about 1% of marine habitats and had a median size of 4.6 km^2 (Spalding et al., 2013; Bertzky et al., 2012; Marinesque et al., 2012; Toropova et al., 2010; Wood et al., 2008). Fortunately, a few more nations stepped forward to declare large-scale marine protected areas (MPAs); i.e.,

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[1] Shared first authorship. The original concept for the Big Ocean Network was developed by T.A.W., NOAA Superintendent for PMNM. She and T.T., Executive Director for PIPA, led the founding of Big Ocean Network under a sister-site agreement between U.S.A. and the Republic of Kiribati. The inaugural planning team for the Big Ocean Network included T.A.W., T.T., S.T., J.P., N.L. and Regen Jamieson.

[2] The Big Ocean Think Tank at the 25th International Congress for Conservation Biology included the following additional participants and organizers: K. Aiona, S. Anderson, Z. Basher, J. Bosanquet, J. Brider, N. Brownie, T. Carruthers, R. Constantine, T. Durbin, R. Jamieson, R. Kosaki, K. Morishige, J. Philibotte, R. Rotjan, G. San Martin, T. Short, A. Skeat, T. Tenuata, W. Tooma, S. van Dijken, I. Wright, and L. Wright-Koteka.

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MPAs > 240,000 km^2 that are actively managed for protection (Table 1).

The first large MPA was the Great Barrier Reef Marine Park at 344,000 km^2, founded in 1975 by the Government of Australia and recognized as a U.N. World Heritage site in 1981. In 2000 a second large MPA was established in the Northwestern Hawaiian Islands (360,000 km^2), now recognized as the Papahānaumokuākea Marine National Monument since 2006 and a U.N. World Heritage site since 2010. This was the first truly remote and uninhabited large-scale MPA. The Republic of Kiribati established a third large MPA in 2008, the Phoenix Islands Protected Area, and three more large-scale MPAs were established in the next 6 years (Table 1), with several others being likely to be declared soon.

Momentum continues to build. On the 20th anniversary of the original CBD (June 4, 2012), the Australian Government unveiled plans for the world's largest network of marine parks to "turn a corner on protection of our oceans." In August 2012, the Cook Islands and New Caledonia both announced plans to create marine parks spanning over 1,000,000 km^2 which would represent the largest MPAs on the globe. While some question whether such large-scale MPAs are effective, needed, or even actively divert attention from policies that could actually make a difference (Pala, 2013; Anonymous, 2013; The Nature Conservancy, 2012; Starck, 2009), here we outline why neither the science nor the reality support these views.

The vast majority of the world's MPAs have focused on nearshore and shallow-water habitats, but recent developments have spurred a new momentum for the creation of MPAs in offshore and open ocean areas as well. After the establishment of the Papahānaumokuākea Marine National Monument and declaration of the intent to establish the Phoenix Islands Protected Area in 2006, discussions began among managers and conservation professional to address the unique challenges faced by such large MPAs, especially the governance and protection of vast tracks of open ocean (Islands, 2007). These led to a sister-site agreement between the U.S.A. and the Republic of Kiribati aimed at addressing the challenges of managing very large MPAs (Wilhelm et al., 2011). Managers, scientists and partners from other sites (Fig. 1) soon joined this discussion and formed an alliance to share experiences, identify scientific gaps and to collaborate on efforts to cope with major challenges facing such large and remote sites. This led to the founding of a unique conservation organization in 2010, "Big Ocean: A Network of the World's Large-Scale Marine Managed Areas", (http://www.bigoceanmanagers.org/), focused on professionalizing this new genre of marine conservation. Big Ocean was launched with the straightforward objective of providing a forum for communication among the rapidly expanding network of large MPAs. In addition to improving efficiency and effectiveness of management at existing sites, Big Ocean also provides a foundation of experience and resources for new MPAs (Wilhelm et al., 2011). The launch of Big Ocean included the first managers' communiqué, formulated by the inaugural Big Ocean partners, providing a shared forum for discussion while recognizing that each site is in different stages of evolution and development, and with different scientific knowledge bases (Wilhelm et al., 2011).

1 year after the inaugural meeting, Big Ocean managers and scientists working in these areas convened a workshop in conjunction with the 25th International Congress for Conservation Biology Marine Think Tank in Auckland, New Zealand titled, "Big Ocean: A Research Agenda and Science Dissemination Strategy for Large-Scale MPAs". This workshop addressed the role of large-scale MPAs in achieving the goal of protecting 10% of the world's oceans by 2020, and how to ensure that the right habitats, species and ecosystem functions are protected in the process. The workshop focused on the unique set of benefits and challenges for large-scale MPAs, including ecological, economic, and political considerations.

Foremost among the ecological benefits of large MPAs is the protection of both entire ecosystems (Sheppard et al., 2012) and the synergistic links to adjacent ecosystems (Toonen et al., 2011) which is the most direct and effective manner of maintaining intact ecosystem services. Until recently, MPAs have largely focused on nearshore and shallow-water habitats, but Big Ocean has spurred the momentum for protection of offshore and open ocean areas as well. A unique feature of oceanic ecosystems is that key habitats, such as eddies and upwelling zones, will change in location and intensity over time; only large-scale MPAs will incorporate such mobile habitats, and protect vulnerable marine ecosystems such as seamount chains. Further, these MPAs afford greater protection to the oceanic migrants or highly mobile species whose home ranges vastly exceed the confines of coastal MPAs (Fox et al., 2012; Lester et al., 2009). A few studies have now considered the effectiveness of pelagic MPAs (Game et al., 2009; Notarbartolo-di-Sciara et al., 2007), and only very large-scale MPAs are likely to reach the ~20% 'rule of thumb' proportion of habitat required for effective protection (Lester et al., 2009). Additionally, large MPAs buffer against the inevitable uncertainties in manage-

Table 1
Inaugural sites of the Big Ocean Network.

Name	Country	Founded	Size	Proportion of site that is no-take (%)	Comments
Great Barrier Reef Marine Park	Australia	1975	344,000 km^2	33	U.N. World Heritage site in 1981.
Papahānaumokuākea Marine National Monument (PMNM)	U.S.A.	2000	362,074 km^2	100	Created as Northwestern Hawaiian Islands Ecosystem Reserve in 2000 and became a Marine National Monument in 2006. U.N. World Heritage Site in 2010.
Phoenix Islands Protected Area (PIPA)	Republic of Kiribati	2008	408,250 km^2	4	PIPA declared in 2006 and established in 2008. U.N. World Heritage Site in 2010.
Mariana Trench Marine National Monument (MTMNM)	Common-wealth of Northern Mariana Islands U.S.A.	2009	246,609 km^2	100	Only protected deep-sea trench in the world.
British Indian Ocean Territory (BIOT) Marine Protected Area	U.K. Overseas Territory	2010	640,000 km^2	100	British Indian Ocean Territory consists entirely of the Chagos Archipelago and surrounding waters, with the exception of Diego Garcia Atoll out to 3 nm. Contains 32% of the world's fully protected marine reserves.
Motu Motiro Hiva Marine Park	Chile	2010	150,000 km^2 (with planned expansion to 411,000 km^2)	100	Isolated reefs northeast of Rapa Nui (Easter Island), explicitly created to protect one of the last pristine ecosystems in the Pacific Ocean and advance the 10% goal of the Aichi Biodiversity Targets.

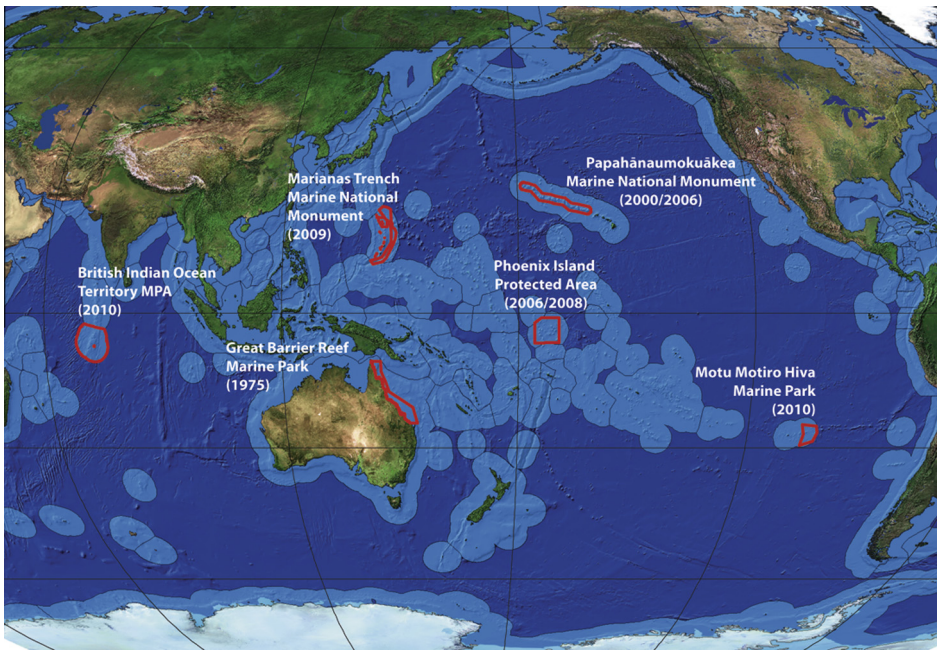

Fig. 1. Map showing the location of the six founding sites of the Big Ocean Network. Dates in parentheses indicate years of designation.

ment, as well as reducing the substantial edge effects associated with smaller MPAs (Keller et al., 2009). In ecosystems where little is known about the distribution of key species or where species distributions vary greatly between seasons or years (e.g., Ashmole and Ashmole, 1967), large MPAs are far more likely to encompass and protect critical habitat or processes that maintain populations and ecosystem stability, and prove resilient to large-scale disturbances. Finally, if climatic changes alter species distributions (Hazen et al., 2013), large-scale MPAs are more likely to encompass habitat shifts than are smaller protected areas tightly aligned with contemporary habitat.

Foremost among economic benefits, large MPAs are more efficient, both in terms of establishment and maintenance. Although overall establishment costs of large MPAs are generally higher than smaller MPAs, on a per-km^2 basis the Marianas Trench MNM and PMNM had the lowest establishment costs of any MPAs studied to date – up to an 82.0% savings in cost over the next least expensive MPA (Seaflower in Colombia, 65,018 km^2) (McCrea-Strub et al., 2011). Further, the long-term cost of MPA maintenance per km^2 drops drastically as size increases, providing broad economic, conservation and science benefits (McCrea-Strub et al., 2011). Conversely, the premier political and logistic challenges to biodiversity conservation facing these sites include the global issues of climate change and ocean acidification (Selkoe et al., 2009), as well as more localized challenges of surveillance and enforcement. Illegal, unreported and unregulated fishing is still common in the Pacific and Indian Oceans, and these large biodiversity havens make tempting targets in an increasingly depleted global ocean, bringing a spotlight to enforcement and protection costs.

Recent history indicates that large-scale MPAs have strong appeal to coastal and island nations seeking to achieve their biodiversity objectives and treaty obligations. The Big Ocean network serves as not only a source of information, expertise and resources to be shared among existing member sites, but also as a peer-support group to assist new sites in developing management models that suit their needs. New large-scale MPAs that are in the works, such as the Coral Sea (Australia and New Caledonia) have already consulted with Big Ocean and were active participants in the Think Tank. Similarly, the Cook Islands participated in the Think Tank, and have subsequently been established as an MPA and accepted into the Big Ocean network. Notably, these forward-thinking governments have increasingly been assisted by non-governmental and private organizations to assist in efficient and effective management from establishment.

Some of the strongest criticisms of the establishment of such large-scale MPAs stem from a lack of complete protection over their entire areas. Of course large MPAs are not the only solution to arresting ocean decline, and must be viewed in the context of a complex suite of conservation measures. Complete 'no-take' status has been declared for several Big Ocean sites, but some large MPAs with multiple-use zones are a necessity, especially in ocean nations managing their entire EEZ, where there are large human populations that rely on marine resources as their main source of protein. One of the primary goals of Big Ocean managers is to strike a balance between complete protection where possible and multiple-use where desirable, while avoiding 'paper parks' that do not effectively extend beyond the initial government declaration. Several Big Ocean MPAs afford limited protection and allow for commercial fishing across substantial portions of their sites (Table 1), and will help to better understand the contributions to biodiversity that no-take versus multiple-use reserves make. However, even the low no-take protection in PIPA, includes more than 15,000 km^2 of complete no-take that protects ~80% of identified priority habitats, with plans for increased protection through time. Thus it is important to note that the establishment of a MPA is a process, not a single and final act, and the establishment of many sites, both small and large, requires a phased approach to building protection measures over time. Experience has shown that once an MPA is established, building protection and other effective measures for conservation can be a lengthy process (Fernandes et al., 2005).

The Big Ocean network recognizes the critical importance of smaller and coastal MPAs, but growth and area coverage of the latter is too slow to attain the Biodiversity Convention target of protecting 10% of the world's oceans in the near future (Fig. 1) and are not stemming global declines (Bertzky et al., 2012). Likewise, simply increasing coverage is not the ultimate goal of the Target, which also seeks to create effective management of these regions. Additionally, small coastal MPAs struggle with the Aichi Target 11

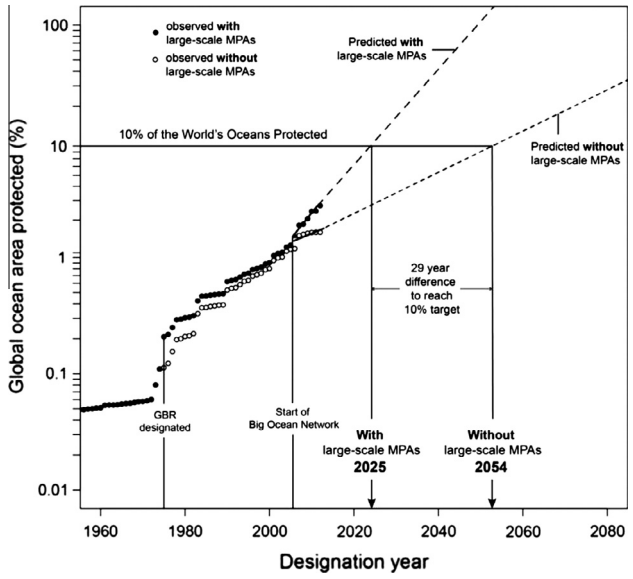

Fig. 2. Projection of the annual rate of increase of global marine area protected between 2006 and 2012 and into the future with (2.82%, $r^2 = 0.94$) and without (1.65%, $r^2 = 0.48$) large-scale MPAs. Projected dates to reaching the target goal of 10% of the world's oceans protected by marine protected areas adopted by the Convention on Biological Diversity (CBD) are denoted. Data is from the MPAtlas (www.mpatlas.org) and projections were done using simple linear regression following Wood et al. (2008).

intent of global goals in terms full representation of ocean habitats, and preservation of ecosystem services more so than these large scale sites. Finally, most small and coastal MPAs are located directly adjacent to large human population centers, and therefore face massive problems in terms of effectiveness even when completely no-take (Halpern et al., 2013). Conversely the Big Ocean sites contain some of the most intact and least impacted ecosystems left on the planet (Halpern et al., 2008), and protecting them now before they are actively targeted makes sense. Clearly, the best hope for the future of the oceans includes both large and small MPAs. Collectively, Big Ocean sites already contain more than 3.1 million km^2, an area over twice as large as the Gulf of Mexico, which has fundamentally changed the possibilities of achieving the Aichi Biodiversity Target for effective ocean conservation. Without these sites, the Aichi 10% area coverage goal would be reached at best around the year 2054, whereas with them the current prediction is roughly 2025, an almost three decade difference (Fig. 2). The Big Ocean sites now account for over 80% of the global marine protected area (Fig. 2), and while numbers alone are clearly not as important as effectiveness (Halpern et al., 2013), this is a strong start with support from increasing numbers of governments, scientists and NGOs. In addition to biodiversity conservation, these large-scale MPAs provide refugia that will help replenish other areas.

The Big Ocean network is growing. Efforts currently underway could dramatically increase the total area under protection in the near future. However, imposing challenges remain for marine conservation efforts to fulfill the competing human need for food and biodiversity protection; ~54 more large-scale MPAs of this magnitude (the mean size of current Big Ocean sites) will be necessary to reach the Aichi targets (Fig. 2). Regardless, these sites represent substantial progress, and like small scale MPA networks proposed in the coastal waters of individual countries, the sheer size and scope of the Big Ocean sites provides our best hope for arresting the decline in marine ecosystems on a global scale.

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