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Building the future of MPAs – lessons from history

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ABSTRACT

1. Marine protected areas (MPAs) have a long history, originating in traditional and cultural initiatives often focused on reserving resources for food security. A handful of 'parks' were established between the 1870s and 1940s and, following World War II, increased awareness of threats to the ocean led to global programmes that started in the 1970–1980s.

2. Initially IUCN became the leader, piloting a science-based 'critical marine habitats' approach, by which MPAs were aimed at conserving the healthiest and most diverse ecosystems, endangered and charismatic species, and high-profile habitats.

3. During the 1970s, with the support of WWF, UNESCO, UNEP, and growing national efforts, the MPA concept evolved to include biosphere reserves, marine reserves and sanctuaries, large ocean reserves, and other designations that aimed to reconcile long-term protection with human use.

4. From the 1980s, MPAs greatly expanded in number and scope. By the turn of the millennium, MPAs were proliferating, and principles and methodologies were available to guide their establishment and management in a harmonized manner. Zoning for different uses was widespread, but questions were being raised about the efficacy of biodiversity conservation in areas where extractive uses were permitted.

5. MPA implementation accelerated once targets were introduced by the Convention on Biological Diversity. Campaigns and fundraising by non-governmental organizations and further national efforts resulted in a rapid increase although, by 2015, less than 4% of ocean surface was protected.

6. Current challenges include: (1) understanding the role of MPAs in maintaining ecosystem services, fishery management, climate change adaptation and mitigation, and other emergent problems; (2) more rigorous

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network design; (3) effective governance and demonstration of 'success'; and (4) integrating MPAs with marine spatial planning.

7. While MPAs have provided one of the most viable and politically acceptable approaches to marine conservation for 50 years, their role in developing a fully effective marine ecosystems management regime has yet to be fully explored and understood.

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INTRODUCTION

Fifty years ago, in 1966, a symposium on marine protected areas (MPAs) took place in Tokyo, Japan (Committee on Marine Parks, 1966). The meeting, small by modern standards, triggered many of the global and national initiatives underway today. Although paper records are available in archives, little documentation about the early efforts to set up MPAs is available in digital form. Given the speed with which marine conservation is evolving and, before the collective memory and understanding of the history is lost from those directly involved, it is a good moment to provide an overview of the history of MPAs and their evolution, expanding on Ray (2015), the more substantive reviews by Claudet (2011), Ray and McCormick-Ray (2014) and Jones (2014), and an earlier exploration of some of the key issues by Agardy *et al*. (2003).

An MPA is defined by IUCN as: 'any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment' (Kelleher, 1999). For inclusion in the World Database of Protected Areas (WDPA) and to be recognized by IUCN, a protected area must have the primary objective of conservation of nature or biodiversity, although there may be additional objectives such as improving livelihoods or promoting education or research. The general IUCN definition of a protected area is 'a clearly defined geographical space, recognised, dedicated and managed, through legal and other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values' (Dudley, 2008).

IUCN has designed a system of six protected area management categories that help to define the different types of spatially managed area that fall within the definition of a protected area. These are based on the objectives for which the area has been designated (recognizing that all protected areas must have long-term nature conservation as their ultimate goal) and range from category I sites, designated to protect outstanding ecosystems and species that would be degraded or destroyed by anything other than the lightest form of human activity, to Category VI sites designated for locations where conservation and sustainable use can be mutually beneficial (Day *et al.*, 2012). A protected area is thus not defined by IUCN according to the way in which it is managed, and it can have a variety of objectives and thus uses. This is significant in looking at the history of MPAs as there is a wide range of views on what an MPA is and also a strong school of thought that believes that to be called an MPA, an area must be closed to extraction i.e. a no-take area (Agardy *et al.*, 2003).

As is the case for all protected areas, a plethora of terms has evolved for MPAs, often with different meanings in different places. A legally gazetted marine 'reserve' can mean a multiple-use protected area in one country (e.g. Kenya), but a strictly protected no-take area in an adjacent country (e.g. Tanzania); and the term marine reserve is often used in the literature for highly protected no-take areas of all types. Specific guidance was prepared on how to apply the IUCN protected area management categories to MPAs (Day *et al.*, 2012) in order to address these issues and to help generate a more

standardized approach to the understanding of protected area objectives in the marine environment. In this paper, the term MPA is used in the IUCN sense and includes all protected area categories. It is acknowledged that others consider MPAs also to be tools for commercial fish stock management and recovery (O'Leary *et al*., 2016).

EARLY HISTORY OF MANAGED MARINE AREAS

Many people think of MPAs as a recent addition to the conservation 'tool box', but the idea of establishing areas in which marine life is specially managed, particularly when this is a key food source, has a long history. Long before the evolution of the western concept of 'protected areas' specifically for nature conservation, the indigenous concept of *tapus*, *taboos* or *ra'ui* (all terms describing an area of land or sea closed to exploitation) was widespread in the Pacific. Such areas were usually imposed by a community or its leaders, normally for a defined period of time, often to allow resources to recover, and often they would result in protection of biodiversity in general (Johannes, 1978). It is important to understand the long history of such areas as they continue to be a fundamental component of spatial marine management in many places; the fact that their primary objective is not necessarily nature conservation, but that this is what is often achieved, is at the core of much global debate and discussion on protected areas today.

There are many examples of such areas. In the Cook Islands, a *ra'ui*, or a ban on harvesting over a defined area, can be imposed by a reef-owning clan's chief to allow stocks to increase. The *ra'ui* can be lifted and moved to another area or re-established in the same area once harvesting has taken place. Some areas are similarly managed for spiritual or cultural reasons. In Palau, everyone learns from childhood that they are caretakers of the sea and, traditionally, marine resource management rests within the village unit. The village is governed by the Council of Chiefs which has the power to implement and enforce a *bul*, a temporary moratorium on the take of a certain resource or an area closure, when resources become scarce or during known fish spawning and feeding periods. Fines are imposed on members of the village or outsiders that violate its provisions. Because fines are usually settled between chiefs, the burden for settlement is placed on the whole clan or the village housing the perpetrators and provides a powerful incentive against violation.

Similar practices occurred in the Western Indian Ocean in pre-colonial times. There were taboos prohibiting use of destructive practices such as poison, regulating access to fishing grounds and their use by 'foreign' fishers, and control through kinship and clan affiliation (Aswani *et al*., 2012). In Madagascar, the Fokonolism system, used to manage marine resources, dates back to the 9th century (Rakotoson and Tanner, 2006).

Elsewhere, spatial closures were used to restore fisheries or guard against political or economic aggression. In medieval Britain, commercially valuable fish and shellfish stocks were managed in certain places through controls on, or prohibition of, particular fishing methods, such as the *wondyrechaun*, a newly developed dredge-like device developed in the late 1300s that damaged life on the sea bed (Philpots, 1890).

Early MPAs (mid-1800s–1940s)

In the mid- to late 1800s, protected areas in the modern sense of 'parks' were being established on land out of the growing recognition of the wildlife value of particular locations and some of these included estuaries or other intertidal habitat. Examples include Royal National Park, New South Wales, Australia (1879)[1] (NSW National Parks and Wildlife Service, 2000), Greater St Lucia Wetland Nature Reserve, South Africa (1895) (now iSimangiliso Wetland Park), and Breton National Wildlife Refuge, Louisiana, USA (1904)[2]. A few sites were specifically protected for

[1]Includes the submerged and intertidal lands of South West Arm and Cabbage Tree Basin which support seagrass beds, mangroves and important fish and invertebrate nursery areas

[2]A chain of barrier islands with sandy beaches important for nesting seabirds and turtles; boundaries include some intertidal/subtidal water (USDI/FWS, 2008)

their intertidal and marine resources, such as St. Paul and St. George in the Pribilof Islands, off Alaska, protected in 1869 for northern fur seals (*Callorhinus ursinus*) (Scheffer *et al*., 1984), and the Matang Mangrove Forest Reserve (1906) in Malaysia (Goessens *et al*., 2014), established for sustainable management of mangroves. Morant and Pedro Cays in Jamaica (Yugorsky and Sutton, 2004) were established in 1907 for fisheries management but seabirds and turtles were also protected, which was perhaps one of the earliest examples of conservation for the value of marine nature per se.

However, public perception of the ocean in the western world was still largely based on stories told by sailors, whalers, and fishermen, and visits to see specimens in museums. This, combined with the common view that the ocean held an inexhaustible supply of fish, did not lead widely to a sense that protection of the sea was needed. Some concerns began to be expressed, notably about declining fisheries stocks. For example, in the UK, removal of oysters under a certain size was banned in 1871 to reverse the fortunes of the declining oyster industry in Swansea Bay, Wales. The Swansea Bay Corporation also proposed closing grounds within the Bay for two years but this could not be agreed, and within two years the oyster beds were exhausted. As noted by Philpots (1890), a contemporary observer: 'The closing of a part of the ground has, therefore, been merely nominal. It is much to be regretted that a fair trial has not been given to the system of making reserves.'

By the 1920s, however, subtidal habitat was being included in protected areas as at the Isla de Guadalupe and Surrounding Waters Reserved Area, Mexico (1922), Glacier Bay National Monument, USA (1925), Fort Jefferson National Monument, USA (1935), and Green Island National Park, Australia (1938). The coastal parts of Setonaikai National Park, Japan (1934) and the Hundreds Islands National Park, Philippines (1940) were among the first marine areas to be protected also with recreational objectives in mind. All of these suggest a movement was being born.

Developing MPAs in the IUCN sense (1950s–1970s)

After the Second World War, attention was drawn more specifically to marine wildlife, with the advent of scuba diving, the huge popularity of the first underwater films produced by Jacques Cousteau, the publication of his eye-opening book *The Silent World* (Cousteau and Dumas, 1953) and subsequent popularity of snorkelling for pleasure for those who lived near areas abounding with life, such as coral reefs, or could afford to visit them. The first strong warnings about human impact on the oceans were sounded by Rachel Carson in *The Sea Around Us* (Carson, 1951), and shortly after, in one of the earliest field guides to marine life, Ray and Ciampi (1956) called for protection of the ocean: 'Some of the richest areas should be set aside and protected as are 'wilderness' areas on land. The taking of any marine life, animal or plant, by any means, should be prohibited.' This idea came to the attention of the New York Zoological Society's Conservation Foundation, which supported a survey of an area in the Bahamas, resulting in the designation of the Exuma Cays Land-and-Sea Park under the Bahamas National Trust in 1958. This was probably the first protected area to incorporate land and subtidal sea together under a single jurisdiction (Ray, 1999). It was followed by Buck Island Reef National Monument, US Virgin Islands (1961), expansion of the US Virgin Islands National Park to include subtidal waters in 1962, and establishment of John Pennekamp Park, Florida (1963).

The potential for protected areas as a core nature conservation tool in the western sense was first clearly stated in 1958 at IUCN's 6th General Assembly in Delphi, Greece. In 1960, IUCN established a National Parks Commission, the precursor to the World Commission on Protected Areas (WCPA). The First World Conference on National Parks, held in 1962 in Seattle, Washington, had only one marine paper (Ray, 1962) but this led to the formal recommendation that 'the Governments of all those countries having marine frontiers, and other appropriate agencies, to examine as a matter of urgency the possibility of creating marine parks or reserves to

defend underwater areas of special significance from all forms of human interference ….' Preservation of rare marine species, replenishment of fish stocks, and marine scientific research were also urged (Adams, 1962).

As a result, the Special Symposium on Marine Parks was organized in 1966, as part of the 11th Pacific Science Congress (Committee on Marine Parks, 1966), and was attended by 168 participants. Given the current focus on MPA networks, it may come as a surprise to many that this early Symposium recommended the development of a 'systems approach to preservation of marine environments', and the setting up of a working group to define the elements of a marine park system, objectives for each element, guidelines for establishment, maintenance, and management, and a nomenclature and/or classification for such areas. An 'international marine park system' was also proposed for the western Pacific Ocean, to link islands through a system of strict nature reserves, undersea observatories, museums, visitor centres, and marine research centres; although not followed through at the time, this was very early recognition of the need for systems and networks of MPAs (Tamura, 1972).

The Second World Conference on National Parks, in 1972, noted the threat posed by the fact that the oceans were largely thought of in terms of their economic importance and called for governments to '… set aside appropriate marine areas as national parks and reserves and to take action to extend the boundaries of existing terrestrial national parks and reserves to include representative marine ecosystems' (Elliott, 1974). The need for an ecosystem approach was identified, given the continuity of marine spaces and the impossibility of demarcating marine parks with fences (a key aspect of terrestrial protected areas at that time) (Ray, 1974). It was also becoming evident that new national and international legal mechanisms to define jurisdictional boundaries were needed for MPAs.

In 1973, IUCN, with support from World Wildlife Fund (WWF), UNESCO and UNEP, initiated the 'critical marine habitats' (CMH) Project (Ray, 1976). CMHs were areas containing high diversity, endemism and productivity, and including spawning and nursery grounds, migration stopover points and bottlenecks, and areas of importance to vulnerable species. The project involved developing a marine classification system to identify and describe marine areas, with criteria for selection of MPAs, and the preparation of guidelines for their management. The CMH approach was central to discussions at the 1975 International Conference on Marine Parks and Reserves in Tokyo, which was the first major global meeting on this topic, with 107 participants from 33 countries (IUCN, 1976), and led to the launching of the IUCN/WWF Marine Programme in 1976.

Two other developments helped to propel MPAs forwards. The UNEP Regional Seas Programme was established in 1974 and adopted the CMH approach for the development of its regional instruments, the earliest being the Mediterranean Action Plan in 1975 and the Barcelona Convention in 1976. Regional meetings for the Northern Indian Ocean, Red Sea, and Persian Gulf in 1975 (which pulled together studies for Sri Lanka, India, Pakistan, and the Western Indian Ocean (Salm, 1976)), the Pacific in 1978 and the Mediterranean in 1980 set the stage for the regional conventions and protocols that support so many MPAs today.

The second catalyst was the concept of 'biosphere reserves' which arose from the ecosystem-oriented International Biological Programme (1962–1973). In 1974, a Task Force developed a spatial hierarchy of core, buffer, and transitional areas designed to reconcile the need for long-term protection of natural and semi-natural ecosystems with human uses, while also recognizing that interdisciplinary research would be essential to achieve this. The Task Force proposed criteria for selection of sites, including representativeness, diversity, naturalness, and effectiveness as a conservation unit, versions of which were subsequently widely adopted. This approach is particularly suitable for the characteristics of the marine and coastal zone, and recommendations for establishing Biosphere Reserves in marine environments were drawn up by Ray and Dasmann (1976), with subsequent elaboration by Batisse (1990). In the late 1980s this approach to MPAs was further encouraged by UNESCO's Man and the Biosphere (MAB)

Programme, building on the experiences of early biosphere reserves such as Sian Ka'an (Mexico), Mer d'Iroise (France), and the Gulf of Mannar (India) (Kenchington and Agardy, 1990; Price and Humphrey, 1993).

During the 1970s, MPAs became a firmly established global concept with the focus on conserving the healthiest and most diverse ecosystems, endangered and charismatic species such as turtles, seabirds and marine mammals, and high-profile habitats such as coral reefs, intertidal wetlands and rocky shores. In 1974 there were an estimated 125 sites on the new world list of marine parks and reserves (Björklund, 1974), and many more under development. For example, Japan, acting on the 1962 recommendation at the First World Conference on National Parks, had undertaken a nation-wide coastal survey and established a statutory marine park system in 1970, with 40 sites designated by 1975 (IUCN, 1976).

The formal movement to establish MPAs in the USA began in 1972, when the US Congress established an MPA programme managed by the National Oceanic and Atmospheric Administration (NOAA). The National Marine Sanctuary Act of 1972 allowed for the establishment of national marine sanctuaries (NMSs) which permitted a variety of forms of use, and also addressed the ecosystem approach, unlike other MPAs in the USA at that time. This programme progressively evolved into a comprehensive management system that balanced marine biodiversity protection with human use and long-term public benefit. The USS *Monitor* NMS, North Carolina (established for a historically valued shipwreck), and Key Largo NMS, Florida Keys (replacing the offshore portion of John Pennekamp Park), established in 1975, were the first two NMSs.

The Great Barrier Reef Marine Park (GBRMP), Australia, the legislation for which was also passed in 1975, similarly used the multiple use approach and fast became the over-riding model for the zoned approach to MPA design and management. The concept of zoning helped open the door for many more MPAs as it made it possible for managers to allow a range of activities in an area while achieving goals of conservation and protection. The benefits of managing MPAs for recreational use was becoming particularly clear, notably at Bonaire Marine Park, Netherlands Antilles, established in 1979, which piloted the use of permanent moorings at dive sites, and user fees (BMP, 2015). The view that an MPA needed to be protected from all forms of exploitation if pristine habitats were to be preserved was also developing: Leigh Marine Reserve, New Zealand was set up in 1975 very much with this in mind (Ballantine, 2014).

In Europe, legislation that could be used to protect marine waters included the 1960 National Parks Act in France, the 1970 National Parks and other Reserves Act in Portugal and the 1976 Wildlife Act in Ireland but these resulted in sites being predominantly those adjacent to coastal areas of conservation value. Examples include the Froan Skerries (1979) in Norway (a Nature Reserve and Landscape Protected Area with controls on hunting and activities which would disturb wildlife such as birds, seals and otters), Valassaaret-Björkögrunda (1974) in Finland (a protected area in the Baltic with a zoning scheme), and Limski Zaljev (1979) in Croatia (a submerged canyon in the Mediterranean). International collaboration to provide protection was also notably achieved for the Wadden Sea through a 1978 trilateral agreement between the Netherlands, Germany and Denmark.

Many MPAs were also being established in developing countries over this period, although often by replacing traditional systems with state-led western style approaches that used a top-down approach with little community or stakeholder involvement. In the Indian Ocean, notable examples include Watamu and Malindi Marine Parks, Kenya (1968), Bazaruto Marine National Park, Mozambique (1971), St Anne Marine National Park, Seychelles (1973) and Hikkaduwa Park, Sri Lanka (1979) established mainly for coral reefs and marine turtles. Attention also turned to large pelagic species, as in the Pacific: Cocos Island National Park (1978), Costa Rica, which was designated to protect sharks, rays, tuna and dolphins; and Laguna Ojo de Liebre Whales and Calves Refuge Zone (1972) in Mexico for cetaceans.

The value of the marine environment to its users was nevertheless still very important, particularly where poor coastal communities had high dependence on marine resources. As early as 1974,

the idea that stakeholders should be involved in MPA establishment and management and that MPAs could provide socio-economic as well as conservation benefits, was recognized through the establishment of Sumilon Marine Reserve in the Philippines (Russ and Alcala, 1999). The GBRMP Act was also notable for specifying the complex stakeholder involvement processes that had to be followed in the development of the Marine Park.

By the end of the 1970s, the IUCN Commission on National Parks and Protected Areas (CNPPA) was recognizing the importance of management effectiveness and financial sustainability for protected areas in general, and developing its system for categorizing protected areas. Most significantly for MPAs was the growing understanding of the need for legal mechanisms to determine use of ocean space, both within and beyond national marine boundaries, as the legal framework for the UN Convention on the Law of the Sea (UNCLOS) was being drawn up.

The 1980s and 1990s – 20 years of expansion

The 1972 UN Conference on the Human Environment in Stockholm and the publication of IUCN's World Conservation Strategy in 1980 helped to expand the idea of protected areas for nature conservation as places to be 'set aside' to include sites that could provide and maintain the critical goods and services needed for sustainable development.

The 3rd World National Parks Congress in 1982 in Indonesia saw a fundamental policy change for protected areas in general (McNeely and Miller, 1984; Mace, 2014). The Congress included a workshop on MPAs at which some of these concepts were explored, and which demonstrated the need for a more formal mechanism for MPA practitioners to communicate, resulting in the creation of the position of Vice-chair Marine in the CNPPA in 1986. Many of these ideas were formalized in Resolution 17.38 of the IUCN General Assembly of 1988 in Costa Rica[3] which called for countries to develop national systems of MPAs that would not only protect ecologically important and threatened species and habitats, but would also 'provide for the continued welfare of people' affected by such MPAs and that would 'accommodate within appropriate management regimes a broad spectrum of human activities compatible with the primary goal'. The Resolution also recommended the development of an agreed marine biogeographical classification system and a review of existing MPAs to determine the level of biogeographic representation within them, which resulted in the publication *A Global Representative System of Marine Protected Areas* by Kelleher *et al*. (1995). Resolution 19.46[3] at the IUCN General Assembly in 1994 (Buenos Aires) reiterated the call for national representative systems of MPAs, and also called for establishment of MPAs in areas beyond national jurisdiction (ABNJ).

Marine conservation was given a clearer framework with the 1992 UN Earth Summit in Rio (UNCED or Rio Summit). Chapter 17 of UNCED's comprehensive plan, *Agenda 21*, specifically focused on ocean management and protection. UNCED also led to agreement on the legally binding Convention on Biological Diversity (CBD) which came into force in 1993 and which takes a broad ecosystem approach to conservation; protected areas are seen as essential but not the only mechanism to achieve conservation. The CBD Conference of the Parties (COP) in 1995 agreed to the Jakarta Mandate on the Marine and Coastal Biological Diversity, reflecting a global consensus on the importance of marine and coastal biological diversity and calling for development of criteria for establishment and management of MPAs. This policy decision led, in 1998, to the establishment of the CBD programme of work to assist implementation of the Jakarta Mandate, with a high priority accorded to the establishment and management of MPAs.

Equally important in terms of providing a legal framework for marine conservation was the legally binding UNCLOS which came into force in 1994. This gave nations sovereign rights to all resources in their Exclusive Economic Zone (EEZ), thus dividing ocean space between national and international jurisdictions. UNCLOS also contains

[3]https://portals.iucn.org/library/efiles/html/BP3%20Guidelines_for_marine_protected_areas/Pag-003/Annex%204%20Resolutions%2017.38%20And%2019.46%20Of%20The%20Iucn%20General%20Assembly.html

an unambiguous obligation for all States to protect and preserve the marine environment, including rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life (UNCLOS Articles 192 and 194.5) (Ray and McCormick-Ray, 2014).

The UNEP Regional Seas Programme and associated Conventions continued to expand in the 1980s and 1990s, with regional conventions adopted for the Eastern African Region in 1985 (Nairobi Convention), the Baltic in 1994 (HELCOM), and the North-east Atlantic in 1998 (OSPAR). Specific protocols on MPAs were developed in several cases which provided regional frameworks for the countries involved and provided significant impetus to MPA establishment; the Mediterranean and Caribbean particularly benefited from, respectively, the 1982 Protocol on Specially Protected Areas under the Barcelona Convention, and the 1990 Protocol Concerning Specially Protected Areas and Wildlife (SPAW) under the Cartagena Convention.

The World Heritage Convention (WHC) was another important global initiative, and during this period the first marine World Heritage Sites (WHSs) were designated, including the Great Barrier Reef (1981), Sian Ka'an in Mexico (1987), the Belize Barrier Reef (1996), and the Galapagos (2001). By 2015, there were 47 marine WHSs in 36 countries, and a strategy in place for ensuring that further appropriate marine sites are listed (Abdulla *et al.*, 2013). Although not necessarily increasing the area of ocean protected (WHSs must be nationally designated sites before they can be nominated for the WH List), this initiative provides a major incentive for good management. The WHC has also taken a particular interest in MPAs, with the establishment of the WHC Marine Programme in 2005, and has improved management of many of the large iconic MPAs, and produced a best practice manual (Douvere, 2015).

The 1980s and 1990s saw the production of many of the manuals and guide books that became the fundamental and most-used guidance for many MPA practitioners, providing the principles and tools for MPA establishment and management: Salm and Clark (1984); Salm *et al.* (2000); Kelleher and Kenchington (1992); Norse (1993); Gubbay (1995) and Kelleher (1999). An additional essential resource, set up in 1999, was the University of Washington's monthly *MPA News* which reported on the theory and practice of MPAs worldwide and has continued to this day.

At national level, the creation of MPAs began to accelerate. By 1985, an estimated 430 MPAs had been created that, with some exceptions, were mainly small coastal areas (De Silva *et al.*, 1986). Ten years later, the number had tripled to 1306 MPAs with subtidal habitat (and many more if those with only intertidal habitat were included), and the median size was now much larger (Kelleher *et al.*, 1995). Although a considerable achievement, it should be noted that an estimated 37 000 terrestrial protected areas were in place by that time (Jones, 2001).

For the western world, an international seminar organized by the US National Marine Sanctuary Program in 1986, and attended by 36 MPA managers and scientists with representatives from Australia, Canada, the UK and the US, was the first of several such events that led to valuable international collaboration and exchange of experiences on the practicalities of MPA management. The US designated 11 new NMSs between 1980 and 1994, including the large Florida Keys NMS established in 1990, and developed a standard approach to their management plans. The US Congress required NOAA to form a Sanctuary Advisory Council for the Florida Keys NMS, with representatives from all user groups, scientists, and others, thus ensuring more effective public consultation. As a result, all 14 MPAs managed by NOAA have Sanctuary Advisory Councils made up of more than 470 voluntary members who help to prepare the management plans and provide advice.

Having been initially slow to focus on MPAs, countries in Europe began to make more significant progress following adoption in 1992 of the European Union (EU) Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (The Habitats Directive) which requires the establishment of Special Areas of Conservation (SACs) for habitats and species listed as being of European importance. This built upon experience with and complemented the 1979 EU Directive on the Conservation of Wild Birds

which requires the creation of Special Protection Areas (SPAs) for areas of critical importance for listed birds. SACs and SPAs make up the EU Natura 2000 network (European Commission, 2007). Among other activities, the Directives require Member States to agree on protected area management arrangements and to fund research to identify, map and describe biodiversity. A disadvantage of the Directives is that only a limited number of marine habitats and species are covered, and thus the ecosystem approach is not easy to implement. However, by the end of 2014 there were some 3024 marine Natura 2000 sites covering just over 318 100 km^2 (European Commission, 2015) and, as a Europe-wide initiative, the Directives have given momentum to the national programmes of EU Member States to establish MPAs, which may have broader objectives.

By the mid-1990s there were 49 MPAs in the Mediterranean, 43 in the Baltic and 41 in the North-east Atlantic (Kelleher *et al.*, 1995). They included very different habitats such as Lundy (UK) an offshore island, Gullman (Sweden) a sheltered fjord, the stoney reefs of Herthas Flak (Denmark), and seagrass beds at Ses Negres (Spain). The Trilateral Wadden Sea agreement and the First Wadden Sea Plan (1997) was a landmark in terms of its size (>11400 km^2), recognition of the need to manage features at landscape scale (the largest unbroken system of intertidal sand and mud flats in the world), and cooperation over objectives and management between three countries. It was also significant because the MPAs in the Wadden Sea were set into a framework for the integrated management of a much larger but interconnected area (CWSS, 2010).

In other parts of the world, over this period, the development goals set under UNCED and the associated requirements for good governance, improved efficiency, equity and poverty reduction led to widespread decentralization and changes in the way natural resources were managed, with many countries embracing co-management and/or community management. In the Philippines, for example, following on from the success of Sumilon Island Reserve, several community reserves (such as Apo Island Reserve) were established in the 1980s that included all or a portion of their area in no-take fishing zones. Unusually for that period, the impact of management was often measured, using size and abundance of fish, adjacent fish harvest and coral cover (White, 1987). The proven improvements in coral reef health, fish abundance and fishery yields and benefits to communities meant that the model rapidly caught on around the country and attracted tourists, academics and international attention (White *et al.*, 2002).

In the Pacific, community-owned and managed conservation areas were promoted in the 1990s by the South Pacific Biodiversity Conservation Programme. Seventeen Conservation Areas (CAs) were established in 14 countries, of which seven were marine, most of which are still operational, such as Arnavon CA in the Solomon Islands. This approach was formalized in 2000 in the term 'locally managed marine area' (LMMA) which is defined as 'An area of nearshore waters and coastal resources that is largely or wholly managed at a local level by the coastal communities, land-owning groups, partner organizations, and/or collaborative government representatives who reside or are based in the immediate area' (Govan *et al.*, 2008; Govan, 2009). Those sites that have biodiversity as the primary objective, and that a country wishes to see recognized as a protected area, are now formally recognized by IUCN as MPAs and listed on the WDPA. Many other LMMAs, however, are also having a significant conservation impact particularly in the marine environment (Govan, 2009).

Many state managed, multiple use MPAs were also established over these two decades. In Indonesia, with the support of WWF, five marine parks were established between 1980 and 1992. This country had taken an early interest in MPAs. Recognizing its lack of capacity to manage the vast area of the archipelago, and given the emerging exploration of oil, gas, and mineral wealth, a network of sites of critical conservation importance had been identified (Salm, 1984), some of which were designated on the assumption that management would follow as capacity was built. Potentially a risky policy that could have led to 'paper parks', this in fact laid the foundation for much of the current national network. Given the emphasis often now placed on the need for formal scientific evidence prior to designation, this demonstrates that local knowledge and preliminary

surveys can be a good starting point, and that designated sites can be a useful tool to at least provide a presumption against future development and the introduction of harmful activities. Successful management of the network, however, took longer to achieve, partly because of the initial lack of stakeholder participation (Clifton, 2003).

Following the IUCN General Assembly Resolution 19.46 of 1994, discussions began in earnest about the need for MPAs in ABNJ, given that ABNJ cover nearly half of the planet's surface and the lack of a globally recognized legal mechanism for managing the high seas and seabed areas for long-term nature conservation. The International Whaling Commission had designated two 'whale sanctuaries': the Indian Ocean Sanctuary in 1979 covering the entire Indian Ocean south to 55°S; and the Southern Ocean Sanctuary in 1994 covering the waters around Antarctica (IWC, 2015). However, since these only prohibit commercial whaling they do not fulfil IUCN's definition of a protected area. A system of Wild Ocean Reserves had been proposed in 1991.

In 1996, an MPA workshop at the Montreal IUCN World Conservation Congress addressed 'international waters' among other issues. Progress started to be made with the creation of the Pelagos Sanctuary for Marine Mammals in the Mediterranean Sea in 1999 by France, Italy and Monaco through a specific agreement (the *Accord Mediterranée*), which was finally formally agreed in 2002. The Pelagos Sanctuary incorporates not only the territorial waters of the three Parties but also the adjacent water column outside their national jurisdictions, which at the time covered 53% of the MPA. This demonstrated that mechanisms could be found at the regional level but the inability to control the behaviour of outside nations revealed the need for a global mechanism (Gjerde *et al.*, 2016).

THE NEXT DECADE (2000–2010) – GLOBAL INITIATIVES AND ACCELERATING NATIONAL PROTECTION

By the end of the 1990s, much of the scientific and conservation discussion on MPAs was dominated by a debate over the potential role of marine reserves (the term used by many authors for no-take MPAs) in addressing the growing crisis in the world's fisheries (Roberts, 1997; Lauck *et al.*, 1998; Hilborn *et al.*, 2004). For many, there was a sense that the threat to the oceans from overfishing was so severe that MPAs should be used to manage fisheries, as much as to protect biodiversity. Guidelines specifically for marine reserves were produced by Roberts and Hawkins (2000) and Sobel and Dalgren (2004). In 1998, the US Marine Conservation Biology Institute (MCBI) had issued *Troubled Waters*: *A Call for Action*, a statement signed by 1605 scientists which, among other recommendations, called for an increase in the number and effectiveness of marine reserves in order to protect 20% of both EEZs and the high seas by the year 2020. Subsequent high profile campaigns, based on further science, raised the target to up to 40% of the ocean to be fully protected (Roberts, 2007; PISCO, 2011).

The concept of targets was gaining prominence more generally. At the World Summit on Sustainable Development (Rio + 10) in 2002, the Johannesburg Plan of Implementation called for the establishment of MPAs 'consistent with international law and based on scientific information, including representative networks by 2012' among other recommendations. This was reiterated in 2003 in the Evian Agreement, drawn up at the meeting of the G8 nations, and in the Durban Action Plan produced at the Fifth World Parks Congress. In 2004, the Programme of Work on Protected Areas (PoWPA) agreed at COP7 of the CBD, similarly required parties to establish and maintain by 2012 'comprehensive, effectively managed and ecologically representative national and regional systems of protected areas …' for the marine environment, with 'effective conservation of at least 10%' of each ecological region (UNEP-WCMC, 2008).

The CBD requirement for 'ecological representation' made the development of a globally recognized classification of marine biogeographic types and ecosystems essential and required scientific analysis that had begun with an early classification by Hayden *et al.* (1984). The need for a workable classification had been recognized and called for at the IUCN World Parks Congresses of 1982, 1988 and 1992, as well as the 17th (1988) and

19th (1994) IUCN General Assemblies, but was proving difficult to develop (UNEP-WCMC, 2008). The concept of large marine ecosystems (LMEs), elaborated by Sherman and Alexander (1989), opened the door to new thinking on this. IUCN's CNPPA divided the world's oceans into 19 biogeographical regions and established MPA working groups for each (Kelleher *et al.*, 1995). LMEs ultimately figured less in MPA development than in the large-scale regional marine management programmes of the Global Environmental Facility, but catalysed the production of Marine Ecoregions of the World (MEOW), a nested system of 12 realms and 62 provinces, based largely on the earlier biogeographic systems, and 232 ecoregions (Spalding *et al.*, 2007) and the Global Open Ocean and Deep Sea biogeographic classification system for areas beyond the continental shelf (UNESCO, 2009).

New methods were also being developed to facilitate the identification and design of networks, such as MARXAN (Possingham *et al.*, 2000), and were translated into user-friendly guidance by IUCN (IUCN, 2008). Pioneering work in developing a science-based approach to establishing MPA networks was undertaken in California (Botsford *et al.*, 2014), followed by other countries such as the UK (Natural England and JNCC, 2010).

The CBD targets and principles established in 2004 had a significant impact on the scale of work on protected areas, both terrestrial and marine, with numerous countries and regions developing their own national targets and widespread adoption of systematic conservation planning approaches to facilitate the development of ecologically representative systems. A review by UNEP-WCMC (2008) described 20 regional, 30 national and 35 sub-national MPA networks under development. By 2005 there were 216 MPAs in Europe (Gubbay, 2005) and, with the establishment of the French MPA Agency in 2006 and its ambitious MPA designation programme, this continent began to play a more significant global role.

Increasingly the major non-governmental organizations (NGOs) took a lead role, raising funds, supporting the development of methodologies and assisting developing countries. For example, in 2005 The Nature Conservancy (TNC) helped jump start the CBD PoWPA through its programme of National Implementation Support Partnerships (NISPs) which provided support for designing and strengthening MPA networks in Latin America, the Caribbean and South-east Asia. Only 2.3% of the territorial waters of Latin America and the Caribbean had been designated as MPAs by 1990, but this had risen to 9% by 2000 (Elbers, 2011; FAO, 2012). By 2008, a total of 756 MPAs had been established in this region, covering more than 300000 km^2. Of these, 98 were no-take MPAs covering only 0.1% of the coastal and shelf waters, and many biogeographic provinces were still under-represented, notably the southern Pacific and southern Atlantic coasts of South America (Guarderas *et al.*, 2008).

In the Pacific, by 2009, more than 500 communities in 15 countries were managing 12 000 km^2 of coastal resources, including 1000 km^2 of no-take area (Govan, 2009). In many cases, the traditional *tabu/raui/bul* concepts have been codified into the modern system of law, as in Palau, where the traditional *bul* system has become the basis for a network of 21 nationally-designated protected areas under the Protected Area Network (PAN) law. This looks first to local leaders and their traditional guidance, and then to scientists, to identify vulnerable ecosystems and coordinate the community, national, and international assistance necessary to institute appropriate protection.

The need for regular meetings of practitioners became clear during this decade, and the series of biennial International MPA Congresses (IMPAC) was initiated, with the first held in Australia in 2005, IMPAC2 in the USA in 2009 and IMPAC3 in France in 2014. These bring together practitioners, scientists and policymakers to share lessons learned, experiences and scientific advances. Numerous regional 'social and learning' networks of MPA practitioners were also set up such as the North America Marine Protected Area Network (NAMPAN), the Caribbean MPA Managers Network (CaMPAN) and the Mediterranean Protected Area Network (MedPAN).

Growing discussion on the role of MPAs in protecting the many highly threatened large marine mammals from the wider range of impacts than direct exploitation, necessitated the development of conservation strategies very different from those for more sedentary, shallow

water habitats and species (Hoyt, 2005). The protection of migratory corridors and key feeding and breeding grounds and nursery areas, even when these extended beyond coastal waters and into the high seas, was clearly necessary. Concern over the impact of deep sea bottom fishing on cold water coral reefs and sponge beds in ABNJ drove attention to deeper waters. At the national level interest in deeper and open ocean waters was growing as well. Four MPAs protecting chemosynthetic ecosystems were created only a few decades after the discovery, in the late 1970s, of deep-sea vent ecosystems, in: Canada (Endeavour Hydrothermal Vents MPA, 2003); Portugal (Azores Hydrothermal Vent MPAs, 2007); Mexico (Guaymas Basin and Eastern Pacific Rise Hydrothermal Vents Sanctuary, 2009); and the USA (Mariana Trench National Monument, 2009) (Van Dover *et al.*, 2011).

The realization took hold that protection of ABNJ and deeper waters would be critical for sustaining ecosystems and biodiversity across the planet. A WCPA-Marine High Seas MPA task force was established in 2003 (followed later by the WCPA-Marine task force on 'very large' MPAs in 2013 and the WCPA and SSC Joint Task Force on Marine Mammal Protected Areas in 2014). The first workshop specifically on high seas MPAs was held in Germany in 2001, followed by a second in 2003 in Spain convened by IUCN/WCPA and WWF which resulted in a 10-Year Strategy for High Seas MPAs. This was adopted at the 5th World Parks Congress, and the issue of high seas MPAs was for the first time formally explored at the UN through the UN Informal Process related to Oceans and Law of the Sea, both also in 2003. In 2004, the UN established an Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biodiversity in areas beyond the limits of national jurisdiction (informally called the BBNJ Working Group) (IISD, 2015). Further discussions were held at the 2005 meeting of the CBD Ad hoc Open ended Working Group on Protected Areas, in Italy, and again at COP 8 of the CBD in 2006, when agreement was reached that scientific and technical advice should be developed.

In 2006, the United Nations General Assembly (UNGA) adopted a resolution calling for the protection of 'vulnerable marine ecosystems' (VMEs), a concept that has since been used primarily by FAO and regional fisheries management organizations (RFMOs) to incorporate deep sea biodiversity protection into fishery management in ABNJ (SEAFO, 2014). However, a wider set of criteria were needed for guiding the development of area-based management tools including MPAs and impact assessments in ABNJ. In 2008, at COP 9 in Bonn, Germany, the CBD adopted seven scientific criteria for identifying 'ecologically or biologically significant marine areas' (EBSAs) in need of protection, as well as guidance for designing representative networks of MPAs including in open-ocean waters and deep-sea habitats. The criteria were subsequently acknowledged by UNGA in 2009. An expert team, comprising scientists from the Census of Marine Life, OBIS, CSIRO, Duke University Marine Geospatial Ecology Lab, UNEP-WCMC, MCI and BirdLife International among others, and supported by IUCN and Germany, compiled data and explored the tools and models needed to identify candidate EBSAs. The name 'the Global Ocean Biodiversity Initiative' was adopted at a Canadian government hosted workshop in 2009, and a formal partnership evolved, focused on providing technical guidance to describe EBSAs and other areas in need of protection in ABNJ. Since then, many EBSAs within national EEZs and ABNJ have been described, the responsibility for identifying EBSAs and adopting relevant conservation or management measures lying with States or relevant international organizations (Dunn *et al.*, 2014).

Although often painful and slow for the participants, the numerous meetings and discussions on MPAs in ABNJ began to pave the way for some real advances, particularly through the regional conventions. In 2009, under the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), the South Orkney Islands Southern Shelf Marine Protected Area was established in the southern Atlantic Ocean (CCAMLR, 2009). In Europe, a High

Court ruling in the UK in 1999[4] and a ruling by the European Court of Justice in 2005[5] clarified that the EU Habitats Directive applies to EEZs or, in the case of the Atlantic seaboard, up to 200 nm from the coastline of Member States. This meant that 'offshore' SACs and SPAs could and should be part of the Natura 2000 network.

THE LAST FIVE YEARS – RAPID GROWTH

By 2008 when an estimated 5000 MPAs had been established, Wood *et al.* (2008) demonstrated that with 'business as usual' scenarios, the 10% target would not be achieved until at least 2047, rather than 2012 as agreed by the CBD in 2004. At COP 10 in 2010 therefore, the CBD Parties, in adopting the new Strategic Plan for Biodiversity 2011–2020 and developing the Aichi Biodiversity Targets, strengthened but did not increase the MPA target (Toropova *et al.*, 2010). Aichi Target 11 requires that, by 2020, at least '…. 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures'. The Aichi Targets emphasize that protected areas are part of the broad array of conservation efforts that are needed to protect biodiversity, with the ecosystem-based approach being essential, and expressly state the need to integrate biodiversity conservation into development practices, and to conserve ecosystem service benefits for human well-being.

Aichi Target 11 was reaffirmed at the UN Conference on Sustainable Development (Rio + 20) in 2012, and has had a significant impact on MPA coverage. Globally, some 9000–10 000 MPAs had been designated by 2013 (Spalding *et al.*, 2013; Costello and Ballantine, 2015).

In Asia, particular progress has been made in six countries (Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands and Timor Leste) as a result of the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF). Initiated in 2007 and endorsed by the six countries in 2009, the CTI-CFF produced the Coral Triangle MPA System Framework and Action Plan in 2013, which lays out minimum standards for national reporting on the status of the MPAs and a common set of indicators for tracking progress and evaluating management effectiveness. The regional framework allows the countries to compare progress with each other and generates healthy 'peer pressure' and an incentive to improve national budget allocations for MPAs. In the case of the Philippines there is also a national incentive in the form of annual awards for the best planned and managed MPAs. By 2014, the six CTI-CFF countries had 1972 MPAs covering approximately 1.3% of their EEZs, 9.4% of their territorial waters to 12 nm offshore and 17.8% of their coral reef habitat. Several of these countries have, in addition to nationally declared MPAs, numerous local government or community managed MPAs, often with no-take areas; by 2015, the Philippines had more than 1600 such sites (White *et al.*, 2014).

Rapid advances have also been made in East Africa where new co-management legislation has built on and strengthened existing traditional systems such as community closures (*tengefu*) in Kenya, *Dina* in Madagascar, and the national social *Ujamaa* system in Tanzania, with many of these areas now established as LMMAs (Cinner *et al.*, 2012; Rocliffe *et al.*, 2014). There are now numerous community-managed areas, NGO-led protected areas (e.g. Cousin Island managed by Nature Seychelles) and private sector arrangements such as Chumbe Island Coral Park (managed by a private company), collaborative management areas in Tanzania and community fisheries councils in Mozambique. Madagascar has the largest network of community managed areas consisting of 64 LMMAs coordinated under a national network Mihari that is facilitated by NGOs including Blue Ventures, WWF and WCS.

One key global development has been the designation of very large MPAs, an approach driven in large part by the Pew Charitable Trusts' Global Ocean Legacy Campaign but with

[4]UK Case n°CO/1336/1999 The Queen -v- The Secretary of State for Trade and Industry ex. parte Greenpeace Limited
[5]C-6/04 of 20 October 2005

significant support from governments and other international NGOs. This approach had started to gain ground as a result of the Micronesia Challenge (launched in 2006, with a target to protect 30% of the EEZs of the countries involved by 2020) and the Caribbean Challenge (launched by 10 countries in 2008 with a target to protect at least 20% of nearshore marine and coastal environments by 2020). Since 2006, when Papahānaumokuākea Marine National Monument, a no-take area of 362000 km^2 was declared in Hawaii, vast MPAs have been declared in many countries including Kiribati, USA, Mozambique, Indonesia, the UK (British Indian Ocean Territory), Chile, Cook Islands, Australia, France (New Caledonia), and Ecuador (Galapagos). The size of the US NMS estate has grown particularly rapidly to 14 MPAs covering nearly 465 000 km^2. There are now at least 24 MPAs in the world >100 000 km^2, and in two cases sites cover more than one million km^2 and incorporate the entire EEZ of a jurisdiction (Pala, 2013; Thomas *et al*., 2014; Lubchenco and Grorud-Colvert, 2015; Boonzaier and Pauly, 2016).

By 2014, MPAs covered 7.9% of waters less than 200 m deep (Thomas *et al*., 2014). With the additions since then and the new commitments that have been made (Lubchenco and Grorud-Colvert, 2015; Boonzaier and Pauly, 2016) there is an expectation that 10% of marine waters under national jurisdiction will be protected by 2020. However, although Aichi Target 11 has been reached for terrestrial protected areas, MPA coverage of the ocean as a whole is still only just over 3%. Using the WDPA, Thomas *et al*. (2014) estimated coverage to be 3.4%. More recent analyses, using different datasets, give slightly different figures: Lubchenco and Grorud-Colvert (2015) estimated 3.5% using the MPAtlas dataset and Boonzaier and Pauly (2016) estimated 3.3% using a database maintained by the Sea Around Us Project.

These analyses indicate that the global target will not be met unless significant progress is made in ABNJ. By 2009, UNGA-driven action to protect deep-sea biodiversity from high seas bottom fishing had started to result in some large high seas bottom fishing closures. In 2010, OSPAR adopted the first network of six MPAs in ABNJ in areas largely overlapping with deep-sea closures (Antialtair Seamount, Altair Seamount, Josephine Seamount, Milne Seamount Complex, Mid-Atlantic Ridge North of the Azores, Charlie-Gibbs South) (O'Leary *et al*., 2012), with a seventh MPA adopted in 2012 (Charlie Gibbs North) (OSPAR Commission, 2013). The OSPAR Commission has developed a mechanism (a 'Collective Arrangement' between competent international organizations) to improve cooperation that is underpinned by more formal Memoranda of Understanding (Gjerde *et al*., 2016).

In 2011, the UNGA BBNJ Working Group agreed to consider a possible multilateral agreement in addition to better implementation of existing agreements. That same year, the High Seas Alliance, a partnership of organizations and groups aimed at building a common voice and constituency for high seas conservation (and currently consisting of 31 NGOs and IUCN), was founded. At Rio + 20 in 2012, States committed themselves to urgently addressing the issue of the conservation and sustainable use of marine biodiversity in ABNJ. That same year, the International Seabed Authority defined nine areas of 'particular environmental interest' in the Eastern Pacific Clarion-Clipperton Fracture Zone, where applications for deep-sea mining for exploration or exploitation will be prohibited over an interim 5-year period, thus providing another precedent for creating conservation measures in ABNJ.

In 2015, the UN BBNJ Working Group reached consensus on the need for a legally binding agreement on the conservation and sustainable use of BBNJ under UNCLOS and shortly after, the UNGA adopted a formal resolution to develop a legally-binding instrument on marine biodiversity in ABNJ that will cover, among other issues, area-based management tools such as MPAs. The resolution calls for a two-year preparatory process (2016–2017) to develop recommendations for the treaty elements, with progress to be reported to UNGA by the end of 2017, when a decision will be taken on launching an intergovernmental negotiating conference to formally adopt the new instrument.

'LESSONS LEARNED' AND FUTURE CHALLENGES

Looking back at the early literature, it can be seen that the broad biological, ecological, legal and cultural principles for effective MPAs were anticipated from the 1960s and 1970s but not well understood. These principles include: the need for MPAs to be designed to protect critical marine habitat and developed as part of larger 'systems'; the importance of representativeness as an ecological criterion to define such systems; the need to embed MPAs in wider management regimes; the essential role of local communities and stakeholders in planning and management; the requirement for long-term monitoring to allow meaningful evaluation of success and provide the information needed for adaptive management; and a solid resource and financing basis.

Developments since the 1980s have largely been in terms of the evolving science, thereby refining these concepts, producing the necessary methodologies and guidance, planning and establishing MPA networks, increasing the area of ocean protected, and building capacity for management. There have been some shifts in approach, notably in relation to how MPAs might be used, the range of objectives that MPAs might have beyond the primary one (as defined by IUCN) of biodiversity conservation, and how other area-based management tools may be used to benefit biodiversity conservation. With progress starting to be made towards achievement of the quantitative element of Aichi Target 11, attention has now turned to the qualitative aspects of the target i.e. that marine biodiversity should be 'conserved through **effectively and equitably managed, ecologically representative and well connected systems** of protected areas and **other effective area-based conservation measures, and integrated into the wider landscapes and seascapes**.' (Watson *et al*., 2016).

Many issues remain to be resolved as discussed below.

An expanding role for MPAs

Protected areas, as defined by IUCN, may have secondary objectives to the primary one of biodiversity protection, and it has always been recognized that they can play a key role in sustainable development. This understanding has been particularly important in the case of MPAs, given the dependence of many local communities and national economies on the marine environment (Kelleher and Kenchington, 1982). It is now becoming evident that MPAs can address a wide range of ecosystem services and fisheries-related issues, and ensure the provision of many goods and services (Rice *et al*., 2012; Green *et al*., 2013). Demonstrating these roles, and determining how MPAs can be best designed and managed to fulfil such roles is now an important research topic.

The potential benefits of MPAs to their users are now considered by many on a par with their role in biodiversity conservation. The open access nature of the oceans has meant that the establishment of an MPA requires a sound understanding of international law, traditional rights, fishing and navigation activities, as well as careful consideration of existing uses, and involvement of the users. The participatory approach is firmly enshrined in guidelines and principles for MPA establishment and management, supported by the adoption of the Human Rights Based Approach to development, which requires both accountability and responsibility. This is helping to drive work on economic benefits of MPAs (Brander *et al*., 2015), sustainable financing (Mangos and Claudot, 2013), and the potential co-location benefits of MPAs with other activities such as offshore wind farms and underwater heritage sites.

In relation to fisheries, there is good evidence that effectively managed MPAs can maintain and protect habitats on which commercial fish depend or, in the case of no-take areas, improve catches through the spill-over effect (Caveen *et al*., 2015; Costello and Ballantine, 2015; da Silva *et al*., 2015). Although no-take areas have particular fisheries benefits, 'partially protected' areas may also have positive ecological effects and are therefore a valuable tool in places where exclusion of all extractive activities is not a socio-economically and politically viable option (Sciberras *et al*., 2013). Equally, fishery management areas often have a positive impact on biodiversity and ecosystem health. Where coastal communities still depend heavily on fishing, MPAs and no-take areas are often accepted specifically

because they benefit fisheries. Many productive locations for fishing have habitats and species (e.g. coral reefs, temperate rocky habitats, and sedentary species such as molluscs) for which closure to exploitation may have a very immediate positive impact on size and abundance of target species. There are fewer examples of MPAs improving commercial harvests in pelagic and temperate waters (Stewart *et al.*, 2008; Caveen *et al.*, 2012), as immediate benefits for these fisheries are harder to demonstrate, which has made it difficult to convince the commercial fishery sector of the need for MPAs.

International law under the UN Fish Stocks Agreement and the FAO Code of Conduct recognizes the need to protect biodiversity, and FAO has produced guidance on fisheries and MPAs (FAO, 2011). The role of MPAs in reconciling fisheries management with conservation was discussed at an international workshop in Norway in 2011 (Rice *et al.*, 2012) and it was concluded that well managed MPAs that segregate activities in space could contribute to resolving many potential conflicts between fisheries and conservation objectives, if appropriate mechanisms are used and if management of the MPA is inclusive and participatory. A general framework for the governance of MPAs for both fisheries and biodiversity conservation was developed.

Tourism and leisure, understood in many countries to be a key ecosystem service, is often now tightly linked to MPAs. MPA managers and agencies increasingly face a dilemma between promoting tourism to build revenue and regulating visitor pressure. In the future, this task is likely to become more difficult as increasing volumes of tourists venture into ever more remote places. Some countries have already had to take drastic action: marine parks in Thailand are being closed out of the tourist season to allow habitats to recover, particularly coral reefs suffering from bleaching[6].

Consideration is also being given to the role of MPAs in an era of climate change. MPAs that include ecosystems such as mangroves and seagrasses may play a significant role in protecting carbon stocks. Equally importantly MPAs may be able to build resilience to climate change and its various impacts. The assumption is that by reducing or eliminating stressors (such as over-harvesting or pollution), the species and habitats within MPAs will be more resilient. The ecological principle of 'resilience' refers to communities that are able to bounce back or recover after experiencing a stressful event such as coral bleaching (Shamberger *et al.*, 2014), or that are able to keep pace with sea-level rise (van Woesik *et al.*, 2015). If such resilient locations can be identified, it would be possible to consider reconfiguring MPAs to include them, according to the nature of the stress involved. Numerous studies are underway (McLeod, 2013; McLeod *et al.*, 2013) but further work is necessary to determine whether such a concept could apply for all marine ecosystems, current work being largely limited to coral reefs (Olsen *et al.*, 2013).

Design of MPAs and MPA networks

More than 30 years ago, Salm and Clark (1984) stated that 'There is no consensus among the experts on the optimal size and design for protected areas'. This still holds true to some extent although the criteria for protected area systems or networks have been much improved, to include concepts such as adequacy, viability and connectivity. The greater problem, even where appropriate tools and technology exist, is translating science understanding into the appropriate spatial arrangement of MPAs. Socio-economic and political realities, including lack of willingness on the part of governments and stakeholders, often prevent this with the result that MPAs are placed in areas where they provide minimal protection of overall ecosystem structures, functions and processes and produce relatively little direct benefit for people (Devillers *et al.*, 2015).

The question of optimum size of MPAs has long occupied scientists and practitioners alike. Research has tended to focus on no-take MPAs. On the one hand, there are cases where small no-take MPAs can be correlated with better performance (Fox *et al.*, 2014). Conversely Edgar *et al.* (2014) found that large no-take MPAs are more successful,

[6]http://www.sawadee.com/thailand/diving/closure_diving_spots.html

especially for those organisms that require more space, i.e. larger protected areas are better at regenerating fish stocks and other species than smaller ones, as they protect more space for the dispersal of larvae as well as habitat necessary for early life stages. Larger areas are also credited with providing more 'spill over' of biomass outside the MPA than smaller protected areas, as well as exposing species within the areas to less stress resulting from 'edge effects' and increasing resilience to climate change (Wilhelm *et al.*, 2014). However, effectively managed networks of smaller MPAs may be able to fulfil criteria for ecological representation more easily.

Equally challenging is the question of how networks or systems[7] of MPAs should be designed, and what the precise criteria should be. The general principles, such as adequacy, representation, resilience, connectivity (IUCN, 2008) are understood and there is no shortage of broad guidance. However, there is little help for questions such as 'how much of each habitat would ensure representation in any particular situation'. To address representation, the marine conservation component of the *Promise of Sydney* (a set of statements that summarizes the outputs and recommendations of the 2014 WPC)[8] suggests that a network within a certain location 'should include at least 30% of each marine habitat' within MPAs. Individual countries have adopted their own guidance (Natural England and JNCC, 2010), but assessing progress towards representation at the global scale will not be easy. Connectivity similarly remains a major challenge, with the practice yet to catch up with the theory. Representation and replication, however, provide a stop gap measure to buy time and reduce risk of wrong decisions, particularly in the face of the many uncertainties posed by climate change. Green *et al.* (2015) provide guidance on determining minimum size for no-take MPAs on coral reefs, as well as locating MPAs within networks so as to optimize connectivity, using the ranges of fishes and durations and life cycle characteristics of reef larvae. Further work will be needed to see how this can be adjusted to other marine ecosystems.

Furthermore, if the concept of protecting potential climate change refugia or resilient locations is to work globally, such sites will need to be identified quickly and prioritized carefully for inclusion in MPA networks. Many MPAs are already known to be highly or moderately susceptible to climate change (e.g. in the Western Indian Ocean (Maina *et al.*, 2008)). In addition, with oceanographic regimes changing and some species moving towards the poles as waters warm (some are already known to be moving north as sea temperatures warm (Cheung *et al.*, 2009)), designing MPA networks across latitudinal gradients to ensure protection of species as their ranges change might be necessary.

Developments in the use of remote sensing technologies, and satellite tracking and telemetry for monitoring marine systems at very large scales will help with many of these issues. The expense and labour intensive nature of working in the ocean was a major constraint to data gathering, research and management in the early days. Through remote sensing, scientists can define the extent of essential ecosystem processes, most notably warming and current dynamics that are fundamentally different from similar features on land. In the USA, NOAA's remote sensing capabilities and spatial and temporal coverage has revolutionized MPA planning with, for example, the ability to track water circulation and fish and lobster movements, and calculate sea surface temperature and the level of chlorophyll in the water. Similarly, new modelling tools, such as MARXAN, can be used to assess multiple variables for MPA planning. A disadvantage is that over-dependence on technology can draw attention away from the need for careful ground- truthing to verify scenarios generated by the models.

A further uncertainty related to the design of MPA networks is the fact that Aichi Target 11 proposes that protected area systems should include 'other effective conservation measures' (OECMs) (Watson *et al.*, 2016). OECMs are place-based/spatial conservation measures that do not meet the IUCN definition of a protected area but that contribute to achievement of conservation objectives. A newly established international IUCN WCPA Task Force

[7]The terms 'network' and 'system' tend to be used interchangeably in the protected area literature, with the former being more prevalent with MPAs. See UNEP-WCMC (2008) for further discussion.
[8]http://worldparkscongress.org/downloads/approaches/ThemeM.pdf

on OECMs, with marine representation, is looking at how the concept can be better defined and will provide guidance to the CBD on how this aspect of the target can be met. These discussions will provide an opportunity for improved understanding of different types of MPAs and the incorporation of other effective spatial conservation measures into MPA networks.

Effective governance and management

MPA designation is only the beginning of a much longer road to successful management. Much of the success of an MPA depends on how well it is managed and enforced. As just one example of how long this can take, the Tubbataha Reefs Natural Park in the Philippines was gazetted in 1988 and five years later in 1993 it was designated as a WHS. This gave rise to increased financial support, international attention, and national capacity building, and finally the process of management planning and enforcement began, leading to the current effective management (Dygico *et al.*, 2013). In 2010, just 15% of coral reef MPAs were effectively managed (Burke *et al.*, 2011). Samoilys and Obura (2011) found that the only successful government-established MPAs in the Western Indian Ocean were those in Kenya.

Limitations include political will, financial resources (in 2004, less than 16% of MPA managers felt they had adequate funding for effective conservation (Balmford *et al.*, 2004)), human education and capacity, the lack of ability of governments to plan and execute integrated programmes that cross all government and social sectors and inadequate consideration of social and economic issues. These limitations apply equally to developed and developing countries, and indeed many of the current successful approaches to MPA management have arisen in the southern hemisphere, where there is often better public understanding of the importance of healthy oceans to coastal livelihoods, national economies and sustainable development.

The problems faced by the GBRMP epitomize the difficulties. In 2014 this iconic MPA experienced such serious degradation due to lack of sufficient control over fisheries and pollution from increasing extent and forms of freshwater use outside the boundaries of the GBRMP that its status as a WHS was questioned (Hughes *et al.*, 2015). The challenge of effective control mechanisms and governance structures for activities beyond MPA jurisdictional boundaries is deepening with increasing urbanization, industrialization, agricultural intensification and expansion. Another substantial challenge will be finding effective management mechanisms for the new very large MPAs, particularly those in remote areas or under the jurisdiction of poorly resourced countries (De Santo, 2013), although new technologies to monitor the activities of vessels in distant waters will help to change this.

The Western Indian Ocean provides a good example of how capacity can be built up rapidly through regional and national initiatives, involving the establishment of thematic groups to share experiences and knowledge regionally, the inclusion of capacity building and training activities in large donor funded initiatives, and the facilitation by the regional organization, the Western Indian Ocean Marine Science Association, of a wide range of activities including symposia for regional scientists and the professionalization of MPA management through a certification program, the western Indian Ocean Certification of Marine Protected Area Professionals (WIO-COMPAS).

One obstacle to improving management (as well as to designating new sites) is the limited documentation of MPA success, despite the many rational arguments for stakeholder benefits and economic livelihoods they can provide (Bennett and Dearden, 2014; Fox *et al.*, 2014). 'Success stories' are limited mainly to relatively small-scale situations and particular species and habitats, such as coral reefs (Lester *et al.*, 2009). A fundamental requirement, if MPAs are to demonstrate success in terms of maintenance and recovery of ecosystem health, are long-term monitoring programmes. The Philippines and Indonesia now require that monitoring programmes are formally part of the MPA planning and adaptive management process, and the Wildlife Conservation Society and its partners have supported monitoring programmes in the Western Indian Ocean since 1987 (McClanahan *et al.*, 2014). Linking trends in ecosystem health and species demographics to particular management

interventions, however, is not easy. Methodologies to assess the management effectiveness of protected areas (Pomeroy *et al.*, 2004; Hockings *et al.*, 2006) are increasingly addressing this and such assessments are proving a key incentive for improving management (Wells, 2006; Muthiga, 2009). The IUCN Green List of Protected and Conserved Areas, launched by IUCN at the WPC in 2014, provides a further incentive for effective management of all protected areas; four MPAs are already on the list (Wells *et al.*, 2016).

A critical and well-documented catalyst for long-term success is the involvement of local stakeholders in MPA designation and management. This takes many forms. In the Philippines, for example, authority for coastal and marine management has been devolved formally to the local municipal and city governments since 1991, and some dedicated budget provided (White *et al.*, 2002; Maypa *et al.*, 2012). Co-management and collaborative management are now widespread in the Western Indian Ocean (Cinner *et al.*, 2012). In the UK, in the 1970s and 1980s, when there was no statutory backing for MPAs, voluntary marine conservation areas were identified by local interest groups, and codes of conduct used to promote appropriate management. These were by and large unsuccessful and a top-down approach followed which resulted in sites with little management. A new policy and initiative to establish a national network in 2009 adopted stakeholder involvement from the initial stage of site identification and, although not without problems, now implementation is underway, will potentially result in more effective MPAs (Jones, 2012).

MPAs in the wider context – spatial planning and land–sea interdependence

Early MPAs were generally inshore areas and considered as entities in their own right. However, as early as the 1962 WPC (Adams, 1962) it was proposed that spatial planning policies, as commonly implemented on land, be extended to marine areas – i.e. zoning for different activities. Integrating MPAs within a wider spatial planning approach for the oceans and an ecosystem-based management (EBM) approach for the oceans as a whole are now fundamental goals, even if implementation is not straightforward.

MPAs and MPA networks need to be key components of integrated coastal zone management (ICZM) and marine spatial planning (MSP), which are now formal processes in many countries, backed by legislation. On the one hand, MPAs are a key tool for ensuring that biodiversity conservation and protection of ecosystem services are addressed; and on the other, the existence of a good MSP regime or ICZM plan around an MPA helps to reduce impacts from activities outside the boundaries, such as shipping, aggregate and mineral extraction, and coastal development (Agardy *et al.*, 2011). Ensuring that MPAs are included in early stages of ICZM and MSP initiatives also helps to recognize MPAs as legitimate use of sea space along with other sectoral interests. The idea of the 'coastal realm as a conservation unit' has also been proposed (Ray and McCormick-Ray, 2014). The development of MPA networks must take place with a good understanding of adjacent and connected fisheries management areas and seasonal closures, local and national ICZM areas, 'particularly sensitive sea areas' (PSSAs), areas to be avoided (ATBAs), and Special Areas that can be established through the International Maritime Organization and MARPOL (IMO, 2015a, b) and other forms of marine spatial planning.

Early MPA pioneers were very aware of the threats posed by pollution and land-based activities to MPAs and the features they protect (IUCN, 1976). However, there has been surprisingly little effort given to developing and testing mechanisms to address and mitigate these impacts, and correspondingly little in the scientific literature on MPAs and land-based sources of damage. The recent concern about the status of the GMRMP is a case in point. Addressing such threats is fundamentally difficult, compared with those posed by recreation and fisheries; indeed Costello and Ballantine (2015) note the bias of MPA literature towards fishery management. Activities on land are regulated by a wide range of authorities and often result in cumulative impacts, which only now are starting to be addressed (Judd *et al.*, 2015). Some of the larger multiple use MPAs and MPA networks, such as the California

State MPAs and the GBRMP, are managed using MSP approaches, cognisant of land–sea interactions. MPAs often function more effectively if they can be linked to terrestrial protected areas, either as buffer zones or as part of an integrated management regime (Salm and Dobbin, 1989a). The coastal zone management plans in the Sultanate of Oman (Salm and Dobbin, 1989b) and Belize (Gibson *et al.*, 1998) were early examples of this. The 'reef to ridges' approach practised in Pacific Islands, such as Hawaii in pre-contact days, is also being resuscitated and tested, with formal and informal instruments and alliances implemented to achieve this.

CONCLUSION

Ray (2015) suggests that what we do next may 'depend on perspective and location'. MPAs are diverse in objectives and in the impacts on them, and their roles differ as a result of their individual histories, location, prescriptive mandate, management, and the degree to which scientific principles and information are applied. This explains the difficulty in finding general conclusions that are applicable across the board: for example, the big versus small MPA debate; the multiple-use versus no-take debate; or the debate on MPAs for protection of nature primarily or for services for people.

There will always be a good argument for each point of view in a particular location. Thus, for coral reefs in developing countries, stakeholder involvement and resilience are likely to be paramount. For Arctic sea-ice habitat, and its charismatic seals, walruses, and polar bears, little can be done to reduce the pace of diminishing sea-ice habitat due to climate change (Ray *et al.*, 2016) but there are plans for a regional network of MPAs (PAME/Arctic Council, 2015) based on the precautionary belief that MPAs can help to reduce other stressors and build resilience. The precautionary approach is essential, particularly in an era of rapid environmental change and in regions such as the poles where changes are most rapid.

The target approach is proving invaluable in accelerating the establishment of MPAs and inspiring action that otherwise would not have been taken. The Promise of Sydney raised the stakes in 2014, stating that 'The ultimate aim is to create a fully sustainable ocean, at least 30% of which has no-extractive activities', which was reiterated in 2016 at an international workshop of marine scientists and MPA practitioners in Rome.[9] There are indeed many scientific studies that reinforce the view that adequate biodiversity protection will only be achieved if a much larger area of ocean is closed to fishing (O'Leary *et al.*, 2016). However, these well intended initiatives must be balanced against the risk of selecting areas for MPAs that are easy options and that do not take account of relevant ecological and socio-economic criteria, are not ecologically representative or connected, and ignore stakeholder rights and concerns (De Santo, 2013). Given the range of levels of protection and management, should we perhaps be modifying or qualifying what we count towards the targets in terms of area protected, and tailoring targets to the local, national or regional context before rolling up to the international level?

What is certain is that MPAs and MPA networks need to be effectively managed, complemented by other types of conservation measures, and nested within an ecosystem-based approach to management of the oceans as a whole (Agardy *et al.*, 2003). With the drive of many nations towards a 'blue economy' and the hopes that MPAs can contribute to this through the goods and services they provide, the original purpose of such sites (i.e. biodiversity protection) must not be forgotten. Planning and establishing MPAs to help better achieve sustainable development and provide economic benefits is urgently needed but this must not be done by compromising their many other benefits.

The next four years, until 2020, will see further rapid advances, as well as development of methods to assess progress to Aichi Target 11. The MPA and broader conservation community needs to work together on this, coordinate resources for collecting and analysing data, collaborate and develop compatible and harmonized methods and datasets, and share experiences of successful national and regional

[9]http://www.italyun.esteri.it/rappresentanza_onu/resource/resource/2016/03/scientists_consensus_statement_on_marine_protected_areas.pdf

approaches. MPAs comprise an expanding global experiment (Olsen *et al*., 2013), involving the testing of different treatments to the common problem of achieving no less than global networking at multiple scales. To get good results from the experiment, setting targets and building peer-reviewed systems to track progress within multinational settings, particularly at the regional level, are essential. Building public and political support is no less so, simply because healthy, biodiverse marine systems are dominant features of civilization's life-support system.

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