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Review

Missing marine protected area (MPA) targets: How the push for quantity over quality undermines sustainability and social justice

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ABSTRACT

International targets for marine protected areas (MPAs) and networks of MPAs set by the World Summit on Sustainable Development and United Nations Convention on Biological Diversity failed to meet their 2012 deadline and have been extended to 2020. Whilst targets play an important role in building momentum for conservation, they are also responsible for the recent designation of several extremely large no-take MPAs, which pose significant long-term monitoring and enforcement challenges. This paper critically examines the effectiveness of MPA targets, focusing on the underlying risks to achieving Millennium Development Goals posed by the global push for quantity versus quality of MPAs. The observations outlined in this paper have repercussions for international protected area politics with respect to (1) the science-policy interface in environmental decision-making, and (2) social justice concerns in global biodiversity conservation.

1. Introduction

The past decade has witnessed a dramatic increase in the number and size of large marine protected areas (MPAs) designated by nation states in order to meet international protected area targets set by the World Summit on Sustainable Development (WSSD) and the United Nations Convention on Biological Diversity (CBD). Despite this increase in coverage, it was clear that protected area targets would not be met by their 2010/2012 deadlines, and they were consequently extended to 2020 at the 2010 Conference of Parties to the CBD in Nagoya, Japan. Whilst critiques of protected area targets are not new (Soulé and Sanjayan, 1998; Agardy et al., 2003; Pressey et al., 2003; Rodrigues et al., 2004a, 2004b; Chape et al., 2005; Locke and Dearden, 2005; Wells et al., 2007; Wood et al., 2008; Wood, 2011), to date there has been less debate regarding the influence of targets in marine environmental conservation. This paper argues that focusing on global protected area targets risks undermining the achievement of sustainable long-term conservation objectives in two key ways. Firstly, focusing on percentage targets may weaken the science-policy interface in environmental decision-making by prioritizing "political" over "ecological" networks of protected areas and/or ecological information over socioeconomic data. Secondly, by encouraging the designation of increasingly large MPAs closed to any human use, percentage targets may also undermine social justice in global biodiversity conservation, resulting in stakeholder distrust, which in turn can lead to infringements in the protected area down the line as well as future opposition to the designation of MPAs.

Two ways in which we can see the manifestation of protected area targets playing out in the marine environment is via the push for MPA networks on the one hand, and for increasingly large MPAs on the other. These two approaches are examined in the context of, respectively, the developing regime for MPAs in Canada, and the UK's designation of one of the world's largest MPAs, surrounding the Chagos archipelago. It goes without saying that the designation of increasingly large protected areas in the marine environment poses significant challenges for the long-term achievement of conservation objectives due to the inherent difficulty in monitoring and enforcing such enormous areas. The paper closes with a discussion of the importance of marine spatial planning (MSP) as a way forward, as a means of achieving a better balance of science-policy integration and stakeholder engagement, as well as compliance and thus long-term achievement of conservation objectives.

Before delving into these arguments, it is worth pointing out the different physical and management challenges posed by marine ecosystems.[1] Compared with their terrestrial counterparts, marine

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[1] These physical and management challenges are explained in greater depth by Jones (2001) and Carr et al., 2003.

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ecosystems tend to occupy wider spatial scales with relatively indistinct boundaries such as sea temperature, salinity, currents and tectonic features. In the marine environment, areas that are physically separated tend to be functionally connected, due to the three-dimensional, fluid nature of water. Marine environments are also highly variable, complex, and difficult to predict, and they seem "alien" to many people, *i.e.* not only invisible but also unfamiliar, mysterious, and less charismatic than some terrestrial areas and species. These physical attributes pose significant management and conservation challenges, including dealing with uncertainty and limited scientific knowledge, as well as multiple anthropogenic uses. That is to say, in terrestrial areas different activities tend to occur in dedicated areas and interaction between them can be managed more easily than in marine areas where jurisdictions are unclear. This lack of clarity is a key reason why spatial approaches to marine management are important, and why this paper argues for a more MSP-driven approach to managing nation states' exclusive economic zones (EEZs),[2] balancing ecological conservation with socioeconomic use, rather than relying on enormous, unenforceable protected areas and/or inefficiently designed networks of MPAs to meet percentage targets.

2. Materials and methods

This review article is based on the author's doctoral work and subsequent research on MPAs, involving a desktop analysis (*i.e.* a detailed literature review and legal analysis of relevant legislation and policies) and informational interviews with members of the regulatory, academic and environmental non-governmental organization (NGO) communities. The author's observations are also based on participant observation at international environmental conferences including the 2008 IUCN World Conservation Congress, the 2008 9th Conference of Parties to the Convention on Biological Diversity, the 2008 and 2010 meetings of the Global Forum on Oceans, Coasts and Islands, and the 2009 and 2011 International Marine Conservation Congresses.

3. The development of "bigger is better" approaches to marine conservation

As most recently defined by the International Union for Conservation of Nature (IUCN), a protected area is "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley, 2008: 6). MPAs have increasingly become a key tool for marine conservation despite the fact that they are often implemented without a firm understanding of both the ecological and socioeconomic considerations of conservation (Agardy et al., 2003). In addition, a lack of clarity exists with regard to definitions of different types of MPAs, leading to confusion and mistrust among stakeholders. For example, whilst some consider all MPAs to be no-take, *i.e.* closed to all forms of extractive use, others only consider "marine reserves" to fulfill this role, and still others consider marine reserves to be open to multiple uses. For consistency, this paper will focus on MPAs generally, comparing no-take MPAs with multiple-use MPAs as two broad categories of management.

In October 2010 at the 10th Conference of Parties (COP) to the CBD held in Nagoya, Japan, Parties reaffirmed and extended global targets for protected areas, such that "by 2020, at least 17% of terrestrial and inland water and 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, and integrated into the wider landscape and seascapes".[3] These targets built on previous calls[4] for representative networks of marine protected areas to be implemented by 2012. It has been noted that the initial protected area targets were set "without prior assessment of their achievability" (Wood et al., 2008: 340) and that overall, the rate of MPA designation has lagged far behind terrestrial protected areas,[5] to the extent that the international community is unlikely to achieve the 10% target before 30–50 years past the original 2012 deadline, assuming a constant rate of designation based on that of the past 40 years (Wood et al., 2008). According to recent estimates, as of 2010 global MPA coverage represented 1.17%[6] of the global ocean surface, an increase of over 60% of the area recorded as protected since 2007 and 150% since 2003 (Spalding et al., 2010: 32; and Chape et al., 2003). In 2012, this figure was adjusted to reflect recent large designations (and including some corrections on large MPA areas), and it is now believed that MPA coverage represents 2.3% of the global ocean surface, with 5.69% of EEZs and 0.17% of the High Seas included (Spalding et al., 2012). Whilst some of this increase is due to improvements in the accuracy of global datasets, it is also true that a key factor in the relatively rapid increase of global ocean conservation is the recent trend toward designating increasingly large MPAs.

From an ecological perspective, larger protected areas are better at regenerating fish stocks than their smaller counterparts, as they protect more space for the dispersal of larvae as well as habitat necessary for early life stages (*e.g.* nursery habitats) (Walters, 2000; Roberts et al., 2001). Larger areas are credited with providing more "spillover" of biomass outside the MPA than smaller protected areas, as well as exposing species within the areas to less stress resulting from "edge effects". In addition, it can be argued that larger areas are more likely to withstand unpredictable pressures caused by climate change, as do networks of MPAs designed to be ecologically representative, adequate, resilient, and connected, criteria recommended by the CBD and the United Nations Environment Programme World Conservation Monitoring Centre (UNEP WCMC).[7] However, there is no guidance or evidence showing that extremely enormous MPAs on the scale of hundreds of thousands of square kilometers are more likely to achieve conservation objectives than effectively managed networks of MPAs. Indeed, extremely enormous MPAs run the risk of being no more than "paper parks" due to the difficulty of monitoring and enforcing them.

As outlined in Table 1, the first decade of the twenty first century witnessed the rapid designation of several extremely large MPAs,

[2] Exclusive Economic Zones, defined by the UN Convention on the Law of the Sea, extend out 200 nautical miles from the baseline (usually the low water line).

[3] CBD COP 10 Decision X/2 Strategic Plan for Biodiversity 2011–2020, available online: http://www.cbd.int/decision/cop/?id=12268.

[4] *I.e.* the 2002 World Summit on Sustainable Development (WSSD), 2003 IUCN World Parks Congress, and 7th CBD COP in 2004. CBD Decision VII/28 Protected Areas (Articles 8(a) to (e), available online: http://www.cbd.int/decision/cop/?id=7765).

[5] At the time of the 2010 CBD COP, the global protected area coverage according to the World Database on Protected Areas (excluding Antarctica) was 12.7% for terrestrial areas and 1.17% for marine areas globally.

[6] The exact global coverage of MPAs varies according to different sources due to differences in reporting and jurisdictional overlaps. For example in the summer of 2012, a coalition of non-governmental organizations in the United Kingdom reported global MPA coverage to be at 3.2% but this estimate was not based on WDPA data (MPA News, 2012). This lack of precision may be confusing for the public and interested stakeholders.

[7] For a review of progress on MPAs and networks of MPAs as of 2008, see UNEP WCMC, 2008.

Table 1
Recent (since 2006) designations of large Marine Protected Areas (MPAs) and potential sites under development.

Year	MPA name, country	Extractive activities allowed?	Total size[a]
2006	Papahānaumokuākea Marine National Monument, North West Hawaiian Islands, USA	Initially bottomfish fishing was allowed. Since 15 June 2011 the entire area has been no-take.	341,362 km^2
2007	Benthic Protection Areas, New Zealand (17 sites)	Off-bottom trawl fishing permitted with strict controls in most sites. Kermadec Islands' territorial waters (7450 km^2) is currently no take – but there is a proposal to make the entire 620,500 km^2 area no-take, which would represent 56% of total combined area of New Zealand's Benthic Protection Areas	Combined area of: 1,100,000 km^2
2007	South East Commonwealth Marine Reserve Network, Australia (14 sites)[b]	Depending on the area, recreational fishing, charter fishing, mining, some commercial fishing. 68% (154,435 km^2) is no-take[c]	226,458 km^2
2008	Phoenix Islands Protected Area (PIPA), Kiribati	1. Distant Water Fishing Nation (DWFN) tuna fishing 2. Domestic commercial fishing licenses 3.87% (15,800 km^2) is no-take, to be increased to 25% when trust fund becomes active	408,250 km^2
2009	Marine National Monuments, USA (1) Marianas Trench (246,608 km^2) (2) Pacific Remote Islands[d] (225,039 km^2) (3) Rose Atoll (34,838 km^2)	Commercial fishing is prohibited but recreational, non-commercial and traditional/ sustenance fishing may be allowed.	Combined area just under: 500,000 km^2
2009	Prince Edward Islands Marine Protected Area, South Africa	Commercial fishing 34% (61,415 km^2) is no-take[e]	180,633 km^2
2009	South Orkneys Marine Protected Area, British Antarctic Territory (UK/Argentina/high seas)	The entire area is no-take	93,787 km^2
2010	Chagos Archipelago, British Indian Ocean Territory, UK (also claimed by Mauritius)	The entire area is no-take	640,000 km^2
2010	Motu Motiro Hiva Marine Park, Chile	74% (150,000 km^2) of the area is no-take	203,374 km^2
2012	Coral Sea Commonwealth Marine Reserve (Australia)	51% (504,820 km^2) is proposed to be no-take. Recreational fishing and selected commercial fishing gear types allowed in remainder, but demersal trawling, demersal longlining, and gillnetting are banned throughout.	989,842 km^2
2012	South Georgia and South Sandwich Islands MPA (UK/Argentina)	Commercial bottom trawling is banned throughout. Longlining is allowed at depths >700 m in a small area of the MPA, under strict regulation. There are three existing restricted impact areas, covering 3563 km^2 in which long-lining is not normally allowed. Territorial waters (12 nm) surrounding each island and the Shag Rocks are no-take, a total of 20,000 km^2 (2% of total area)	1,000,000 km^2
TBD	Cook Islands MPA (in planning)	TBD	1,000,000 km^2
TBD	Sargasso Sea MPA (in planning, high seas)	TBD	5,000,000 km^2
TBD	Pitcairn Island (UK)	TBD	800,000 km^2
TBD	Antarctic Ross Sea	TBD	3,600,000 km^2
TBD	Bermuda's EEZ (UK)	TBD	300,000 km^2

[a] Areas calculated by the World Database on Protected Areas (WDPA) unless indicated otherwise.
[b] Australia is in the process of establishing Commonwealth Marine Reserves throughout its EEZ, which will result in a total combined area of 3,100,000 km^2 (http://www.environment.gov.au/marinereserves/index.html).
[c] Author's own calculation based on information available on the South East Commonwealth Marine Reserve Network website: http://www.environment.gov.au/coasts/mpa/southeast/index.html.
[d] The Pacific Remote Islands Marine National Monument includes five sites: (1) Wake Island, (2) Howard and Baker Islands, (3) Johnston Atoll, (4) Palymra Atoll and Kingman Reef, and (5) Jarvis Island.
[e] According to the WWF: http://awsassets.wwf.org.za/downloads/peicombinedreportkb.pdf.

including the Papahānaumokuākea Marine National Monument in the North West Hawaiian Islands in 2006, seventeen benthic protection areas in New Zealand and fourteen protected areas in the South East Commonwealth Marine Reserve Network of Australia in 2007, the Phoenix Islands Protected Area (PIPA) of Kiribati in 2008, three additional US Marine National Monuments,[8] the Prince Edward Islands Marine Protected Area in South Africa, the South Orkneys Marine Protected Area in the British Antarctic Territory in 2009, and in 2010 the designation of the Chagos Archipelago in the British Indian Ocean Territory as well as the Motu Motiro Hiva Marine Park[9] in Chile. In 2012, Australia moved the bar closer to 1,000,000 km^2 with the designation of the Coral Sea Commonwealth Marine Reserve, and the UK followed suit with the South Georgia and South Sandwich Islands MPA in the British Ocean Territory near Argentina. The average size of these eleven large designations (combined areas) since 2006 is approximately 517,260 km^2. There are also calls for a network of large MPAs in the Antarctic. Table 2 lists the world's 28 largest MPAs in the world, defined as sites greater than 30,000 km^2, 22 of which were designated since 2000. These sites are also shown in Fig. 1.

How and why has this trend toward enormous MPAs evolved? It is likely that evidence of the effects of climate change on marine ecosystems, including increased temperature and acidity of ocean water, has driven the political agenda toward a pre-emptive "protect as much as you can" approach, especially with regard to coral ecosystems, which are highly vulnerable to these climate effects. Large-scale analyzes of ocean health highlighting the widespread impact of human activities on fisheries (Pauly et al., 2002; Myers and Worm, 2003; Worm et al., 2006) and the marine environment more generally (Halpern et al., 2008) have also instilled a sense of impending apocalypse and need for urgent action. In addition, there has been a growing environmental discourse around MPAs as "globally applicable" tools to be used to protect "global oceans" (Gray, 2010: 280). However it seems likely that these large designations are also driven by the international push for protected area targets outlined above.

Table 3 shows the recent evolution of the protected areas biodiversity target. Interestingly, whilst there have been calls for

[8] The three US monuments designated in 2009 total 506,485 km^2, "far short of the 2.2 million km^2 advocated by many marine scientists" (Pala, 2009, 192).
[9] Formerly known as the Sala y Gómez Marine Park. There is currently a proposal to extend this area to include Easter Island (Rapa Nui) which would result in an MPA covering up to 700,000 km^2. The current proposal aims for the area to be mostly no-take, with some fishing in a small area.

Table 2
The world's 28 largest MPAs (defined as sites greater than 30,000 km^2) in order of their designation (adapted from Spalding et al., 2010 and updated).

Year	MPA name, country	Size (km^2)	Size rank	UNESCO world heritage	Number on map
1971	Great Barrier Reef Marine Park, Australia	343,480	6	Inscribed 1981	1
1988	North-East Greenland National Park, Greenland	96,598	17		2
1994	Franz Josef Land Zakaznik, Russia	123,877	14		3
1998	Galapagos Marine Reserve, Ecuador	137,975	13	Inscribed 1978, extended 2001	4
1999	Macquarie Island Commonwealth Marine Reserve, Australia	161,895	12		5
1999	Nearshore Bristol Bay Trawl Closure, USA	65,030	19		6
2002	Heard Island and McDonald Islands Marine Reserve, Australia	64,267	20		7
2005	Seaflower MPA, Colombia	61,099	21	On the tentative list	8
2006	Papahānaumokuākea Marine National Monument, USA	341,362	7	Inscribed 2010	9
2007	Kermadec Benthic Protection Area, New Zealand	620,500	4	On the tentative list	10
2007	Antipodes Transect Benthic Protection Area, New Zealand	108,200	15		11
2007	Sub-Antarctic Deep Benthic Protection Area, New Zealand	98,400	16		12
2007	Freycinet Commonwealth Marine Reserve, Australia	57,942	22		13
2007	Hikurangi Deep Benthic Protection Area, New Zealand	54,025	23		14
2007	Norfolk Deep Benthic Protection Area, New Zealand	44,231	24		15
2007	Tasman Fracture Commonwealth Marine Reserve, Australia	42,501	25		16
2007	Fjordland Transect Benthic Protection Area, New Zealand	40,600	26	On the tentative list	17
2007	Challenger South Benthic Protection Area, New Zealand	30,553	28		18
2008	Phoenix Islands Protected Area, Kiribati	408,250	5	Inscribed 2010	19
2009	Marianas Trench Marine National Monument, USA	246,608	8		20
2009	Pacific Remote Islands Marine National Monument, USA (five sites)	225,039	9		21
2009	Rose Atoll Marine National Monument, USA	34,838	27		22
2009	Prince Edward Islands Marine Protected Area, South Africa	180,633	11	On the tentative list	23
2009	South Orkneys MPA (UK/Argentina)	93,787	18		24
2010	Chagos Marine Protected Area, British Indian Ocean Territory	640,000	3		25
2010	Motu Motiro Hiva Marine Park, Chile	203,374	10		26
2012	Coral Sea Commonwealth Marine Reserve, Australia	989,842	2		27
2012	South Georgia and South Sandwich Islands (UK/Argentina)	1,000,000	1		28

networks of MPAs since 2002, the 10% target only emerged in 2006. As mentioned earlier, the dramatic increase in designations of large MPAs since 2006 is understandable given this legal context. Table 4 shows the recent progress made in global MPA coverage. As mentioned above, the most recent estimate (Spalding et al., 2012) puts the global MPA coverage as of 2012 at 2.3% with 5.7% of the waters under national jurisdiction protected. Protecting 10% of the world's oceans (360 million km^2) will require herculean efforts in the coming decade, if these recent enormous designations served only to raise global MPA coverage within one percent. Given that EEZs encompass 140 million km^2 or roughly 34% of the global ocean, we would need to set aside 46 million km^2 of EEZs (five

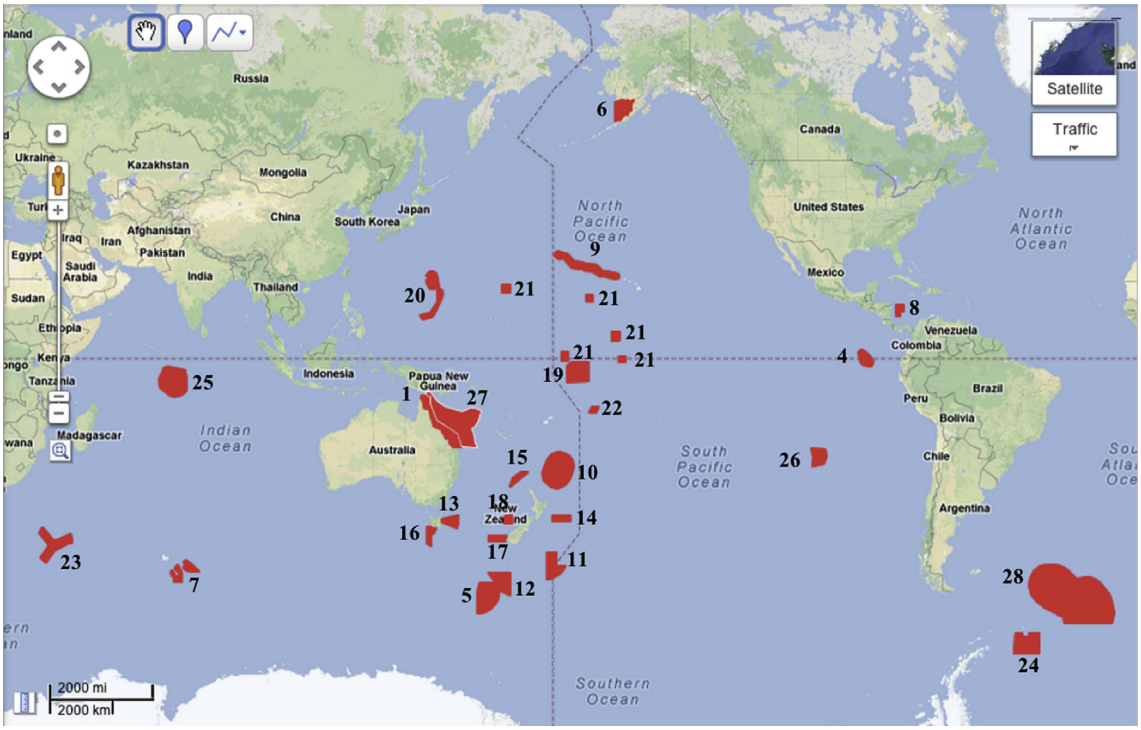

Fig. 1. Map showing locations of 26 of the world's 28 largest MPAs (defined as sites greater than 30,000 km^2, numbers correspond to Table 2. MPAs number 2 and 3 are not shown). Data from the World Database on Protected Areas (www.protectedplanet.net).

Table 3
Evolution of the 10% biodiversity target for MPAs.

Year	Legislative instrument	Text of commitment
2002	World Summit on Sustainable Development (Rio +10),	"Develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive fishing practices, the establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012 [...]" (Plan of Implementation section IV, para. 32(c)).
2002	Convention on Biological Diversity, 6th Conference of Parties (CBD COP 6)	"Parties commit themselves [...] to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional, and national level as a contribution to poverty alleviation and the to the benefit of all life on earth" (Decision VI/26, para. 11).
2003	IUCN 5th World Parks Congress	"Establish by 2012 a global system of effectively managed, representative networks of marine and coastal protected areas [...] these networks should be extensive and include strictly protected areas that amount to at least 20–30% of each habitat" (Recommendation 5.22).
2003	Ministerial meeting of the OSPAR Commission	"[...] we endorse the Recommendation on a Network of Marine Protected Areas. Working with HELCOM and the European Community, we shall identify the first set of such areas by 2006, establish what gaps then remain and complete by 2010 a joint network of well-managed marine protected areas that, together with the NATURA 2000 network, is ecologically coherent" (Bremen Statement, para. 11).
2004	CBD COP 7	Target: "By 2010, terrestrially and 2012 in the marine area, a global network of comprehensive, representative and effectively managed national and regional protected area system is established as a contribution to (i) the goal of the Strategic Plan of the Convention and the World Summit on Sustainable Development of achieving a significant reduction in the rate of biodiversity loss by 2012; (ii) the Millennium Development Goals – particularly goal 7 on ensuring environmental sustainability; and (iii) the Global Strategy for Plant Conservation" (Decision VII/28, Goal 1.1).
2006	CBD COP 8	Target 1.1: "At least 10% of each of the world's ecoregions effectively conserved" (Decision VIII/15).
2010	CBD COP 10	"By 2020, at least 17 percent of terrestrial and inland water areas, and 10 percent 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 [...]" (Decision X/2, Target 11).

times the current global area coverage of MPAs, approximately 8.3 million km^2) to reach 10%. Consequently, effectively managing these zones within an MSP framework that balances conservation with other marine uses will have greater success at achieving conservation objectives than a target-driven global focus on enormous no-take MPAs that does not adequately take long-term monitoring and enforcement into account.

As mentioned earlier, debates on the efficacy of conservation targets are not new. Percentage area targets have been called into question given that (1) biodiversity is not evenly distributed across the planet, therefore protected areas should not be (Rodrigues et al., 2004a), (2) the percentage of area already protected in a given country or biome is a poor indicator of additional conservation needs (Rodrigues et al., 2004a), (3) targets create the unintended and false impression that a fixed proportion of nature set aside would be enough to stave off extinction (Soulé and Sanjayan, 1998), (4) nations are likely to prioritize areas with low economic and biodiversity value in order to meet deadlines, (5) protected areas are increasingly being recast as tools for social planning and income generation (Locke and Dearden, 2005), and insufficiently-protected areas are inflating figures, (6) focusing on increasing the area under protection may divert resources away from improving the management effectiveness of existing MPAs (Wells et al., 2007), (7) percentage targets in and of themselves are arbitrary, too uniform, and do not reflect a worldwide scientific consensus (Pressey et al., 2003; Rodrigues et al., 2004a), and (8) targets may ultimately weaken the political process to create protected areas if the expected benefits are not observed (Wood et al., 2008).

However it is also acknowledged that targets can help to generate political will (Gray, 2010; Wood et al., 2008) and contribute to international "peer pressure" between governments toward conservation action. As a galvanizing and agenda-setting mechanism, it is true that protected area targets have made a significant impact on the global effort toward establishing MPAs and networks of MPAs. That being said, it is worth examining the role of targets in more depth, specifically with respect to the science-policy interface and issues related to social justice. These concerns are discussed within the context of MPA network planning and the designation of enormous MPAs.

Table 4
The recent growth of MPAs relative to the global ocean area (figures adapted from Spalding et al., 2010, 2012; Wood et al., 2008).

Year	Global MPA coverage (km^2)	Percent of global oceans
2003	1,640,000	0.45%
2006	2,350,000	0.65%
2008	2,590,000	0.72%
2010	4,700,000	1.31%
2012	8,300,000	2.3%

4. Challenges of enforcing large MPAs

Monitoring and enforcing conservation measures in large, remote marine areas pose significant challenges. This issue is widely recognized as imperative for successful conservation, as evidenced by the recent convening of an international conference on MPA Enforcement, organized by WildAid in November 2012, as well as several discussions and contributed pieces in the practitioner-oriented publication MPA News (2010). Illegal shark fishing within large "shark sanctuaries", marine reserves, and even the Galapagos UNESCO World Heritage site has been well documented (Carr et al., 2013). Illegal fishing has also been observed by Greenpeace in the Chagos MPA (Greenpeace, 2012) and by National Geographic and Oceana in the Motu Motiro Hiva Marine Park (Munoz, 2011).

For large offshore sites, particular attention must be paid to sustainable financing, adequate technology, and logistical partnerships for successful monitoring and enforcement. For example, Operation Kurukuru in the Western Pacific, a massive international exercise that took place over ten days in 2009, combined efforts to track down illegal fishing, smuggling and human trafficking (MPA News, 2010). This effort covered an area of approximately 10 million square kilometers, encompassing the EEZs of several island nations including the Cook Islands, Kiribati, Niue, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, and Vanuatu. Fisheries surveillance and enforcement staff from these countries worked in partnership with their counterparts from Australia, New Zealand, France and the US, combining their efforts and technology, which included patrol vessels and aerial surveillance. Financing, technology, and partnerships must work together, *i.e.* the cost of obtaining an

Table 5
Protected areas in Canada, the UK, US and Australia, as of 2010. MPA coverage is given within territorial seas (km^2) and as a percentage of territorial sea area. Terrestrial protected areas are given in total area (km^2) and as a percentage of total land mass (source: IUCN and UNEP-WCMC, 2011).

Country	MPA coverage within territorial seas (km^2)	MPA coverage (%)	Terrestrial PA coverage (km^2)	Terrestrial PA coverage (%)	Combined terrestrial and MPA coverage (km^2)	Combined terrestrial and MPA coverage (%)
Canada	33,215.11	1.25%	740,592.22	7.51%	773,807.33	6.17%
UK	9408.31	5.70%	64,850.69	26.35%	74,259.00	18.06%
USA	229,604.45	28.60%	1,155,552.67	12.38%	1,385,157.12	13.66%
Australia	264,332.59	28.34%	814,698.67	10.55%	1,079,031.26	12.47%

adequate number of surveillance vessels required to patrol an area on the scale of tens or hundreds of thousands of square kilometers is prohibitive, thus remote sensing technologies such as vessel monitoring systems (VMS) or automatic identification systems (AIS) that can track vessel movements via satellite are necessary. However, these tools are useless for tracking illegal fishing vessels that lack satellite tags.

In terms of non-governmental approaches and partnerships, the Sea Shepherd Society has been assisting with policing the Galapagos Marine Reserve since 2000, and the US-based Marine Conservation Institute is working with enforcement agencies in the southeastern US and Pacific to address surveillance and enforcement capacity for large marine protected areas. One advantage to having NGOs involved in MPA surveillance is the fact that these organizations raise revenue from private donors, providing financial support to cash-stripped government agencies. Sea Shepherd has provided funds for hiring personnel and obtaining police dogs as well as implementing new radio systems in the Galapagos reserve (MPA News, 2010). Actual patrolling and enforcement activities in the reserve are still conducted by the Ecuadorian Navy however. Other large MPAs would likely benefit from partnerships with privately-funded NGOs to help bolster surveillance capacity. The Chagos MPA, for example, is currently patrolled by only one vessel.

5. Impediments to the science-policy interface posed by target-driven MPA networks

The IUCN defines an MPA network as "a collection of individual MPAs or reserves operating cooperatively and synergistically, at various spatial scales, and with a range of protection levels that are designed to meet objectives that a single reserve cannot achieve" (IUCN WCPA, 2008: 12). Although not explicit in this international, ecologically-focused definition, there is a complex political aspect to setting up networks of MPAs, given the multiple and often overlapping jurisdictions operating in the coastal and marine environment. Several countries have launched strategies toward networks of MPAs, both nationally and regionally,[10] a process that has been strongly driven by international protected area targets. As mentioned earlier, four key ecological aspects of protected area networks are emphasized in planning MPA networks: representativity, adequacy, resilience and connectivity. It can be argued that large MPAs might be seen as a means of overcoming the difficulty of determining how to balance these aspects into an effective network, by encompassing enormous amounts of space and thus meeting multiple ecological objectives in one fell swoop.

For countries designating networks of MPAs, translating science into policy is a challenge that is further strained by the pressure to meet international protected area target deadlines. The situation in Canada provides an interesting example for exploring the way in which different forms of science are being translated into policy with respect to MPA networks and achieving conservation objectives. Comparing how the federal and national MPA networks have been designed and implemented provides an example of how "networks" can be interpreted and implemented politically rather than ecologically. These are explained in more depth below. In addition, the use of scientific information to inform decision-making can be questioned, especially with respect to differences in the prioritization of ecological versus socioeconomic data in the site-selection process.

Bordered by three oceans and possessing the world's longest coastline, Canada was viewed as a leader in ocean management in the recent past, however this perception is arguably fading (Jessen, 2011). Canada is currently focusing on establishing both federal and national networks of MPAs, but its protected area coverage lags significantly behind other developed nations as a proportion of its total land and sea area. Table 5 shows Canada's current terrestrial and marine protection in comparison with the US, UK and Australia, according to the WDPA. Whilst Canada may have large areas protected in terms of total area, it is behind in terms of percentages (however it should be noted that only territorial seas out to 12 NM are included in the WDPA figures, not EEZs out to 200 NM).

As part of Canada's federal MPAs strategy,[11] the federal network will combine (1) Oceans Act MPAs established by Fisheries and Oceans Canada (DFO), (2) Marine Wildlife Areas (MWAs) established by Environment Canada, and (3) National Marine Conservation Areas (NMCAs) established by Parks Canada. Given these three federal agencies all have the mandate to establish and monitor protected areas in the marine environment (MPAs, MWAs and NMCAs, respectively) and each has its own objectives and management approaches, there will likely be communication and coordination challenges. However the three agencies recognize this fact, and in their public outreach materials on the federal network they indicate a willingness to collaborate better.

Of concern, however, is the call for specific numbers of additional MPAs to be designated within this network in order to meet 2012 targets. In 2007, Canada's Health of the Oceans Initiative[12] provided funding for six additional Oceans Act MPAs to be established by 2012, one in each of Canada's large ocean management areas (LOMAs[13]). Only seven MPAs have been designated under the Oceans Act since it came into effect in 1997, therefore expecting to implement six sites in five years was clearly an unattainable goal. In addition, establishing one MPA per LOMA does not represent an ecosystem-based network approach, which should focus on attaining representativity, adequacy, resilience and, perhaps most importantly, connectivity between MPAs in the network and across Canada. That is to say, each MPA is being assessed and chosen independently of the other MPAs in the network, not in terms of

[10] See UNEP WCMC, 2008 for an overview of global progress toward networks of MPAs.

[11] Available online: http://www.dfo-mpo.gc.ca/oceans/publications/fedmpa-zpmfed/index-eng.asp.

[12] Available online: http://www.dfo-mpo.gc.ca/oceans/management-gestion/healthyoceans-santedesoceans/index-eng.htm.

[13] Canada's LOMAs include the Pacific North Coast, Beaufort Sea, Gulf of St. Lawrence, Eastern Scotian Shelf, and Placentia Bay/Grand Banks.

how they would interact ecologically. Consequently there is a significant risk that the federal MPAs network will be more of a political than ecological network.

On a more positive note, it is worth noting that federal MPA network planning in Canada is increasingly focusing on a "bioregional" approach to LOMAs. In the early months of 2011, the Canadian government held a consultation on the other, broader MPA network approach it is undertaking, that of a national network which will incorporate federal and provincial MPAs into one overarching framework. The national framework was released in September 2011.[14] Only a small fraction of Canada's total marine territory is currently protected (approximately 1.03% (DFO, pers. comm.), and the 2020 CBD targets are mentioned as a driving force for implementing the network. The national network will focus geographically on Canada's 13 bioregions[15], an approach that may be more effective than the preceding federal network's LOMA approach in terms of attaining ecological objectives, provided enough MPAs are designated.

However, it can also be argued that ecology outweighs socioeconomics in the determination of appropriate sites, which risks alienating stakeholders in the long run and further slowing down the MPA designation process in Canada. In 2010 DFO conducted a public consultation on the designation of a new area of interest (AOI) on the Eastern Scotian Shelf in Nova Scotia, to eventually join the group of Oceans Act MPAs that will be part of the federal network. In the consultation documentation[16] that outlined three potential AOIs for public review, the entire focus was on the sites' ecological conservation value. Several months into the consultation, it was recognized that additional information would be necessary for the most accurate evaluation of the three sites' relative merit for protection, at which point brief socioeconomic reports[17] on each site were released to the public. These reports focused mainly on fishing industry revenue and showed a clear preference for one of the three candidate sites (St. Anns Bank), which had far less economic activity than the other two, arguably due to the fact that the area has already been heavily fished. However, potential revenue estimates from oil and gas exploration were not included, which could provide the province with millions if not billions of dollars,[18] nor were the potential interactions with commercial shipping or other activities (*e.g.* renewable energy) discussed. Consequently, improvement in integrating socioeconomic information into the site selection process is necessary, as are improvements in increasing the transparency of the process and integrating stakeholders better than has been done to date.

6. Social justice implications of large MPAs

Moving from MPA networks to extremely large MPAs, the ecological benefits are obvious. The larger the area, the smaller its border-to-area ratio, reducing the amount of "edge" habitat (*i.e.* habitat close to the edge of a protected area is more exposed to outside pressures/threats than habitat located closer to the center), an approach recognized in ecological theory as beneficial for achieving conservation objectives (Woodroffe and Ginsberg, 1998). Extremely large no-take MPAs, by enclosing enormous areas and reducing edge effects, consequently can be seen as maximizing ecological objectives. However, areas that are entirely no-take are by their very nature exclusionary. The history of protected areas has been rife with debates about "parks versus people" and the social justice implications of prioritizing nature conservation over human use (Brockington et al., 2008), however these debates have been discussed less in marine contexts, especially with regard to enormous MPAs. There are serious social justice implications for the designation of increasingly large no-take MPAs, as evidenced by the Chagos case described in more depth below. By completely excluding any human activity in these enormous areas, advocates are failing to use a resource that could help meet the tremendous challenge of monitoring and enforcing these vast areas: local human networks.

Whilst most of the enormous MPAs that have been designated in the past few years are in relatively remote areas with little human habitation, there are some with a history of subsistence fishing, as outlined in Table 1. It is worth noting that some of these areas also have a US military presence and/or history (including the US Marine National Monuments, PIPA, and Chagos). The Chagos MPA, located in the British Indian Ocean Territory (BIOT) is the most contentious large MPA designation to date. Following their displacement from the island in the 1960s by the UK government to make way for the construction of a US military base, the Chagossian people have been arguing for their right to return, most recently in the European Court of Human Rights, where proceedings were lodged in 2004 under the European Convention on Human Rights. In 2010, the UK declared the entire 200 NM EEZ of the BIOT surrounding Chagos to be the world's largest MPA. This designation has been particularly controversial as it prohibited even subsistence fishing and was enacted whilst exiled Chagossians' petition for the right to return was pending judgment in the European Court of Human Rights (De Santo et al., 2011). This controversy continued into 2011 as a second legal case emerged between Mauritius and the UK regarding the latter's claim to the Chagos Archipelago within international law, and therefore ability to designate it as an MPA. In addition, documents published by WikiLeaks have shown that the UK and US both consider the entire BIOT as "reserved for military uses" (De Santo and Jones, 2011). In December 2012, the European Court of Human Rights dismissed the Chagossians' case, arguing that (1) the BIOT does not fall within the jurisdiction of the European Convention on Human Rights (despite the fact that many Chagossians reside in the UK and are now UK citizens), and (2) compensation paid to the Chagossians by the UK government in 1972 and 1982 rendered the present case inadmissible. Why it took eight years for the Court to come to this decision is not clear.

The importance of social justice and equity in MPA designation is increasingly recognized (Jones, 2009; Blaustein, 2007; Paavola, 2004). Within the context of MPAs, social justice can be defined as the fair allocation of adequate access to fishing or other activities that people depended on for their economic sustainability prior to the MPA's designation. Whilst this can be quite a contentious issue in smaller MPAs, especially in areas close to shore with a long history of fishing, for very large MPAs, allowing some small amount of subsistence human use activity should in theory be more acceptable. What we see, however, is the opposite. Although several of the large MPAs listed in Table 1 have a history of some human use, the trend more recently is to declare these areas to be entirely no-take and/or to phase out human activity if it exists. Whilst this is arguably the best case scenario from an ecological perspective, it risks alienating stakeholders as well as removing potential surveillance for the area. In stark contrast to the exclusionary declaration in

[14] Available online: http://www.dfo-mpo.gc.ca/oceans/publications/dmpaf-eczpm/framework-cadre2011-eng.asp.

[15] Canada's marine bioregions include the Atlantic Ocean (the Scotian Shelf, Newfoundland-Labrador Shelves, and the Gulf of St. Lawrence), the Pacific Ocean (the Northern Shelf, Strait of Georgia, Southern Shelf, and the offshore Pacific) and the Arctic Ocean (the Hudson Bay Complex, Arctic Archipelago, Arctic Basin, Eastern Arctic, and the Western Arctic).

[16] Available online: http://www.mar.dfo-mpo.gc.ca/folios/00263/docs/AOI_Consultation_Booklet_FINAL.pdf.

[17] Available online: http://www.mar.dfo-mpo.gc.ca/e0010385.

[18] Nova Scotia Department of Energy, personal communication.

Chagos, the Papahānaumokuākea Marine National Monument undertook substantial environmental communication and outreach prior to the MPAs designation (Ward, 2010), phased out extractive activities over a five year period, and the site is recognized for both its cultural and maritime heritage. PIPA is currently 3.87% no-take, and will become 25% no-take once a trust fund established by Conservation International and the New England Aquarium comes into effect, which will in effect buy out the tuna fishery and reimburse the Kiribati government for revenue they would have made from selling fishing licenses.

A full exploration of social justice concerns related to conservation is beyond the scope of this article, however the designation of large no-take MPAs raises a question of legitimacy, defined as behavior or sets of circumstances that society defines as just, correct or appropriate. Within the context of protected areas, legitimacy can be seen as an indicator of "sincere involvement in the political discussions and management options of protected area management" (Brechin et al., 2003: xii). The Chagos example highlights what can be seen as a lack of legitimate authority on the part of the UK in designating the world's largest MPA, both with respect to the legal and jurisdictional issues currently being addressed in the courts, and also more broadly with regard to stakeholder involvement.

In addition to legitimacy, an important concept worth exploring within the context of social justice and MPAs is that of "sustainability." As outlined in Table 3 above, the initial language on protected area targets emerged within the context of sustainable development and attaining goal number seven of the Millennium Development Goals, on ensuring environmental sustainability. Short-term gains from closing off huge areas to meet international protected area targets do not equate with long-term enforceability or environmental sustainability, particularly for populations dependent on subsistence fishing for their livelihoods. This is especially true if we recall the 1987 Bruntland Commission definition of sustainable development as "development that meets the need of the present without compromising the ability of future generations to meet their own needs." A key way forward for balancing different uses of the marine environment is the development of marine spatial planning (MSP) approaches.

7. The potential benefits of wider spatial approaches to marine management

Given the Canadian example described above, international MPA targets acting as a driver for MPA network planning can be seen as having had mixed results, which in turn has ramifications for the science-policy interface in environmental decision making. Prioritizing ecological considerations over socioeconomics in MPA network planning poses a significant impediment to finding a balance between human-based and ecological objectives. However the reverse is true as well; prioritizing political boundaries over ecological connectivity threatens the very nature of effective networks of protected areas. In addition, the increased reliance on large no-take MPAs as a short-term way of meeting percentage targets is not a long-term solution.

Large-scale marine spatial planning (MSP), defined by UNESCO as "a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives" (Ehler and Douvere, 2009) provides a mechanism for finding this balance between human uses and conservation objectives, *i.e.* a closer approach to sustainable development and hence the origins of protected area targets in the first place. MSP is increasingly being recognized as a way of bolstering MPA efforts and addressing the shortcomings of MPAs, such as: (1) mismatches of MPA scale to issue and context, (2) inappropriate planning and/or management, (3) MPA failure due to the degradation of unprotected surrounding ecosystems, (4) issues of displacement and other unintentional impacts, and (5) MPAs that create the illusion of protection (including "paper parks") (Agardy, 2010; Agardy et al., 2011). There is also significant potential for adequately incorporating stakeholder involvement through these processes. Whether and how MSP will be effectively implemented world-wide remains to be seen; there is still significant opposition to the idea of ocean zoning and its perceived permanence. However, as evidenced by a rezoning exercise of the Great Barrier Reef Marine Park in 2004 in which tens of thousands of people participated in the process and the proportion of the park designated as "no-take" was increased to 30%, adaptive management is a key component of MSP and has both ecological and socioeconomic impact.

In addition, MSP provides the framework for a key issue underlying the efficacy or lack thereof of large offshore MPAs: enforcement. As it stands, most of the world's largest MPAs are within developed countries' EEZs, *i.e.* within 200 nautical miles from shore and therefore subject to individual countries' enforcement capacities through existing satellite-based vessel monitoring systems. A more comprehensive MSP approach to nation states' EEZs, allowing for competing uses and using ocean zoning to partition the marine environment may be a more effective way forward than designating huge no-take areas on their own, provided MSP includes coordination for monitoring and enforcement of zoned areas and across sectors. Beyond EEZs, we are starting to see the designation of high seas MPAs, which poses another set of challenges. For MPAs set up in high seas areas that are currently being managed by nations or groups of nations via regional fisheries management organizations (RFMOs), monitoring and enforcement should be straightforward, however the efficacy of these organizations varies.

MSP is not a panacea however. Like MPAs, MSP provides a tool to help manage human use of the oceans, and it requires an adaptive and precautionary approach. Any zoning of ocean space has the potential to displace users to other areas. In addition, the highly participatory nature of MSP can lead to situations of decision paralysis, where it becomes impossible to reconcile the positions of a multitude of stakeholders (Pomeroy and Douvere, 2008). At the same time, however, MSP requires compromise and trade-offs between different ocean users, and a recent analysis of MSP in Massachusetts Bay (White et al., 2012) demonstrated the value added from MSP over sectoral management in a situation where renewable energy was a catalyst for MSP. In other examples where conservation is driving MSP, it may be more difficult to quantify the value added of protecting habitats and species for their intrinsic and/or long-term value to an ecosystem. Consequently one can see the argument for protecting large areas, yet if we consider the expense and difficulty in monitoring and enforcing these areas, a more comprehensive zoning approach to national EEZs that promotes compliance seems more likely to succeed at achieving conservation objectives in the long-run.

8. Conclusions

Despite the recent push for increasingly large MPAs, the 2012 10% target was not met and has now been extended to 2020 by the CBD. How will this affect MPA and MPA network planning? It is likely that the momentum for designating large, unenforceable no-take MPAs will continue, both offshore and increasingly on the high seas. At the same time, networks of MPAs will continue to grow, hopefully building on the experiences of existing networks and implementing MSP and ocean zoning approaches, including the increased and more effective incorporation of stakeholders.

Nevertheless the somewhat obvious question remains: are not well-managed no-take MPAs set up within a network of multiple-use areas (*i.e.* using MSP and ocean zoning) more likely to achieve conservation objectives than large offshore no-take areas that are difficult if not impossible to monitor and enforce? Large zoned protected areas like the Great Barrier Reef Marine Park and MPA networks like the US National Marine Sanctuary System have been doing MSP for decades, it is not a new concept. In terms of achieving a truly ecosystem-based approach to MPA design and management, which includes recognizing that humans are part of the ecosystem, implementing MSP and focusing on effectively managing and protecting nation states' EEZs should be more of a priority than establishing enormous, unenforceable no-take MPAs in order to meet international protected area targets.

This push for large no-take MPAs also has implications for the UNESCO World Heritage program, the marine component of which is expanding. As noted in Table 2, the Papahānaumokuākea Marine National Monument and PIPA were inscribed as Marine World Heritage sites in 2010. The Great Barrier Reef Marine Park was inscribed as the first Marine World Heritage site in 1981 and it remained the largest until these two sites joined the list. Several large MPAs are on the tentative list for World Heritage designation, and it seems likely that the World Heritage program will continue to inscribe large MPAs on its list. There is reason to be concerned about the future of Marine World Heritage designations given the fact that the Galapagos Marine Reserve was put on the "sites in danger" list in 2007 due to threats posed by invasive species, uncontrolled tourism, and illegal fishing, yet removed prematurely from the list in 2010 due to political pressure from Ecuador and against the advice of the IUCN.

Whilst the international community is making progress toward conserving more of the world's oceans, there is reason to be concerned about the long-term effectiveness of designating enormous no-take areas, given how difficult they are to enforce. In addition, there should be more attention focused on the legacy these sites will have for how MPAs are perceived more widely, especially by those who are excluded from using them even on a subsistence level. It can be argued that greater transparency in the decision-making process of nation states implementing MPA networks is needed. The existing paradigm, which has been largely driven by natural scientists, would benefit from greater integration with social scientists and planners in order to implement sustainable approaches to marine management, including building international assistance initiatives for helping less developed countries plan effective MPAs and networks of MPAs. It is hoped that these lessons will be learned before we reach the next MPA target deadline in 2020.

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Appendix A. Supplementary data

Supplementary data related to this article can be found online at http://dx.doi.org/10.1016/j.jenvman.2013.01.033.

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