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Bridging the divide: A framework for social-ecological coherence in Marine Protected Area network design

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Abstract

1. Marine Protected Areas (MPAs) and networks of MPAs are being implemented globally as a spatial management tool for achieving conservation objectives. There has been considerable progress in reaching the prescribed 10 % protected area target for 2020 outlined in the Convention on Biological Diversity Aichi Target 11 and the United Nations Sustainable Development Goal 14.

2. Application of MPA network design principles (e.g. representativity, ecological connectivity) which underpin ecological coherence are still lacking or insufficient in many regions. Poor ecological coherence hinders the ecological performance of MPA networks leading to dysfunction in the flow of ecosystem services and reduced ecosystem benefits with potentially negative consequences for human wellbeing

3. This paper presents four pivotal focus points for future progress that can bridge a gap between the ecological and the social systems. The aim is to shift the discourse of "ecological coherence" further into the social sphere and hence support the alignment of the process of designating ecologically coherent MPA networks with the 'triple bottom line' of economic development, environmental sustainability and social inclusion as described in the SDGs to achieve social-ecological coherence in MPA network design.

Key words: Ocean, Marine Protected Areas; Sustainable Development Goals; ecosystem services; ecological coherence.

1. Introduction

Marine Protected Areas (MPAs) are regarded as an important tool for the maintenance of marine ecosystem functionality, health, and ecosystem integrity through the conservation of significant species, habitats, or entire ecosystems (Sobel & Dahlgren, 2004). There is growing evidence that, when properly designed, resourced and managed, MPAs are an effective spatial management tool for achieving conservation objectives (Edgar et al., 2014; Lester et al., 2009; Sciberras, Jenkins, Kaiser, Hawkins & Pullin, 2013; Sheehan, Stevens, Gall, Cousens & Attrill, 2013; Stewart et al., 2009). Developments in social-ecological systems (SES) research emphasize the crucial interdependencies between the natural and the human system (Berkes, Folke & Colding, 2000; Liu et al., 2007) (Figure 1). From a SES perspective, protecting the habitats and species, which are the subject of conservation management measures within MPAs, supports ecological functions and processes (Pollnac et al., 2010; Potts et al., 2014). In turn, this delivers flows of ecosystem services that support human wellbeing (e.g. food, flood protection, opportunities for recreation) (Arkema et al., 2013; Arkema et al., 2015; McCook et al., 2010; Pollnac et al., 2010; Potts et al., 2014; Rees et al., 2014; Rees, Rodwell, Attrill, Austen & Mangi, 2010; Roberts, Bohnsack, Gell, Hawkins & Goodridge, 2001) (Figure 1). Given the high level of functional and spatial connectivity within marine ecosystems and variable and uncertain distribution of risks from ecosystem disturbances, individual MPAs are not considered to be adequate to safeguard the important ecosystem processes and services they underpin (Jones, Srinivasan & Almany, 2007; Margules & Pressey, 2000) and networks of MPAs are needed (Olsen et al., 2013).

Global MPA policy has developed to address the broader spatial requirements for marine conservation within this SES context. In 2004, Convention on Biological Diversity (CBD) Parties decided that “marine and coastal protected areas are essential tools and approaches in the conservation and sustainable use of marine and coastal biodiversity”, committing to a target of “effective conservation of at least 10% of each of the world’s ecological regions by 2010” (UNEP/CBD/COP/DEC/VII/5). In 2010, CBD Parties adopted the Strategic Plan for Biodiversity 2011-2020, including its 20 Aichi Biodiversity Targets. Among these targets, Parties reaffirmed the importance of area-based conservation measures, including MPAs, as a tool for the conservation of biological diversity and the sustainable use of its components. Specifically, Aichi Target 11 states 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 landscapes and seascapes'(CBD, 2010). Aichi target 11 notably expands upon the quantitative 10% spatial target for protected areas and, through the qualitative aspects (Ecologically representative; Areas of particular importance for biodiversity and ecosystem services; Management equity and effectiveness; Well-connected and; Integration into wider landscape and seascape (Rees, Foster, Langmead, Pittman & Johnson, 2017). These qualitative aspects of Aichi reflect best practices developed in MPA network design by broadening the scope of conservation planning to be more systematic (Margules & Pressey, 2000) and also enable the wider consideration of the relationship between the protection of biodiversity and human wellbeing. The qualitative aspects of Aichi Target 11 link to the principles of "ecological coherence" (Ardron, 2008; Laffoley, Brockington & Gililand, 2006), whereby a "network of MPAs" (a collection of individual MPAs or reserves operating cooperatively and synergistically, at various spatial scales) is designed to

- Interact and support the wider environment (OSPAR, 2006, , Sects. 5.3, 6);
- Maintain the processes, functions, and structures of the intended protected features across their natural range (Laffoley, Brockington & Gililand, 2006);
- Function synergistically as a whole, such that the individual protected sites benefit from each other to achieve the above two objectives (based on OSPAR, 2006, , Sect. 5.2);
    - Additionally, an ecologically coherent network of MPAs may be designed to be resilient to changing conditions (OSPAR, 2006, , Sect. 5).

In recognition of the importance of these qualitative aspects of Aichi Target 11 the Conference of the Parties to the CBD (Decision XI/24, 2012), invited Parties to undertake major efforts to achieve all elements of Aichi Biodiversity Target 11. Progress towards this goal has been slow. The fourth edition of the Global Biodiversity Outlook (GBO 4) reported that while the quantitative elements of Aichi Target 11 (the 10% protected areas target) are on track to be achieved at the global level by 2020 for marine areas within national jurisdiction, the other elements relating to ecological representation, coverage of areas important for biodiversity, management effectiveness, governance, and integration of protected areas into wider seascape, still need more attention in order to be achieved (Secretariat of the Convention on Biological Diversity, 2014).

Since GBO 4 there has been further sustained progress towards the 10% spatial target (Lubchenco & Grorud-Colvert, 2015). The MPAtlas reports that 2.98% of the global ocean is within an MPA, with 7.29% in national jurisdictions (Marine Conservation Institute, 2017). Proposed MPAs will add a further 3.15%, with an additional 6.33% of MPAs designated within national jurisdictions (Marine Conservation Institute, 2017). Whilst this increase represents a significant achievement in terms of increasing the spatial protection of marine habitats and species within national jurisdictions, a significant gap remains in areas beyond national jurisdiction and other parameters of ecological coherence, that are the cornerstone of Aichi target 11, are potentially lost (e.g. well-connected, ecologically representative) (Jones & De Santo, 2016). Furthermore, arguments have been put forward that suggest that the 'ease of establishment' of MPAs (in some planning areas) has overridden the need to underpin ecological coherence of marine systems (Devillers et al., 2015). Overall, it can be argued that spatial targets alone, which confer no positive or negative biodiversity outcomes, will potentially undermine efforts to halt the continued degradation and loss of marine habitats and species (D. Spalding et al., 2016; Jones & De Santo, 2016)which, in turn, then further impairs the ability of marine systems to continue to provide ecosystem services that underpin human wellbeing (Worm et al., 2006).

Since GBO 4 a number of assessments at a regional MPA network level have been undertaken to assess whether MPA networks are ecologically coherent in their current configuration. Sub-regional assessments for parameters of ecological coherence of MPA designations in North America (Jessen, Morgan & Bezaury-Creel, 2016); The Caribbean (Pittman et al., 2014); the UK (Lieberknecht, Mullier & Ardron, 2014; Ridgeway, Cornthwaite, Wright & Davies, 2014); Northern Ireland (Barnard, Burdon, Strong & Atkins, 2014); the Celtic Seas (Rees, Foster, Langmead & Griffiths, 2015b); the OSPAR region (Johnson et al., 2014; OSPAR, 2013); Chile (Tognelli, Fernández & Marquet, 2009); The English Channel (Foster et al., 2014); the Baltic (Piekäinen & Korpinen, 2008); and the NE Atlantic (Evans, Peckett & Howell, 2015), demonstrate that whilst progress is being made towards the 10% protected area target, and some areas are moving towards ecological coherence, none of the existing MPA networks are ecologically representative of the full range of ecosystems nor are they well-connected. Additionally, whilst there has been progress towards the development of methods to assess management effectiveness (Hockings, Stolton, Leverington, Dudley & Courrau, 2006; International Union for the Conservation of Nature, 2016). Regional assessments of management effectiveness reveal a lack of progress in meeting conservation objectives and establishing management plans for networks of protected areas (OSPAR, 2013; Rodríguez-Rodríguez, Rodríguez & Abdul Malak, 2016). There is also lack of a formal process for reporting management effectiveness at a national level scale to support regional assessments (Foster et al., 2014; OSPAR, 2013).

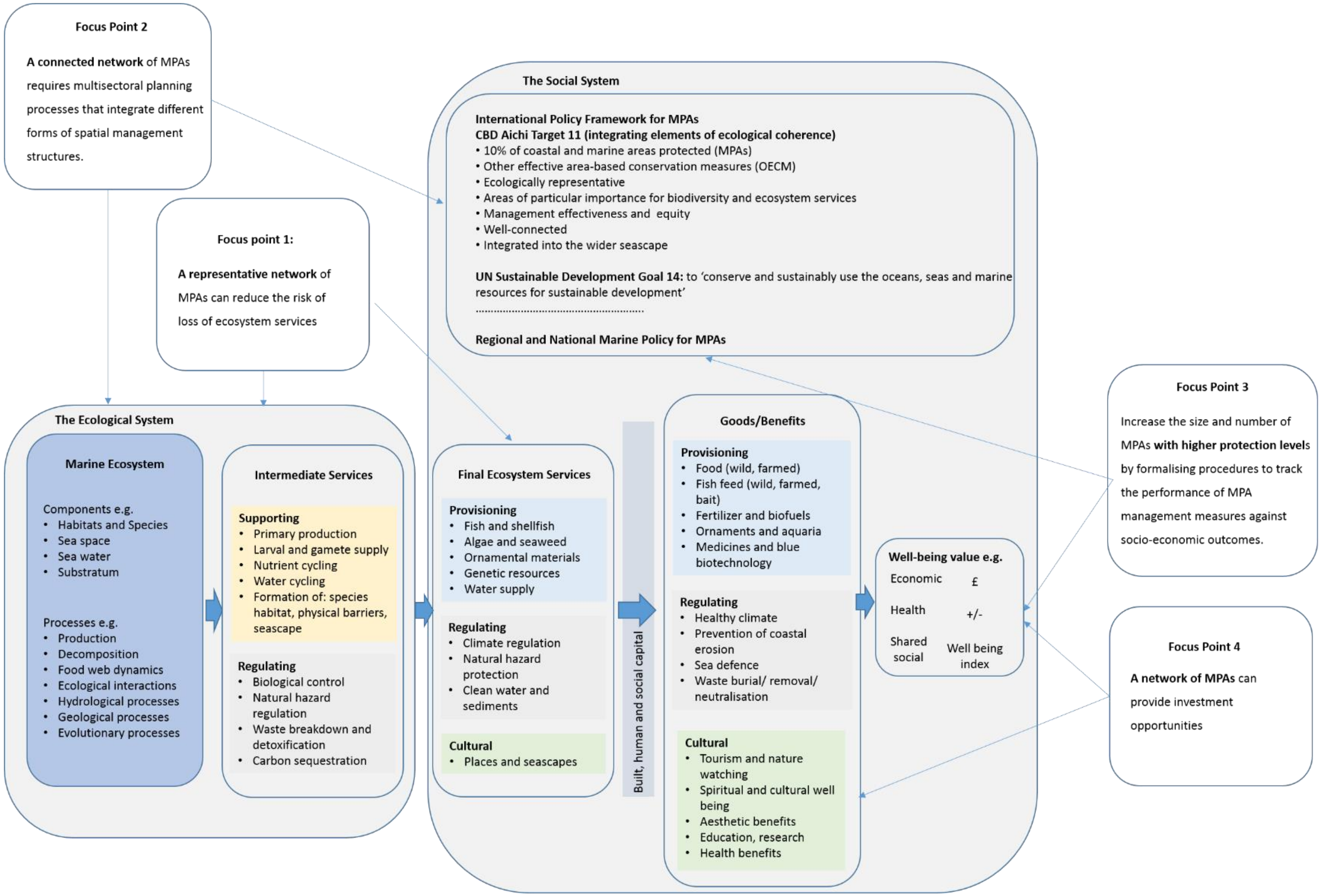
1.1 A new policy context

Further priority is given to the relationship between oceans and human wellbeing in the United Nations (UN) Sustainable Development Goals (SDGs), designed to succeed the Millennium Development Goals (MDGs) as reference goals for the international development community for the period 2015-2030. The SDGs advocate a 'triple bottom line' approach to maintaining human wellbeing; these being economic development, environmental sustainability and social inclusion (Sachs, 2012). SDG Goal 14 to 'conserve and sustainably use the oceans, seas and marine resources for sustainable development' reaffirms the CBD 10% spatial target (SDG 14.5), but places this ecological goal firmly within the economic and social context of SES to aid global development (Figure 1). There are notable alignments between Aichi Target 11 and the SDGs not only in terms of SDG 14, but also in terms of synergies with Goal 1: End poverty in all its forms everywhere and; Goal 13: Take urgent action to combat climate change and its impacts (Diz, Morgera & Wilson, 2017; Rees, Foster, Langmead, Pittman & Johnson, 2017).

The SDGs provide an opportunity to address a more fundamental issue. Namely, global conservation policy in relation to the marine environment has seen major advances in recent years but the building blocks of conservation planning (the broader goals of achieving ecological coherence in conservation planning) are not following the same trajectory. It is noted that the discipline of conservation biology (from where ecological coherence is rooted) has grown from the 'deep green' idea that nature has an intrinsic value and that we should protect nature ‘for nature’s sake’ (Vucetich, Bruskotter & Nelson, 2015). This idea, is shared, to some extent, by the general populous but is limited by a broad spectrum of factors such as: other competing values; institutional frameworks; social norms and; knowledge of what is or is not acceptable in terms of ‘harm’ to nature (burden of proof) (Vucetich, Bruskotter & Nelson, 2015). This ‘deep green’ idea has, in the past, pervaded in the development of conservation policy, which often appears to lack any explicit connection between the ecological and the social system. In addressing this gap there has been a movement to “restore and reemphasize the fundamental links between nature and human wellbeing” though the development and application of the ecosystem services framework to conservation policy (Armsworth et al., 2007; Millennium Ecosystem Assessment, 2005; Natural Capital Committee, 2014; TEEB, 2010).

Increasingly, it is becoming recognized that approaches rooted firmly in ecological science are not the only solution to conservation issues (Hicks et al., 2016). Here we present a set of four focus points (Figure 1) for future development that can construct a bridge between the ecological and the social systems. The aim is to shift the discourse on “ecological coherence” further into the social sphere and hence support the alignment of the process of designating ecologically coherent MPA networks with the ‘triple bottom line’ of economic development, environmental sustainability and social inclusion as described in the SDGs to achieve social-ecological coherence in MPA network design.

Figure 1: The social-ecological system. Marine ecosystems are essential to maintain human wellbeing. The links between ecosystems (marine) and human well-being (adapted from NCC 2012) REF The policy frameworks from the CBD Aichi Target 11 and the UN Sustainable Development Goal 14 influence how marine ecosystems are managed with the aim to underpin human wellbeing. Four focus points are presented to develop social-ecological coherent MPA network.



[Figure 1 here]

2. Focus points

Focus point 1: A representative network of MPAs is more likely to reduce the risk of loss of ecosystem services

Representativity refers to the inclusion of the full range of ecosystems, habitats, biotic diversity, ecological processes, and environmental gradients (e.g. depth, wave exposure) within the MPA network (HELCOM, 2010; OSPAR, 2006; Roberts et al., 2003; Rondinini, 2010; UNEP-WCMC, 2008). The objective in applying this criterion to MPA networks is to ensure representative coverage of all biodiversity and biogeographic regions within the network (Jackson, Hiscock, Evans, Seeley & Lear, 2008; Roberts et al., 2003). The key premise behind representativity is that the full range of biodiversity is protected worldwide. This includes the species, as well as evolutionary patterns, distinct communities, refugia habitats in anticipation of environmental change and a range of key ecological processes that sustain global biodiversity (Spalding et al., 2007). Also, often included in processes for MPA network design, is a criterion for 'replication'. Replication of habitats and species within an MPA network aims to ensure natural variation and to minimize the effects of damaging events and long-term changes (resilience), adequate replication of all habitats and species is recommended within MPA networks (HELCOM, 2010; OSPAR, 2007). Replication enhances the resilience of ecosystems to change and reduces the possibility that catastrophic events may wipe out entire populations of species or habitats within the network (HELCOM, 2010; OSPAR, 2007; Roberts et al., 2003).

Representativity (and replication) of species and habitats within an MPA network aims to underpin ecological resilience and to spread risk (of permanent loss, regime shifts) across a geographically broad region. From a social perspective the notion of 'insurance' is familiar for material goods. The valuation of goods and benefits derived from marine ecosystems falls firmly within the social system (Figure 1). According to the insurance hypothesis from an ecological perspective, biodiversity can provide insurance for ecosystems against potential future declines in their functioning because the more species that are present provides a greater likelihood that some will maintain functioning even if others are lost (Naeem & Li, 1997). Although species diversity does not necessarily guarantee high resilience, in theory, ecosystems with high functional redundancy (functional overlap) will be more robust to loss of species than ecosystems with low functional redundancy (Naeem 1998). In coastal marine systems, however, limited research indicates that low functional redundancy could be typical even in the highest diversity ecosystems such as coral reefs (Micheli & Halpern 2005), yet very little is known about seascape redundancy with reference to habitat patch types. Ultimately, the loss of functional processes or regime shifts can impact upon the realization or delivery of ecosystem services that support human wellbeing (Folke et al., 2004).

Several researchers have argued that the CBD target of 10% is too low to achieve the objective of protecting biodiversity underpinning ecosystem services and meeting socioeconomic priorities (O'Leary et al., 2016). At the 2016 IUCN World Conservation Congress in Hawai'i, Resolution 50 calls on the Director General and the IUCN to "designate and implement at least 30% of each marine habitat in a network of highly protected MPAs and other effective area based conservation measures (OECMs), with the ultimate aim of creating a fully sustainable ocean, at least 30% of which has no extractive activities, subject to the rights of indigenous peoples and local communities" (IUCN, 2016). Proposals to achieve this encourage IUCN State and Government Agency Members to commit to a programme of work to designate and implement 30% of national waters as MPAs and OECMs; to engage in the process of establishing MPAs in areas beyond national jurisdiction (ABNJ) and to develop a new legally-binding instrument under the United Nations Law of the Sea "for the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction, and that such a new instrument contains a robust mechanism for establishing effectively and equitably managed, ecologically representative and well connected systems of marine protected areas, including reserves. Additionally IUCN member States are urged to accelerate progress towards achieving Aichi Target 11 and all Parties to the CBD are encouraged to develop post 2020 targets to achieve spatial management measures via MPAs for 30% of marine areas.

It must be noted that IUCN resolutions do not have any legal standing and that it is governments and competent international organisations that must further these resolutions into national and international policy. From a social perspective, SDG14 aims for the conservation and sustainable use of all the oceans, seas and marine resources, underpinned by networks of MPAs (10% spatial coverage). Processes to determine the risk of loss of ecosystem goods and benefits and identify the potential societal consequences in relation to current levels of representativity within MPA networks may resonate further with governments and civil society to increase ambition for marine conservation (and sustainable resource use). There are recent innovations in next generation risk assessments for coupled natural-human systems (Elliott et al., 2017; Holsman et al., 2017) that can be applied to marine systems. At this stage, however, without an understanding of risk, an ecologically representative network of MPAs (meeting the CBD Aichi target 11 and SGD 14 10% target) may only be considered as a minimum spatial requirement to 'insure' for human wellbeing.

Focus point 2: A connected network of MPAs requires multisectoral planning processes that integrate different forms of spatial management structures.

Functional connectivity in ecological systems describes the extent to which populations in different parts of a species' range are linked by the exchange of eggs, larvae, recruits or other propagules, juveniles or adults (Palumbi, 2003). The connectivity between two populations is dependent on: (i) the larval characteristics of the species (e.g. duration of the planktonic stage and swimming behaviour of propagules), (ii) the abundance of the source population, (iii) the availability and suitability of surrounding habitat, and (iv) the characteristics of the physical environment (e.g. speed and direction of ocean currents, temperature, salinity) (Shanks, Grantham & Carr, 2003; Treml, Halpin, Urban & Pratson, 2008). The movements of adult life stages also influences connectivity and MPA performance and therefore requires consideration in MPA network design (Green et al., 2015; IUCN-WCPA, 2008; Olds et al., 2016). Understanding larval dispersal and marine population connectivity remains a highly complex analytical challenge. Processes to model connectivity require interdisciplinary approaches that combine high-resolution biophysical modeling and empirical data on movement capabilities of individual species (Cowen, Gawarkiewic, Pineda, Thorrold & Werner, 2007).

Progress towards MPA networks that are considered well-connected are usually based on broad structural connectivity metrics that serve as spatial proxies for actual functional connectivity e.g. distance between MPAs. Geopolitical boundaries such as territorial limits of sovereign nations (i.e. exclusive economic zone boundaries) often appear to hamper structural connectivity between MPA networks. Recent sub-regional assessments reveal that there is virtually no connectivity of MPAs across jurisdictional boundaries (Foster et al., 2014; Jessen, Morgan & Bezaury-Creel, 2016; Rees, Foster, Langmead & Griffiths, 2015a). As stated earlier there also remain relatively few MPAs in ABNJ (Marine Conservation Institute, 2017). Whilst understanding connectivity and translating this to MPA network planning remains challenging, the gaps in connectivity point towards a compounding societal challenge of how to further marine biodiversity protection in synergy with other management structures that operate across jurisdictional boundaries and in ABNJ.

The potential for OECMs aside from statutory MPAs to contribute to ecologically representative and well-connected MPA networks is increasingly receiving attention (Borrini-Feyerabend et al., 2014; Diz et al., 2017; Dunn, Maxwell, Boustany & Halpin, 2016; Jonas, Barbuto, Jonas, Kothari & Nelson, 2014; Laffoley et al., 2017; Spalding, Meliane, Milam, Fitzgerald & Hale, 2013; Woodley et al., 2012). There is currently no formal definition of an OECM under the CBD though a IUCN Task Force on 'Other Effective Area based Conservation Measures' has, so far, defined OECMs as "a geographical space where de-facto conservation of nature and associated ecosystem services and cultural values is achieved and expected to be maintained in the long term regardless of specific recognition and dedication" (Borrini-Feyerabend et al., 2014).

Potential OECMs may include some of the spatial management measures of Regional Fisheries Management Organizations (RMFOs) some of which, such as Vulnerable Marine Ecosystems (VMEs), are coincidental or overlap with Ecologically or Biologically Significant Areas (EBSAs) described by CBD Regional Workshops (Johnson et al., in review). The North East Atlantic Fisheries Commission (NEAFC) has been identified as an RFMO that has implemented 'good practice' through enacting closures to protect deep sea ecosystems from bottom towed fishing gear (Hoydal, Johnson & Hoel, 2014; Wright, Ardron, Gjerde, Currie & Rochette, 2015). In Australia, spatial closures that are enacted for fisheries by the Australian Fisheries Management Authority (AFMA) exceed the spatial extent of areas that are designated as Commonwealth Marine Reserves (CMR). It is argued by Bax and Cresswell (2012) that AMFA regulated areas are more restrictive on fishing activities than the proposed zonation of fisheries activities in the CMRs. Similar arguments can be put forward for environmental protection measures implemented by the International Maritime

Organization (Particularly Sensitive Sea Areas, Special Areas) and the International Seabed Authority (Areas of Particular Environmental Interest). Diz et al (2017) also describe how locally managed marine areas (LMMAs) with targeted biodiversity conservation can support fishing communities.

From an SES perspective and to improve social and ecological coherence of MPA networks though connectivity there is a need for States and competent international organizations to collaborate to join up and recognize areas of ecological significance that support the delivery of ecosystem goods and benefits and to coordinate protective measures though multi sectoral planning to achieve this end.

There remains a diverse set of sectoral and political interests involved in the establishment of multilateral agreements between countries for the protection of shared resources. From a national perspective, ocean policy needs to reflect the importance of connected marine ecosystems with an interdepartmental structure that mandates this policy. Moving forward with such structures it should be considered a priority to invest in capacity building to train practitioners with interdisciplinary skills who can facilitate the inclusion of a diverse set of stakeholders into new shared governance structures to develop equitable rights and management with regards to a network of MPAs and OECMs that is both socially and ecological coherent. For ABNJ the prospect of a future legally binding “Implementing Agreement for the protection of biodiversity beyond national jurisdiction” (BBNJ), with a proposed focus on four distinct topics (the so-called “package”) and one being area-based management tools, provides an important opportunity to make progress on this focus point (Long & Rodriguez Chaves, 2015) .

Focus point 3. Increase the size and number of MPAs with higher protection levels by formalising procedures to track the performance of MPA management measures against socio-economic outcomes.

The World Commission on Protected Areas (WCPA) states that the ecological coherence of MPA networks is supported by sites with a range of protection levels that are designed to meet objectives that a single reserve cannot achieve (WCPA/IUCN, 2007). Indeed those areas that have proven to have the most benefits for biodiversity are ‘no-take’ marine reserves (IUCN Ia Strict Nature Reserve) where extractive activities are strictly controlled

(Edgar et al., 2014; Sciberras, Jenkins, Kaiser, Hawkins & Pullin, 2013). From a perspective of habitat recovery, some no-take MPAs have been shown to support complete shifts in the structure of ecosystems and reversal of trophic cascades (Behrens & Lafferty, 2004; Guidetti, 2007; Salomon, Shears, Langlois & Babcock, 2008). The potential of these highly protected sites to enhance sustainable economic development is strongly supported with evidence in the academic literature (Aburto-Oropeza et al., 2008; Halpern, Lester & Kellner, 2009; McCook et al., 2010). However, the practical reality is that no-take MPAs, particularly in the nearshore environment, are largely viewed as being unequitable and have, in many places, been difficult to implement because of social and political opposition (Agardy et al., 2003).

Equity, the premise that there is a fair distribution of benefits and costs between individuals and groups of people, is a subject that is recognized as having a potential to influence intended conservation outcomes (Tallis, Polasky, Lozano & Wolny, 2012) and it is embedded in the Aichi Target 11 text. Some accounts emerging from the academic literature demonstrate how supporting studies that document the ecological, social and economic impacts of MPA management measures (i.e. proof of the societal benefits of protection) can convince stakeholders of the efficacy area with higher protection levels (Erisman et al., 2017; Oliver et al., 2015; Rees et al., 2016; Vandeperre et al., 2011). From a community perspective these sites are essentially 'control sites' that support experimental design to robustly demonstrate the impact of management measures on the ecological system (e.g. reef recovery (Sheehan, Stevens, Gall, Cousens & Attrill, 2013)) and consequently benefits to the socio-economic system (e.g. increased landings (Rees et al., 2016)).

From a perspective of social-ecological coherence and achieving higher protection levels there is a need to formalize equity in the decision making process and track MPA performance beyond biological metrics. This can be achieved through the development of protocols for the monitoring and reporting on the effectiveness of MPAs (at an individual site and network level) that include socio-economic performance indicators (monetary and non-monetary) alongside conservation objectives for an MPA to reveal which characteristics of MPAs are most beneficial and acceptable to communities and how management measures can promote these.

Lessons can be learnt from behavioral psychology in that peoples' intentions to choose pro-environmental behavior (e.g. to agree and comply with no-take zones) is predominantly influenced by self-interest and pro-social motives (Bamberg & Möser, 2007). Areas with higher protection levels that can be used as 'control sites' for scientific monitoring essentially support equity via the opportunity for interested parties to be involved with rather than excluded from MPA management. This is an alternative consensus building approach, grounded in motivations that support human well-being (what can the MPA provide for me/my community), which may, in the long-term lead to greater social acceptability and broader spatial protection at higher levels.

Focus point 4: Networks of MPAs can provide investment opportunities.

Policy appraisal tools, applied by governments, are essential to consider the wider costs and benefits to society of an intervention, e.g. an MPA or a network of MPAs. Progress towards designation of ecologically coherent MPA networks, has, in some cases, slowed down or ground to a halt when subject to a policy appraisal at the government level (McGowan & Possingham, 2015; Rees et al., 2015). For example, Fletcher et al (2015) highlight a number of weaknesses in the recent Impact Assessment (IA) undertaken by UK Government to take forward the designation of the second round of MPAs (Marine Conservation Zones) required to work towards an ecologically coherent network of MPAs in England and Wales~~the UK.~~ Costs are presented as quantified monetary values calculated using conventional economic assessment methods adapted to specific marine sectors, whereas benefits are described in non-monetary qualitative terms using an ecosystem services framework not tailored to specific sectors. This difference in methodology limits the policy appraisal tool's ability to fairly assess the costs and benefits of effective conservation. Furthermore, no method is employed in the IA to take into account the cost of inaction (i.e. of doing nothing) despite evidence that demonstrates that there are opportunity costs associated with delayed conservation action or inaction (Grantham, Wilson, Moilanen, Rebelo & Possingham, 2009) and that the overall health and functionality of the marine environment is deteriorating (Jackson et al., 2001; Lotze et al., 2006; Worm et al., 2006), thus, requiring a corresponding declining economic baseline. Additionally, there is no consideration of the benefits of an ecologically coherent network of MPAs versus site-based costs. The result of this policy appraisal process is that where an MPA is contested, (considered to be inequitable though for example, loss of income, opportunity or rights) then gaps appear in the MPA network that undermine ecological coherence. It is argued that such contention can lead to a network of ‘residual’ MPAs that afford no step-change in the management of activities and therefore no additional benefits for biodiversity (Devillers et al., 2015).

Undeniably the purpose of policy appraisal processes are to define social and economic equity in the decision-making processes and this can identify inequitable trade-offs between biodiversity conservation and socio-economic objectives. However, equity is more than a narrow trade-off between resource use and rights occurring directly within the boundaries of the MPA. MPAs may have both localised and broader societal benefits. A series of studies in different parts of the world are contributing to a body of evidence that supports this. For example, an economic investment by the US government (American Recovery and Reinvestment Act of 2009) to restore degraded coastal habitat (blue infrastructure) has led to job creation in the short term, further economic benefits through the rebuilding of fisheries and coastal tourism and benefits to coastal economies, such as higher property values and improved water quality (Edwards, Sutton-Grier & Coyle, 2013). McCook et al. (2010) demonstrate that the economic returns of the rezoning of the Great Barrier Reef Marine Park are estimated to be 130 times greater than the cost of management. Further protection for corals and fish could potentially have knock on benefits (opportunity costs) for the tourist industry and commercial fisheries (McCook et al., 2010). Arkema et al. (2015) showed that presence of intact reefs and coastal vegetation reduce the likelihood and magnitude of losses resulting from extreme weather events and sea-level rise. Jackson, Rees, Wilding, & Attrill (2015) demonstrate that, by providing habitat for species during essential life history stages, seagrass (*Posidonia oceanica*) meadows are worth around **€**78 million every year to commercial fishing and **€**112 million to recreational fishing in the Mediterranean. Investment in effective conservation will underpin this value and the associated employment. In the U.S. Virgin Islands, economic valuation has estimated that nearshore coral reefs are worth approximately US$200 million annually (Van-Beukering, Brander, Zanten, Verbrugge & Lems, 2011) and in Hawaiʻi are estimated at US$360 million per year (Cesar & Beukering, 2004). These are powerful socio-political arguments for investment in conservation.

New strategies are required from Governments to move decision-making beyond site-based cost benefit analysis towards broader strategies for investment in ecosystems (Natural Capital Committee, 2014). It is possible for identified centralized costs (e.g. enforcement or management) to become opportunities for investment (supporting sustainable growth) or offsetting (loss of jobs) rather than a direct trade off against site based ecosystem service benefits. Flagship projects led by national governments that integrate investment (both public and private) with the conservation of priority biodiversity areas e.g. The Brazil Blue Fund are pioneers in the development of coastal and marine conservation strategies that aim to underpin sustainable development in a new accounting model. Exactly how an 'ecology coherent' network of MPAs may support such investment strategies is yet to be fully substantiated. However, the reduction of risk (of loss of benefits) though planning for aspects of ecological coherence, such as representativity of habitats and species within an MPA network (focus point one), along with case studies that demonstrate positive social and economic outcomes (Focus point 3) would seem to support such investment strategies. Such an approach might enable MPA managers to become more influential in marine spatial planning activities that envision future scenarios of the optimal use and allocation of maritime space.

3. Conclusion

Despite the development of appropriate criteria, thresholds and policy frameworks (to develop ecologically coherent networks of MPAs, overall progress towards achieving them is slow. Whilst biodiversity considerations underpin MPA selection, the SDGs with their 17 goals to "transform our world" are broadening the focus of ecological sustainability to encompass social and economic objectives. This leads us to a wider consideration of how conservation can underpin human well-being and how the current drive towards ecologically coherent networks of MPAs can be aligned with broader policy objectives.

The key premises are that 1) MPAs are an effective spatial management tool for achieving conservation objectives; and 2) Ecologically coherent networks support the high level of functional and spatial connectivity within marine ecosystems so that the network as a whole supports those ecosystem services that underpin human wellbeing. The focus points presented here are directed at those in a position to influence MPA policy and/or MPA management with the intention of shifting the discourse of “ecological coherence” into the social and economic sphere. Reframing the discourse for ecological coherence in this way offers opportunities for integration with other disciplines beyond conservation biology such as individuals or groups that specialize, for example, in risk management, finance, investment, natural capital assessments and performance management. There are also opportunities for new partnerships with wider stakeholder groups who operate in the marine environment but under different sectoral management strategies e.g. ocean energy. Such integration may advance progress towards the aim of ecologically coherent networks of MPAs and therefore support the ecological, social and economic goals (the ‘triple bottom line’ of sustainable development) outlined in the SDGs.

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