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Co-operation between large-scale MPAs: successful experiences from the Pacific Ocean

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ABSTRACT

1. Nations have recently committed to protecting 20–30% of the ocean at various global summits; however, marine protected areas currently cover <3% of the ocean. Large-scale marine protected areas (LSMPAs, >100 000 km^2) are a new concept in global marine conservation that offer real hope in achieving global conservation targets.

2. Many of the existing LSMPAs are remote islands in the Pacific that share common natural history, threats, culture, as well as scientific and management needs.

3. As a result of their common ancestry, many Pacific cultures have a long history of collaboration, including sharing resources, information and expertise to ensure the long-term sustainability of their resources.

4. Management, governance and research capacity limitations are magnified in LSMPAs, therefore highlighting the need to return to these prior forms of collaboration to achieve conservation objectives.

5. Several LSMPAs in the Pacific have collaborated to achieve their management and scientific goals, including documented collaborations among the Papahānaumokuākea Marine National Monument, the Phoenix Islands Protected Area, the Pacific Remote Islands Marine National Monument, the Marianas Trench Marine National Monument, the Motu Motiru Hiva Marine Park, the Natural Park of the Coral Sea, and the Cook Islands Marine Park.

6. Collaborations among LSMPAs in the Pacific include bilateral agreements, learning exchanges, as well as research, monitoring and enforcement activities. By working together, Pacific LSMPAs have been able to overcome some of the management and scientific challenges associated with conserving vast areas of the oceans.

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INTRODUCTION

The ocean has always been an important source of food, transportation and commerce, but for much of our history it has been perceived as a resource to be exploited with little concern for adverse impacts or long-term consequences. Declines in the health of many marine ecosystems around the world, and the likelihood that climate change will only exacerbate this problem, have led to a call for dramatic action to confront this impending crisis (Jackson *et al.*, 2001; Worm *et al.*, 2006; Hoegh-Guldberg and Bruno, 2010). Marine protected areas (MPAs) have been shown to conserve biodiversity within their borders and enhance fisheries in adjacent areas, and have thus been strongly advocated for as a tool to help combat these global declines (Roberts *et al.*, 2001; Lester *et al.*, 2009; Halpern *et al.*, 2010; Edgar *et al.*, 2014). As a result, MPAs have become a key conservation tool, with most nations agreeing to commitments to protect 10–30% of the world's ocean at various global summits (Wood *et al.*, 2008). However, most MPAs are small (<1 km^2) and currently account for $<3\%$ of the ocean, and thus substantial increases in conservation measures will need to be implemented in order to achieve protection targets (Halpern *et al.*, 2010; Mora and Sale, 2011; Spalding *et al.*, 2013). Fortunately, several nations have recently announced the creation of large-scale MPAs (LSMPAs, $>100\ 000$ km^2), which are much more effective in protecting entire ecosystems and the services they provide, as well as helping to achieve global conservation targets (Sheppard *et al.*, 2012; Toonen *et al.*, 2013, Wilhelm *et al.*, 2014). Ten of the largest MPAs, either currently in existence or under creation, account for $>50\%$ of the world's total MPA coverage (Devillers *et al.*, 2015).

LSMPAs protect entire ecosystems, particularly habitats that are not typically part of nearshore MPAs, such as the deep sea, seamounts and pelagic realms (Hyrenbach *et al.*, 2000; Game *et al.*, 2009; Wedding *et al.*, 2013; Wilhelm *et al.*, 2014). In addition, LSMPAs directly protect highly mobile species such as tunas, billfish, sharks and other targeted fisheries species, as well as sea turtles, marine mammals, seabirds and other pelagic species, which are taken as by-catch in pelagic fisheries. Protection of seamounts is critical as they provide habitat and spawning grounds for numerous species, and represent important biodiversity hotspots owing to their extremely high levels of endemism (McClain, 2007; Friedlander *et al.*, 2013b). Deep-sea communities have extremely slow recovery rates and fragile habitat structures, leaving them vulnerable to physical disturbances such as deep-sea mining, which is now becoming both technologically feasible and economically viable (Wedding *et al.*, 2015). LSMPAs not only provide the means to protect such unique ecosystems, but also provide the opportunity for adopting a precautionary approach to management, which is particularly important given the uncertainty associated with climate change (Pressey *et al.*, 2007; Halpern *et al.*, 2010; Toonen *et al.*, 2013).

Despite the theoretical arguments for the importance of large MPAs, there is a limited amount of empirical data to support their benefits since most LSMPAs have only been created in the past few years (Edgar *et al.*, 2014; Wilhelm *et al.*, 2014). Monitoring the efficacy of LSMPAs is extremely difficult, particularly for wide-ranging pelagic species that might only spend a portion of their lives inside the protected areas (Kaplan *et al.*, 2013). In addition to research and monitoring challenges, enforcement of vast and remote areas of the ocean present a number of hurdles, especially for developing countries (Agardy *et al.*, 2011; Toonen *et al.*, 2013; Devillers *et al.*, 2015). Sustainable financing, adequate technology, and logistical partnerships are just a few of the elements necessary for successful monitoring and enforcement of LSMPAs, which are unfortunately not available to all countries, particularly developing ones (De Santo, 2013).

In economic terms, LSMPAs are more efficient to establish and maintain than smaller ones

(Wilhelm *et al.*, 2014). Although the overall cost to establish the Papahānaumokuākea Marine National Monument (PMNM) was higher than any other MPA at the time, the cost per unit area was among the lowest (McCrea-Strub *et al.*, 2011). Furthermore, the long-term cost of MPA maintenance per unit area drops significantly as size increases, thereby providing broad economic, conservation and scientific benefits (Toonen *et al.*, 2013). To put this into context, the worldwide cost to manage MPAs at full capacity is estimated to be ~US$2 billion annually (McCrea Strub *et al.*, 2011), compared with the US$25–29 billion a year spent on subsidies to fishing (e.g. fuel, low-interest loans, etc.; Sumaila *et al.*, 2010).

The concept of LSMPAs as a formal management tool emerged in the late 1990s, when momentum towards protecting the Northwestern Hawaiian Islands began. Before that, the only protected area at LSMPA scale was the Great Barrier Reef Marine Park (344 000 km^2), established in 1975 by the Government of Australia and later recognized as a World Heritage Site in 1981 (Toonen *et al.*, 2013). In 2000, the Northwestern Hawaiian Islands Coral Ecosystem Reserve (362 074 km^2) was established as the world's first truly remote and uninhabited LSMPA. It was subsequently expanded and designated as PMNM in 2006, and inscribed as a World Heritage Site in 2010. The Republic of Kiribati established a third LSMPA in 2008, the Phoenix Islands Protected Area (PIPA), which is by far the largest marine conservation effort of its kind by a Least Developed Country. Since then, more than a dozen LSMPAs have been established (Spalding *et al.*, 2013; Toonen *et al.*, 2013; Devillers *et al.*, 2015; Wilhelm *et al.*, 2014), with several others in various stages of advocacy, planning and implementation (Table 1).

Many of the existing LSMPAs consist of remote islands in the Pacific Ocean (Figure 1), and as a result share many similarities in terms of natural history and threats, thereby having common scientific and management needs (Big Ocean, 2013; Toonen *et al.*, 2013; Wilhelm *et al.*, 2014). Furthermore, many of these locations are connected by common history, culture and ancestry. For millennia, people in the Pacific have relied on the ocean for survival, and more recently have demonstrated strong global leadership in their commitment to marine conservation (Laffoley *et al.*, 2008). As of 2010, approximately 20% of the Pacific

Table 1. Large-scale marine protected areas that are part of the Big Ocean Network

Country	MPA name	Cultural heritage	Year designated	Total area (km^2)	Percent no-take (%)
Australia	Great Barrier Reef Marine Park	Australasian	1979	344 400	33
USA	Papahānaumokuākea Marine National Monument	Polynesian	2000	362 074	100
Republic of Kiribati	Phoenix Islands Protected Area	Micronesian	2006	408 250	4
USA	Marianas Trench Marine National Monument	Micronesian	2009	250 487	0
United Kingdom	British Indian Ocean Territory Marine Protected Area	Chagossian	2010	640 000	100
Chile	Motu Motiro Hiva Marine Park	Polynesian	2010	150 000	100
Cook Islands*	Marae Moana (Cook Islands Marine Park)	Polynesian	2012	1 100 000	TBD
New Caledonia*	Le parc naturel de la mer de Corail (Natural Park of the Coral Sea)	Melanesian	2014	1 292 962	TBD
USA	Pacific Remote Islands Marine National Monument	Polynesian	2009	1 271 526	100
Australia*	Norfolk Commonwealth Marine Reserve	Australasian	2012	188 443	22
Australia*	Coral Sea Commonwealth Marine Reserve	Australasian	2012	989 836	51
Australia*	South-west Corner Commonwealth Marine Reserve	Australasian	2012	271 898	47
Australia	Macquarie Island Commonwealth Marine Reserve	Australasian	2012	162 000	36
Australia*	Argo-Rowley Terrace Commonwealth Marine Reserve	Australasian	2012	146 099	43
			Total	7 547 033	

TBD = to be determined.
*MPAs have been designated, but are not yet implemented.
Size and no-take data retrieved from MPA Atlas (www.mpaatlas.org).

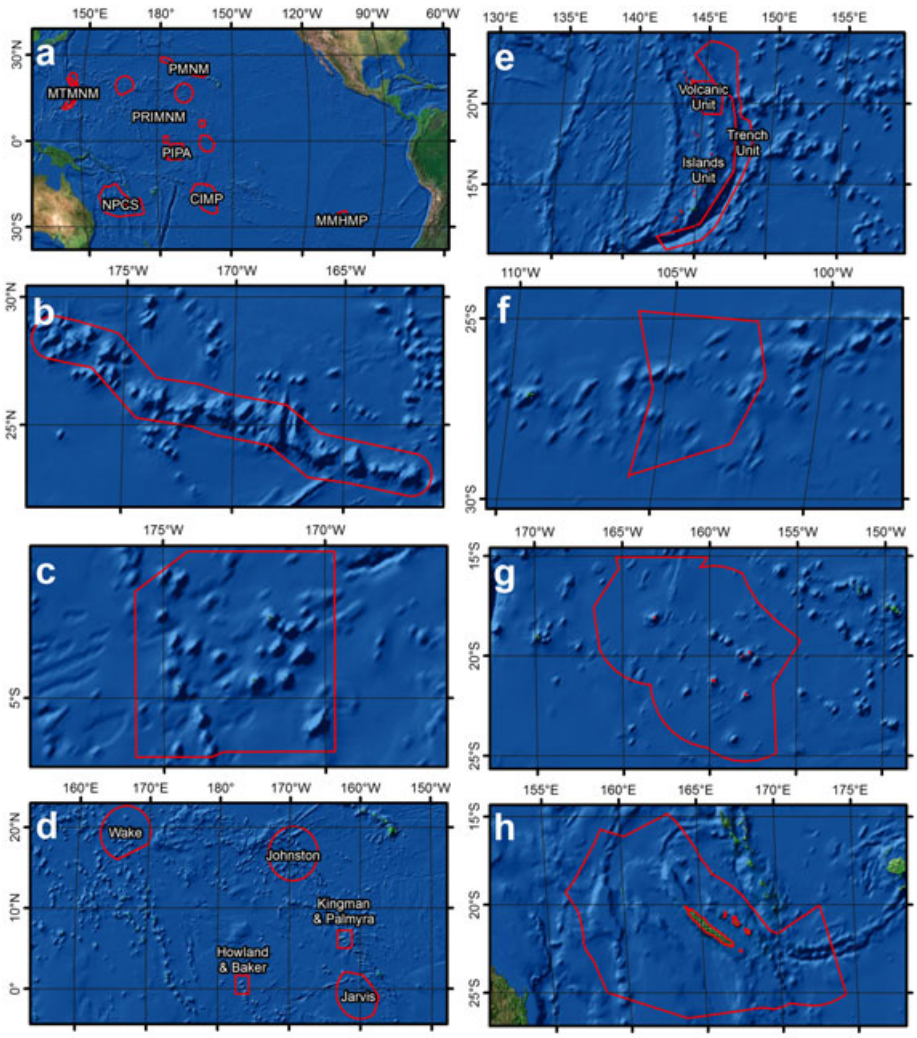

Figure 1. (a) Pacific large-scale marine protected areas (LSMPAs) with a long history of collaboration as discussed in this article; (b) the Papahānaumokuākea Marine National Monument (PMNM); (c) the Phoenix Islands Protected Area (PIPA); (d) the Pacific Remote Islands Marine National Monument (PRIMNM); (e) the Marianas Trench Marine National Monument (MTMNM); (f) the Motu Motiro Hiva Marine Park (MMHMP); (g) the Cook Islands Marine Park (CIMP); and (h) the Natural Park of the Coral Sea (NPCS).

was protected in some form (Spalding *et al.*, 2013), with established marine managed areas (MMAs), community-based and traditional management approaches in nearly every jurisdiction of the region (Johannes, 2002; Cinner and Aswani, 2007; Bartlett *et al.*, 2009; Friedlander *et al.*, 2013a).

Although LSMPAs are often removed from centres of human population, the similarities and connections between these islands make it important to further common ties across national jurisdictions and share lessons learned to achieve long-term sustainability. Large ocean areas, both within national boundaries or in the high seas, are often undervalued and underappreciated for their cultural heritage and importance (Wilhelm *et al.*, 2014). Despite the role the ocean has played for millennia in global maritime heritage, much of the value people place on them is focused on coastal uses. Recently, increasing attention has been paid to the natural heritage value of remote ocean areas, resulting in increased protection efforts (Freestone *et al.*, 2014). Across time, the ocean has provided pathways for human migration, transportation and harvest. For many Pacific cultures, the ocean serves as a pathway of connection to each other, and is essential to cultural preservation (Finney, 1993). Even when ocean areas are remote and unpopulated, they do

not necessarily lack cultural connections. Although not always obvious, such cultural connections should be considered as important components of management, in order to build support for conservation, education and historical data collection, which can help establish biological and ecological baselines (Jokiel *et al.*, 2011).

Historically, many locations in the Pacific share a common cultural heritage, as the indigenous people originating from common ancestors systematically migrated over expansive distances to inhabit practically every corner of this region (Finney, 1974, 1993; Irwin, 1992; Howe, 2007). Using increasingly sophisticated maritime strategies, navigational skills and voyaging technology, relationships between distant island communities were built, which were maintained for hundreds of years (Irwin, 1992; Allen, 1996; Aswani and Graves, 1998; Rollet, 2002). Exchange and cooperation were core dimensions of island life and played a vital role in sustaining populations and island groups, as it provided an important mechanism for reducing risk and ensuring long-term survival. The result was a shared cultural heritage and regional identity that was best exemplified in the voyaging alliance and socio-political union of island chiefs that spanned different remote islands in the Pacific. The marae temple Taputapuakea in Ra ʻiātea in the Society Islands served as a centralized hub for regional meetings, shared knowledge and cooperative agreements in traditional times (Henry, 1928; Buck, 1938; Finney, 2000). As this era passed, these ancient alliances faded, however, ties to this common heritage still continued to exist in various forms well into the post-western contact period. Some Pacific Islands rose to be independent island nations and subsequently developed international treaties across international boundaries (Sai, 2013; Beamer, 2014).

The challenges of maintaining cooperative initiatives across geographical distances were as real then as they are today. Owing to the enormous geographical size and remoteness of many LSMPAs, resource managers of these areas typically face much larger and more complex challenges (Big Ocean, 2013; Toonen *et al.*, 2013; Wilhelm *et al.*, 2014). For instance, several LSMPAs have faced substantial objections from powerful lobbies such as commercial fisheries, due to the great value of resources that no longer may be extracted. In addition, the great value of resources in many LSMPAs increases the need for surveillance and enforcement, which come at a much greater overall cost when spread over the large and remote area of LSMPAs.

Collectively, the complexity of these management challenges highlights the need for LSMPAs to collaborate in order to achieve success. An example of this collaboration was the creation of the Pacific Oceanscape Initiative in 2009, a network of organizations, countries and communities, which provides a combined voice advocating for conservation and sustainable development of ~40 million km^2 of Pacific Ocean – nearly 8% of the earth's surface. This framework has been endorsed by 23 Pacific Island nations, regional intergovernmental agencies and the conservation community, to conserve and sustainably manage this vast region of islands and ocean for future generations. The distinctive challenges faced by LSMPAs, especially the governance and protection of vast tracks of open ocean, also 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://bigoceanmanagers.org) which focuses on professionalizing this new genre of marine conservation (Big Ocean, 2013; Toonen *et al.*, 2013; Wilhelm *et al.*, 2014). The objectives of this article are to highlight a series of case studies that exemplify collaborations between LSMPAs in the Pacific, in order to showcase the lessons learned from these collaborative experiences.

DESCRIPTION OF PACIFIC LSMPAs WITH WELL-ESTABLISHED COLLABORATION

The Papahānaumokuākea Marine National Monument (PMNM) was established in 2006 to protect the north-westernmost portion of the Hawaiian Archipelago (Figure 1). As a result of its geographic isolation, the marine ecosystem is virtually intact, dominated by large apex predators and with numerous endangered or threatened species

(Friedlander and DeMartini, 2002; Baker *et al.*, 2007; Friedlander *et al.*, 2009). This isolation has also resulted in an extremely high degree of endemism in both terrestrial and marine environments (DeMartini and Friedlander, 2004; Cowie and Holland, 2008; Kane *et al.*, 2014). The area also has deep traditional significance for Native Hawaiian culture, serving as a training ground for both ancient and modern navigators.

The total Monument area consists of 362 074 km^2 and is co-managed by the Secretary of Commerce through the National Oceanic and Atmospheric Administration (NOAA), the Secretary of the Interior through the US Fish and Wildlife Service (FWS), and the State of Hawaii, in cooperation with the Office of Hawaiian Affairs (OHA). The co-trustee agencies are responsible for managing the Monument and protecting its natural and cultural resources. PMNM is perhaps one of the first sites in the USA, if not the world, in which highly restrictive measures on activities for protecting the natural heritage also help preserve the cultural heritage that is inextricably linked to the place, particularly to the indigenous people of Hawaii. Accordingly, throughout the process of developing the laws and management plans, there has been a substantial effort by the US Government to cooperate with the State of Hawaii in consulting with representatives of the Native Hawaiian community.

In 2010, PMNM was designated as the first mixed site in the United States being recognized as a place of outstanding universal value for both its natural and cultural heritage. It is also the world's first cultural seascape recognized for its continuing connections to living indigenous people. Recognizing that both PMNM and the Phoenix Islands Protected Area (PIPA) were preparing World Heritage Site applications at the same time, managers of these two sites assisted one another in preparing their applications. This collaboration proved to be fruitful and resulted in both sites successfully obtaining World Heritage Site designation. Collaborating, instead of competing in the multi-year inscription process, marked the beginning of cooperation between the managers of these two LSMPAs (see below).

The Phoenix Islands Protected Area (PIPA) is a 408 250 km^2 expanse of eight atoll and low reef islands in the central Pacific Ocean (Figure 1), which are largely uninhabited, and are among the most remote coral reefs on Earth (Obura *et al.*, 2011). The Republic of Kiribati declared the creation of PIPA in 2006 and adopted formal regulations in 2008 to make it the largest MPA on Earth at the time. While other larger MPAs have since been created, PIPA remains the largest marine conservation effort of its kind by a Least Developed Country. PIPA conserves one of the world's largest intact archipelago ecosystems, together with 14 known underwater seamounts and other deep-sea habitats. The area consists of a wide range of marine environments and displays high levels of marine biodiversity, especially apex predators, sea turtles, giant clams, coconut crabs, and globally significant seabird nesting grounds (Allen and Bailey, 2011; Obura *et al.*, 2011). The area also protects rare traditional plants that have cultural and medicinal values in Kiribati, but are now threatened on the more populated islands of the Republic.

In 2010, PIPA was inscribed as a UNESCO World Heritage Site and is the first World Heritage Site to extend to the full limit of a State's exclusive economic zone (EEZ). The legal protection of the area is established under the 2008 PIPA regulations that (1) delineate the boundaries of PIPA, (2) establish a management committee, and (3) stipulate the development of a management plan, which was successfully created in 2010. Kiribati committed to a government approach with partners in order to ensure a management system that is both sustainable and suitable to the circumstances of a small developing state. Of particular note is the continued success in the capture and fining of illegal fishing vessels, and in the removal of invasive species from globally important islands for seabird conservation.

The PIPA Conservation Trust was established to provide long-term sustainable financing for PIPA and is governed by the Board of Directors appointed by each of the Government of Kiribati, the New England Aquarium and Conservation International. The PIPA Trust's Endowment Fund, which is capitalized by private and public contributions, covers the annual costs associated with managing PIPA in accordance with the Management Plan, and provides payments to the

Government of Kiribati for enforcing PIPA regulations. Kiribati has also committed to improving management capacity, particularly for surveillance and enforcement, through national, international and regional partnerships.

The Pacific Remote Islands Marine National Monument (PRIMNM) was established by President George W. Bush in 2009, pursuant to his authority under the Antiquities Act. President Barak Obama subsequently expanded the Monument in 2014. The PRIMNM now covers 1 271 526 km^2 and consists of Wake, Baker, Howland, Jarvis, Johnston, Kingman and Palmyra (Figure 1; Table 2). It is currently the largest MPA in the world and is cooperatively managed by the Secretary of Commerce (NOAA), and the Secretary of the Interior (US Fish and Wildlife Service), with the exception of Wake Island and Johnston Atoll, which are currently managed by the Department of Defense. National Wildlife Refuges also exist at each of the islands within the Monument.

Palmyra and Kingman support higher levels of coral diversity (180–190 species) than any other location in the central Pacific (Kenyon *et al.*, 2012), whereas Kingman harbours some of the highest biomass of fishes known, including sharks, jacks and snappers (Sandin *et al.*, 2008; Friedlander *et al.*, 2010). Palmyra supports one of the last remaining *Pisonia grandis* forests in the Pacific, as well as more than one million nesting seabirds and is the second largest red-footed booby colony in the world (Flint, 1999; Maragos *et al.*, 2008). Wake Island is the northernmost atoll in the Marshall Islands geological ridge and is perhaps the oldest atoll in the world (Clouard and Bonneville, 2005). The waters surrounding Baker, Howland and Jarvis are highly productive due to equatorial upwelling and support important seabird colonies and high biomass of apex predators such as sharks and jacks (Rauzon *et al.*, 2011; Williams *et al.*, 2011, 2015).

The Marianas Trench Marine National Monument (MTMNM) was established in 2009 by President George W. Bush pursuant to his authority under the Antiquities Act. Similar to PMNM and PRIMNM, MTMNM has a cooperative management scheme involving NOAA, the US Fish and Wildlife Service and the Government of the Commonwealth of the Northern Mariana Islands, in consultation with the Department of Defense. The Monument encompasses 250 487 km^2 of the submerged lands and waters of the Mariana Archipelago (Figure 1). The Monument is made up of three units: the Islands Unit, which includes the waters and submerged lands surrounding the three northernmost islands in the Mariana Archipelago, the Trench Unit, which includes the submerged lands portion of the Mariana Trench in the US EEZ, and the Volcanic Unit, which includes the submerged lands surrounding 21 submarine volcanoes (Table 3). The Monument includes the deepest known areas on Earth, as well as the greatest diversity of seamount and hydrothermal vent life discovered to date (Embley *et al.*, 2004; Baker *et al.*, 2005, 2008). The waters of the Monument support the largest biomass of reef fishes in the Mariana Archipelago, with high numbers of apex predators, including large numbers of sharks (Williams *et al.*, 2011, 2015).

The Motu Motiro Hiva Marine Park (MMHMP) was created by the Chilean Government in 2010. The park consists of a no-take marine reserve of 150 000 km^2 surrounding the small island of Salas y Gómez, ~400 km east of Easter Island (Rapa Nui) in the south Pacific Ocean (Figure 1). The park expanded Chile's total coverage of MPA by >100 times, from 0.03% to 4.4% of its entire EEZ.

Table 2. Management units of the Pacific Remote Islands Marine National Monument (PRIMNM)

Unit	2009 area (km^2)	Current area (km^2)
Wake Atoll	36 762	407 785
Howland and Baker islands	51 658	51 658
Johnston Atoll	38 051	442 447
Kingman Reef and Palmyra Atoll	53 503	53 503
Jarvis Island	35 325	315 085
Totals	215 299	1 270 478

Table 3. Management units of the Marianas Trench Marine National Monument (MTMNM)

MTMNM	Area (km^2)
Trench unit	204 496
Volcanic unit	189
Islands unit	42 487
MTMNM total	247 173

This pristine area contains extremely high levels of endemism, abundant populations of vulnerable species such as sharks and lobsters, and high deep-sea biodiversity (Friedlander *et al.*, 2013b). MMHMP was designed to protect a unique marine ecosystem, but also to help the recovery of degraded fished resources around Easter Island, based on the anticipated spill-over from MMHMP and the seamount chain between both islands, which likely connects them geologically and biologically. Salas y Gómez and its surrounding waters have cultural importance for the Rapanui people, and its protection and management therefore affects them and generates local interest (Gaymer *et al.*, 2014).

In Chile, the Undersecretariat for Fisheries and Aquaculture of the Ministry of Economy, Development and Tourism (SUBPESCA) regulates fisheries, aquaculture, as well as marine parks and reserves. The National Forest Corporation of the Ministry of Agriculture (CONAF) is the agency in charge of administrating the national system of terrestrial protected areas and promoting the sustainable use of the forest ecosystems (Cárcamo *et al.*, 2013). However, the future Biodiversity and Protected Areas Service (SBAP), coordinated by the Ministry of the Environment (MMA) will likely oversee all of the protected areas presently regulated by SUBPESCA and CONAF (Jorquera-Jaramillo *et al.*, 2012; Squeo *et al.*, 2012). The SBAP is still under discussion in parliament, but could see the light in the next years.

Marae Moana, also known as the **Cook Islands Marine Park (CIMP)**, was established in 2012. The marine park is a multiple-use park encompassing 1 100 000 km^2 that provides a framework to promote sustainable development by balancing economic growth, while also conserving core biodiversity and natural assets in the ocean and on land. The Cook Islands commitment is the largest by a single country to integrate ocean conservation and management. The area includes remote atolls, high volcanic islands and seamounts (Figure 1) that host rich marine biodiversity, including rare seabirds, whales, manta rays, and several shark species. A number of these species are listed as endangered or threatened by IUCN. Marae Moana will contain a variety of zones with different levels of protection, including areas where all fishing will be banned, and buffer areas where tourism and carefully monitored fishing will be allowed.

Le parc naturel de la mer de Corail, also known as the **Natural Park of the Coral Sea (NPCS)**, was first designated in 2012, and formally established by legislative decree in 2014. This ~1.3 million km^2 multi-use MPA covers all of New Caledonia's EEZ (Figure 1). It was the first contribution to the Pacific Oceanscape Initiative by a Melanesian country or a French Overseas Territory, and included ridges, deep sediment basins, seamounts, coral reefs, and volcanic structures (Figure 1). The park includes the deepest site in France (7919 m), 25 species of marine mammals, 48 shark species, 19 species of nesting birds and five species of marine turtles. The management committee for the park is co-presided over by the High Commissioner of the Republic (representing the French Government) and by the President of New Caledonia, and is composed of representatives of relevant stakeholders groups.

DESCRIPTION OF COLLABORATION BETWEEN SITES

PIPA and PMNM

In early 2007, the *Our Sea of Islands Forum* brought together more than 100 community and traditional leaders, practitioners and managers from Oceania, including PMNM and PIPA, with expertise in marine managed areas (MMAs). The forum was initiated and co-chaired by UNESCO's World Heritage Centre and PMNM to foster collaborative partnerships, learn from one another, and share experiences across Oceania. A primary output of this forum was the *Our Sea of Islands Communique*, a shared regional statement that called for collaboration among governments and organizations towards the protection, surveillance, monitoring and research of MMAs (Our Sea of Islands, 2007). In 2010, relationships forged at the forum led to the signing of a bilateral sister-site agreement between the United States and the Republic of Kiribati to facilitate collaboration between PMNM and PIPA. The agreement was developed as a sub-agreement to

the 1979 Treaty of Friendship signed by the two countries, which encourages cooperation to protect the unique natural and cultural resources of Kiribati.

Specifically, the sub-agreement was signed with the intent to facilitate on-the-ground communication, information exchange, and staff consultation between the management agencies charged with carrying out the mandates and protection set forth in the respective codifying laws and regulations that established PMNM and PIPA. Guiding principles included: (1) encouraging and supporting the free exchange of ideas, information and experiences; (2) minimizing duplication and costs for similar management efforts by encouraging partnerships across management initiatives; (3) maximizing positive outcomes for each site, while keeping costs of implementation of this cooperative arrangement reasonable; (4) periodic review of the effectiveness of agency efforts; and (5) providing scope for the development of future agreements, which may include an additional exchange of resources and funds.

The primary outcomes from the partnership, which began prior to the signing of a formal agreement included: (1) cooperation toward successful World Heritage inscription of both sites in 2010; (2) direct input and engagement in the development of science plans for both sites and subsequent cooperation in field research; (3) the co-founding of Big Ocean: A Network of the World's Large-Scale Marine Managed Areas in 2010 (Big Ocean, 2013); and (4) the co-hosting of a Think Tank on the unique scientific needs and challenges of LSMPAs in 2011 that resulted in the development of a Shared Research Agenda for LSMPAs in 2013 (Big Ocean, 2013).

Owing to the remoteness of these MPAs, enforcement is a huge concern. Although not directly related to the PIPA-PMNM sister-site agreement, the United States and Kiribati signed a cooperative maritime law enforcement agreement, or ship rider agreement, allowing Kiribati law enforcement officers to embark on select US Coast Guard and Navy vessels and aircraft to patrol their waters.

PMNM and PIPA have also cooperated on various other activities including learning exchanges. In 2013, led by NOAA's International MPA Capacity Building Program, and in partnership with Conservation International, the New England Aquarium and IUCN, staff from both PMNM and PIPA facilitated a two-week workshop, which focused on providing a basic understanding of managing MPAs to resource managers of various government agencies in Kiribati. In addition, as part of the work of Big Ocean, PIPA and PMNM have led in the provision of structured technical assistance workshops with emerging LSMPA sites held coincident to annual network meetings.

PIPA and PRIMNM

Following the designation of the PRIMNM in 2009, the relationship between United States and Kiribati received increased attention, as the PRIMNM areas of Howland and Baker islands lie just north of PIPA in the Phoenix Island chain (Figure 1). The idea of transboundary cooperation was envisioned by President Tong of Kiribati and endorsed by *Pacific Island Forum* leaders in their 2010 communiqué. The concept of a PIPA-PRIMNM relationship was furthered through a Statement of Intent to Cooperate issued in 2012 by the United States Secretary of State. This collaboration arrangement was also signed under the US–Kiribati Treaty of Friendship.

In 2012, representatives of the two countries began work to develop a formal relationship between PRIMNM and PIPA that facilitated working together on scientific research, law enforcement, shipwreck removal and eradication of non-native species. Signed at the World Parks Congress in 2014, the arrangement strengthened cooperative management of these two protected areas across political boundaries, collectively called the Phoenix Ocean Arc. This concept fosters protected area design and investment that focuses on the archipelagic nature of the central Pacific, including the full range of approaches to protected areas, from local village-based management to international collaboration for open ocean protection. One of the first exchanges was the sharing of marine invasive species prevention protocols for PIPA, which in turn was helpful in drafting best management practices for PRIMNM and other US sites. A joint research expedition aboard the NOAA ship *Okeanos Explorer* that will

map and survey deep-water environments of these two sites is scheduled for 2017, and will provide multibeam bathymetry data, as well as remotely operated vehicle video data of deep-water habitats that have not previously been explored in these two LSMPAs.

PMNM and MMHMP

The Hawaiian Archipelago and the Easter Island Ecoregion (Easter Island and Salas y Gómez) share a common Polynesian heritage and have many ecological similarities. They are both remote subtropical locations, with a high proportion of endemic species, making them unique biodiversity hotspots (DeMartini and Friedlander, 2004; Friedlander *et al.*, 2013b). Despite being separated by >7000 km, they share several species that exist only at these two locations, suggesting some evolutionary biogeographic connection (Randall and Cea, 2010).

In 2013, the United States National Parks Service (NPS), NOAA's National Ocean Service (NOS), the Ministry of the Environment of Chile (MMA), CONAF and SUBPESCA signed a memorandum of understanding (MoU) to facilitate cooperation of terrestrial and marine protected areas between the US and Chile. The MoU builds on a long history of successful collaborations between these two countries in terms of terrestrial and marine conservation. Recent visits by US Government representatives to both mainland Chile and Easter Island have led to more formal collaboration between PMNM and MMHMP. In general, the agreement focuses on sharing of experiences and expertise among the participants, as well as leveraging resources and opportunities for collaboration among the participating protected areas. Learning exchanges promoted by Big Ocean meetings have allowed managers and scientists to discuss common challenges, management problems and scientific needs for LSMPAs.

Scientists from Hawaii and Chile have been working together in MMHMP since 2011 using similar standardized methodologies, and thus allowing for robust comparisons between the two locations. These scientists have identified a number of research topics common to both systems, and are currently developing joint proposals to address these issues. Some of the priority research topics include: (1) deep-water biodiversity; (2) endemism; (3) remote reef characterization using new technologies; (4) trophic web dynamics; (5) effects of geographic isolation; (6) design and monitoring of coastal and remote MPAs; and (7) LSMPA management (Gaymer *et al.*, 2011; Friedlander *et al.*, 2013b; Toonen *et al.*, 2013; Wilhelm *et al.*, 2014). In the autumn of 2015, a group of 10 scientists from Chile and Hawaii conducted a scientific workshop, a field sampling trip to Easter Island and an international graduate course in Chile, with the goals of strengthening scientific collaborations between both sites, as well as developing common research strategies, creating joint proposals and producing peer-reviewed publications.

US Pacific LSMPAs

The US Pacific includes three LSMPAs (PMNM, PRIMNM, and MTMNM) that all face very similar management challenges. Since they are co-managed by the same federal agencies (US Fish and Wildlife and NOAA, among others), there has been strong collaboration to fulfill their management and research needs. For example, NOAA's Coral Reef Ecosystem Division (CRED) leads the Pacific Reef Assessment and Monitoring Program (Pacific RAMP), which provides scientific information in support of the management and conservation of coral reefs across the United States Pacific, including the waters of PMNM, PRIMNM and MTMNM. Since its inception in 2000, Pacific RAMP has established baseline ecosystem assessments and initiated long-term monitoring of trends that integrate biological observations with water quality and oceanographic data. Pacific RAMP is also a key component of the NOAA Coral Program's National Coral Reef Monitoring Plan (NCRMP), a long-term effort to monitor the status and trends of US coral reef ecosystems. Pacific RAMP provides information essential to resource managers and policymakers for the sustainable management of coral reef resources.

Beginning in 2015, a team of NOAA and external partners, led by the NOAA Office of Ocean Exploration and Research, initiated the Campaign

to Address Pacific Monument Science, Technology, and Ocean Needs (CAPSTONE). This three-year effort is aimed at systematically collecting baseline information to support science and management needs within and around the United States marine national monuments and other protected places in the Pacific. During the first year of this effort, CAPSTONE conducted four separate expeditions that included mapping and remotely operated vehicle operations in PRIMNM, PMNM and surrounding areas in the Main Hawaiian Islands, in order to collect baseline data critical to protecting vulnerable deep-sea habitats in these LSMPAs.

MMCIMP and NPCS

An agreement between the Cook Islands and New Caledonia was signed during the ministerial session of the 3rd International Marine Protected Areas Congress in 2013. The sister-site agreement, signed by representatives for the two governments, will help to coordinate and inform research and management of their respective LSMPAs, which together encompass more than 2.5 million km^2. The decision to collaborate was inspired by the PMNM-PIPA sister-site agreement, and focuses on leveraging resources from both sites. New Caledonia plans to share its experience in the field of trans-disciplinary and multi-sectoral scientific exploration. In turn, the Cook Islands will bring their expertise in the field of integrated marine governance, both at community and national levels. As with the other examples of these arrangements, the primary objectives are to facilitate communication, information, discussions and decision-making. The agreement was recognized as further contributing to the vision of the Pacific Oceanscape initiative.

LEGAL FRAMEWORK AND CONSIDERATIONS FOR COLLABORATION

The Law of the Sea Convention (LOSC) addresses various activities in maritime zones, including fishing and conservation of the high seas (UNCLOS, 1982). While there is no express reference to marine protected areas in the LOSC, it nonetheless reflects the public interest in protecting the marine environment and provides the legal framework for the protection and management of activities conducted in the ocean, and thus the establishment of MPAs. The public interest in protecting the ocean is also reflected in other international laws and policies developed to protect the natural and cultural heritage. Another example of this is the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter of 1972 (the 'London Convention'), which was one of the first global conventions to protect the marine environment from human activities. Furthermore, article 123 of the LOSC has been used as a legal basis for joint marine management by states bordering enclosed or semi-enclosed seas (Maes, 2008) and can therefore be viewed as a justification for collaboration in the creation and management of LSMPAs. The 1992 Convention on Biological Diversity (CBD) has conservation of biological diversity and the sustainable use of its components as its stated goals, with the designation and management of MPAs as an important objective for the parties to the CBD. CBD provides a good legal framework for ecosystem-based management, to which the creation of LSMPAs can be an added value (Maes, 2008).

DISCUSSION

Ecosystem and cultural heritage preservation benefits from collaboration, particularly when the different actors share common interests, agree on common practices, as well as have social and economic ties (Bodin and Crona, 2009; Kark *et al.*, 2015). Collaboration can lead to more efficient conservation planning by sharing information, knowledge and expertise. These collaborations recognize the ecological and cultural connection between these places in the Pacific, which are very remote, and embrace cultural connections across geopolitical boundaries (Table 4). These collaborations are valuable in that they set the stage for continuing connections far into the future. The benefits of collaborations include: (1) exchange of best practices and lessons learned; (2) developing shared research methods so data

Table 4. Types of engagement between LSMPAs in the Pacific

Collaborations	Bilateral agreements	Research and monitoring	Enforcement	Learning exchanges and workshops
PMNM-PIPA	X	X		X
MMHMP-PMNM	X	X		X
PRIMNM-PIPA	X		X	
PRIMNM-PMNM-MTMNM		X	X	
MMCIMP-NPCS	X			X

are comparable; (3) leveraging shared research platforms; (4) building capacity (e.g. student training, workshops); (5) sharing of community engagement practices and strategies; (6) effective management planning and site design; and (7) increased understanding of important social, cultural and economic considerations (Big Ocean, 2013; Wilhelm *et al.*, 2014).

While most of the existing LSMPAs lie in the Pacific Ocean, there are several proposals to develop LSMPAs in other places as well, including the Atlantic and Southern Oceans. While these places have fewer cultural connections than in the Pacific, collaborations between these newer LSMPAs and existing ones will still bring many of the benefits of collaboration mentioned above. In such cases where LSMPAs do not share common cultural heritage, it may take more time to bridge language and cultural differences, but the benefits of the collaboration will still remain the same.

Although collaborations between LSMPAs provide a number of benefits, they also come with several obstacles (Table 5). Basic information technologies (e.g. Internet, email, phone) are critically important given the distances and differences in time zones among sites. Difficulties in the optimal success of these collaborations stem from the fact that interactions are infrequent because sites and managers are far from one another, and travel between sites is difficult and expensive. Building partnerships takes considerable time and effort, and is thus particularly difficult to achieve when interactions with potential collaborators are infrequent. In addition, there are myriad other demands on managers, who often lack staff that are dedicated specifically to building and maintaining such collaborations. Other challenges faced by these collaborations include: (1) access to the remote locations of LSMPAs by managers and researchers; (2) surveillance and enforcement of

Table 5. Benefits and disadvantages to collaborative approaches in LSMPAs

Type of collaboration	Benefits	Disadvantages
Bilateral arrangements	• Long lasting • Formalized statement of governmental intent • Greater engagement • Increased awareness of relationship	• Time consuming to establish • Obstacles presented by differences in governance structure • Non-binding • Often no funding attached
Research and monitoring	• Research projects may be more cost effective when shared • Builds relationships between scientists • Opportunity to build capacity in developing programmes • Supports comparison between sites • Documents ecosystem trends • Can lead to the development of shared monitoring and data storage protocols	• Expensive to conduct and time consuming to plan • Limited expertise in conduct of this type of project • May require additional permitting or governmental approvals • Potential for disagreement on research objectives and priorities
Enforcement	• Preserves integrity of site • Broadens the reach of individual enforcement programmes • Opportunity to build relationships and capacity	• Costly • Technological, legal and regulatory limitations
Learning exchanges and workshops	• Relatively easy to conduct • Flexible format • Increased cultural exchange • Engage wide range of people • Fosters peer learning	• No force of state • Not institutionalized • Infrequent meetings do not lead to sustained collaborations

regulations; (3) maintenance of infrastructure and scientific instruments; (4) administration, staffing and capacity; and (5) species and habitat rehabilitation and restoration.

Given these challenges, there are several issues that managers considering pursuing collaborations with LSMPAs should keep in mind. First, potential collaborators should share common interests and agree on common practices. Second, it may be necessary to use an experienced facilitator who understands the local culture and customs of both sides when building the partnership. This is particularly important when there are language barriers between the LSMPAs. Third, partnerships require regular care and maintenance in order to be sustainable in the long term. Therefore, it is important to plan for future investments of time, effort and resources that will be needed for the collaboration to be successful. Finally, investment in such partnerships needs the support of government leaders on both sides. This can best be achieved through institutionalization of the partnership, for example, by incorporating into strategic plans for management including cooperation on research, monitoring, enforcement and education. Without this step, it is unlikely that partnerships will be maintained over the long-term, as the original participants retire or move on to new positions.

A number of transnational initiatives have been developed in marine areas to protect the environment and improve communication and partnerships among scientists and managers (Koh, 1982; Big Ocean, 2013). Existing MPAs in the Red Sea between Israel and Jordan and among Mediterranean Sea nations at the Bonifacio Strait have been in place since the 1990s (Crosby *et al.*, 2002; Chevalier, 2004). Newer initiatives between the Philippines and Indonesia in the Coral Triangle and among South Korea, North Korea and China in the Yellow Sea are moving rapidly forward despite the political instability in the region (Nam *et al.*, 2007). Lessons learned from these initiatives can be applied to improve effectiveness of collaboration in large-scale marine conservation.

Under-resourcing of protected area management is one of the primary reasons for poor performance in protected area effectiveness (Bruner *et al.*, 2001). Although this has always been the case for developing countries, this is also becoming increasingly true for developed countries (Watson *et al.*, 2014). Therefore, it is more important than ever for management agencies, researchers and NGOs to share resources and knowledge in order to most effectively conserve these vast areas of the sea.

The creation of LSMPAs is not without controversy (Pala, 2013). The rapid growth of large MPAs runs the risk of being biased toward places that are remote or unpromising for extractive activities and hence residual to commercial uses (Devillers *et al.*, 2015). In addition, the implementation and the management of LSMPAs have not been well explored in practice or theory (Leenhardt *et al.*, 2013). Despite these potential shortcomings, LSMPAs have been shown to be a highly effective conservation tool and continued work into the ecological, social, economic and governance dimensions of protecting these large ocean areas will only help to improve their performance (Sheppard *et al.*, 2012; Toonen *et al.*, 2013; Wilhelm *et al.*, 2014).

LSMPAs are essential baselines and natural laboratories that present unique opportunities to understand how natural ecosystems function, to understand what we have lost, and to identify rigorous, unbiased management and conservation goals (Big Ocean, 2013; Toonen *et al.*, 2013). These relatively pristine areas need to be protected and studied, as otherwise we will not have a baseline for understanding what a healthy ocean looks like, and how an intact ecosystem functions (Big Ocean, 2013). This latter point is even more significant given future uncertainty as a result of rising levels of atmospheric CO_2 and other climate change impacts.

CONCLUSION

Following the early successes of cooperative relationships between remote LSMPAs like PMNM and PIPA and networking through Big Ocean and the Pacific Oceanscape Initiative, several additional agreements have recently been developed between other LSMPAs. These types of collaborative strategies mitigate many of the management challenges and build on the common heritage and culture of many

LSMPAs in the Pacific. Given that resource limitations are magnified when managing a larger area, working together is a necessity for LSMPAs. The growth in number of collaboration arrangements, particularly transboundary cooperation efforts, from both the terrestrial and marine environments, demonstrates the utility of this tool. Many Pacific cultures have a long history of working together to manage their resources. It is only through the revival of these customary agreements and cooperative alliances, and learning from other experiences, that we have a real hope of overcoming future declines of our ocean resources. Cooperation among nations through LSMPAs consistent with the LOSC is perhaps one of the best ways to accomplish the international goals for conserving biodiversity as well as cultural heritage.

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