EXPLORING THE BALANCE OF ECOLOGICAL, ECONOMIC, GOVERNANCE, AND SOCIAL CONSIDERATIONS IN MARINE PROTECTED AREA NETWORK EVALUATIONS

By

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Abstract

Marine protected area networks (MPANs) are a critical tool at the forefront of global marine biodiversity conservation and sustainable development agendas. MPANs are complex tools that seek to provide important ecological and human benefits. The Convention on Biological Diversity "Aichi Targets" were developed to safeguard biodiversity and enhance benefits for people through sustainable use. Target 11 (draft 2030 action Target 3) describes elements of the key (environmental, economic, governance, social) dimensions associated with MPANs from a global perspective.

Understanding the balance of these interrelated dimensions in MPAN evaluations is critical to developing future conservation strategies that can adapt to changing contexts and conditions. This dissertation draws on Aichi Biodiversity Target 11, and its associated multidimensional foundation to understand how MPANs are evaluated toward their global targets. The research herein was grounded in this multidimensional context to offer insight into how MPANs have been evaluated.

I performed a systematic literature review to understand the indicators used to evaluate Aichi Target 11 qualitative elements. Results showed that the qualitative elements were unevenly evaluated in MPAN literature. I then conducted a two-part online survey to characterize attributes of ecological, economic, governance, and social dimensions considered in MPAN evaluations, and identify the indicators used to evaluate them. Survey results indicated that MPANs with both biodiversity and socially-oriented objectives considered a larger suite of attributes in their evaluations than those without social considerations, without de-emphasizing ecological considerations. In practice, attributes

were informed by a suite of indicators with varied composition, unlike the single, attribute-specific indicators identified in the literature.

This dissertation aligned with an increased interest in MPANs that go beyond a focus solely on biodiversity conservation to encompass sustainable models, which incorporate socially-oriented objectives. The findings revealed limited use of approaches that holistically assess MPANs. Existing practices tend to be biased towards ecological and governance dimensions. Future research is needed to identify attributes and indicators to help elucidate challenges from all dimensions, and in every part of the MPAN process, from design through evaluation.

General summary

Marine protected area networks (MPANs) are essential biodiversity conservation and management tools. MPANs often benefit both humans and the ecosystems important to people. They are important to people because they can provide food, recreation, beautiful views, and cultural or spiritual traditions. The global community considers MPANs so important that the international Strategic Plan for Biodiversity was adopted in 2010 agreeing to 20 biodiversity-related “Aichi Targets”. Target 11 specifically calls for a global network of MPAs to safeguard biodiversity and enhance benefits for people through sustainable use and fair and equitable sharing of the benefits they provide.

Evaluating MPANs is important to ensure they are achieving their objectives. these evaluations, however, need to consider the balance of interrelated ecological and human dimensions that are complicated and often overlooked. Understanding if the key dimensions (environmental, economic, governance, and social) associated with MPANs are considered in evaluations is critical to developing effective conservation strategies that can change if they are not working to their fullest potential.

This dissertation uses a multidimensional context to offer insight into how MPANs have been evaluated. A systematic literature review provided evidence that the qualitative elements of Aichi Target 11, and the dimensions that support each element, were unevenly evaluated in MPAN literature. A two-part online survey asked MPAN experts to 1) characterize what parts of the ecological, economic, governance, and social dimensions were considered in MPAN evaluations and 2) identify the indicators used to evaluate them. MPANs with both biodiversity and socially-oriented objectives considered multiple dimensions more evenly without de-emphasizing ecological considerations. In practice,

different parts of each dimension were measured by a large group of indicators, but in the literature, indicators were very specific in what they measured.

This dissertation aligned with an increased interest in MPANs that go beyond a focus solely on biodiversity conservation to encompass sustainable models, which incorporate socially-oriented objectives. The findings revealed that existing evaluation practices tend to be biased toward ecological and governance dimensions. Future research is needed to identify attributes and indicators to help elucidate challenges in every part of the MPAN process, from design through evaluation.

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This is not a dissertation where I claim to present a solution to the woes of the world. Rather, this dissertation is an exploratory investigation about how marine protected areas are evaluated. It was my intention to describe the ways that the tools we use may be improved to offer better outcomes for marine and coastal biodiversity. I hope this work contributes, at least in a small way, to that goal. This has been a long journey, and I want to thank all the people who helped me along the way.

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original people of Labrador. I strive for respectful relationships with all the peoples of this province as we search for collective healing and true reconciliation and honour this beautiful land together.

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CBD	Convention on Biological Diversity
EEZ	Exclusive economic zone
MPA	Marine protected area
MPAN	Marine protected area network
nMDS	Non-metric multidimensional scaling
PERMANOVA	Permutational multivariate analysis of variance
SDG	Sustainable Development Goal
Target 11	CBD Aichi Target 11

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1. Introduction

1.1 Context

Global concerns over declining marine and coastal biodiversity (Cheung et al., 2009) have generated international attention toward establishing marine protected areas (MPAs) (Wood et al. 2008; CBD 2010). An MPA is considered "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" (Day et al., 2012). MPAs have become prominent tools in marine conservation, used to safeguard biodiversity, manage fisheries, and protect habitat (Kelleher 1999; Sala et al. 2002; Lubchenco et al. 2003; PISCO 2007; IUCN-WCPA 2008; Charles & Wilson 2009; Gaines et al. 2010). A system of well-connected, representative MPAs may provide more benefit than individual MPAs (IUCN-WCPA 2008; Grorud-Colvert et al. 2014; Horigue et al. 2014). These marine protected area networks (hereafter MPAN) are a collection of individual MPAs intentionally arranged into an organized group that operates in a collaborative manner (IUCN-WCPA 2008).

MPANs are explicitly recognized and called for in international strategies regarding coastal and marine biodiversity conservation and sustainable development, such as the Convention on Biological Diversity's (CBD) Strategic Plan for Biodiversity Aichi Target 11 (IUCN-WCPA 2008; CBD 2014; UNEP-WCMC & IUCN 2016). In 2010, the international community, supported by the Convention on Biological Diversity, adopted the Strategic Plan for Biodiversity 2011–2020. This plan agreed on 20 biodiversity-related "Aichi Targets" to be achieved within a decade (CBD 2011). The goal of these targets was to safeguard biodiversity and enhance its benefits for people through sustainable use and fair and equitable sharing. Target 11 pertains directly to MPANs, stating that "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, and integrated into the wider landscape and seascape" (CBD 2010).

Aichi target 11 includes several quantitative and qualitative elements that describe how to achieve the target (Rees et al. 2018). The qualitative elements ('areas of importance for biodiversity conservation and ecosystem services', 'ecological connectivity', 'equitable management', 'effective management', 'integration into the wider land and seascape', and 'ecological representation') provide context about how an MPAN can contribute to biodiversity conservation(Barnes et al. 2018; Rees et al. 2018). Evaluating MPANs based on the quality of the areas under protection may provide a more robust understanding of the connectivity within marine systems and between human and biophysical systems (Hill et al. 2016; Amengual & Alvarez-Berastegui 2018; Rees et al. 2018). Such a means of evaluation can help to identify gaps in MPAN performance and improve their contribution to global biodiversity conservation targets. However, there has not yet been a review of MPAN evaluations about the Aichi Target 11 qualitative elements in the academic literature.

This dissertation was undertaken near the culmination of the 2011-2020 Strategic Plan for Biodiversity and its targets. Negotiations are currently underway, after several delays due to the COVID-19 pandemic, to update the Aichi Targets for the next decade. Preliminary drafts indicate that covering at least 30% of the planet in protected areas will be included, while the qualitative elements may largely remain the same (CBD 2021a). At the time of writing, a new target had not been finalized; hence this thesis refers mostly to Aichi Target 11 and the multiple dimensions that underpin it.

This dissertation is grounded in a multidimensional context, drawn from the complex, interdependent relationships that exist in society and between society and conservation initiatives (Adams et al. 2004). Furthermore, the strategic plan for biodiversity was set up for a period of 10 years, upon which the strategy and targets are revisited and adapted to reflect a new era (whether or not the targets were achieved). This potential for change in the upcoming post-2020 agenda, and the complexity of the qualitative elements (Campbell & Gray 2018) prompted me to draw heavily on a multidimensional framing to examine each dimension considered in MPAN evaluations and the indicators used to measure them. All of the Aichi Target 11 elements are supported by complex interdependent relationships among multiple (environmental, economic, governance, and social) dimensions. Each dimension is comprised of unique characteristics, called attributes, of MPANs (See Chapter three for a full description).

Achi Target 11 describes a suite of corresponding elements that aim to focus biodiversity conservation initiatives on the variety of multifaceted ecological, economic, governance, and social dimensions that may influence the desired outcome (e.g., conserving biodiversity, improving habitat health). In this dissertation I use the terms element and attribute interchangeably, referring to the qualitative elements of connectivity, representativity, and integration into the broader land and seascape as ecological attributes (Woodley et al. 2012; UNEP-WCMC & IUCN 2016; Gannon et al. 2017).

The qualitative elements also incorporate effective and equitable management, which specifically refers to how an MPAN is managed. These management elements are broad classes composed of attributes that span all four dimensions. Important ecological and management attributes that should be considered for individual MPAs evaluations have been identified, as well as important indicators needed to measure them (Edgar et al. 2014; Di Franco et al. 2016; Ban et al. 2017, 2019; Gill et al. 2017). However, there has not yet been a comprehensive review of whether multiple dimensions are considered in MPAN evaluations, nor a classification of the indicators that contribute to understanding associated ecological or management-related attributes in practice.

Using a diverse set of methods, this dissertation aims to fill these gaps by investigating how MPANs are evaluated in terms of identifying the qualitative elements assessed and the indicators used to measure them in the literature, the attributes considered when performing evaluations, and indicators used to measure each attribute in practice. The research herein is summarized in three separate manuscript chapters that are the focus of the next three chapters (Chapters two-four). Within the remainder of this introductory section, I briefly provide background on MPANs and delve into the multiple dimensions associated with MPANs, which, when used to frame MPAN evaluations, can help improve our understanding of how MPANs function.

1.1.1 Protecting against threats to marine biodiversity

Human activities continuously impact marine and coastal ecosystems, amplifying marine biodiversity loss over time (McCauley et al. 2015; Rees et al. 2018). Threats to biodiversity include, but are not limited to, overfishing, which reduces healthy fish stocks (Davies & Baum 2012; Yan et al. 2021), nutrient pollution, which increases the severity of deoxygenation and acidification (Breitburg et al. 2019), and habitat removal or alteration, which destabilized food webs and shorelines (Sundblad & Bergström 2014; Jellison & Gaylord 2019). These threats have widespread social, economic, and biological consequences (Halpern et al. 2008; Costello et al. 2010; Parravicini et al. 2013; Fredston-Hermann et al. 2016; Holon et al. 2018). The magnitude of these threats has been increasing throughout various ecosystems (Halpern et 2008; Tilman & Lehman, 2001; Vitousek, 1994), as have actions to abate them (United Nations General Assembly 2017). Many approaches have been promoted to tackle the threat of biodiversity decline and to restore and protect habitats. Protecting biodiversity involves reducing threats to marine and coastal ecosystems by limiting or eliminating harmful human activities (FAO 2011). Spatial protection measures such as marine protected areas (MPAs) are one of the leading tools promoted to tackle threats (Braun 2017).

1.1.2. Marine protected areas

As noted, an MPA is a marine or coastal area specifically designed to benefit biodiversity conservation while contributing to ecosystem services and cultural enrichment. Well-enforced, managed, and highly protected MPAs demonstrate increased biomass and density of animals and plants, increased animal body size, and higher species diversity and richness (Halpern 2003; Micheli et al. 2004; Lester & Halpern 2008; Stewart et al. 2009; Robb et al. 2011; Sala & Giakoumi 2017; Grorud-Colvert et al. 2021). While improving biodiversity, MPAs have demonstrated impacts (both positive and negative) on humans (Charles and Wilson 2009). MPAs can reduce or eliminate threats within their boundaries, but are limited in their ability to mitigate large-scale threats or protect species whose range extends beyond MPA boundaries, such as albatrosses, whales, and sharks (Terauds et al. 2006; Ward-Paige & Worm 2017; Allan et al. 2021) unless they are large (Wilhelm et al. 2014). No-take MPAs, where all extractive activities are prohibited, provide the greatest biological benefits compared to partially protected and multiple use areas (Lester & Halpern 2008; Sciberras et al. 2015), but have been challenged with low social acceptance and compliance (Sciberras et al. 2015). MPANs have been proposed as a mechanism to implement large-scale protection that reflects species' life history distributions and considers various potential impacts with human use (Green et al. 2007; Horigue et al. 2014). Individual MPAs may provide relevant insights for MPANs (IUCN-WCPA 2008). The ecological benefits of fully protected individual MPAs (Lester & Halpern 2008; Sala & Giakoumi 2017) and factors such as size, age, socioeconomics, and governance that influence the effectiveness of individual MPAs (Charles & Wilson 2008; Claudet et al. 2008; Mizrahi et al. 2018) have been validated in MPANs (Lowry et al. 2009; Grorud-Colvert et al. 2014).

1.1.3 Marine protected area networks

As a strategically organized group of MPAs, MPANs may promote species and habitat recovery, resilience, and productivity to a greater degree than their individual counterparts (Woodley et al. 2012; UNEP-WCMC & IUCN 2016; Grorud-Colvert et al. 2021). MPANs can encompass spatial scales that better reflect species' life history distributions than small individual sites (Green et al. 2007). They can help mitigate impacts from human use and climate change through the application of network design elements such as replication, representation, and connectivity (Abesamis et al. 2006; WCPA/IUCN 2007; McLeod et al. 2009). They also provide for a variety of areas with diverse levels of protection that may allow for certain human uses (Grorud-Colvert et al. 2021). MPANs aim to strike a balance between protecting marine and coastal ecosystems from human impact while simultaneously allowing sustainable activities to occur (Horigue et al. 2014). Some MPANs allow for continued commercial fishing activity in the spaces between protected areas. As such, MPANs may enable conflict relief in high-use areas and provide for cost-sharing and collaboration among human user groups (White et al. 2005; Horigue et al. 2014). In this way, MPANs are expected to contribute to a variety of multifaceted ecological, economic, governance, and social dimensions.

1.1.4 Multiple dimensions and attributes of marine protected area networks

MPANs have been propelled into the forefront of international efforts to manage and protect coastal and marine resources because of their multidimensional properties (IUCN-WCPA 2008; Levin et al. 2009; Barragán-Paladines et al. 2015; United Nations 2015). All of the dimensions are apparent in Aichi Target 11, although attributes associated with the ecological dimension are described most clearly (CBD, 2010). The relationship between society and biodiversity conservation interventions (Charles and Wilson 2009) is clearest with respect to the elements of ecosystem services and effective and equitable management. This makes explicit the coupled relationship between the ecological, economic, governance, and social dimensions. Human dimensions (economic, governance, and social) have a strong influence on the ecological outcomes of an MPAN (Pollnac et al. 2010). As well, ecological outcomes, such as healthy and abundant food sources, the presence of cultural land and seascapes, and clean water, influence human health and wellbeing and are associated with all human dimensions (Ban et al. 2019; Mbaru et al.

2021). Some attributes may have reciprocal qualities and are linked with more than one dimension (Pollnac et al. 2010).

The ecological dimension refers to the species and habitats of concern within a particular area. MPAN establishment is centered around this dimension as the primary aim is to protect biodiversity (IUCN-WCPA 2008). Ecological attributes include the representation of biogeographically diverse ecosystems; replication of ecological features, habitats, and species; and connectivity between sites (Abecasis et al., 2017; Ban et al., 2011; Burt et al., 2014; Cabral et al., 2015; CBD, 2008; DFO, 2009; Grorud-Colvert et al., 2011; IUCN-WCPA, 2008; Magris et al., 2018; Roberts et al., 2003; WCPA/IUCN, 2007). MPANs that are representative of diverse habitats and species, connecting individual sites for larval and/or species exchange, help provide resilience against potential natural and anthropogenic events (Holling 1994; Nyström et al. 2000; Dudley & Parish 2006; IUCN-WCPA 2008; Thomas & Shears 2013; Burt et al. 2014).

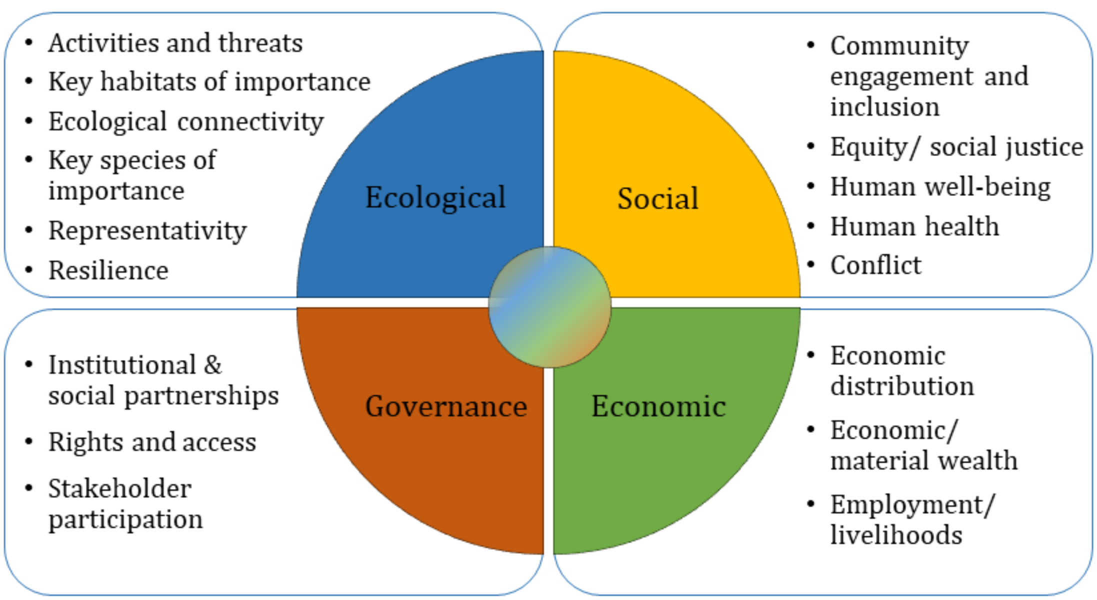

Figure 1.1 Dimensions and associated attributes of MPANs identified from the literature.

A variety of economic impacts and benefits can accrue because of MPAN implementation. This economic dimension consists of the financial resources and capital necessary to implement and manage MPANs and achieve conservation goals (Allen Consulting 2009; Gill et al. 2017). This dimension also refers to the procurement and distribution of economic wealth, employment, or income-generating livelihood endeavors (Ahmed 2010). Economic attributes include funding for management, economic activities, and impacts associated with MPAN implementation. Additionally, economic attributes include household and community-wide economic benefits and costs, such as employment opportunities, household wealth, and the distribution of wealth (Rees et al. 2015). Improved economic prospects can occur through non-extractive uses of MPANs, like eco-tourism and recreational services (Oikonomou & Dikou 2008; Angulo-Valdés & Hatcher 2010; Rees et al. 2015). As well, unintended economic consequences as a result of tourism-related activities may promote inequality (Christie et al. 2003; Bennett & Dearden 2014; Larrosa et al. 2016).

The governance dimension is characterized by complex institutional, procedural, instrumental, and organizational decision-making processes (Monkelbaan 2019). These actions include managing, regulating, coordinating, policy-making, and establishing guidance for cooperation (Spangenberg 2007; Monkelbaan 2019). Governance attributes therefore include stakeholder participation and partnerships that help maintain or influence legislation, management, and decision-making. More effective and equitable conservation approaches are facilitated by MPANs that address inefficiencies in social and institutional coordination and resource use (IUCN-WCPA, 2008).

The social dimension reflects the cultural and personal values and beliefs wellbeing associated with MPANs (Galligan 2012; Murphy 2012). Social attributes include health, community engagement, human wellbeing, conflict, and elements of equity throughout the MPAN process of design, implementation, and evaluation. Social networks are key features of effective MPANs (Alexander 2014; Bustamante et al. 2014; Wenzel et al. 2019). A social network describes human relationships in and across communities or groups of resource users (Bodin & Crona 2009; Stevens et al. 2015) and is associated with both individual MPAs as well as MPANs. Social networks can help improve the ecological outcomes of an MPAN by overcoming barriers to management. For example, social networks and alliances can bridge gaps in understanding diverse or common practices used to manage shared migratory resources (Alexander 2014; Bustamante et al. 2014; Wenzel et al. 2019). This could be considered a governance indicator; however, due to social relationships, we categorized this as a network-specific social indicator. Alexander (2014) argued for the inclusion of a social network perspective in MPAN analyses as social networks can influence cooperation between individuals or communities among sites, mediate conflict, influence decision-making processes, share information, provide enforcement, and affect behavior (Bodin & Crona 2009; Stevens et al. 2015; Alexander et al. 2018). Wentzel et al. (2019) described a decade of sister site partnerships in the USA that connected MPAs based on ecological and cultural links.

Benefits to people include increased catch, and spillover of fisheries resources (Gell & Roberts 2003; Aburto-Oropeza et al. 2011). Benefits to human wellbeing also occur through enhanced educational or knowledge opportunities (Sanchirico et al. 2002; Yates et al. 2019). MPAN establishment can also impair people through the displacement of fishers

(Govan 2009; Cinner et al. 2014) and increased conflict over tenure and resource use (Christy 1997; Govan 2009). Further unintended ecological and economic consequences that can occur with MPAN implementation include the promotion of inequity and cultural impacts from tourism-related activities (Christie et al. 2003; Bennett & Dearden 2014; Larrosa et al. 2016). Equity and social justice are emerging social attributes that are imperative to realizing MPAN effectiveness (Zafra-Calvo et al. 2017). Conservation outcomes of MPANs can be improved by incorporating equity into MPAN planning (Hill et al. 2016; Campbell & Gray 2018; Law et al. 2018; Moreaux et al. 2018) and considering the equitable distribution of benefits amongst communities. All of these attributes in every dimension are known to influence how MPANs conserve biodiversity (Pomeroy et al. 2005; Blicharska et al. 2019). Indeed, researchers have identified that disproportionate focus on one or few dimensions without reflecting on the full suite can be counterproductive for both human and environmental outcomes, stemming from heightened conflict and community tensions, including poaching and reduced legitimacy (Adams et al. 2004; Christie 2004; Dehens & Fanning 2018).

1.1.5 Evaluating marine protected area networks to reach global goals

Global efforts to implement MPANs come with a responsibility to assess their effectiveness in achieving their intended goals and objectives. Ensuring MPANs are living up to their promises requires a clear understanding of how they are being evaluated across the world. Implementing effective MPANs requires careful consideration of the ecological, economic, governance, and social factors, also known as dimensions, that work in concert to influence ecological outcomes (McGinnis & Ostrom 2014; Hill et al. 2016; Gill et al. 2017; Yates et al. 2019). Evaluating the effectiveness of MPANs will require assessing individual MPA contributions, as well as those specifically associated with MPANs. How an MPAN is evaluated may also include the process of evaluation (e.g., participatory process, who was involved in measuring and evaluating) or the components of the evaluation (what is being measured, what indicators are used). The focus of this dissertation is on the latter, the components of evaluations.

Monitoring and Evaluation (M&E) have a long history in conservation to identify how well a project or strategy is delivering on its objectives (Stem, Margoluis, Salafsky, & Brown, 2005). Evaluations can inform managers and decision-makers about the performance of the MPAN and what (if anything) needs to change for improved performance (Hockings et al. 2000; Pomeroy et al. 2005; Geldmann et al. 2020). Determining how well an MPAN is achieving its objectives involves more than simply assessing the amount of area protected (Rife et al. 2013), or only biological outcomes (Pajaro et al. 2010). It is important to evaluate activities that occur throughout the process of MPAN design, implementation, and evaluation (hereafter "MPAN process") because activities within each of these steps (e.g., participation) may influence performance and can be changed based on evaluation results (Hockings et al. 2000; 2006). Evaluations of conservation tools such as MPANs are performed by monitoring a set of attributes understood as important to the overarching objectives, and evaluating any changes observed against established benchmarks (Hockings et al. 2000; Pomeroy et al. 2005). This is done by using indicators to measure the change in the attribute, tracking progress and understanding if intended or unintended impacts are occurring while meeting objectives (Salafsky et al. 2002).

1.1.6 Marine protected area network indicators

Indicators are quantitative and qualitative variables used to measure key attributes of a system that are intended to change due to a management action (USAID 2005; Pomeroy et al. 2008; Heink & Kowarik 2010). Indicators aim to aid in understanding progress by identifying status (where you are), direction (which way you are going) and relative position (how far you are from where you want to be) from a target or objective. In addition to monitoring impacts, indicators also help to communicate findings about progress toward the objectives of a management decision such as an MPAN (Pelletier et al. 2005; Pomeroy et al. 2005; Bundy et al. 2017). Indicator theory suggests there need to be clear linkages between indicators and the objectives they measure to monitor the progress of MPA implementation (Pomeroy et al. 2005; Stem et al. 2005; Hockings et al. 2006; Pelletier 2011). Because MPAs are most commonly designed to conserve biodiversity (Agardy 1994; Yates et al. 2019), their effectiveness is often measured with ecological indicators (i.e. biomass, abundance) (VanStrien et al. 2009; Castilla 2010; Beliaeff & Pelletier 2011; Scianna et al. 2015; Roberts et al. 2018). MPA effectiveness is influenced by the effectiveness of the institutions, communities and economic circumstances surrounding the area (Gurney et al. 2014; Verweij et al. 2015) as well as the ecological context. Therefore, explicitly including social, economic, and ecological indicators in MPA network evaluation is important to determine how these factors influence the conservation outcomes. Many of these characteristics are difficult to measure, such as success of environmental goals, which can be assessed using a range of indicators that cover social, economic and ecological dimensions of marine conservation approaches (Pomeroy et al., 2005). Latent characteristics such as good governance or equitable management, can be assessed using a suite of indicators that measure best-fitting proxies, such as participation, rule of law, legitimacy, and income equality among many others (Pomeroy et al. 2008; Zafra-Calvo et al. 2017; Gill et al. 2019; Mbaru et al. 2021). Context-specific variables and indicators can be integrated into a collection of similar indicators referred to as "headline indicators" (Pomeroy et al., 2004). Headline indicators enable scaling up from local to global level initiatives, which is particularly important for evaluations from a global perspective. Headline indicators are used through the evaluation literature and guidance to arrive at a shared language toward common goals and objectives in diverse areas. While indicators do provide much-needed understanding about how an MPAN may function, including achieving objectives, impacting or benefiting people or key species of importance, there are tensions with how they are used and developed (Turcu 2013; Muhl et al. 2022). These tensions, including data accessibility, cost of data collection, and power dynamics between what is considered important to measure and how it is measured, amongst other concerns need to be considered when developing indicators (Muhl et al. 2022).

This dissertation draws upon several existing MPA evaluation frameworks to organize indicators and ensure a practical connection to existing evaluation initiatives (Pomeroy et al. 2004; Leverington et al. 2010; Gannon et al. 2017). These frameworks provide context and structure for attribute and indicator organization. Many MPAs and MPANs have been evaluated at the local levels (Fox et al. 2018) using these frameworks. However, indicators used to measure network-specific attributes (e.g., connectivity, representativeness, integration, social networks) have not been clearly identified in the literature, or in practice (Gannon et al. 2017; Geldmann et al. 2020). Furthermore, a synthesis of indicators that can be used for evaluating effectiveness of MPANs in achieving Aichi Target 11 (e.g., equity, land-sea integration) is still needed (Geldmann et al. 2020).

1.1.7 Integrating academic and practitioner knowledge

Weaving together academic research and experiential knowledge is important to provide a holistic perspective of how MPANs are evaluated (Murray et al. 2020; Chambers et al. 2021; Stephenson et al. 2021). Situational contexts influence an individual's perspective (Himes 2007; Christie 2011; Yates et al. 2019). Practitioners are influenced by the contexts in which they, and the MPAs they serve are situated (Hopkins et al. 2016; Aswani et al. 2017). Incorporating the perspective of multiple practitioners (including site managers, researchers, academics, and government officials, etc.) who are intimately involved in evaluating MPAN processes can provide a point of view that reflects the complex reality involved in understanding the myriad of attributes that influence MPANs and the "fit for purpose indicators" (Geldmann et al. 2020, p.6) used to evaluate them (Arlettaz et al. 2010; Toomey et al. 2017; Reed & Abernethy 2018; Wyborn et al. 2019; Jarvis et al. 2020). This can provide important feedback for research on MPAN evaluations. Attributes and indicators used to evaluate an MPAN from practitioners' perspectives may be different from those identified in literature. Understanding perspectives from the literature and practice can fill gaps in understanding how MPANs are evaluated, and a path forward to improve evaluations, thereby improving MPAN performance (Pullin & Knight 2009; Sunderland et al. 2009; Arlettaz et al. 2010; Cook et al. 2013; Walsh et al. 2015; Toomey et al. 2017). For example, Pajaro et al. (2010) found that indicators constructed through a mix of academic efforts, combined with the understanding of practitioners and participants who are part of the process, yielded more useful and reliable indicators. I wanted to extend this thinking to include how MPAN evaluations are contextualized- the important attributes considered in MPAN evaluation, and the indicators used to measure the attributes.

1.2 Research purpose and gaps this thesis aims to address

While the momentum from international goals and targets to implement MPANs is well founded and necessary, the rapid rate of implementation begs a question as to how MPANs are being evaluated toward the long-term objectives for effective, equitable and viable biodiversity conservation (Jones et al. 2013; Ban et al. 2014; Pendleton et al. 2017; Sala et al. 2018). Despite well-established ecological, economic, governance, and social attributes associated with MPANs, the attributes associated with MPAN performance are often addressed in isolation from one another (Tognelli et al. 2009; Grorud-Colvert et al. 2011; Hargreaves-Allen et al. 2011; Heck et al. 2011; Davis et al. 2014; Horigue et al. 2014; Bixler et al. 2016; Zamborain-Mason et al. 2017). Studies focus on one or two individual characteristics, rarely evaluating them in an integrated manner (Halpern et al. 2010). Doing so may help understand how MPANs are performing by deciphering interactions between outcomes and the unique contexts that influence performance (De Santo 2013; Ban et al. 2014; Pendleton et al. 2017).

It is imperative to ensure evaluations capture a whole (human and biophysical) system perspective to understand the dimensions influenced by MPANs and those that influence their success. Currently, evaluations of MPANs, as understood from a global perspective (contributing to global targets), are largely based on quantitative area-based measures (CBD 2014; Campbell & Gray 2018; Failler et al. 2019), even though qualitative targets have been disseminated that provide holistic evaluation guidance (Hockings et al.

2000; Pomeroy et al. 2005; Geldmann et al. 2020; Grorud-Colvert et al. 2021). Contemporary areal-based evaluations are not sufficient to determine how and why MPANs are working (Spalding et al. 2016) as MPANs are not living up to their promise to reduce biodiversity decline (Tittensor et al. 2014; Spalding et al. 2016; Amengual & Alvarez-Berastegui 2018; IPBES et al. 2019).

The purpose of this dissertation was to identify how MPANs are evaluated from a global perspective. Specifically, I aimed to understand whether some of the fundamental attributes of MPANs and the indicators used to evaluate them are missing from MPAN evaluations. Accordingly, this entailed a multidimensional approach drawn from the four dimensions of sustainability to tease apart the composition of each dimension in MPAN evaluations (Murphy 2012; McGinnis & Ostrom 2014; Hill et al. 2015; United Nations General Assembly 2017; Partelow 2018; Wyborn et al. 2019; de Alencar et al. 2020; James & Magee 2020; Stephenson et al. 2021). This approach helps determine whether the overarching dimensions that shape MPANs were considered in evaluations (Boyd & Charles 2006) and describes the indicators used to evaluate them. Identifying MPAN indicators can help in MPAN evaluations, drawing together the elements understood to contribute to effective biodiversity conservation. This work aims to add insight into why we are not seeing the boon that a global network of MPAs promises. I came into this Ph.D. with the intention of carrying out research that would fill the gap in understanding how MPANs are evaluated from an international, multidimensional perspective, in hopes of identifying ways they can be improved. My research aims to answer the overarching question: how are MPANs evaluated from an international, multidimensional perspective? I aimed to answer this question through four more specific research questions:

- What indicators for evaluating MPANs exist in the academic literature, and how well are the elements of Target 11 evaluated? (Chapter two)
- How are the attributes of ecological, social, economic and governance dimensions considered when evaluating MPANs in practice? (Chapter three)
- What indicators are used to evaluate attributes of MPANs in practice? (Chapter four)
- What are the differences between the use of indicators described in the literature and in practice? (Chapter four)

1.3 Significance

Understanding how well MPANs achieve their goals and objectives is a key element in ensuring the success of the management action and progress toward international targets (Hockings et al. 2000, 2015; Pollnac et al. 2001; Salafsky et al. 2001; Pomeroy et al. 2005; Coad et al. 2013; Mascia et al. 2014; Addison et al. 2015). The success of global initiatives toward biodiversity conservation has been based on the quantity of area designated, but the quantitative aerial target is but one component of these goals. Global biodiversity conservation is predicated on achieving CBD Aichi Targets (CBD 2010). The qualitative elements of Aichi Target 11 reflect high-level, global discourse on how an MPAN could improve the status of biodiversity by focusing on the underlying dimensions that influence and are influenced by the MPAN process. These qualitative elements draw attention to elements that exist beyond those that can be easily quantified using areal coverage metrics. They also shift the narrative of conservation success from an ecological focus toward the incorporation of human dimensions by acknowledging the relationship between the protection of biodiversity and human wellbeing (Corrigan et al. 2017; Rees et al. 2018; Adams et al. 2019).

This dissertation is grounded in a multidimensional context that aims to understand the interdependent linkages between ecological and human dimensions that influence the realization of sustainability goals (McGinnis & Ostrom 2014; Partelow 2018; de Alencar et al. 2020; James & Magee 2020). Contemporary MPAN inquiry suggests that attributes of the human dimensions (economic, governance, and social) are imperative for successful ecological outcomes (Osmond et al. 2010; Voyer et al. 2012; Chen & Lopez-Carr 2015; Geange et al. 2017). However, consideration of these dimensions appears fragmented in MPAN evaluation literature (Fox et al. 2012). While an even distribution of indicators across those elements is not expected, focus on the evaluation of one element raises the risk of MPANs not meeting their expected goals. Such narrow focus may also distract from recognizing politically motivated implementation or infringements to social justice, which lead to distrust, conflict and violations (Santo & De Santo 2013; Dehens & Fanning 2018), and other unintended consequences (Weeks et al. 2014; Geldmann et al. 2020). This gap prompted me to wonder if the full range of attributes in each dimension that contribute to MPAN success are being considered in MPAN evaluations. Focus on one dimension raises the risk of a network not meeting its expected goals by overlooking other dimensions important to overall performance. Knowing where the gaps exist will enable further inquiry into where efforts should be focused to identify changes that need to be made for improvement of these biodiversity conservation tools. This study will add to the growing body of literature measuring whether MPANs are achieving their broad goals and objectives while integrating ecological and social considerations to generate effective conservation. As such I argue for a more multidimensional approach to evaluating MPAN performance that reflects the broad contexts that exist where MPANs are located.

1.4 Research methodology

I collected data for this study using a systematic literature review (Chapter two) and an online survey instrument (Chapters three and four). The literature review identified indicators used to evaluate MPANs in achieving the qualitative elements of Aichi Target 11 (Moher et al. 2009; CBD 2011). The data obtained from the literature were then used to characterize what indicators were used in evaluating MPANs and set the stage for the following Chapters. The indicators identified in the literature informed an online survey instrument I developed to elicit information from experts with experiential knowledge about MPAN evaluation through lived and worked experiences (Martin et al., 2011). Individuals were considered 'experts' if their role included that of a manager, researcher, or field technician working in an MPAN. The theoretical perspective underpinning this approach follows a pragmatic research paradigm (Moon & Blackman 2014; Martela 2015; Shah et al. 2018). This pragmatist perspective privileges both positivist methodological position, in focusing on the academically defined indicators used to measure MPAN attributes in the literature, and a constructivist position in recognizing and accommodating for the subjective situational contexts by which MPAN practitioners measure attributes. The online survey was composed of multiple-choice and open-ended questions in using the Qualtrics software (v. 12018). Every survey was available in English, French, and Spanish to be more inclusive of many non-English speaking regions where MPANs currently exist, and I was able to translate them. The survey was anonymous and fully confidential, precluding a measure of response rate. The survey was distributed using a combination of systematic sampling and snowball sampling to reach a broad suite of practitioners. Over 300 invitations were sent to individuals, corresponding authors of peer-reviewed literature on MPANs, and MPAN practitioners whose email addresses were publicly available. Survey invitations were also distributed through mailing lists and on social media. Furthermore, every invitee was requested to forward the survey to team members or collaborative partners in a "snowball approach" (Christopoulos 2011) to achieve broader participation. Only fully completed surveys were used in analyses. I received 156 responses, 77 of which were fully completed, and therefore used in analyses.While we strive for perfection, particularly whilst entrenched in a Ph.D., limitations are inherent in any research design, this is no different. Limitations exist with survey design, elicitation sample, statistical analyses, and even the theoretical constructs underpinning this, and any, investigation.

The survey was publicized and launched on 28 February 2020 until 1 May 2020. Prior to data collection, a pilot of the questionnaire was performed to adjust length and language, if necessary. The pilot was carried out with two government researchers and three university researchers, all of whom work on marine conservation issues. Ethical approval was granted by Memorial University's Interdisciplinary Committee on Ethics in Human Research (Approval #20200830) and the University of Victoria Office of Research Services' Human Research Ethics Board (Approval #19-0363-02). All data collection followed the university's informed consent processes.

1.5 Organization of this dissertation

In addition to this introductory Chapter, this dissertation includes three manuscripts and a final discussion Chapter. Each manuscript (Chapters two through four) focuses on a specific research question designed to understand the dimensions, attributes, and indicators used to evaluate MPANs. Each manuscript is a stand-alone paper intended for publication as a peer-reviewed journal article. Correspondingly, each Chapter contains individual literature reviews, methods, results, and discussions. A small amount of overlap in introductory material can be expected between the manuscripts as a function of this dissertation style.

One of the first steps of this dissertation, described in Chapter two, was to identify existing and proposed indicators of social, ecological, economic, and governance characteristics from peer-reviewed literature that contributed to global targets. The question posed here was: *What indicators for evaluating MPANs exist in the academic literature, and how well are the elements of Target 11 evaluated?* The results from this initial inquiry provided a structure from which the rest of this dissertation was based. Chapters three and four build on the results of Chapter two to structure a two-part expert opinion survey focused on the dimensions assessed and the indicators used to evaluate them. Both Chapters used an expert elicitation survey approach to provide multiple perspectives about the attributes considered important for MPAN effectiveness and the indicators used to measure network elements. Chapter three aimed to characterize attributes practitioners considered in evaluating MPAN effectiveness, and their perceived levels of importance. The question posed here was: *How are the attributes of ecological, social, economic and governance dimensions considered when evaluating MPANs in practice*? In asking this question, this Chapter also addressed the various objectives associated with MPANs, such as cultural values and human wellbeing, and how these might influence the attributes considered and their perceived level of importance. Chapter four builds on the indicators identified and classified from Chapter two, and the additional attributes considered by experts in Chapter three. Two questions were posed here: *What indicators are used to evaluate attributes of MPANs in practice?* and *What are differences between the use of indicators described in the literature and in practice?* In this chapter I compared the indicators from the academic literature to those selected by participants to see if there were differences in the indicators used, and where these differences occurred. Chapter five integrates the previous chapters and discusses the contributions of this dissertation to the field marine conservation. It acknowledges some limitations of the study and points to future areas for research. The relevance of the research is discussed in the context of Aichi Biodiversity target 11, and subsequent post-2020 Global biodiversity framework.

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Co-authorship statement

Chapters two, three and four were co-authored with Dr. Natalie Ban, Dr. Gerald Singh, Dr Rodolphe Devillers and Dr Joachim Claudet. I was the principal contributor in the project proposal, study design, implementation of research methods, data analysis and the preparation of the manuscripts.

For Chapter Two, Dr Devillers and Dr. Ban contributed extensively to the project proposal and study design. Dr Devillers, Dr. Ban, Dr Claudet and Dr Singh contributed and preparation of the manuscript. Chapter Two has been published in the peer-reviewed academic journal Conservation Letters (2020); thus, formatting reflects the journal submission requirements.

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2. How far have we come? A review of MPA network performance indicators in reaching qualitative elements of Aichi Target 11

Abstract

Effective networks of marine protected areas (MPAs) are explicitly recognized and called for in international biodiversity conservation strategies such as the Aichi Targets. While various indicators have been proposed to assess the effectiveness of individual MPAs, no comprehensive set of indicators exists for MPA networks, particularly for Aichi Target 11. The qualitative elements of this target recognize the value of social, economic, governance, and ecological factors in achieving effective biodiversity conservation. Here, we used a systematic literature review to identify indicators of MPA network effectiveness. We reviewed 64 publications, identifying 49 indicators that could be aligned with the qualitative elements. Results showed that evaluations of MPA network effectiveness predominantly focused on effective management while neglecting equitable management and integration into the wider land and seascape. Indicators tended to focus on ecological characteristics, overlooking social, economic, and governance dimensions. Key challenges in addressing these gaps include identifying conflicting priorities and objectives in adjacent marine and land areas that interfere with cooperation and knowledge sharing, and ensuring diverse areas with distinct social and ecological contexts are considered. This study provides the first review of indicators for assessing MPA networks and adds to the literature by assessing whether current and future targets can be met.

2.1 Introduction

The protection of global marine and coastal ecosystems has garnered increased scientific and political interest in the last decade, driven by international targets such as the

Convention on Biological Diversity (CBD) Aichi Target 11 (Sala et al. 2018). Aichi Target 11 calls for "… at least 17 percent of terrestrial and inland water areas, and10 percent of coastal and marine areas of particular importance for biodiversity and ecosystem services [to be conserved through] effectively and equitably managed, ecologically representative, well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape" (CBD 2011). The amount of area each country sets aside for terrestrial and marine protected areas is the principal indicator for determining the effectiveness of this approach (Gannon et al. 2017; Adams et al. 2019). While focusing on the area alone makes it more straightforward to assess and may help bolster political will, such a simple measure falls short as a proxy for protected area effectiveness (Santo & De Santo 2013; Zupan et al. 2018; Coad et al. 2019; Claudet et al. 2020). The six qualitative elements of Aichi Target 11 (hereafter *qualitative elements*; 'areas of importance for biodiversity conservation and ecosystem services', 'ecological connectivity', 'equitable management', 'effective management', 'integration into the wider land and seascape' and 'ecological representation') are designed to ensure that established protected areas are effective beyond consideration of the quantitative target by providing a conceptualization of how MPA networks should attain biodiversity conservation (Rees et al. 2018; Geldmann et al. 2020).

Aichi Target 11 contributes to a growing awareness that conservation strategies need to move beyond protecting individual, isolated areas (CBD 2011; Adams et al. 2019). This is particularly relevant for marine systems, which is the focus of this research. Marine Protected Areas (MPAs) are established to safeguard threatened marine ecosystems and species from destructive human activity (CBD 2011). A collection of individual MPAs intentionally arranged into an organized group is considered an MPA network (hereafter MPAN). MPAs within a network thereby operate in a cooperative and synergistic manner (IUCN-WCPA 2008). As a result, an MPAN is thought to be more than the sum of its parts (Grorud-Colvert et al. 2014). MPANs are essential biodiversity conservation tools designed to improve marine biodiversity protection by encompassing spatial scales that better reflect species' life history distributions (Green et al. 2007). They can help mitigate the impact of climate change through the application of network design elements such as replication, representation, and connectivity (McLeod et al. 2009). MPANs may also enable cost-sharing and collaboration among communities and conflict relief in high-use areas (White et al. 2005). Aichi Target 11 also promotes conservation beyond boundaries by recognizing the crucial role of contextual ecological, economic, governance, and social factors working in concert to influence ecological outcomes (Hill et al. 2016; Gill et al. 2017; Yates et al. 2019). Implementing effective MPANs requires careful consideration of these factors, also known as dimensions, that underlie the social and ecological links within the ecosystem (McGinnis & Ostrom 2014). Therefore, here, we define effectiveness as the degree to which MPANs demonstrate characteristics related to the six Aichi Target 11 qualitative elements (Woodley et al. 2012; Gannon et al. 2017).

Monitoring and evaluation is an important step in deciphering whether a conservation approach is reaching its objective(s) (Heink & Kowarik 2010; Conservation Measures Partnership 2016). This process makes use of indicators to track progress of the project and understand the impacts of the intervention and whether objectives are being attained (Conservation Measures Partnership 2016). An indicator is a variable used to describe or measure the status of a particular characteristic of a system over time, such as change in abundance of a species (Pomeroy et al. 2004; Woodcock et al. 2017). Evaluations of MPA effectiveness exist for a range of objectives, from assessing the effectiveness of community management on livelihoods, fisheries, or agricultural practices to the benefits provided by MPAs for ecosystem health and biodiversity (Coad et al. 2013). Evaluating the effectiveness of MPANs will require assessing individual MPA contributions, as well as those specifically associated with MPANs. For instance, the well-established ecological benefits of individual [fully protected] MPAs (Lester & Halpern 2008; Sala & Giakoumi 2017) and the factors such as size, age, socioeconomics, and governance that influence effectiveness across various scales (Charles & Wilson 2008; Claudet et al. 2008; Mizrahi et al. 2018) have been validated in MPANs (Lowry et al. 2009; Grorud-Colvert et al. 2014). As such, individual MPAs may provide relevant insights for MPANs (IUCN-WCPA 2008).

While many studies proposed indicators that can help assess the effectiveness of individual MPAs (Woodcock et al. 2017), indicators for measuring network-specific elements (e.g., connectivity, representativeness) are infrequently used in practice (Gannon et al. 2017; Geldmann et al. 2021). Furthermore, a synthesis of indicators that can be used for evaluating the effectiveness of MPANs in achieving Aichi Target 11 (e.g., equity, land-sea integration) are still needed (Geldmann et al. 2020). Here, we draw upon several existing MPA evaluation frameworks to organize indicators and ensure a practical connection to existing evaluation initiatives (Pomeroy et al. 2004; Leverington et al. 2010; Gannon et al. 2017). These frameworks were developed over time, in consultation with global participants; as such, they provide a context and structure for indicator organization. Furthermore, these frameworks apply guidance for assessing management effectiveness which details six management stages that outline the iterative process inherent in effective protected area management (Hockings et al. 2000). Finally, the frameworks provide a categorization of indicators based on the ecological, economic, governance, and social dimensions previously discussed.

The purpose of our literature review was to identify existing indicators from the MPAN evaluation literature, then characterize the use of these indicators in evaluating MPAN effectiveness toward achieving Target 11. MPANs are multi-faceted, as a tool for conservation, they influence and are influenced by complex social and ecological relationships (Corrigan et al. 2017; Rees et al. 2018). We explored how indicators are used to measure each qualitative element, including the dimensions (social, ecological, economic, and governance) and six management stages (context, planning, process, input, output, and outcome) they are associated with. We identified the gaps in the types of indicators used to evaluate MPANs and their diversity and distribution in evaluating the qualitative elements. The gaps identified through this review will enable further inquiry into the best approach to evaluate networks of MPAs.

2.2 Methods

We conducted a systematic literature review to identify indicators used to assess MPAN effectiveness in achieving the qualitative elements (Moher et al. 2009). We searched peer-reviewed publications using Web of Science core collection database (1900 to April 2019) and Elsevier's Scopus database (1995 to April 2019) (see Table A2.1 for the search terms used). In addition, we used the citation tracing method (i.e., reviewing citations within selected publications) to add relevant publications that were not captured in the original literature search. For all selected publications, we reviewed titles and abstracts to ensure that studies evaluated or discussed the effectiveness of some aspects of an MPAN or system of MPAs. To avoid the introduction of subjective error through interpretation, we accepted what each study identified as an MPAN, not further evaluating whether it fit our definition. Publications that discussed MPAN design or the status of an area prior to MPAN implementation were excluded (Fig 2.1) as we wanted studies that specifically assessed the network after implementation. We coded each of the final publications selected for: (1) the geographic location of the study; 2) one or more of the six Aichi Target 11 qualitative elements evaluated (Table 2.1, Fig 2.2); (3) one or more of the dimensions covered by the research (ecological, social, economic, or governance, Table 2.2); (4) the stages being evaluated in the process of effective management (i.e., context, planning, inputs, process, and outputs) as proposed in Hocking et al.'s (2000) framework for the evaluation of protected area management effectiveness; and (5) the variable(s) used to evaluate each element of the MPAN. Finally, (6) we hierarchically organized each variable into an indicator, noting that some variables were already indicators.

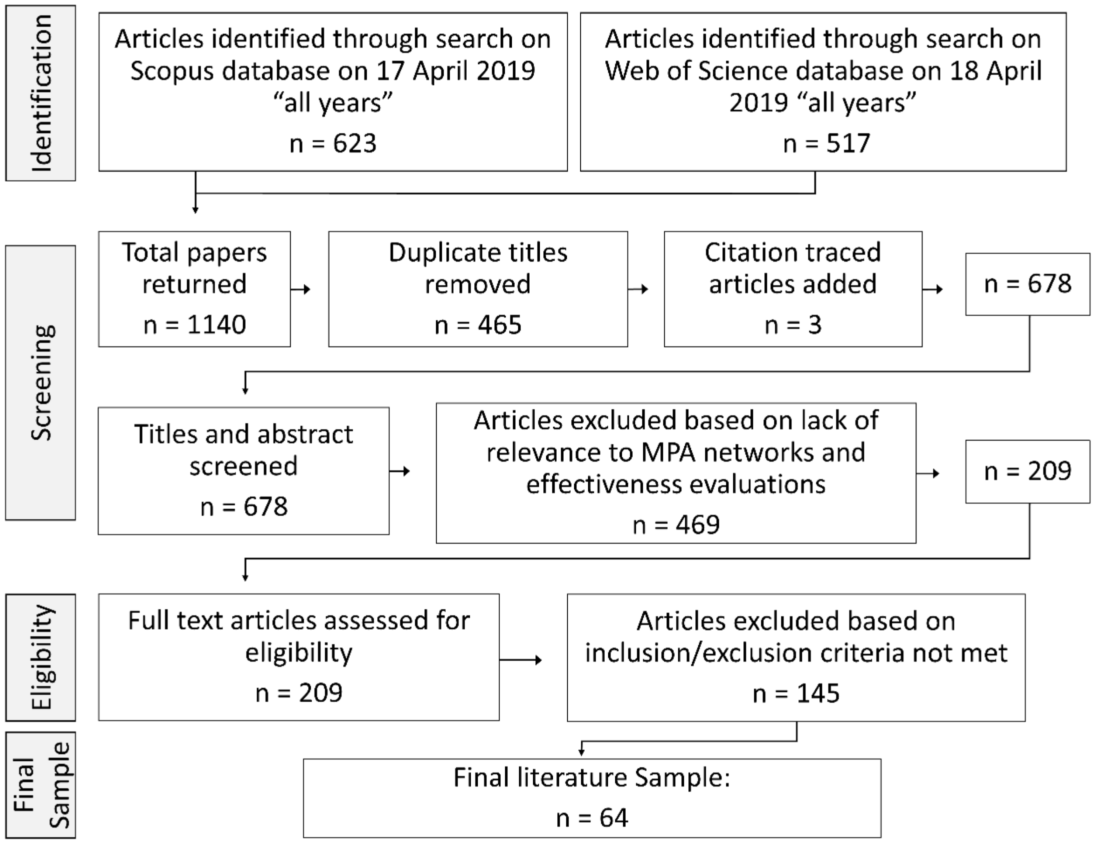

Figure 2.1. Flowchart outlining the literature search and review process based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Four Phase Flow Diagram for Systematic Reviews (Moher et al. 2009).

Table 2.1 Description of the six Aichi Target 11 qualitative elements used in this review; abbreviations used in some figures are in parentheses.

Aichi Target 11 qualitative element	Description
Areas of particular importance for biodiversity and ecosystem services (Areas of Importance)	Areas of importance are considered "geographically or oceanographically discrete areas that provide important [biodiversity and ecosystem] services to one or more species/ populations of an ecosystem or to the ecosystem as a whole, compared to other surrounding areas or areas of similar ecological characteristics, or otherwise meet the criteria as identified in annex I to decision IX/20" (CBD 2008).
Effectively managed	Effective management describes the extent to which management achieves goals and objectives designated for a particular area (Hockings et al. 2006). This includes design issues relating to both individual sites and protected area systems; adequacy and appropriateness of management systems and processes; effective public participation and social policy processes, and delivery of protected area objectives (Woodley et al. 2012).
Equitably managed (Equity)	Equitable management highlights the impact and benefit of conservation actions on human wellbeing and social systems, including: the fair distribution of benefits and livelihood opportunities (distributional equity); the process for involvement and inclusion of stakeholders in planning, implementing, and administering (procedural equity); and the process of acknowledging and accepting the legitimacy of rights, values, interests, and priorities of different actors and respecting their human dignity (recognitional equity) (Juffe-Bignoli 2014; Schreckenberg et al. 2016).
Ecologically representative (Representative)	Representativeness is considered the inclusion of areas that represent the entire suite of "different biogeographical subdivisions of the global oceans and regional seas that reasonably reflect the full range of ecosystems, including the biotic and habitat diversity of these marine ecosystems" (CBD 2008). Representative includes the element of replication to ensure risk is minimized in the event of unforeseen or catastrophic events (Rees et al. 2018).
Well-connected (Connectivity)	Connectivity in relation to MPA networks concerns the "linkages whereby protected sites benefit from larval and/or species exchanges, and functional linkages from other network sites" (CBD 2008).
Integrated into wider landscape and seascape (Integrated)	In recognition that Protected Areas cannot work in isolation, this element identifies the importance of integrating MPAs with other conservation and management tools, such as fisheries management or land use plans for land-based sources of pollution. Other considerations for this element include potential cumulative impacts stemming from climate change, ocean acidification, ocean noise, and pollution (Juffe-Bignoli 2014; Rees et al. 2018).

We consider a variable as a factor, trait, or condition that noticeably responds to a management action and can therefore be used to measure the effect of that action. Although variables may or may not be explicitly identified as such in the publications, we considered each measurement of a qualitative element as a variable (Pelletier et al. 2005). The distribution of pink sea fans in southwest UK waters (Pikesley et al. 2016), for example, is considered a variable for assessing MPAN connectivity. We hierarchically classified each site-specific variable into indicators to reduce the redundancy of site-specific variables and match indicators at a similar scale of measurement (Leverington et al. 2010). The variable “distribution of pink sea fans" for example was organized into the indicator “species distribution” (See Table A2 for categorization). This hierarchical classification was based on existing frameworks designed to assess individual MPAs (Pomeroy et al. 2004; Leverington et al. 2010) and MPA networks (Gannon et al. 2017).

We counted the number of times each element was assessed, the indicators used to assess it, and the dimensions and management stages associated with each indicator. Finally, we identified gaps in indicators used in the literature [to date] by evaluating the

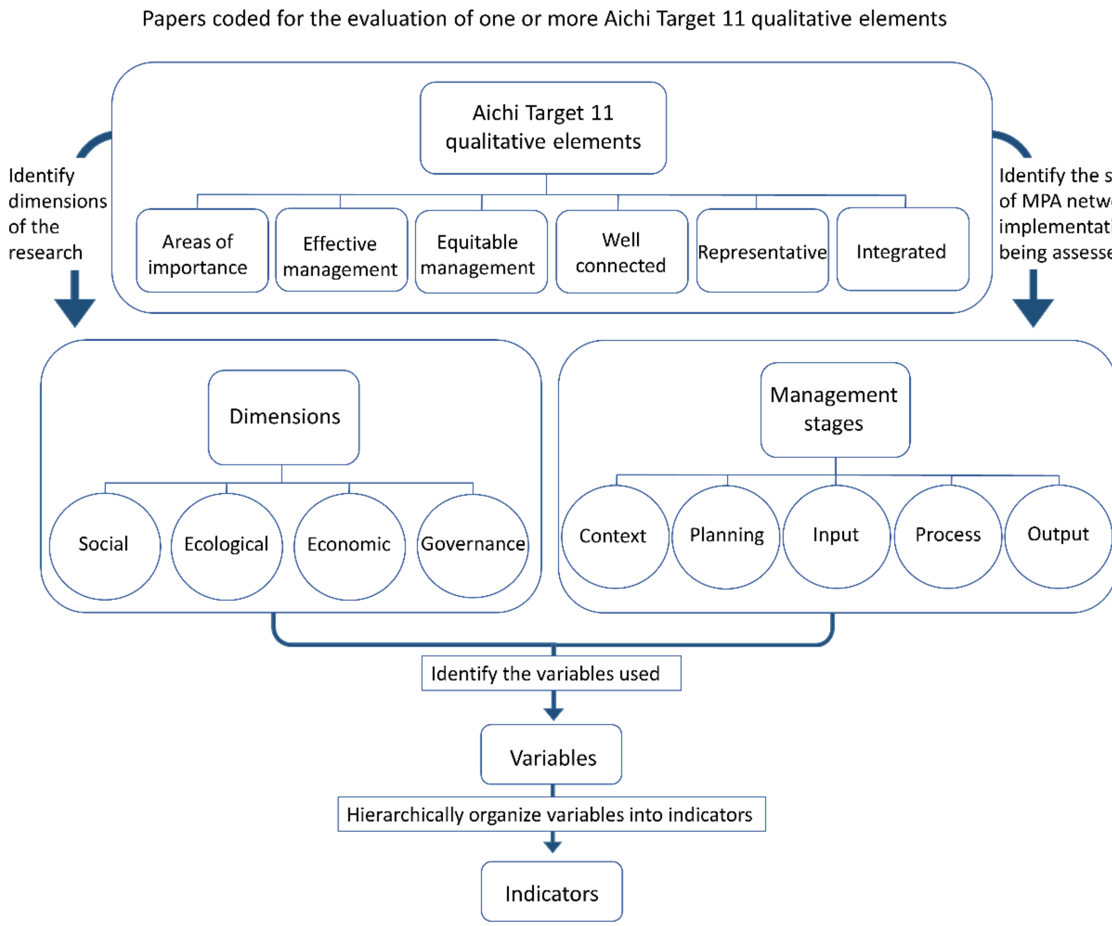

Figure 2.2. Organizational structure of the decision-making process. Papers were first coded for the Aichi Target 11 qualitative elements they evaluated, then each paper was assigned to one or more dimensions in which the research was associated and to a management stage based on where in the process of MPAN management and implementation the research was taking place (following Hockings et al. 2006). The factor(s) that were used to measure change were identified as variables. The variables were then hierarchically assigned to indicators based on Pomeroy et al. (2004), Leverington et al. (2010), and Gannon et al. (2017).

composition of the indicators, specifically the dimensions and management stages associated with each indicator. We then developed a flow diagram (SankeyMATIC, Bogart 2016) to show the structure and distribution of the suite of indicators measuring the qualitative elements. This diagram reflects the frequency each indicator is linked to the management stages, dimensions, and qualitative elements.

Table 2.2 Description of the terminology used in this paper.

Term	Description
Variable	An observed (quantifiable) factor, trait, or condition that responds to a local change such as the implementation of a management action (Pelletier et al. 2005).
Indicator	An indicator is a suite of one or more qualitative or quantitative variables (social, environmental, etc.) used to measure the status or change over time of a particular characteristic of interest in an ecosystem (Pomeroy et al. 2004).
Dimension	Dimensions are the ecological, economic, governance, and social factors inherent in social-ecological systems that influence and are influenced by a management action (Pomeroy et al. 2004). Several attributes of each dimension overlap with other dimensions. The ecological dimension is important to understand the state of the system, the species, or habitats of interest so that an intervention can proceed in an appropriate manner suitable to the needs of the species and habitats. The governance dimension includes aspects that help maintain or influence legislation, management, and decision-making. The social dimension includes aspects of perceptions, wellbeing, equity, values and beliefs, and human health. The economic dimension includes financial resources and capital necessary to implement and manage MPANs and achieve conservation goals.
Management stage	Six management stages are considered important in the progress toward effective management of MPAs. They outline an adaptive process (context, planning, process, input, output, and outcome) inherent in effective protected areas design, implementation and management (Hockings et al. 2006). Context refers to the underlying conditions associated with a protected area, including status and threats, and target species; the needs, abilities, and desires of the stakeholders. Planning refers to establishing a clear objective, and issues of design, including preferred strategies or approaches to achieve the objective(s). Input refers to the resources (financial, personnel, material) needed for the project to come to fruition. Process relates to how the actions undertaken to achieve results- the adequacy of approaches in relation to the management objectives. Output pertains to the goods and services produced to realize the MPA objectives. Outcome relates to the highest level of results in relation to long term objectives- fully achieving Aichi Target 11.

To support our general findings on the suite of indicators and to help highlight gaps in how indicators are used to measure effectiveness, we calculated Shannon (H’) diversity and evenness (E). These metrics are commonly used in community ecology to characterize species diversity, which we adapted to look at the diversity of indicators across qualitative elements. Shannon diversity incorporates total number and distribution of individuals and is sensitive to rare species, which is necessary to capture the rare presence of indicators for some dimensions. To calculate Shannon’s diversity, we used the formula: $H' = -\sum n_i/N * \ln(n_i/N)$, where n_i is the number of indicators used to evaluate each individual quantitative element *i* and where N is the total number of indicators used across all qualitative elements. A high diversity score means that many different indicators are used to evaluate a specific qualitative element, while a low score means that one or a few indicators are used to evaluate an element. We also calculated Pileau’s Evenness (J’) to quantify the distribution of indicators used to measure each qualitative element, as $E = H'/\ln(S)$, where S refers to the indicator richness, the number of different indicators used to measure a qualitative element (Verberk 2011). A higher evenness score indicates that a given qualitative element is assessed by a wide variety of indicators, with no indicator dominating the evaluations. A low evenness score means that few (or one) indicators are used predominantly to evaluate this element. These matrices show how the indicators were distributed across each Aichi Target 11 qualitative element. All analyses and figures, unless specified otherwise, were done using R (R core team 2019) with package vegan 2.5-6 (Oksanen et al. 2019) and ggplot2 version 2_3.3.2 (Wickham 2016).

2.3 Results

Our review identified 65 papers that discussed the effectiveness of an MPAN or system of MPAs in reaching one or more qualitative elements. Our analysis of those papers identified 223 variables, organized into 48 headline indicators that can help assess the effectiveness of MPANs in achieving Aichi Target 11 qualitative elements. Each indicator identified from the literature matches one or more qualitative elements. We found an uneven distribution in the evaluation of Aichi Target 11 qualitative elements in the literature. MPANs were predominantly evaluated for management effectiveness. Ecological indicators identified in our study are closely aligned with those of individual MPAs (Pomeroy et al. 2004; Leverington et al. 2010) and with indicators previously identified for MPANs (Gannon et al. 2019). Publications reviewed focused on 34 MPANs from 15 countries (Fig 2.3, Table A2.3), and four regions including the Mediterranean Sea (n=5), Northeast Atlantic (n=2), Western Pacific (n=1), Persian/Arabian Gulf (n=1), and three studies located in an area beyond national jurisdiction (ABNJ), the OSPAR network. Several studies were global in scope (n=5). We found that MPANs in Australia were assessed most often (n=14), followed by the USA (n=11) (Fig 2.3). Several networks were assessed multiple times by various researchers, including the Great Barrier Reef, and the Hawai'ian MPANs (see Table A2.3 for list).

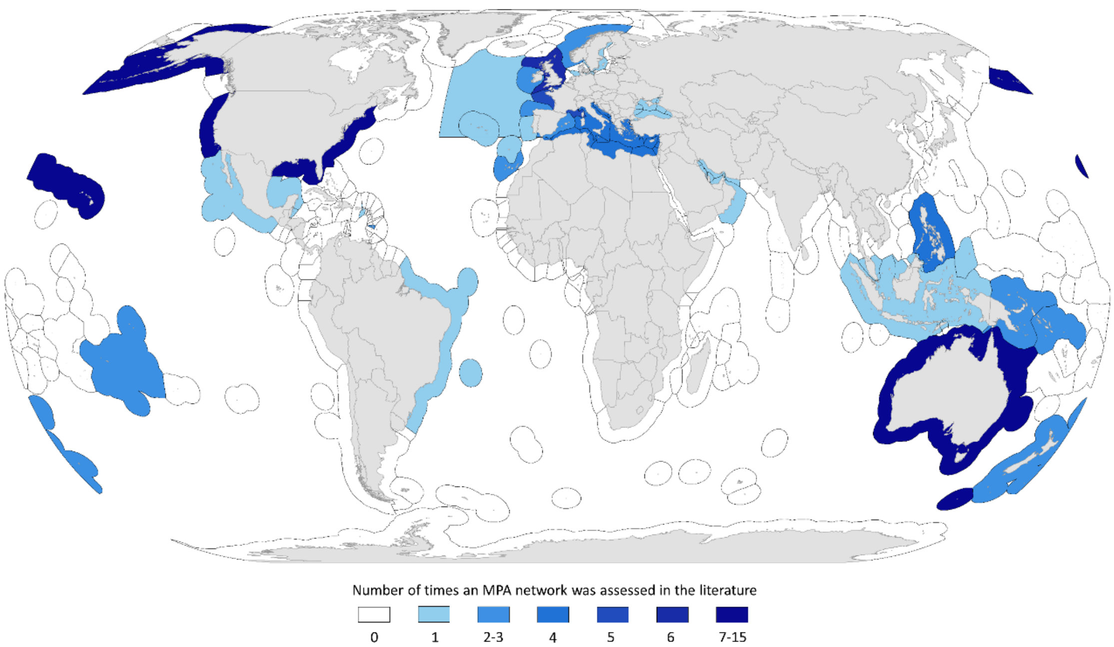

Figure 2.3. Exclusive economic zones (EEZs) of countries and regions that have MPANs evaluated in our literature review. Color grades represent the number of times an MPAN was studied in the countries associated with the EEZ; OSPAR area beyond national jurisdiction (ABNJ) is also depicted, having been assessed once.

2.3.1 Aichi Target 11 qualitative elements

'Effective management' was the qualitative element assessed most thoroughly. This element was assessed 155 times, 69% of all indicators identified were used to evaluate this element (Fig 2.4). Indicators used to evaluate effective management were associated with all dimensions and all management stages though disproportionately assessed ecological and governance dimensions (48% and 40% respectively) over social and economic dimensions (7% and 5% respectively; Fig. 2.5a). Output and process- associated indicators made up half of indicators used in evaluating effective management (31% and 21%, respectively), while outcome, context, planning, and input made up the remainder (16%, 14%,10% and 8% respectively, Fig 2.5b).

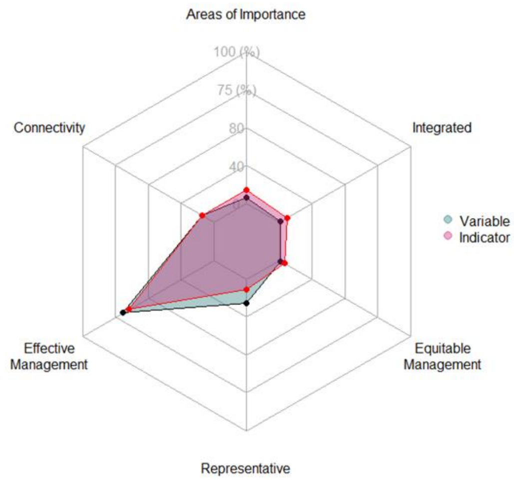

Figure 2.4. Proportion of indicators used to assess each Aichi Target 11 qualitative element. The blue line represents the proportion of times each qualitative element was evaluated in the studies reviewed. Qualitative elements were assessed a total of 232 times; this corresponds to the number of variables identified in the papers we reviewed. The orange line represents the proportion of indicators used to assess each qualitative element. A total of 49 indicators were identified.

Evaluations of 'Equitable management' were limited. 'Equitable management' was evaluated twice, with two indicators (Fig 2.4, Table A4). The indicators were used to assess the social and governance dimensions of this element (Fig 2.5a), with a focus on the context and outcome stages of management (Fig 2.5b). The social indicator "Perception of MPA effects on livelihood" measured fishers' satisfaction with the process of implementing an MPAN (distributional equity)(Fig 2.6, Table A2.2). Indicators used to assess recognitional, procedural equity and other aspects, such as equitable distribution of benefits, human wellbeing were missing in this review.

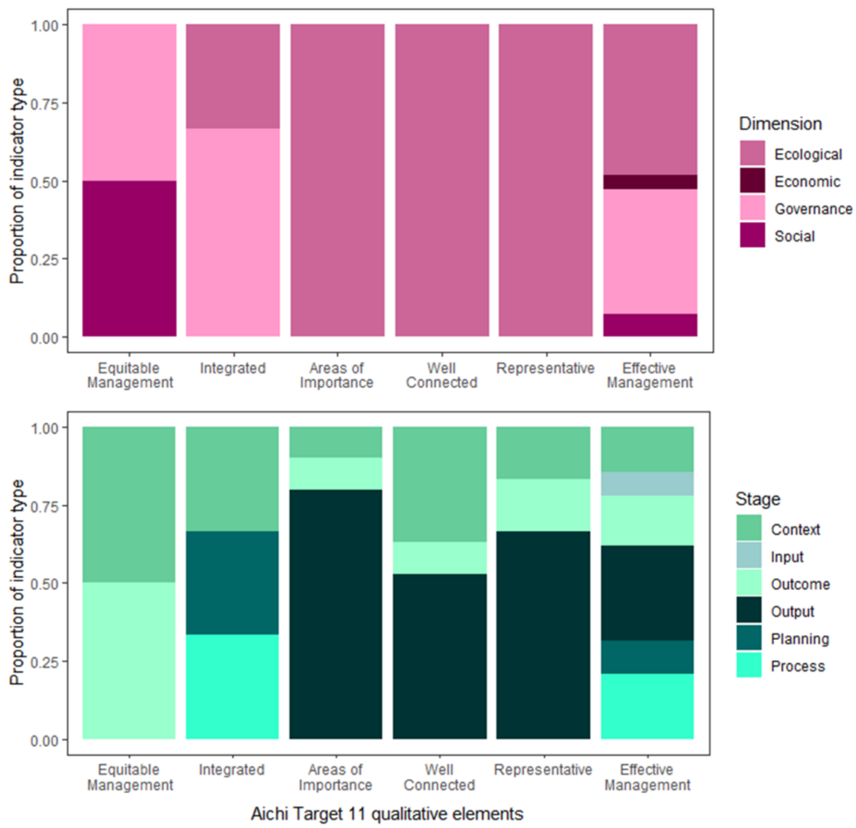

Figure 2.5. Proportion of indicators associated with the different dimensions (a) and management stages (b) used to measure each qualitative element. The various dimensions are represented in panel (a), the management stages are represented in panel (b).

'Areas of importance for biodiversity conservation' was assessed 10 times using five indicators (Fig 2.4). All of the indicators were used to assess the ecological dimension of this element (Fig 2.5a). These indicators also most commonly focused on outputs (80% of the indicators for this element; Fig. 2.5b) to evaluate effectiveness of MPAs in covering key species and biodiversity areas. Indicators measured ecological outcomes (10%) for species richness in areas of importance covered by an MPA. Indicators measuring ecological context (10%) focused on distribution patterns of focal species in order to make decisions on appropriateness of spatial arrangements (Péron et al. 2013).

‘Ecological connectivity’ was evaluated 19 times. All five indicators used to evaluate this element focused in the ecological dimension (Fig 2.5a). Output (53%), context (37%) and outcome (11%) were the management stages evaluated (Fig 2.5b). Ecological connectivity indicators focused on species and habitat distribution and dispersal, and spatial arrangement of protected areas in a network (Fig 2.6; Table A2.2).

‘Ecological representation’ was assessed 36 times using four indicators (Fig 2.4). These indicators were used to measure output (67%), outcome (17%) and context (17%) stages of implementation solely within the ecological dimension (Fig 2.5). The indicator “Number of replicate habitats” was not previously associated with indicators from existing frameworks. This indicator was used to evaluate the effectiveness of a representative system in minimizing risk of negative impacts (Fernandes et al. 2005).

‘Integration into the wider landscape and seascape’ was assessed three times (Fig 2.4). One ecological indicator was used to evaluate the influence of terrestrial sediments on an MPA. Two governance indicators were used to measure planning and process stages of integrated and transboundary management (Fig 2.6; Table A2.2), “Level of regional cooperation and coordination” and “Existence of integrated management measures in management plans”. The indicators used to evaluate integration were not identified in existing frameworks. Indicators used to assess integrated practices regarding the land-sea connection, and those to assess social aspects of integration such as community cohesion or knowledge sharing are largely missing.

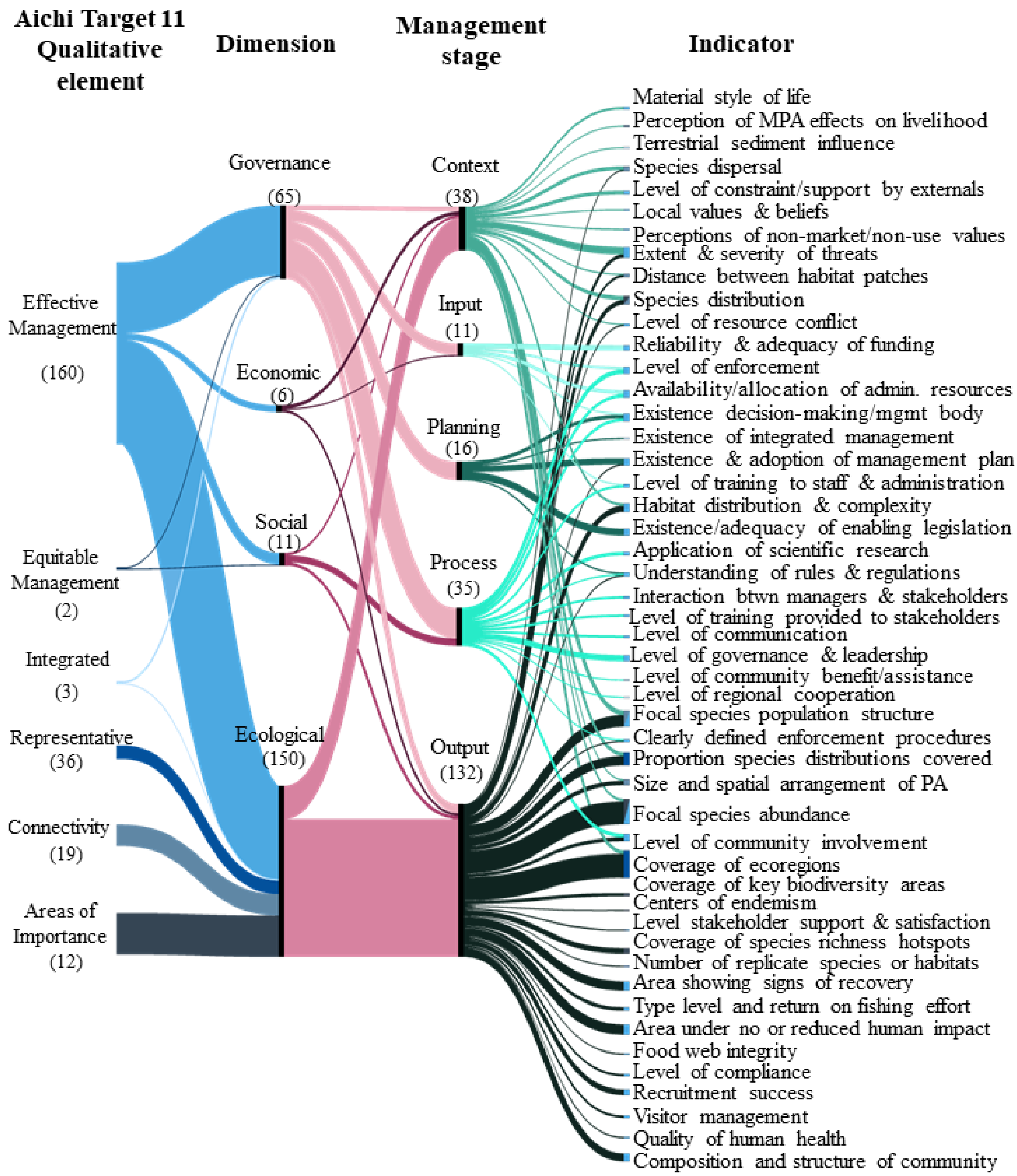

Figure 2.6. Flow diagram describing the use of indicators in evaluating the Aichi Target 11 qualitative elements with their associated dimensions and management stages. For definitions of the Aichi elements, see Table 2.1. The colors are a visual aid to decipher the Target 11 qualitative elements, dimensions, management stages and indicators. Each node, represented by a rectangle, represents a qualitative element, dimension, management stage or indicator, as described in the diagram. The thickness of the nodes and lines is proportional to the number of times an indicator was used in that component. The width of each line is proportional to the number of times (number in parentheses) this component was assessed. Dimensions describe the governance, social, economic, and ecological factors that influence MPANs. Management stages describe where in the process of MPAN implementation the indicators are being used (for definitions see Table 2.2).

2.3.2 Indicator dimensions and management stages

Indicators were primarily associated with ecological and governance dimensions (20 and 19 indicators, respectively), while indicators associated with economic and social dimensions were more limited (4 and 5 indicators, respectively; Fig 2.6). Outputs and outcomes were predominantly evaluated with ecological indicators. Input was the management stage assessed the least and only evaluated in terms of governance and economics of effective management. Ecological indicators were used to assess context, output and outcome stages of five of the six Aichi Target 11 qualitative elements (Fig 2.6, Table A2). Governance indicators were also used in the evaluation of five of the six management stages. Social indicators were used to assess context, input, process, and output stages of effective management and equitable management, while economic indicators were used to assess context, input, and output stages of effective management.

2.3.3 Indicator diversity

Results from measuring diversity of each suite of indicators that represent an Aichi Target element (Table 2.3) allowed us to quantify how the indicators were distributed across each qualitative element (Table 2.3, Fig 2.7). Shannon diversity (H') confirmed that 'effective management', which was evaluated the most, had the greatest abundance and largest diversity of indicators (H' = 3.3). In contrast 'equitable management' was evaluated the least and had the lowest diversity of indicators (H' = 0.69). Diversity of indicators used to assess 'representativeness' was also low (H' = 0.85; Table 2.3). Diversity of indicators used to assess 'connectivity', 'areas of importance', and 'integration' were moderate with respect to the suite of indicators used to evaluate the qualitative elements (H' = 1.5, 1.4, and 1.1 respectively). Evenness scores range between 0.6 and 1. The small sample sizes, however, reduces the reliability of these findings.

Table 2.3 Shannon diversity and evenness of indicators for each qualitative element assessed.

Qualitative element	S Indicator Richness	N Indicator Abundance	H' Shannon Diversity	J' Pileau Evenness J'
Areas of Interest	5	12	1.42	0.88
Well Connected	5	19	1.49	0.93
Effective Management	35	153	3.29	0.92
Equitable Management	2	2	0.69	1
Integration	3	3	1.10	1
Representative	4	36	0.85	0.61

2.3.4 Unique indicators

Several studies used indicators not yet recognized in the MPA evaluation frameworks we used (Pomeroy et al. 2004; Leverington et al. 2010; Gannon et al. 2019). Three of these indicators relate to the element of integration: “Existence of integrated management measures”, “Level of regional cooperation and coordination”, and “Level of terrestrial sediment influence”. One indicator relates to ecological representation: the “Number of replicate habitats” and one relates to the social dimension of effective management: “Level of compliance”. "Level of compliance” was used three times to assess the influence of MPANs on changing levels of compliance and poaching and, conversely how levels of compliance influence effectiveness of MPANs. Finally, 18 indicators used in the referenced frameworks were not mentioned in the literature we reviewed (see Table A2.5). These missing indicators include community social, cultural, economic and governance indicators as well as indicators measuring ecosystem services.

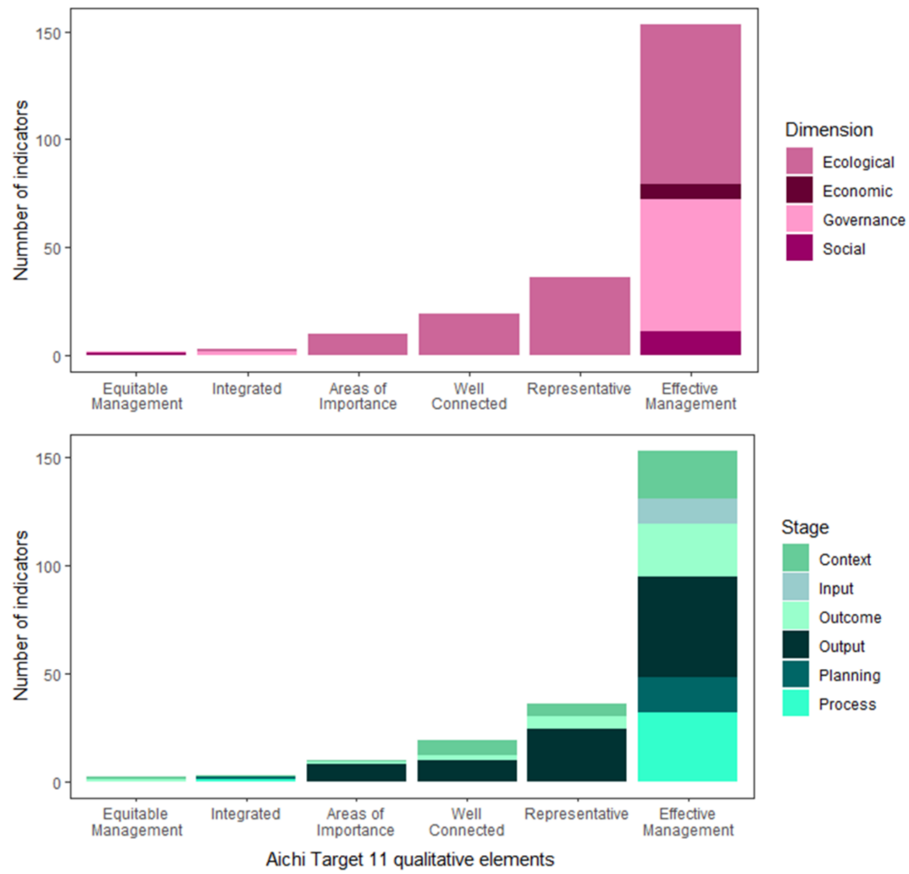

Figure 2.7. Abundance and diversity of the types of indicators used to measure each qualitative element. The number of indicators representing dimensions are shown in panel a; the number of indicators representing implementation stages are shown in panel b. Indicators for effective management show the greatest abundance and diversity while equitable management has the least.

2.3.5 Leading indicators

The indicators most commonly used across responses could form the basis of a core suite of indicators to evaluate MPANs effectiveness (Table 2.4). Chief among these was "Coverage of ecoregions" used 23 times to evaluate representativeness. Another indicator for representativeness that was used more often than others was "Proportion of species distributions covered by MPAs" (Table 2.4).

Table 2.4 Leading indicators for each qualitative element identified from this review.

Qualitative element	Indicator	Count
Representative	Coverage of ecoregions	23
	Proportion of species distributions covered by MPAs	11
Effective Management	Focal species abundance	15
	Focal species population structure	13
	Extent and severity of threats	11
	Area under no or reduced impact	10
Well Connected	Species distribution	6
	Size and spatial arrangement of MPAs	5
	Species dispersal	4
Areas of Importance	Coverage of species richness hotspots	4
	Coverage of key biodiversity areas	3
Equitable Management	Level of stakeholder support and satisfaction in management	1
	Perception MPA effects on livelihood	1
Integrated	Existence of integrated management measures in management plans	1
	Level of regional cooperation and coordination	1
	Terrestrial sediment influence	1

"Focal species abundance" and Focal species population structure" were the principal indicators for effective management (used 15 and 13 times, respectively), followed by "Area under no or reduced impact" and "Extent and severity of threats" (used 10 and 11 times, respectively). Principal connectivity indicators include "Species distribution", "Size and spatial arrangement of PAs" and "Species dispersal" (used 6, 5, and 4 times, respectively). "Coverage of species richness hotspots" and "Coverage of Key Biodiversity areas" were the principal indicators for Areas of Importance, used 4 and 3 times each, respectively. Indicators for Equitable management and Integration were limited; each used once (Table 2.4).

2.4 Discussion

Despite the recent progress in designing and implementing MPANs (Gannon et al. 2019), marine ecosystem health continues to decline (IPBES et al. 2019). Assessing whether MPANs are effective tools for biodiversity conservation is of fundamental importance to help guide future conservation strategies (Grorud-Colvert et al. 2014). In addition to the 10% aerial target, the qualitative elements of Aichi Target 11 provide guidance on how to safeguard marine biodiversity and ecosystem services. These qualitative elements shift the narrative of conservation success from an ecological focus toward the incorporation of human dimensions by acknowledging the relationship between the protection of biodiversity and human wellbeing (Corrigan et al. 2017; Rees et al. 2018; Adams et al. 2019). Our review of peer-reviewed publications found strong evidence of an uneven evaluation of effectiveness across the qualitative elements, with many MPAN evaluations not addressing most elements. While we should not expect an even distribution of indicators across those elements, focus on the evaluation of one element raises the risk of MPANs not meeting their expected goals. Such narrow focus may also distract from recognizing politically motivated implementation or infringements to social justice, which lead to distrust, conflict and violations (Santo & De Santo 2013; Dehens & Fanning 2018), and other unintended consequences (Weeks et al. 2014; Geldmann et al. 2020).

In our study, we found effective management as being the most wholly assessed qualitative element (Fig. 2.6). Indeed, effective management has generally become the most evaluated qualitative element in conservation (Pelletier 2011), for which there are numerous frameworks used throughout the world (Leverington et al. 2010). Effective management provides a means to encourage transparency and accountability (Pelletier

2011), and can help reduce the risk of creating 'paper parks' (Di Minin & Toivonen 2017; Gill et al. 2017). However, an area that is effectively managed may not be effective at conserving biodiversity if, for example, it has limited biological significance to start with (Devillers et al. 2015). Ineffectiveness could also come about if the individual components are not connected to one another in a functionally coherent manner (Woodley et al. 2012), are biologically connected to areas with conflicting objectives (Mackelworth et al. 2019), or lack adequate personnel or financial capacity to ensure goals and objectives are able to be met into the future (Coad et al. 2015).

2.4.1 Gaps and challenges

We showed here that while evaluations of management effectiveness are complex and contain a myriad of indicators, they still poorly incorporate the social and economic dimensions (see Fig. 2.6). Missing these factors may enhance the risks of creating MPANs that generally underperform relative to their promise (Di Minin & Toivonen 2017). In working toward the post-2020 agenda, the conservation community will benefit from knowing how MPANs are being measured toward this (holistic) target. Our review found that indicators used to evaluate input and planning toward MPAN implementation are limited. Input-related indicators reflect capacity, including personnel and funding for management. Planning-related indicators reflect how the mechanisms to achieve management occurs (Hockings et al. 2000), such as design, and legislation or policy that enables the process to move forward in a clear and transparent manner. Appropriate input and planning–related indicators are imperative to successful conservation initiatives.

Effective management will also benefit from improved economic and social indicators (See Fig. 2.5). Indeed shortage in capacity and financial resources have been identified as critical impediments to attaining the post-2020 conservation goals (Coad et al. 2015; Gill et al. 2017). We found four indicators evaluating economic factors among MPANs covering a range of spatial scales, just one evaluated the adequacy of funding to implement a national system of MPAs (Gerhardinger et al. 2011). Evaluations considering both market and non-market values need to be mainstreamed into MPAN effectiveness evaluations (Davis et al. 2019). Furthermore, while social dimensions such as wellbeing, equity, cultural contexts, and Indigenous engagement are enjoying increased attention, means to measure the impact of MPANs on these elements and their influence on MPA success is yet underrepresented (Corrigan et al. 2017). Incorporating these dimensions onto a cohesive monitoring and evaluation framework, albeit daunting, will be necessary to achieve a post-2020 agenda (Addison et al. 2018).

Equitable management has been receiving increased attention (Hill et al. 2016; Law et al. 2018; Rees et al. 2018) including the development of indicators to evaluate this element (Schreckenberg et al. 2016; Zafra-Calvo et al. 2017; Campbell & Gray 2018; Moreaux et al. 2018). We, however, found only two evaluations of equity. These two instances focused on procedural and recognitional equity of stakeholder support and participation in conservation actions (See Table 2.1 for definitions). The indicator of procedural equity "Level of stakeholder support and satisfaction in management" does not specifically address potential discrimination, inclusion, and respect for human rights, as equity frameworks would suggest (Schreckenberg et al. 2016). The other indicator used to assess recognitional equity in MPANs, "Perception of MPA effects on livelihood", assessed how individuals perceived the MPA affected their livelihood, but not the mitigation of potential impacts or acknowledgement of priorities, rights or interests as called for in equity frameworks (Franks & Small 2016; Schreckenberg et al. 2016). Our results corroborate those of Moreaux et al. (2018) who found that the existing evaluation tools cannot adequately evaluate equity in protected areas as they do not capture the complex underlying relationships fundamental to this element. Evaluation of equity is resource intensive and cumbersome, and often results cannot be comparable across sites within a network (Moreaux et al. 2018).

It is well known that protected areas managed in isolation without consideration of issues happening in surrounding areas such as pollution, habitat destruction and overfishing reduces success of the protected area (Agardy et al. 2011). There has been a surge in funding allocated to integrating and mainstreaming protected areas with agricultural sectors (Bacon et al. 2019). The increased commitments by countries toward this element have been met with major limitations (Maxwell et al. 2020). Conflicting priorities, contradictory objectives, and competing interests across different sectors and adjacent regions (Álvarez-Romero et al. 2011; Gannon et al. 2019) as well as the lack of indicators for assessing the integration of protected areas into the wider landscape and seascape challenge the realization of this element (Bacon et al. 2019). We identified three indicators used to evaluate integration (Fig 2.6). These unique indicators focused on governance and land-sea interactions, yet they did not consider measures of integrated practices, community cohesion, knowledge sharing, or distribution of land-based impacts (Partelow et al. 2015; Jupiter et al. 2017).

Another challenge is identifying a suite of indicators that addresses areas of particular importance for ecosystem services. We identified several indicators that captured aspects of areas of importance for biodiversity conservation, while indicators used to evaluate ecosystem services were absent from the literature we reviewed. The gap in evaluations may be due to the lack of a generally accepted approach to measure the suite of services provided by an ecosystem (Gannon et al. 2019). Many ecosystem services do not have a comprehensive suite of indicators to measure them. Indicators that do exist are often inadequate to fully represent the complexity of benefits provided to, and used by, society (McMichael et al. 2005; Brown et al. 2014), especially in the marine realm (Townsend et al 2018).

We identified several leading indicators used to evaluate MPANs but recognize that these are unlikely to be comprehensive and will require further refinement. We recognize the indicators missing or under-represented in this review (Table A2.5) may characterize fundamental components of terrestrial and marine protected area networks and hence help assess whether or not these networks are fulfilling their objectives. In particular, recent initiatives identifying indicators for equitable management (Zafra-Calvo et al. 2017) and integration (Bacon et al. 2019) will help identify priority indicators for evaluation of MPANs against the qualitative elements (Geldmann et al. 2020). Our findings can also be complemented in the future by using other sources, such as grey literature (e.g., technical reports), local management plans, regional strategies, national action plans, and expert opinions, to identify and categorize a core suite of headline indicators to evaluate MPANs effectiveness.

2.4.2 General implications and future work

Our study adds to the growing literature looking at MPANs effectiveness. Other reviews of MPANs have focused on site specific objectives (Sciberras et al. 2013; Davis et al. 2014) or on planning and design (Abesamis et al. 2006). Evaluating effectiveness in the way we did has both advantages and limitations. Each qualitative element was treated independently, allowing for targeted evaluation of progress and may provide insight into the individual contributions of these elements to the whole. In reality, the qualitative elements should work interdependently to successfully conserve biodiversity. The complex and dynamic relationships inherent in protected area networks warrants a holistic, system-level approach to fully appreciate the interactions between the various elements that influence success (Marshall et al. 2016; Mahajan et al. 2019). Assessing the independent and combined contributions of each element and their associated dimensions as a system will have implications for both management and policy. Future work will also benefit from resolving the geographic imbalance in MPANs identified for this review. Including the management stages that indicators are associated with helps to identify the underlying mechanisms of effectiveness - how and why an MPAN is effective. Knowing the management stages associated with indicators can provide insight to identify entry points for targeted interventions, thereby improving successful outcomes for future iterations of the intervention. This adaptive approach is essential to ensure MPANs are delivering successful conservation outcomes (Hockings et al. 2000; Geldmann et al. 2020). The various perspectives regarding ecological and social contexts, and matters of governance from different geographic provinces will ultimately provide insight into the factors that influence MPAN success (Di Marco et al. 2017; Venter et al. 2018). Indicators missing or underrepresented in this review (Table A2.5) may characterize fundamental components of MPANs and hence help assess whether or not these networks are fulfilling their objectives. Our findings could be complemented in the future by using other sources, such as the grey literature (e.g., technical reports), local management plans, regional strategies, national action plans, or expert opinions. Indeed countries appear to be shifting away from quantitative aerial commitments in favor of the qualitative elements (Adams et al. 2019; Bacon et al. 2019), which makes explicit the need to acknowledge quality of protected areas and protected area networks, including the relationship between the protection of biodiversity and human wellbeing (Rees et al. 2018). This is likely to come through implementation and integration of other effective area-based conservation measures (OECMs; CBD 2018). While we did not include OECMs in this review. We note the importance of these measures for conservation, particularly with respect to governance and social dimensions in attaining an effective, representative, and equitable global protected area estate (Corrigan et al. 2017; Bacon et al. 2019).

2.5 Conclusion

It is not surprising that ecological outputs are most often assessed to determine MPAN effectiveness since MPAs are meant to protect biodiversity and ecological processes. However, achieving ecological outcomes often depends on an array of social, economic and governance factors (Ban et al. 2019; Brueckner-Irwin et al. 2019; Yates et al. 2019). Evaluating these factors may help understand root causes of stakeholder cooperation and acceptance, and improve concerns of legitimacy (Dehens & Fanning 2018) and equitable sharing of benefits (White et al. 2005; Franks & Small 2016). Indeed, linked social and ecological dynamics were recognized as influencing conservation effectiveness in some of the literature reviewed (Van Lavieren & Klaus 2013).

Our review highlighted an imbalance in the evaluation of protected areas' effectiveness in conserving and protecting areas of high biodiversity importance in a sustainable manner. Here, we provided, to the best of our knowledge, the first systematic review of indicators used to assess MPANs. This is a first step towards providing guidance for assessing MPANs on a global scale. We found that current evaluations of MPANs are largely built on evaluations used for individual MPAs. This is perhaps unsurprising as individual MPAs contribute to MPANs and MPAN evaluations have developed from the evaluation of individual MPAs. However, MPANs were envisioned to recognize the larger systems in which individual MPAs exist. This may require evaluation criteria that includes structure for interacting systems that does not treat MPANs as a form of individual MPAs or a collection of independent MPAs. Our results indicate that the monitoring and evaluation of MPANs largely overlook the qualitative elements of equity in management and how MPANs are integrated into the wider land and seascape. Additionally important social and economic attributes are seldom measured in MPANs performance evaluations. Evaluation of MPAN performance using a more suitable and balanced suite of indicators will be key to ensure that MPANs can help protect marine ecosystems more effectively.

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3. Finding a balance: Do practitioners consider a balance of ecological, economic, governance, and social dimensions in marine protected area network evaluations?

Abstract

Marine protected areas networks (MPANs) are promised as tools for protecting biodiversity and contributing to sustainable development. The variety of expected social-ecological outcomes associated with MPANs underscores a need to consider ecological, economic, social, and governance dimensions in MPAN design, implementation, monitoring, and evaluation. However, little is known about how these four dimensions are considered or shaped by objectives. We conducted an online survey with MPAN managers, technical staff, and academics from across the globe (77 survey responses that described 48 MPANs located in 59 countries). Our findings confirmed that most MPANs consist of a variety of co-occurring, potentially conflicting objectives. Participants associated with MPANs that had both biodiversity and socially-oriented objectives considered attributes among all dimensions (e.g., human wellbeing and economic distribution, institutional partnerships, and network-specific ecological attributes) in evaluations with greater frequency than MPANs with only biodiversity objectives. Nonetheless, ecological attributes were always perceived important irrespective of the MPAN objective. Reaching synergies between the multiple dimensions of MPANs can be challenging if dimensions get overlooked in MPAN evaluations. Identifying important attributes considered in MPAN evaluations offers insight into the practice of MPAN design, implementation, monitoring, and evaluations, and can help improve MPAN success.

3.1 Introduction

Networks of marine protected areas (MPAs) are increasingly promoted as a cornerstone tool for protecting biodiversity and contributing to sustainable development. MPA networks (hereafter MPANs) have become enshrined in international initiatives, such as the Convention on Biological Diversity (CBD) targets and the Sustainable Development Goals (SDGs). They consist of an organized collection of individual MPAs that work together 'cooperatively and synergistically, at various spatial scales, and with a range of protection levels' to achieve a similar outcome but with a smaller overall protected size than a single large MPA could (IUCN-WCPA 2008, p. 3). MPANs primarily aim to conserve biodiversity over a large area while balancing costs and benefits to people. An MPAN may be transboundary, intending to protect a species' habitat range or an ecosystem that spans multiple countries. The variety of expected social-ecological outcomes associated with MPANs underscores a need to ensure the multiple ecological and human dimensions are considered in MPAN design, implementation, monitoring, and evaluation (hereafter "MPAN process").

Four dimensions – ecological, economic, governance, and social – can be used to describe the complex interdependent relationships within social-ecological systems and are increasingly used to design and evaluate MPANs (Hill et al. 2015; James & Magee 2020). However, the extent these four core dimensions are considered in the MPAN process is not well known. Every dimension has several associated characteristics, which we call attributes (Fig. 3.1). Many attributes are common among individual MPAs and MPANs, yet there are important elements that need to be accounted for to understand whether a network, rather than a group of individual MPAs, functions as expected (Grorud-Colvert et al. 2014). The ecological dimension is essential to understand the system's state, species, or habitats of interest so that the network functions appropriately (IUCN-WCPA 2008). Network-specific ecological attributes include representation of the full range of habitats and species found in a biogeographically intact ecosystem, and replication of ecological features within each representative biogeographic region to safeguard habitats that are important for key lifecycle processes (Dudley & Parish 2006; CBD 2008). Important network-specific ecological attributes also include connectivity between individual protected areas. Well-connected networks ensure that linkages between the system's inherent physical and biological properties, including dispersal and colonization by individuals, are maximized between sites within an MPAN (IUCN-WCPA 2008; Rodríguez-Rodríguez 2019). Resilience is another important MPAN characteristic and is a product of all the aforementioned attributes. Together, these attributes serve to maintain key functions and processes in the face of stresses or pressures such as ocean acidification, climate change, and other major impacts (Holling 1994; Nyström et al. 2000; Grorud-Colvert et al. 2011; Thomas & Shears 2013; Burt et al. 2014).

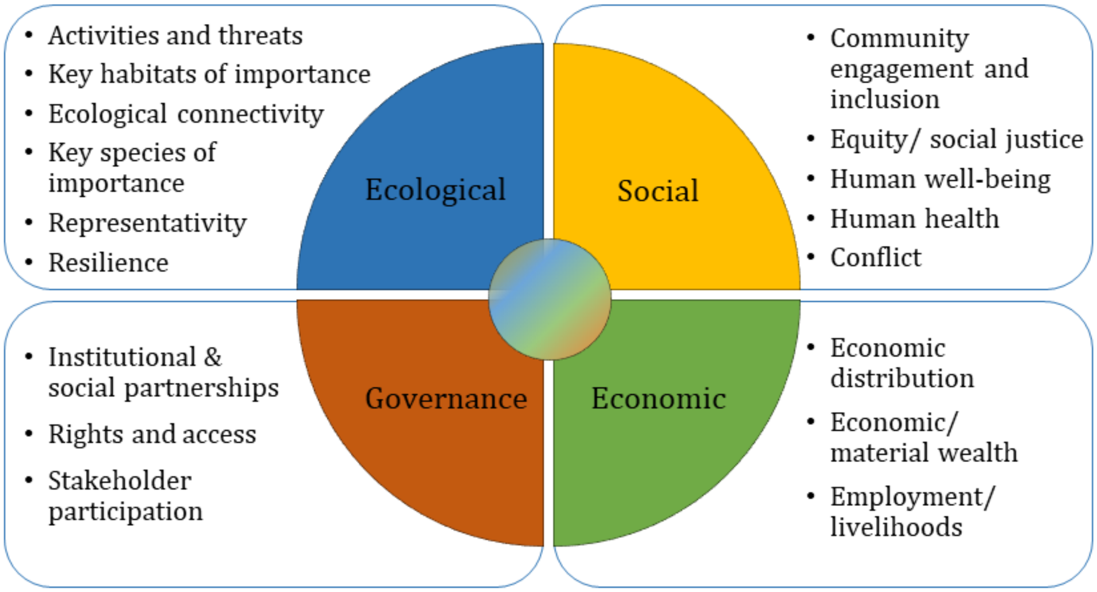

Figure 3.1. Dimensions of MPA Networks and their associated attributes.

The ecological dimension is interconnected with economic, governance, and social dimensions. These human dimensions can influence the ecological outcomes of an MPAN (Pollnac et al. 2010). Social networks are a key feature of effective MPANs (Bodin & Crona 2009; Alexander & Armitage 2015; Horigue et al. 2015). Shared information through collaborative alliances such as "sister site" approaches supported by the United Sates National Oceanic and Atmospheric Administration (NOAA) helps build a common vision for shared resources, thereby improving the ecological outcomes of an MPAN (IUCN-WCPA, 2008; Pittman & Armitage, 2017; Wenzel et al. 2019). Additional social attributes include access to resources, expanded social cohesion, and improved human wellbeing (Miller et al. 2012; Cárcamo et al. 2014; Mbaru et al. 2021). The economic dimension includes financial resources and capital necessary to implement and manage MPANs and achieve conservation goals, as well as potential economic benefits or costs to communities that use or depend on an area designated as part of an MPAN (Allen Consulting 2009; Gill et al. 2017). Sharing administrative responsibility or economic and human resources through collaborative partnerships and coordinated management of shared ecological resources can help reduce economic burden (Lowry et al. 2009; Nelson et al. 2019). Governance attributes include stakeholder participation and partnerships that help maintain or influence legislation, management, and decision-making (Armitage et al. 2012; Borrini-Feyerabend & Hill 2015). Bilateral agreements or other strategies for managing complex marine ecosystems and migratory species amongst MPAs in a network have been shown to help maintain ecological connectivity between individual sites (Cárcamo et al. 2014; Wenzel et al. 2019). Shared experience through collaborative partnerships and governance networks can identify common challenges and solutions in social and ecological contexts, and potential options for coordinated management (Pittman & Armitage 2017). Collaborative programs have been found to be successful in strengthening organizational and community relationships, sharing information, and carrying out collaborative enforcement and surveillance (Bodin & Crona 2009; Friedlander et al. 2016; Wenzel et al. 2019).

These four dimensions are intertwined, forming a complex system (Pomeroy et al. 2005; Pollnac et al. 2010; Fox et al. 2014; Gurney et al. 2019) where social conditions and relationships influence MPAN success (Dehens & Fanning 2018; Kelly et al. 2020). All these dimensions are known to improve the effectiveness of MPANs in conserving biodiversity (Pomeroy et al. 2005; Blicharska et al. 2019). Indeed, research has shown that neglecting these dimensions can be counterproductive for both social and ecological outcomes for conservation, leading to heightened community tensions, including poaching and reduced legitimacy (Christie 2004; Ban et al. 2019; Mbaru et al. 2021). While understood as important, little is known about how these four dimensions are considered in the MPAN process and how their consideration is shaped by diverse MPAN objectives. Previous research found social and economic dimensions poorly represented in the MPAN process literature (Meehan et al. 2020). As such, we want to assess if this same trend is observed in practice.

Here, we seek to investigate how the ecological, economic, governance, and social dimensions are considered within the MPAN process and whether their consideration is influenced by the MPAN objectives. We asked We asked: How are the attributes of ecological, economic, governance, and social dimensions considered when evaluating MPANs in practice? Specifically, 1) What are the objectives associated with MPANs? 2) and how do the attributes of the four core dimensions of MPANs align with diverse objective types? 3) How important do practitioners consider the attributes of each dimension for achieving MPAN effectiveness? To address those questions, we conducted expert elicitation with MPAN managers, technical staff, and academics from across the globe.

3.2 Methods

3.2.1 Eliciting expert knowledge

Here, we elicited information from experts experienced in MPAN research, design, implementation, monitoring, and/or evaluation. Expert elicitation is an approach commonly used in conservation science to inform decision-making (Martin et al. 2011; Krueger et al. 2012) and help improve the process of conservation programs and policies (Álvarez-Fernández et al. 2017; Whitney & Ban 2019). In research expert elicitation aims to gather information from individuals who are considered experts in their fields, this can be a reliable means of data gathering when information is not readily available (Singh et al. 2017). Experts, including MPAN managers, researchers, and field technicians, shared information on the attributes of the four dimensions considered, the MPAN objectives, and the perceived importance of each attribute to the overall effectiveness of MPANs they are familiar with. Expert elicitation was conducted through an online survey in English, Spanish, and French using the Qualtrics software (v. 12018). These languages were chosen to be more inclusive of many non-English speaking regions where MPANs currently exist. We used a combination of systematic sampling and snowball sampling to reach a broad suite of practitioners. We sent 311 invitations to participate in the survey to corresponding authors of peer-reviewed literature on MPANs, and to MPAN managers whose email addresses were publicly available. MPANs were identified through a search of the world database on protected areas (WDPA) (IUCN and UNEP-WCMC 2017) for “networks” or “system” and a follow-up Google search of the MPANs found in the WDPA that matched our search criteria and “marine protected area network”. We also promoted the survey via relevant mailing lists (Table B1) and over social media (Twitter and Facebook). In the invitation, we encouraged invitees to share the survey invitation with other experts familiar with MPANs, helping reach a broad audience. We first publicized the survey and launched it on 28 February 2020 and closed it on 1 May 2020. This research was conducted with approval by Memorial University’s Interdisciplinary Committee on Ethics in Human Research (Approval #20200830) and the University of Victoria Office of Research Services’ Human Research Ethics Board (Approval #19-0363-02). All data collection followed the university’s informed consent processes.

Multiple attributes contribute to each overarching dimension and account for the variety of characteristics that comprise individual MPAs within a network (Fig. 3.1). Our survey specifically set out to explore the attributes of each dimension considered throughout the MPAN process and to assess how important respondents perceive these attributes toward the MPANs' effectiveness. The first question, asking to identify the MPAN they were associated with, was required to initiate the survey (see Appendix A for details). For the first part of the survey, we provided a list of attributes associated with each dimension (ecological, economic, governance, social) and asked respondents to indicate whether they were considered in the MPAN process (i.e., design, implementation, monitoring, or evaluation of the MPAN) they were familiar with. We obtained the dimensions and their attributes from a review of the elements that underlie MPAN function, namely ecological, economic, governance, and social conditions (Meehan et al. 2020). We followed each set of multiple-choice questions with an open-ended response category for respondents to include attributes they thought were missing from the multiple-choice survey answer options. This style of survey elicitation aimed to account for the possibility of a) multiple-choice categories anchoring the participants' responses about indicators (providing answers as multiple choice may bias respondents to select only those answers) and b) account for availability biases that may arise from solely open-ended questions where the expert can be affected by ease of recall or memory from recent experience (Failing & Gregory 2003; Knol et al. 2010). In addition to the survey style, the order of questions could affect respondents' attention to different kinds of indicators (Krosnick 2018). Questions were ordered by dimension and were grouped in sections, within each section questions were randomly assigned; this structure was necessary to force critical thinking along all possible indicators in each dimension. To account for any possible issues with survey length, we only included complete responses across the full survey to avoid results being oversampled for ecological indicators, the first dimension queried. We downloaded survey data into Excel (Microsoft Corporation, 2021) and carried out data preparation and cleaning in the R software v. 4.0.2 (R Core Team, 2020).

Due to the potential for variability between practitioner types, we asked respondents about their affiliation, whether as an academic, academic-practitioner, project manager, project facilitator, habitat specialist, or monitoring technician. We grouped responses into two categories, experts solely affiliated with an academic institution and those that were either not affiliated with an academic institution or were both a manager and academic. We assessed potential differences in response using a permutational multivariate analysis of variance (PERMANOVA, Anderson, 2001).

3.2.2 MPAN objectives

We asked respondents to identify objectives associated with MPANs they are familiar with from a list. These objectives were based on a review of the literature on MPAN goals and objectives and could be attributed to both MPANs and individual MPAs (Meehan et al., 2020). Possible objectives were biodiversity conservation, habitat restoration and protection, maintaining ecosystem services, fisheries management, maintaining cultural values and subsistence, contributing to global initiatives such as CBD targets or SDGs, preserving or improving social wellbeing, and performing scientific research. Respondents could select any number of objectives as being primary or secondary. We also included an open-ended question here to accommodate diverse objective types not encompassed in the multiple-choice options. We created a network graph using igraph in the FSA package (Csardi & Nepusz 2006) in R (R core team 2019) to visualize the relationship among objectives (Janssen et al. 2006).

We were interested in assessing differences between MPANs that only considered biological objectives and those that included biological and socially-oriented objectives. As such, we grouped MPAN objectives into two classes: those including only biodiversity as primary objectives (named "B": conserve biodiversity, restore and protect habitat) and those including both biodiversity and socially-oriented objectives (named "B&S": provide ecosystem services, uphold cultural values, maintain, or improve human wellbeing, manage fisheries, conserve biodiversity, restore and protect habitat). We omitted two objectives from our analysis (i.e., contribute to scientific research and contribute to global initiatives) because they were associated with all objectives, were not immediately relevant to local contexts, and could not easily be classified into socially-oriented or biological characteristics.

3.2.3 MPAN attributes considered

We compiled the attributes selected and added by respondents for each dimension. We categorized these "emerging" attributes that were added manually (those respondents who added to the open-ended category from our attribute list) to link them to existing attributes (e.g., "at-risk species" was incorporated into "key species") or a new attribute category, aggregating them when possible into one overarching attribute (e.g., "heritage/historic use", "traditional use", "pre-existing uses", and "human uses (consumptive and non-consumptive)" were aggregated into "traditional and historic uses"; See Table B3.2 for full and aggregated list). We summarized the number of times each attribute was selected as “considered” by respondents for MPANs with each objective type (B and B&S).

We used multiple analyses to understand the factors that influenced the consideration of dimensions and their attributes. We created figures, and non-metric multidimensional scaling (nMDS) on the matrix of responses by attributes to use in descriptive statistics. As our uncertainty was high, we endeavored to triangulate our results with diverse analyses to examine the consistency between tests with different assumptions. Accordingly we performed a permutational multivariate analysis of variance (PERMANOVA, Anderson 2017) to test whether the attributes considered differed between MPAN objective types. We recategorized our data from the number of times selected “count” to presence/absence format to account for the low abundance of the “emerging” attributes and greater selection frequency of attributes in the survey by participants. We further calculated a multilevel pattern analysis using the Indicspecies package (De Cáceres et al. 2022) to identify which attributes are found statistically more abundantly in one group versus another based on presence-absence data. To get a sense of the balance of attributes considered among the objective types, we evaluated the evenness of the attributes selected for each dimension across the objective types. Figures were done using the R package ‘ggplot2’ (Wickham 2016), and PERMANOVA and nMDS were run using the R ‘adonis’ and ‘metaMDS’ functions in the ‘vegan’ package (Oksanen et al. 2019).

3.2.4 Perceived importance of attributes for MPAN management effectiveness

To assess whether the suite of attributes associated with each dimension was considered as being important for the overall performance of MPANs, we collected information from respondents regarding their perceived level of importance using a Likert-type scale (i.e., not important, slightly important, moderately important, very important, or extremely important) for each attribute. We summarized the Likert-type data using R 'Psych' package (Revelle 2022). We performed an ordinal Chi-square test to evaluate if the MPAN objective type was associated with differences in the perceived importance of attributes across the four dimensions. The ordinal Chi-square is a non-parametric test designed to analyze the association among nominal (names) and ordinal (ordered levels of importance) variables (Agresti 2007). Here we used one independent variable with two levels (B and B&S), an ordered dependent variable (importance), and stratified by the four dimensions. Stratification allowed identifying differences in perception among the attributes according to MPAN objective type within each dimension. We used count data (the number of times a scale choice was selected) per dimension in R built-in package (R Core Team, 2020). We followed this test with groupwise Cochran-Mantel-Haenszel (CMH) tests to determine which dimensions differed in importance levels between objective types. The CMH test is an extension of the chi-square test of association and is used for three-way contingency tables such as ours (Mangiafico 2016)(Agresti 2007). We reviewed the Chi-square residuals to determine if there was an association between the responses from the different MPAN objective types (i.e., to assess if respondents' responses were made more often or less often than expected). Finally, we generated correlograms using R 'Corrplot' package (Wei et al. 2021) with the Chi-square residuals for each attribute to illustrate these differences.3.3 Results

3.3.1 General findings

A total of 156 responses were received, 77 of these were complete and used in the analysis. Survey responses described 48 MPANs located in 59 countries (several networks spanned multiple countries). Survey participants were primarily affiliated with academic institutions or universities (49%), followed by non-government organizations (NGOs) and Federal/National governments (14% and 13%, respectively, Table B4). Respondents' roles consisted primarily of researcher/academic (39%), followed by habitat or species specialist, project manager, and "other" (12%, 11%, and 10%, respectively). The results of PERMANOVA suggest no differences in responses between experts solely affiliated with an academic institution and those not affiliated with an academic institution or with multiple affiliations including academic ($R^2=0.03$, $F=0.97$, $p<0.55$). We confirmed that most (90%) of the respondents selected multiple primary objectives and identified 41 unique combinations of up to 8 co-occurring primary objectives (Table B3). Every MPAN had biodiversity as a primary objective (Fig. 3.2). We grouped each array of MPAN objectives into two classes (Table B3), resulting in 24 responses for MPANs with solely biodiversity (B) objectives, and 53 responses for MPANs with biodiversity and socially-oriented (B&S) objectives. We found that both B and B&S MPANs had a similar distribution of dimensions, with the ecological dimension getting the most consideration (48% of the B MPANs and 40% of B&S MPANs). The governance dimension was considered in 24% and 22% of B&S and B MPANs, respectively, followed by social and economic dimensions (23% and 18%, 13% and 11% of B&S and B-based MPANs, respectively).

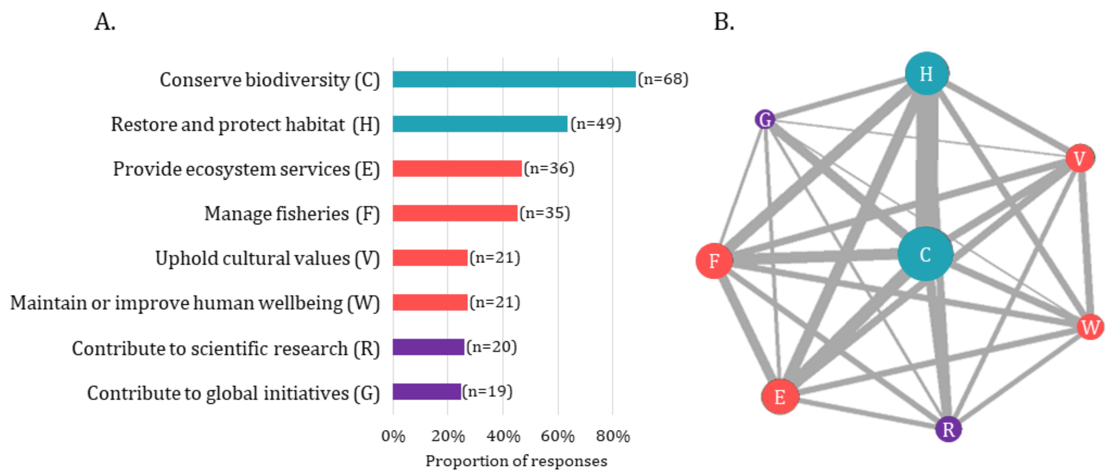

Figure 3.2. (A) The proportion of stated objectives for MPANs from 77 survey respondents. Total count in parentheses. (B) Network diagram showing the connections among primary objectives of MPANs. The size of the nodes indicates the number of times participants selected the objective as primary. Colors indicate groups of objectives: Biodiversity only (blue), biodiversity and socially-oriented objectives (green), and general objectives (pink). Width of linkages indicates the number of times nodes (objectives) co-occurred (ranging from most (C-H, n=47) to least (V-G, n=4)).

3.3.2 Objectives and attributes of MPANs

Generally, respondents associated with B and B&S MPANs considered attributes of the ecological dimension slightly more often in the MPAN process than economic, governance, or social attributes. The selection frequency for total attributes considered in each dimension followed similar patterns among the two objective types (Figs. 3.3 and 3.4). The most frequently considered ecological attributes were key habitats and key species, selected at a similar frequency across the two objective types, though slightly more for B MPANs. The least frequently considered ecological attribute from those included in the survey was resilience, while activities and threats, and ecological connectivity were moderately considered across both MPAN types. Key network-specific ecological attributes, such as representation, connectivity, and resilience, were considered more often in B&S MPANs than in B MPANs (Fig. 3.3). Representation was the most frequently considered network-specific ecological attribute.

Survey participants identified 131 emerging attributes that were not suggested in our survey (39 ecological, 41 social, 15 economic, and 38 governance attributes, Table B2). After coding and organizing responses, we had 31 emerging attributes considered by respondents (Table B2, Figs. 3.3 and 3.4). Governance attributes saw the greatest addition (10 added), while economic saw the least (5 added). Among the emerging attributes, cultural values and significance was the most common (n=4 and 6 for B and B&S MPANs, respectively), followed closely by adequacy (n=4 for both B and B&S MPANs, Figs. 3.3 and 3.4). Cultural values and significance were added to both the ecological and social dimensions. Furthermore, equity and social justice (commonly a social attribute), and rights and access (commonly considered a governance attribute) were considered attributes of governance and social dimensions, respectively. Though suggested less often by respondents, economic activities and economic impacts were also added by respondents across both MPAN types to both economic and social dimensions.

The added ecological network attributes of adequacy, replication, and climate change were considered more frequently in evaluations of B MPANs. Within the economic dimension, employment and livelihoods was considered most frequently, while economic wealth was considered least often among the attributes included in the survey (Fig. 3.3). Among the emerging attributes added by respondents, income-generating activities was considered most frequently in B&S MPANs. Income-generating activities, economic impacts, funding sustainability, and opportunity cost were considered at equal frequency in

B MPANs. Within the governance dimension, stakeholder participation was selected at a similar frequency across the two objective types. Institutional and social partnerships was considered significantly more often by respondents of B&S than B MPANs (Fig. 3.4). Among the emerging attributes, coordinated management and co-management were selected most often in B MPANs, while coordinated management and jurisdictional aspects were selected most frequently by respondents of B&S MPANs. Respondents of MPANs with B&S objectives considered social attributes generally more often than respondents from B MPANs. Respondents across both network types selected community engagement the most frequently, followed by conflict. Equity, social justice, and human wellbeing attributes were selected significantly more often in B&S MPANs than in B MPANs. Among the emerging attributes, respondents selected cultural values and significance the most.

Evenness scores (Table B5) indicate that MPANs with socially-oriented objectives have a slightly more balanced set of attributes considered among all dimensions. Some separation of attributes across objective types can be seen in the NMDS plot, indicating differences in attributes considered among MPAN objective types, although there is an overlap of attributes (Fig. 3.5). The PERMANOVA corroborated these results, indicating some differentiation in attributes considered between the two objective types, although only 3% of the variation is related to objective type ($p < 0.05$). Multilevel pattern analysis further corroborated this result, indicating that MPANs with socially-oriented objectives showed greater consideration for human wellbeing, economic distribution, and institutional partnerships (Table B6).

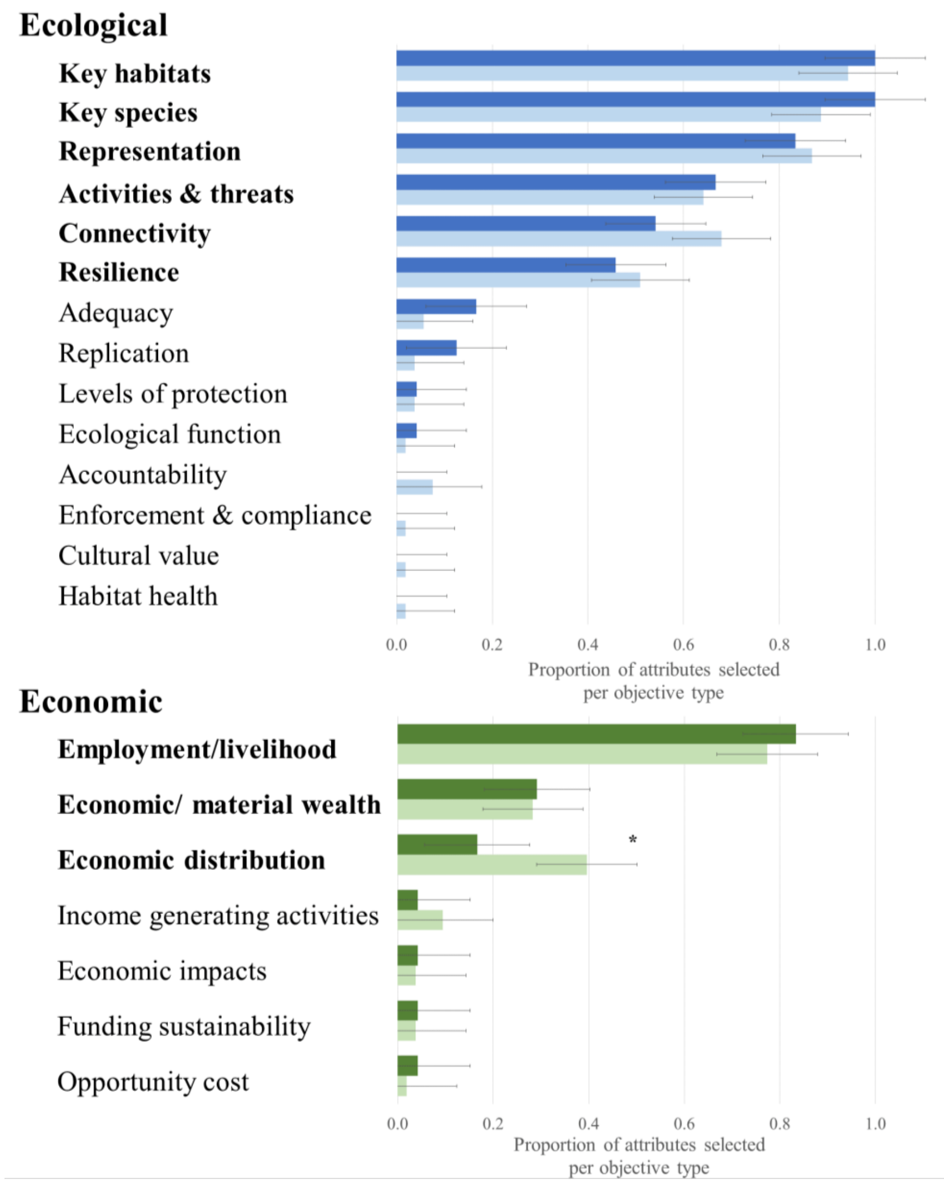

Figure 3.3. Attributes of the ecological and economic dimensions considered among the two objective types in the MPAN process according to survey participants. Bold attributes indicate attributes originally included in the survey; regular text indicate attributes added by participants (emerging attributes, n= 24(B), 53 (B&S)). Dark colors represent the proportion of attributes selected in MPANs with only biodiversity (B) objectives ±SE. Light colors represent the proportion of attributes selected in MPANs with biodiversity with socially-oriented objectives (B&S) ±SE. Asterisks indicate where significant differences occur between MPAN objective types ($p<0.05$, Indespecies).

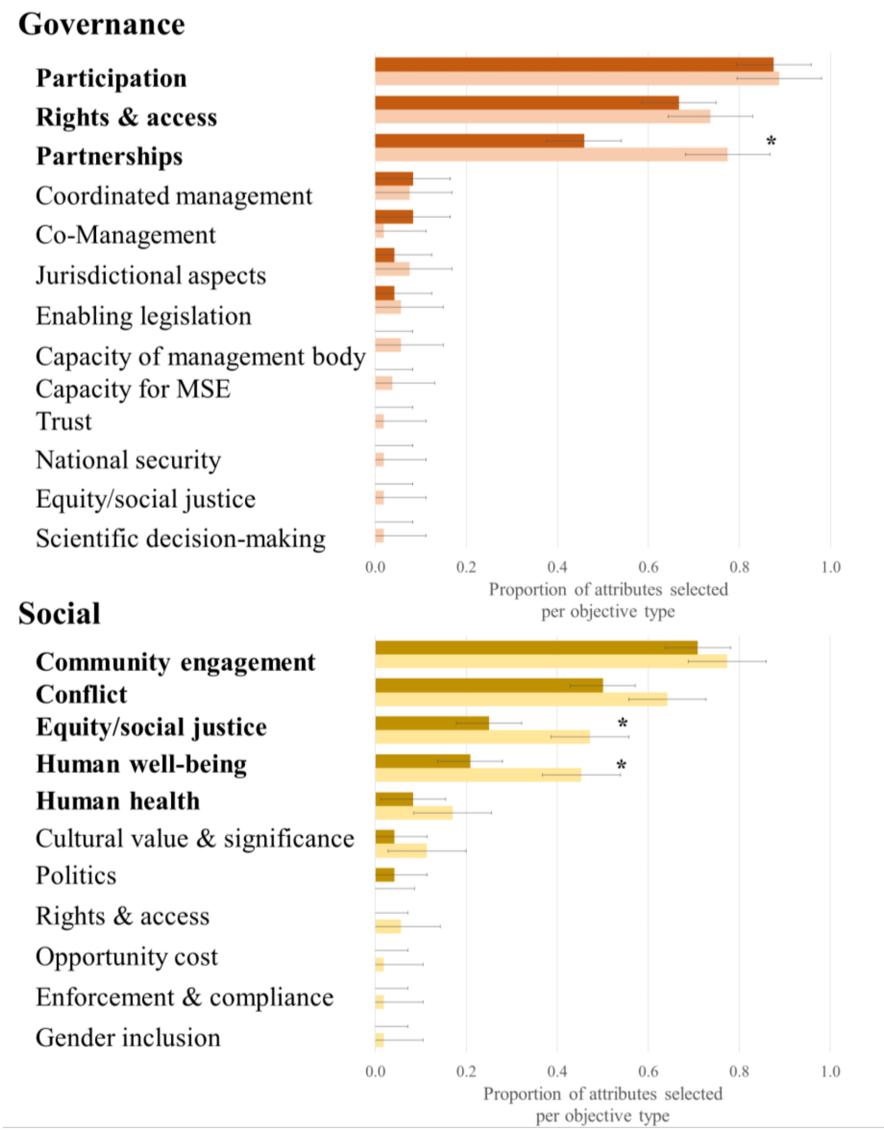

Figure 3.4. Attributes of the governance and social dimensions considered among the two objective types in the MPAN process according to survey participants. Bold attributes indicate attributes originally included in the survey; regular text indicate attributes added by participants (emerging attributes, n= 24(B), 53 (B&S)). Dark colors represent the proportion of attributes selected in MPANs with only biodiversity (B) objectives ±SE. Light colors represent the proportion of attributes selected in MPANs with biodiversity with socially-oriented objectives (B&S) ±SE. Asterisks indicate where significant differences occur between MPAN objective types ($p<0.05$, Indespecies).

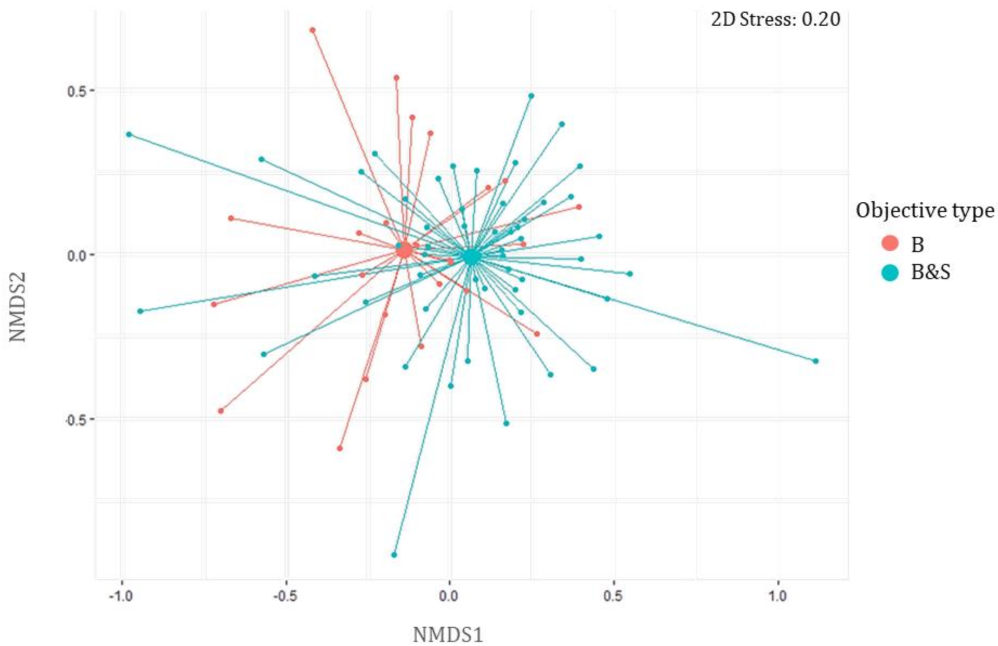

Figure 3.5. Non-metric multidimensional scaling (nMDS) plot showing the differences and overlap in the composition of attributes across the two MPAN objective types.

3.3.3 Importance of attributes for achieving MPAN effectiveness

The same attributes used in the MPAN process were identified by experts as being moderately to extremely important for MPAN effectiveness (Fig. 3.6). Respondents associated with B&S MPANs generally gave higher importance (very to extremely important) to attributes of the economic, governance, and social dimensions than the other respondents (Table B7, Fig. 3.6). Ordinal Chi-square test of association identified differences in levels of importance selected for dimensions between the two objective types ($X^2 = 29$, $p<0.001$, Table B7).

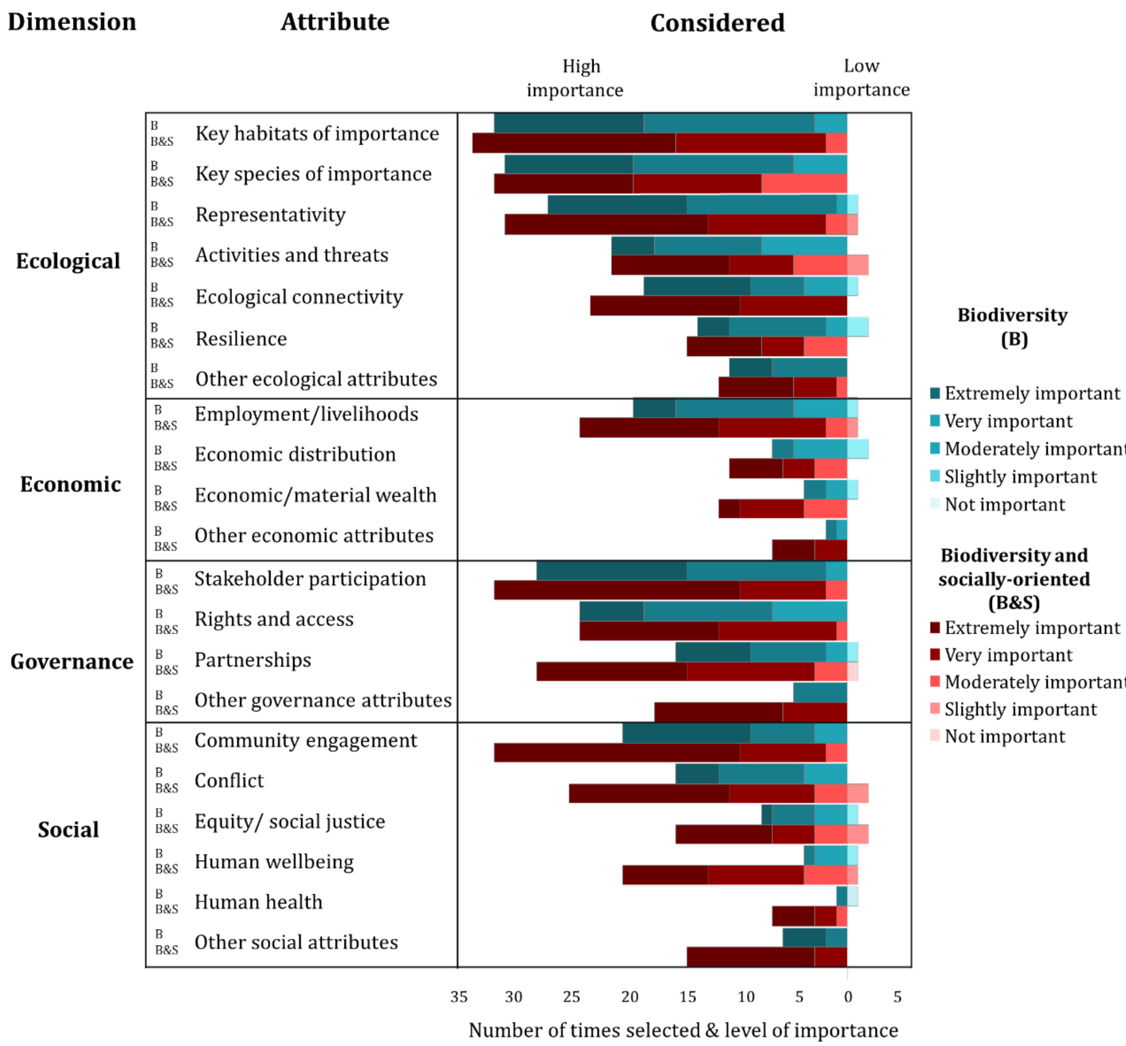

Figure 3.6. Selection frequency (number of times an attribute was selected as considered by survey participants) and levels of importance for the attributes of each dimension considered in the design, implementation, and monitoring of MPANs. Biodiversity only (B) MPANs are indicated in blue-green, MPANs with biodiversity and socially-oriented objective types (B&S) are indicated in orange. Color gradients indicate levels of importance based on survey responses. High importance (Moderate to high) is in darker shades on the left side of each panel, Low importance (Slight to not important) is shown in lighter shades on right side of each panel.

The significant differences identified in the Chi-square analysis suggest that there is a difference in the levels of importance conferred on the dimensions linked to the objective types of the MPAN. Furthermore, groupwise post-hoc analysis identified the economic and social dimensions as having significant differences in levels of importance among objective types (Table B7). Further exploration of residuals shows that differences in the perceived importance of the economic dimension were driven by the attribute “economic distribution”. This attribute was selected as slightly important more often than expected and extremely important less often than expected in B MPANs (Figs 3.6 and 3.1). Funding sustainability was added by survey respondents from three MPANs as an economic attribute perceived to be extremely important for MPAN success, however, this attribute was considered in MPAN evaluations only once. Within the social dimension, significant differences between objective types were driven by differences in perceived importance for human health. Respondents working in B MPANs selected human health as “Not important” much more than expected (Fig. 3.6). Additionally, human wellbeing was selected as extremely important, less than expected for B MPANs, and community engagement was selected as extremely important more than expected in B&S MPANs (Figs 3.6 and B1). Perceived differences in importance in the ecological and governance dimensions were also significant, though to a lesser degree. In these dimensions, differences in perceived importance between the objective types were attributed to differences in the selection of low and moderate levels of importance rather than high importance values (Figs 3.5 and B1).

Notably, participants added attributes in every dimension that were not considered in the MPAN process yet were perceived as very important (Fig. 3.6). Economic attributes of funding sustainability, nonmarket values, and opportunity costs, social attributes include Indigenous values and culture, and access rights. Governance attributes non considered in the MPAN process but perceived to be highly important to successful MPANs include, co-management, coordinated management, funding for management, and overlapping jurisdictions. Ecological attributes include habitat health, levels of protection, representation, and management of human pressures.

3.4 Discussions

Our findings indicate that consideration of diverse attributes across dimensions may not be a zero-sum game – consideration for human dimensions tend not to decrease consideration for ecological dimensions (the primary focus of many MPANs). In fact, network-specific ecological attributes are considered to a greater degree in MPAN with socially-oriented objectives. Our research identified that there is consideration for a more well-rounded suite of dimensions in the MPAN process from respondents of MPANs with biodiversity and socially-oriented (B&S) objectives than MPANs with biodiversity (B) objectives alone. Many countries and environmental organizations are showing an increasing interest in MPANs that are not solely focused on biodiversity conservation but also more broadly on sustainable use and stewardship (FAO 2011; Molenaar et al. 2014; Akins & Bissonnette 2020). This has brought to light the importance of identifying whether the incorporation of socially oriented objectives influences the outcomes of conservation interventions. Our study shows that incorporating socially oriented dimensions in MPAN objectives does not divert attention from considering elements needed to achieve ecological objectives.

Ecological MPAN attributes, such as connectivity, representativity, resilience, and adequacy (size and spacing), are the focal attributes of MPANs and are described extensively in the literature (Grorud-Colvert et al. 2014; Roberts et al. 2018). Interestingly, our results indicate that many of these network-specific ecological attributes are considered at a greater frequency, though not statistically significant, in MPANs with B&S objectives compared to MPANs with solely B objectives. This could be a result of greater interest in the application of MPANs towards ecosystem-based management, which includes socially-oriented objectives, for example, MPANs play an important role in providing ecosystem services and managing fisheries (Halpern et al. 2010; FAO 2011; Weigel et al. 2014; Leenhardt et al. 2015). These objectives comprise both biodiversity and socially-oriented objectives (B&S) as they are intended to benefit people through biological resource management (Bennett et al.al. 2015). Furthermore, the contribution of improved biodiversity to the social dimensions of human wellbeing, health, and social equity have been proposed as reasons for implementing MPAs as part of a regional network (CBD 2010; Ban et al. 2019; IPBES et al. 2019; Zafra-Calvo & Geldmann 2020) and could have influenced more MPANs to incorporate these objectives.

Social network attributes, such as collaborative alliances, community participation, and learning networks, can contribute to improved biodiversity (IUCN-WCPA 2008; Bodin & Crona 2009; Friedlander et al. 2016). However, the literature is short on information about social network features (see Alexander et al. 2017; Pittman & Armitage 2017; Wenzel et al. 2019). We hoped our survey would provide more insight into this attribute but found limited consideration in the MPANs we explored. Our study aligns with others that have identified an inadequate coverage of economic, governance, social and network-specific ecological dimensions in existing evaluations (Moreaux et al. 2018).

Governance attributes such as coordinated management and overlapping jurisdictions are important considerations for MPANs. MPANs can span several countries, states, or territories and span multiple environment types and disparate jurisdictions responsible for the activities therein (UNEP-WCMC 2008). The governance dimension had the most attributes added by survey respondents. These emerging attributes include “co-management”, which refers to partnership arrangements between actors (e.g., communities and governments, government, and private entities, etc.). Another emerging governance attribute, “enabling legislation & strategies”, refers to mechanisms that governments use to create guidelines for accomplishing general principles set out in legislation, such as provisions for an MPAN. This is an important attribute of governance as it helps to specify how it can support collaborative arrangements and adaptive management (Folke et al. 2005). Legislation can hamper progress if the process is cumbersome or does not establish rights and authority for co-management (Pomeroy & Berkes 1997).

Our study found that economic attributes were infrequently considered and generally were not perceived as important to overall MPAN effectiveness. The low frequency of consideration for these attributes is surprising since economic benefits associated with MPAs and MPANs are often touted as reasons for implementation (Davis et al. 2019). These economic benefits can, amongst other things, be attributed to collaborative partnerships that share administrative responsibility or economic and human resources that aim to reduce the economic burden on individual sites (Lowry et al. 2009; Nelson et al. 2019). However, these claims can be overstated without objective means of evaluation (Davis et al. 2019). Unfortunately, we found minimal consideration for economic distribution, which corroborates insights from the literature suggesting that issues around economic inequality in conservation are insufficiently evaluated even though its influence on environmental values is understood (Drupp et al. 2018). Another economic attribute receiving limited attention in MPAN evaluations is the equitable distribution of benefits and costs in the process of MPAN implementation (Davis et al. 2019; Kockel et al. 2019). We did not identify any attributes concerning this economic factor. Funding sustainability was an attribute added by several participants and is the subject of much research and discussion as individual MPAs generally struggle with budgetary and capacity constraints (Gill et al. 2017; Adams et al. 2019).

Differences between practitioners' perception of the importance of social and economic attributes and (lack of) consideration may stem from the difficulty in managing and evaluating the complex combination of elements important to measure MPAN success (Woodhouse et al. 2018; Gill et al. 2019) given diverse objective types. More objectives entail greater capacity needs (Gurney et al. 2021) when it comes to evaluating whether the objectives are met. Capacity is a renowned driver of success, insufficient capacity increases the risk of failure (Gill et al. 2017). A major impediment to implementing nuanced approaches to examine and accomplish broad holistic goals is the need for greater economic, institutional, and individual capacity under constrained circumstances (Fulton et al. 2015; Woodhouse et al. 2015; Law et al. 2018). Differences may also stem from the role participants play within the management of the MPAN. For example, those in a managerial role may be able to influence what indicators are used while others may have limited agency or influence over what is assessed.

Our research suggests that MPAN outcomes would benefit from adding measures of network-specific attributes to evaluations due to their perceived levels of importance among survey participants and contribution from the literature. For example, ecological attributes may include comprehensiveness, adequacy, and resilience; economic attributes may include funding sustainability, income generating activities, and nonmarket values; social attributes may include cultural values, and opportunity cost; and governance attributes may include management capacity, collaborative decision-making, and integration. This research investigated the foundation for MPAN evaluations that incorporate a full suite of social-ecological contexts at a broad scale.

This research is not without limitations. Despite efforts to promote the survey through as many channels and individuals as possible and in several languages, the geographic representation of responses for MPANs was highly skewed to the United Kingdom, United States of America, Canada, and Australia. This geographic bias may have influenced the results to identify more with recent developments about MPAN considerations, as these countries have had tremendous momentum towards increasing MPAN area/estate (De Santo 2013). Similarly, we had a lower sample size for age class, which may have precluded identifying differences between the age of MPANs and attributes considered. This is an area ready for further advancement of understanding. Additionally, respondents were biased toward academics, such that our survey had fewer responses from project managers, facilitators, and monitoring specialists. While we found small difference between responses from academics and those not affiliated with academia, there likely were some differences which are explored more formally in chapter four. Finally, several different respondents were associated with the same MPAN, as such this could have influenced comparisons in terms of the attributes considered in evaluations, weighing some characteristics more due to the common MPAN objectives. This was overcome by using the proportion of attributes selected rather than counts. To get a sense of the overarching consideration in the MPAN process, we asked about the process of

MPAN (design, implementation, monitoring, and evaluation) as a whole rather than each stage individually. Future research can improve on this by specifying the considerations for each stage in the MPAN process (Hockings et al. 2000; Grorud-Colvert et al. 2021). This way, specific stages of the MPAN process can be isolated to target improvements. Finally, while this study focused on whether an attribute was considered, it did not assess the quality of the consideration, or how well it may reflect what is needed to ensure an effective MPAN. While this is a cursory examination, there is merit to looking into the quality of these attributes to measure effectiveness and potential indicators that can accompany them for an evaluation.

3.5 Conclusion

Multidimensional ocean management tools such as MPANs that focus solely on ecological objectives may overlook important influences from and contributions to human considerations. Evaluations of MPANs would benefit from a strong foundation built around the four dimensions inherent in social-ecological systems (McGinnis & Ostrom 2014; Cumming & Allen 2017). Strategic focus on key network attributes from each of the four core dimensions, such as connectivity, coordinated management, and social networks, will provide means to determine enabling conditions, outputs, and outcomes at different points along the MPAN process (Salafsky et al. 2002) to improve biodiversity outcomes (Failing & Gregory 2003; Chaigneau & Brown 2016; Di Franco et al. 2016; Grorud-Colvert et al. 2021). Our research provided a means to differentiate how the various dimensions of MPANs are considered when evaluating their performance. Practitioner input is a valuable contribution to enhancing the understanding of MPAN evaluations on the ground. This input offers insight into the focus of evaluations which can thereby improve an intervention's success.

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4. Lessons learned on the use of indicators in evaluating marine protected area networks: Integrating theory and practice

Abstract

Marine protected areas networks (MPANs) are key tools used for protecting coastal and marine biodiversity. MPAN evaluations need to consider individual and network-specific properties. While there is guidance for evaluating individual MPAs, understanding of network-specific indicators is limited. Here, reviewed indicators identified in the literature to assess MPAN effectiveness, and compared them to those characterized in practice. We conducted an online survey with MPAN managers, technical staff, and academics from across the globe and received responses (n=53) from 16 countries. We examined whether indicators were associated with ecological, economic, governance, and social dimensions, and which attributes of these dimensions they were linked to. We identified several network-specific indicators aligned with each dimension. Individual attributes were informed by many indicators. For every attribute some indicators were more prevalent than the rest, we termed these “leading indicators” as they were used most to measure an attribute. Additionally, in practice evaluations used a suite of indicators that were more comprehensive and evenly distributed across attributes in each dimension. Through this research, we found that the field of MPAN evaluation is yet in its early stages. This is surprising given that protected areas, in general, have a long history of evaluation and indicator development.

4.1 Introduction

4.1.1 Marine protected area networks

Marine protected area networks (MPANs) are an important tool for biodiversity conservation, helping promote sustainable development (IUCN-WCPA 2008; Levin et al. 2009; Commission & Conventions 2010; Kidd et al. 2011; Barragán-Paladines et al. 2015; United Nations 2015). MPANs are an organized collection of MPAs that are designed to work together systematically (IUCN-WCPA 2008; Grorud-Colvert et al. 2014). Several individual MPAs that exist in proximity do not necessarily constitute a network. Beyond the properties of the individual MPAs composing a network, MPANs also have properties related to the network itself, such as its connectivity, representativity, and integration into the broader land and seascape (IUCN-WCPA 2008; McLeod et al. 2009; Burt et al. 2014; Grorud-Colvert et al. 2014). These properties aim to allow MPANs to achieve similar ecological outcomes to those that would be offered by a single large MPA with similar overall protected area estate (IUCN-WCPA 2008, p. 3). Their properties may support social network approaches such as cost sharing and collaboration among communities and conflict relief in high-use areas (White et al. 2005). Consequently, MPANs can provide multiple benefits to species and habitats, and to people (Charles & Wilson 2009; Gaines et al. 2010; Grorud-Colvert et al. 2014; Westlund et al. 2017; Ban et al. 2019).

The interconnectedness of the multiple (ecological, economic, governance, and social) dimensions that underpin MPAN success highlight the variety of expected positive and negative social-ecological impacts associated with MPANs (Pollnac et al. 2001; Christie 2004; Giakoumi et al. 2018; Yates et al. 2019). Each dimension is composed of a collection of attributes that describe specific characteristics relative to MPANs. These dimensions and associated attributes describe where positive and negative impacts are thought to occur and the contexts and relationships in which MPANs operate (McGinnis & Ostrom 2014; Hill et al. 2015; Partelow 2018; de Alencar et al. 2020; James & Magee 2020). As such, attributes may vary based on the MPAN (Chapter three- Meehan et al., 2022). A set of indicators is then used to measure each attribute to determine whether changes have occurred due to MPAN implementation (impacts), or whether changes are necessary to improve outcomes (Hockings et al 2006; Pomeroy et al., 2004).

The ecological dimension is essential to achieve species persistence. This dimension is essential for designing an MPAN to understand where to place MPAs within a network for species survival and knowing if the sites achieving their objectives for those species or habitats in need of protection. Accordingly, ecological attributes of MPANs (see Chapter three for an extended description) include representation of habitats and species in an ecosystem, replication of ecological features important for species persistence, and ecological connectivity between individual protected areas (Dudley & Parish 2006; CBD 2008; IUCN-WCPA 2008; Rodríguez-Rodríguez 2019).

The economic, governance, and social dimensions concern how humans relate to the environment and are imperative to achieve successful ecological outcomes (Christie 2004; Pomeroy et al. 2005; Charles & Wilson 2009). Attributes for these dimensions include economic impacts, changes in employment, funding, rights and access, participation, partnerships, enabling legislation, cross-jurisdictional agreements, engagement and inclusion of community members, equity and social justice, changes in human wellbeing, and cultural value (Lowry et al. 2009; Armitage et al. 2012; Miller et al. 2012; Cárcamo et al. 2014; Borrini-Feyerabend & Hill 2015; Gill et al. 2017; Nelson et al. 2019; Wenzel et al. 2019; Mbaru et al. 2021).

MPAN evaluations (Hockings et al. 2000; Pomeroy et al. 2004) should incorporate attributes from each dimension to understand what influences MPANs and what they are influencing so that they can achieve long-term biodiversity conservation. However, consideration of these dimensions and attributes appears fragmented in MPAN evaluation literature (Meehan et al., 2020). MPAN evaluations have largely been based on quantitative area-based measures (CBD 2016), even though qualitative elements have been publicized that provide holistic evaluation guidance (Hockings et al. 2000; Pomeroy et al. 2005; CBD 2010; Geldmann et al. 2020; Grorud-Colvert et al. 2021). Some individual properties of MPANs have also been well-studied, particularly in relation to connectivity (Almany et al. 2009; Grorud-Colvert et al. 2014; Roberts et al. 2018) and representativity (House et al. 2017). Network-specific evaluations do not yet fully capture multiple dimensions, thereby limiting our ability to evaluate MPANs' contribution to global targets (Grorud-Colvert et al. 2014; Mcowen et al. 2016; Geldmann et al. 2021). Evaluating how MPANs contribute to global targets situates our research in a global context.

4.1.2 MPAN performance indicators

Evaluating the performance of an MPAN is inherently challenging due to its multiple interconnected dimensions (Christie, 2011; Pomeroy et al., 2004). Performance evaluations are generally achieved by monitoring a set of criteria, represented by carefully selected indicators, and evaluating them against agreed objectives, projected targets, or milestones (Hockings et al. 2000). Indicators can be quantitative or qualitative variables that help communicate information to improve decision-making, allowing for accountability about the progress of an intervention (Fig. 4.1; Hockings et al. 2000; Pintér & Swanson 2004; Pomeroy et al. 2004; USAID 2005; Heink & Kowarik 2010). Given that MPANs have multiple dimensions, each with multiple attributes, a multidimensional categorization may be a valuable approach for evaluating MPANs. Categorization may help clarify the properties and attributes considered in evaluations by organizing MPAN-relevant indicators associated with each attribute of the four dimensions of MPANs into 'headline indicators. A "headline indicator" consists of one or more place-associated or context-specific indicators. Headline indicators are used through the evaluation literature and guidance to arrive at a shared language toward common goals and objectives in diverse areas (Alder et al. 2002; Pelletier et al. 2005; Pomeroy et al. 2005).

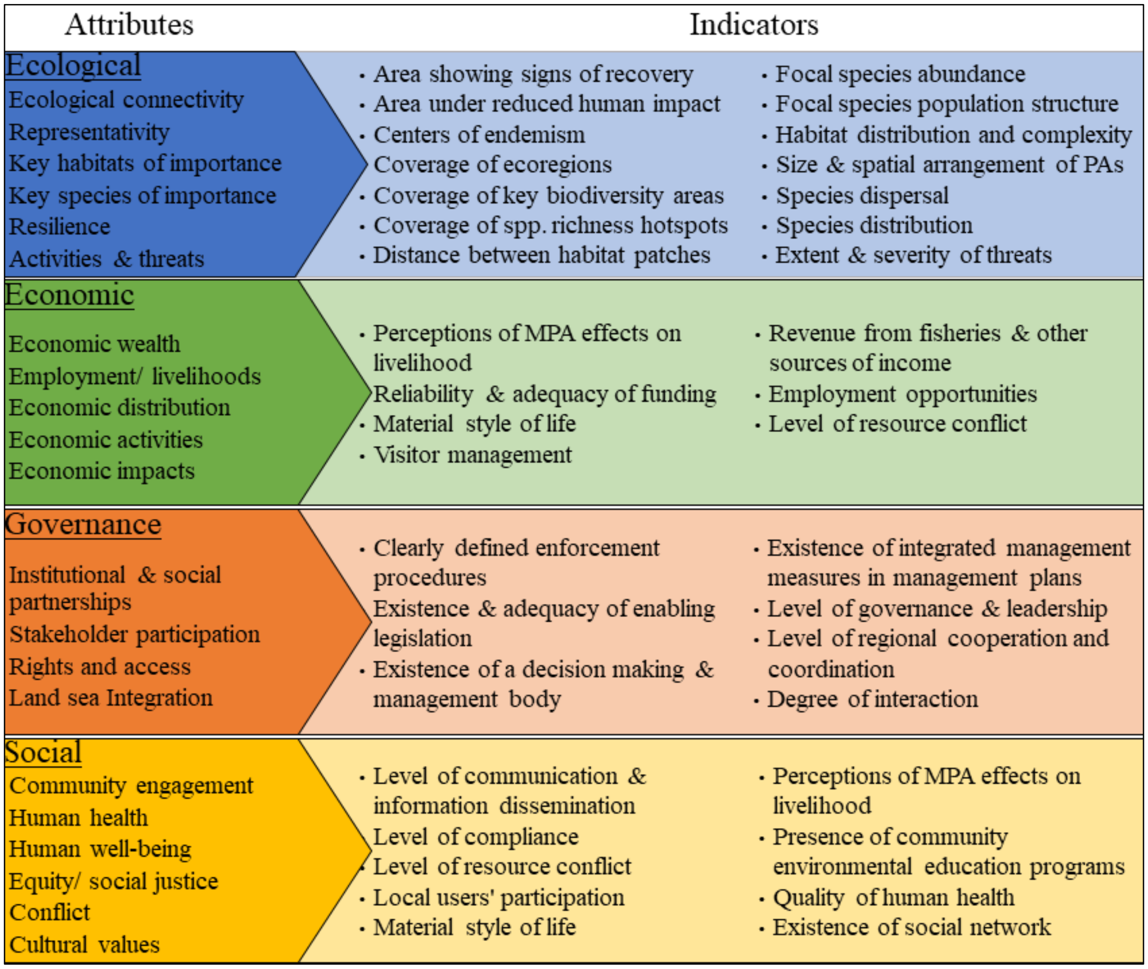

Figure 4.1. Indicators associated with each attribute of MPANs as identified in the literature, organized by dimension.

Contemporary MPA scholarship recognizes that individual MPA performance is affected by specific features, such as the economic wellbeing of stakeholders, management structure, age, levels of protection, and objectives (Kelleher 1999; Edgar et al. 2014; Di Franco et al. 2016; Friedlander et al. 2019; Wenzel et al. 2020). Therefore, MPAN evaluations may also differ based on one or more of these features. Age of an MPAN is an important feature of MPAN success (Edgar et al. 2014). Evaluations also may differ based on age of the MPAN as it takes time to build community and stakeholder input to identify and design elements of interest (Edgar et al. 2014; Ban et al. 2017). Gross domestic product

(GDP) can be used as a proxy for economic wellbeing, which may influence how MPAN evaluations are performed, including capacity to carry out evaluations (Clifton 2009; Jones et al. 2013; Gill et al. 2017). Levels of protection are important to MPAN success in biodiversity conservation (Grorud-Colvert et al. 2021). MPANs come with a variety of protection levels, which could again influence how they are evaluated and what attributes are considered when making evaluations. MPANs often contain diverse, sometimes conflicting objectives. Previous research (Chapter three) found that MPANs with diverse objective types differ in the attributes they focus on when evaluating MPAN performance. If they differ in the attributes considered, perhaps the indicators used to evaluate performance would also differ.

4.1.3 Differences in theoretical understanding and practical use

Academic and practical knowledge are both valuable when evaluating MPANs (Wyborn et al. 2019). Compiling indicators from the academic literature can be useful in identifying general criteria used in monitoring, but indicators may be site or species-specific and irrelevant in a variety of contexts. Practitioners' knowledge is important in bringing in relevant social and economic contexts for any specific MPAN (Himes 2007; Christie 2011; Yates et al. 2019). Attributes and indicators associated with MPAN evaluations from practitioners' perspectives may be different from the literature, which can fill in gaps in understanding how evaluations are undertaken. A survey instrument is one way to allow for broader audience participation in the understanding of what is important and how context-specific attributes are evaluated (Martin et al. 2011).

4.2 Research Methods

4.2.1 Eliciting expert knowledge

We elicited information from marine protected area network (MPAN) practitioners about the indicators used to evaluate an MPAN they are familiar with. MPAN practitioners are experts with an experiential understanding of MPAN design, implementation, and monitoring through lived and worked experiences (e.g., managers, researchers, and field technicians; Martin et al., 2011). Eliciting knowledge from these individuals can provide valuable information in the translation and bridging of theoretical constructs to practical use for understanding complex environmental systems (Krueger et al. 2012). We conducted a global online survey to provide insight into how indicators were used to measure the multidimensional attributes associated with MPANs. Specifically, we aimed to provide a holistic perspective of how MPANs are evaluated by identifying how practitioners conceptualize MPAN indicators. We asked participants to select the indicators they have considered in the design, implementation, or monitoring of this MPA network. We then used this information to illustrate differences between the use of indicators described in the literature and those used in practice.

The survey was composed primarily of multiple-choice questions in English, French, and Spanish, and it was anonymous, precluding a measure of response rate. The survey was developed in Qualtrics (v. 12018) and released from 28 February 2020 to 1 May 2020. The first question queried participants about the MPAN they were associated with as a requirement to initiate the survey (see Appendix A for details). We obtained indicators used to measure each attribute from a review of MPAN-specific ecological, economic, governance, and social conditions (Meehan et al. 2020). We included an open-ended response category for every set of multiple-choice questions to add indicators they thought were missing from the multiple-choice options. This survey structure aimed to account for potential biases common in each of these question types. Namely, biases may include anchoring, where the multiple-choice categories may bias respondents to select only those answers, and availability bias, where an expert can be affected by ease of recall or memory from recent experience to answer solely open-ended questions (Failing & Gregory 2003; Knol et al. 2010). Furthermore, how questions are ordered in the survey can affect respondents' answers about various indicators (Krosnick 2018). We grouped questions in sections, ordered by dimension, while questions in each section questions were randomly assigned. This structure was aimed to force respondents to think about all possible indicators in each dimension. We beta-tested the survey on several practitioner groups who work on marine conservation issues, two who were associated with government research institutes and three associated with universities. We distributed invitations to participate in an online survey to 232 corresponding authors of peer-reviewed literature on MPANs, and to 79 MPAN staff whose email addresses were publicly available on the Web. We also distributed invitations via relevant mailing lists (Table C1) and through social media (Twitter and Facebook). We requested invitees to forward the survey to team members, collaborative partners, researchers, and others who held knowledge of MPAN monitoring and evaluations in a "snowball approach" (Christopoulos 2011) to reach a broad audience. Only fully completed surveys were used in analyses to avoid oversampling of the first dimension queried. I received 156 responses, 77 of which were fully completed, and therefore used in analyses. This research was conducted with approval by Memorial

University's Interdisciplinary Committee on Ethics in Human Research (Approval #20200830) and the University of Victoria Office of Research Services' Human Research Ethics Board (Approval #19-0363-02). All data collection followed the university's informed consent processes.

4.2.2 Indicator selection

We asked participants to select from a list of indicators used to measure each attribute monitored in the MPAN they were familiar with. We based this list on a review of indicators relating to social, ecological, economic, and governance dimensions considered important in MPAN evaluations (Hockings et al. 2000; Pomeroy et al. 2004; Leverington et al. 2010; Gannon et al. 2017; Meehan et al. 2020). We followed each set of multiple-choice questions with an open-ended question and asked participants to add indicators they thought were missing from the multiple-choice survey options (see survey in Appendix A).

To describe the indicators that participants regarded as important in evaluating MPAN success in practice, we counted the selection frequency of each indicator used to measure an attribute among MPANs. We also aimed to identify leading indicators by calculating the proportion of indicators selected for each attribute to get a sense of prevalent indicators that contributed most to the measurement of attributes. We created a Sankey diagram to show the connections between indicators and attributes in each dimension.

We transformed our dataset into a presence-absence matrix to reduce the influence of the dominant indicators that were included in the survey from the literature review, thereby increasing the contribution of the practitioner-added indicators. Since participants were asked to select indicators that were associated with a specific attribute, we assigned a unique letter to each attribute and a unique number to each indicator such that we could evaluate unique indicator-attribute pairs. With this dataset, we performed a nonmetric multidimensional scaling (NMDS) analysis. NMDS is a multivariate method commonly employed in community ecology literature (Oksanen, 2013) to measure and visualize the level of similarity between individual samples (in this case, MPANs) in a multivariate dataset (Legendre and Legendre, 1998). NMDS makes no parametric assumptions about data and is hence widely applicable across various data types. We used the Jaccard distance to measure (dis)similarities in the suite of indicators selected between each pair of sites. The Jaccard distance is a commonly used distance measure for comparing observations with presence-absence values (Legendre and Legendre, 1998). If one indicator was associated with one attribute in several MPANs, we would see multiple sites positioned around that one indicator-attribute pair.

We then conducted a permutational multivariate analysis of variance (PERMANOVA) to identify underlying features associated with differences in the suite of indicator-attribute pairs (Anderson, 2001). We asked survey participants to identify the management structure, age, and levels of protection of the MPAN they were answering for, as these are well-known features associated with effective MPAs (Kelleher 1999; Edgar et al. 2014; Di Franco et al. 2016; Friedlander et al. 2019; Wenzel et al. 2020). Finally, we added a GDP code based on World Bank reported country income level categorization (World Bank, 2022). With this, we aimed to examine whether the composition of indicator-attribute pairs differed between MPANs based on GDP and several features associated with each network (management structure, age, levels of protection). We used an additive model to explore these associations. If the PERMANOVA identified differences in the suites of indicators selected among the various features (i.e. if omnibus PERMANOVA was significant), we performed a *post hoc*, pairwise Adonis analysis (Oksanen et al. 2019) to identify where the differences occurred, employing a Benjamini-Hochberg correction to control for familywise error rate (Benjamini & Hochberg 1995).

4.2.3 Differences between indicators used in practice vs literature

We compared indicators considered important in measuring each attribute in the literature and by survey respondents (experts). We calculated the selection of each indicator used to measure an attribute among all indicators used to measure that attribute (proportion). We then used the Bray-Curtis dissimilarity, and distance measure often used in ecology and biology to quantify the difference between two sites in terms of the species found in those sites. We employed this measure to compare the differences between indicators selected for each attribute among the literature and survey groups. The Bray-Curtis Dissimilarity is calculated as:

$$BCij = 1 - (2 * Cij) / (Si + Sj)$$

Where Cij is the sum of the lesser values for the species found in each site, Si is the total number of specimens counted at site I, and Sj is the total number of specimens counted at site j. The dissimilarity measure (distance between literature and survey groups) always ranges between 0 and 1, identifying attributes with shared indicators (distance close to 0) and those that were distinct (distance close to 1) between the literature and in practice.

Here, we assessed the indicators used to evaluate each attribute, then looked to see if there were apparent differences between the proportion of times indicators were associated with a particular attribute in practice and academic literature. Since some academic researchers whose literature was assessed were also included in the practitioner category, we asked respondents about their affiliation, whether as an academic, academic-practitioner, project manager, project facilitator, habitat specialist, or monitoring technician. We grouped responses into two categories, experts solely affiliated with an academic institution and those that were either not affiliated with an academic institution or were both a manager and academic. We assessed potential differences in response using a permutational multivariate analysis of variance (PERMANOVA, Anderson, 2001). Finally, we calculated Shannon (H') diversity and evenness (E) on the mean number of indicators for the literature and survey responses. We adapted these community ecology methods to look at the diversity of indicators between the literature and survey responses. We calculated Shannon's diversity with the formula

$$H' = -\frac{\sum ni}{N} \times ln \left(\frac{ni}{N}\right),$$

where ni is the number of times indicator I is used (in literature or survey) and where N is the total number of times all indicators are used in MPAN evaluations across both datasets. We performed this analysis for each dimension (ecological, economic, governance, and social) to identify differences between the literature and survey responses per dimension. A high diversity score means that many different indicators were used to evaluate a specific dimension, while a low score means that one or a few indicators were used in evaluations. We also calculated Pielou's evenness (J') to quantify the distribution of indicators per dimension used in the literature and in the survey responses

$$E = H'/ln(S)$$

where S refers to the indicator richness, the number of different indicators used in each group (Verberk, 2011). A higher evenness score means that a given dataset was informed by a wide variety of indicators, with no indicator dominating the evaluations. A low evenness score means that few (or one) indicators were used predominantly in evaluations. These matrices showed how the indicators were distributed across each setting.

We collated survey responses in Microsoft Excel (Redmond, Washington) and subsequently analyzed, unless specified otherwise, using R (R core team, version 4.0.3, 2020) with package vegan 2.5-6 (Oksanen et al., 2019). Figures were graphed using ggplot2 version 2_3.3.2 (Wickham, 2016) and SankeyMATIC (Bogart, 2022).

4.3 Results

4.3.1 What attributes are indicators measuring in practice?

Survey respondents referred to 39 MPANs across 16 countries, 2 regional MPANs (MedPAN in the Mediterranean and The Regional Network of Marine Protected Areas (RAMPAO) in West Africa), and one participant whose work was related to the global MPAN (Table C1). Respondents identified a total of 62 indicators used in practice to measure 32 attributes across the four dimensions (Table C2;27 indicators measured 7 ecological attributes, 6 indicators measured 7 economic attributes, 19 indicators measured 11 governance attributes, and 10 indicators measured 7 social attributes). Survey participants identified 7 new ecological indicators that were missing from our initial list, 3 new economic indicators, and 3 new social indicators. We evaluated the added indicators for redundancy and merged them into 'headline indicators' if they represented specific components of an existing indicator field (Table C2). For example, we combined the added indicators "hydrodynamics (tides, waves, currents)" and "oceanographic considerations" to form the headline indicator "oceanographic parameters". We also organized "level of maternal health and child malnutrition" into the existing headline indicator "quality of human health", and "funding per unit area" into "availability and allocation of MPA administrative resources (secured funding)" (Table C2). The results of PERMANOVA suggest there are no differences in responses between experts solely affiliated with an academic institution and those not affiliated with an academic institution or with multiple affiliations, including academic (R^2=0.03, F=0.97, p<0.55).

Our results showed a considerable overlap of indicators as practitioners often selected the same indicators for multiple attributes in each dimension (Fig. 4.2). More than 70% of the ecological indicators (11 out of 15) were used across most (>50%) of ecological attributes. Every social indicator was used to measure 50% or more of the attributes in the social dimension. Three out of nine social indicators were used to measure all the social attributes. Five of the 12 governance indicators were used to measure all 19 governance attributes. The economic dimension displayed less overlap. Three indicators were used to measure 50% or more of these attributes. As such, we identified leading indicators in each dimension selected to measure each attribute (Table C3). Leading indicators in the ecological dimension were "Area showing signs of recovery" to measure habitat health; "composition and structure of the community" contributed most to the evaluation of ecological function; and “extent and severity of threats” to measure activities and threats (Table C3). The leading indicators in the economic dimension were “perceptions of MPA effects on livelihood” measuring economic activities, and “revenue from fisheries and other sources of income” measuring opportunity cost (see Table C3 for full list). The leading governance indicator was the “level of constraint or support by external political and civil environment”, measuring the governance attribute funding for management. The overlap of indicators to attributes was more apparent in the social dimension (Fig. 4.2). Calculating leading indicators made these associations more apparent, revealing the “extent of traditional practices” as a leading indicator for cultural value and significance and human health; “quality of human health” was a leading indicator measuring human health, and human wellbeing. The indicator “perceptions of MPA effects on livelihood” measured equity/social Justice and traditional and historic uses (Table C3).

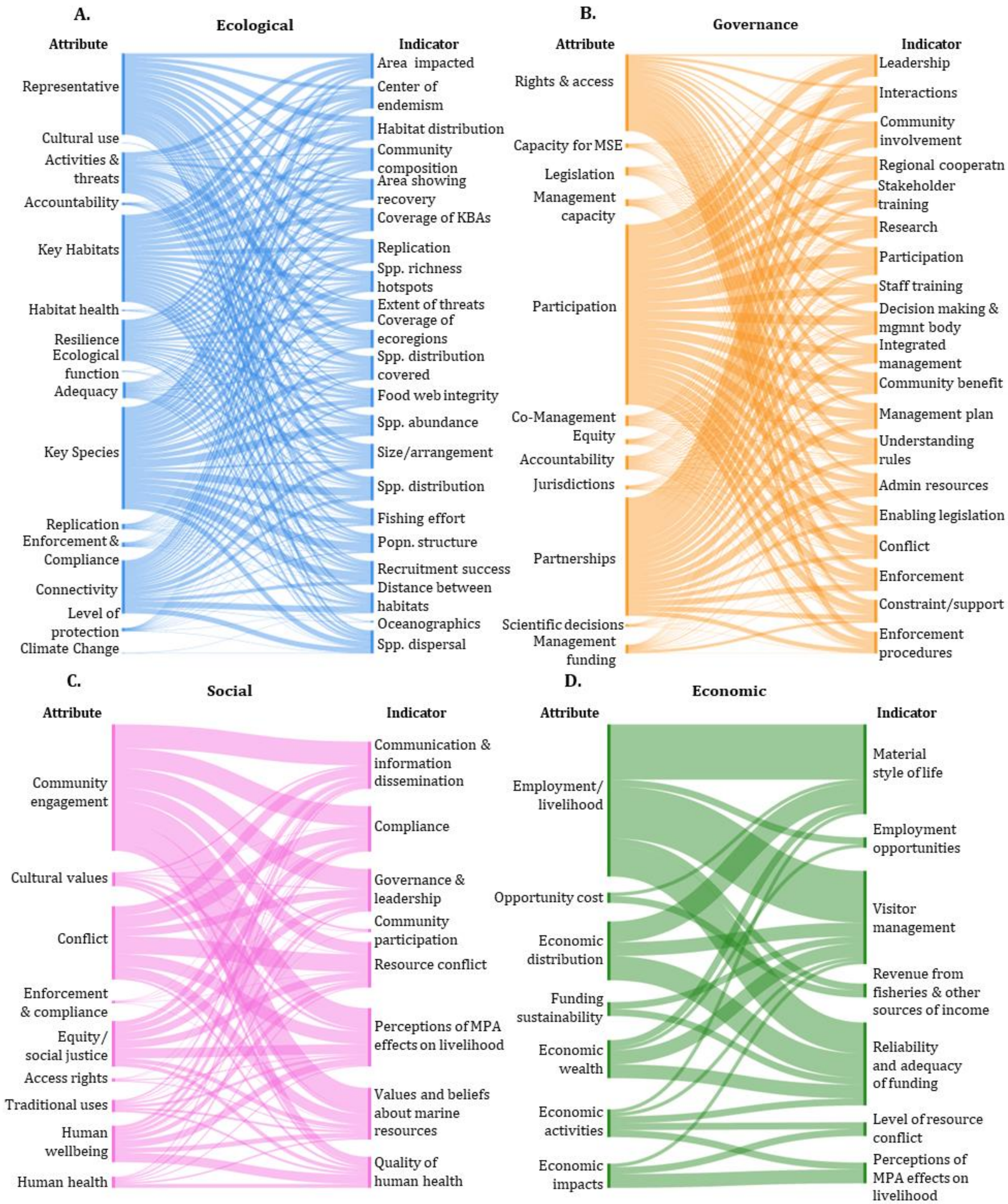

Figure 4.2. Flow diagrams illustrating linkages between attributes and indicators in each dimension. Each figure shows attributes measured by practitioners of various MPANs (left) and the headline indicators (right) used to evaluate the attributes. The size of the connecting line is proportional to the frequency each indicator was used to measure an associated attribute.

Results of NMDS placed MPANs together based on the composition of attributes and indicators used to measure them. Overall, we saw large clusters in the center of the ecological and governance plots (Fig. 4.3), suggesting many indicator attribute pairs were similar among sites in these dimensions. Some indicator attribute pairs extended outside the central cluster in each of the dimensions. Common network-specific attributes in the ecological dimension can be seen as associated primarily with the “number of replicated species/habitats”, the only common indicator used among sites. Six sites measured Adequacy, “size and spatial arrangement of PAs” (Fig. 4.3, indicator 22) was the only indicator shared among all sites. Activities and threats were consistently associated with “area under no or reduced human impact”, “type, level and return on fishing effort”, and “extent and severity of threats” (Fig 4.2). Key species was most consistently associated with “focal species abundance”, “focal species population structure”, and “species distribution.

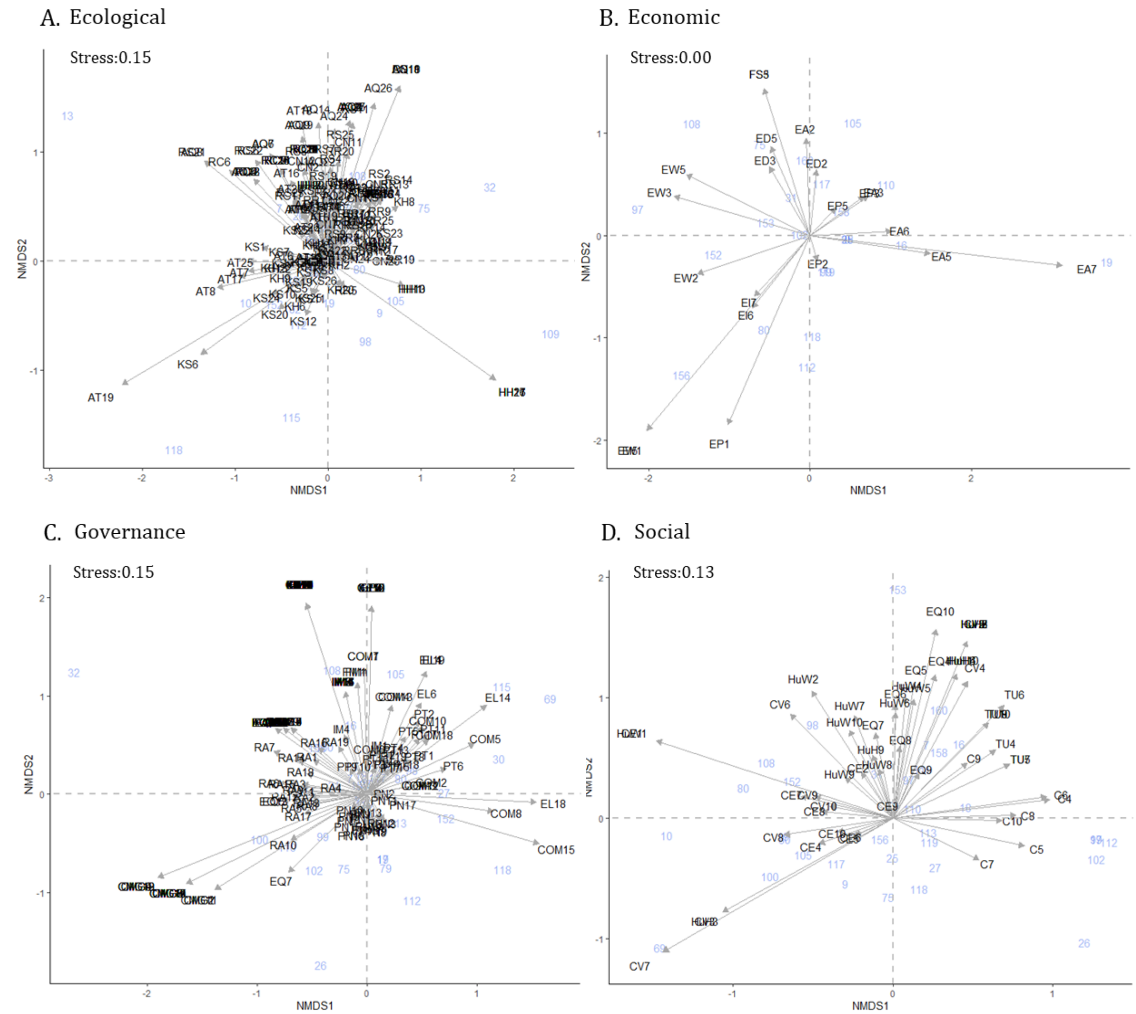

Figure 4.3. Nonmetric multidimensional scaling (NMDS) bi-plot for each dimension: Ecological, Economic, Governance, and Social. Codes for each plot can be found in Table C7.

As indicated by its very low stress level (stress = 0.00; Fig. 4.3B), the dataset of economic attributes was too small to summarize the distances among samples for the NMDS analysis. Nonetheless, we did see some patterns. Of the 23 sites that considered economic attributes, 16 measured Employment/livelihood, hence the central position along NMDS 1 and 2 (Fig. 4.3B). The leading indicators paired with this were "material style of life" and "visitor management". Economic impact was paired with "perceptions of MPA effects on livelihood" (EI6) among all four sites that measured economic impact.

In the governance dimension Participation was assessed in all but two sites, hence its central orientation in the NMDS plot. Six sites on the far right of Fig. 4.3C, along NMDS1, were characterized by a high abundance of indicators measuring Partnerships. On the lower left, along NMDS 2 two sites were characterized by a high abundance of indicators measuring Co-management. Enabling legislation and Capacity are represented along the top of NMDS2, characterizing three sites.

A total of 34 sites evaluated an attribute in the social dimension. Community engagement and inclusion was highly correlated with 28 of these sites. Five sites are represented by a suite of indicators solely measuring Conflict (shown along NMDS 1). Definitive associations between the composition of indicators in each dimension and features understood to influence MPAN effectiveness (GDP, management structure, age of the MPAN, number of MPAs, level of protection, and objective type) were weak. Together, management, GDP, and level of protection explained most of the variation in the datasets (Table 4.1). Results from the PERMANOVA suggest some differences in the composition of indicator-attribute pairs between different groups in the ecological and economic dimensions. Differences between the suite of indicator-attribute pairs in the ecological dimension were associated with GDP (Table 4.1). The composition of indicator-attribute pairs differed significantly within features in the economic dimension (Table 4.1). GDP, objective type, and level of protection were all significant ($p = 0.05$, 0.01, 0.02, respectively). We ran a series of permutational pairwise comparisons (pairwise Adonis) on the features that indicated significance in the suite of indicators (Table C4). Results revealed no differences in the suite of indicators within each feature.

Table 4.1. Results of permutational analysis of variance (PERMANOVA) to identify underlying features associated with differences in the suite of indicator-attribute pairs.

Ecological	Df	Sum of Sqs	R^2	F	Pr (>F)
GDP	7	2.58	0.22	1.25	**0.04**
Objective type	1	0.23	0.02	0.79	0.81
Management	12	3.93	0.34	1.11	0.18
Age	1	0.35	0.03	1.18	0.22
Level of protection	5	1.20	0.10	0.82	0.93
Residual	11	3.23	0.28		
Total	37	11.51	1.00		
Economic					
GDP	6	1.99	0.26	2.18	**0.05**
Objective type	1	0.75	0.10	4.94	**0.01**
Management	9	2.76	0.36	2.02	**0.05**
Age	1	0.30	0.04	1.96	0.10
Level of protection	4	1.63	0.21	2.67	0.02
Residual	2	0.30	0.04		
Total	23	7.74	1.00		
Governance					
GDP	7	2.13	0.22	1.06	0.37
Objective type	1	0.27	0.03	0.95	0.49
Management	10	2.57	0.26	0.89	0.76
Age	1	0.49	0.05	1.72	**0.05**
Level of protection	5	1.23	0.12	0.86	0.77
Residual	11	3.16	0.32		
Total	35	9.85	1.00		
Social					
GDP	7	1.78	0.19	0.96	0.57
Objective type	1	0.29	0.03	1.08	0.38
Management	11	3.70	0.40	1.27	0.14
Age	1	0.12	0.01	0.45	0.93
Level of protection	5	1.31	0.14	0.99	0.50
Residual	8	2.13	0.23		
Total	33	9.32	1.00		

4.3.2 Differences between indicators used in practice vs. literature

We found differences between the academic literature and practice in the indicators used to measure attributes. The multivariate difference in the suite of indicators from the literature and the expert survey were large (Fig. 4.4, Table C5). Our results identified attributes with shared indicators though most were distinct between the literature and in practice. Indicators associated with attributes that survey participants added were obviously different since these were not identified in the literature and had a calculated multivariate distance of 1. Among the indicators identified in both the literature and the survey, the smallest multivariate distance in the ecological dimension was for connectivity, followed by key habitats and key species (Fig. 4.4). In the economic dimension, the multivariate distance was the smallest for the suite of indicators measuring funding sustainability. Funding for management was the attribute with the smallest distance between literature and survey indicators in the governance dimension. The social dimension showed both enforcement and compliance as well as conflict with the smallest distances between the indicators identified in the literature and selected in the survey.

The suite of indicators used to measure attributes that survey participants selected were generally more numerous than indicators compiled from the literature (Figs. C1-C4, Table C6). Literature-compiled indicators were clearly associated with attributes, with little variation. In contrast, indicators used by practitioners were more evenly distributed across attributes in a dimension (Figs. C1-C4). The most used indicator in the literature was "levels of communication and information dissemination", used to measure information diffusion through community engagement, an element of effective management (Meehan et al. 2020). On the other hand, survey responses used this indicator to evaluate conflict and equity considerations, in addition to community engagement. Survey participants also added a few indicators we had not identified from the literature (Table C2).

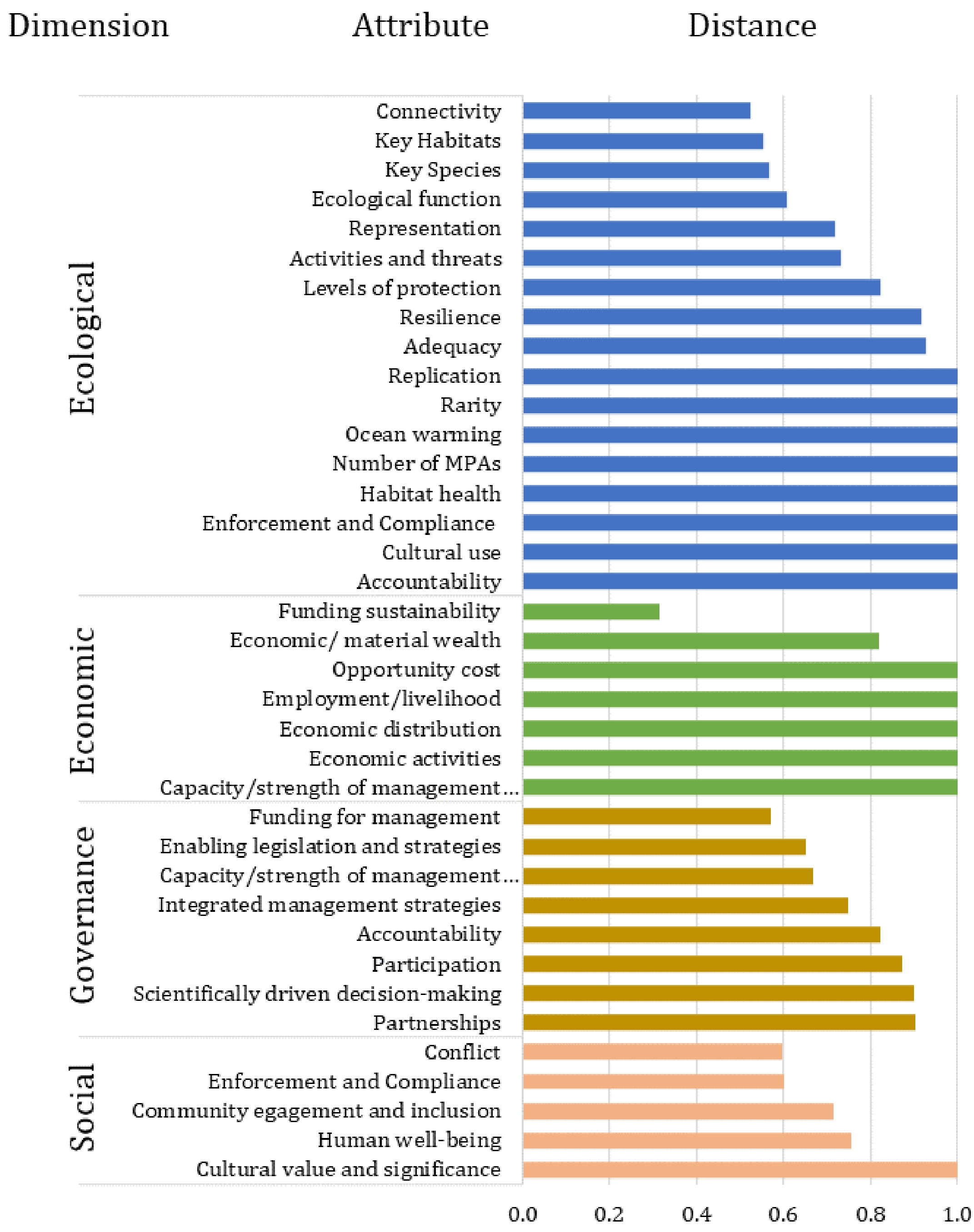

Figure 4.4. The multivariate differences between indicators from the literature and the expert survey for each attribute, organized by dimension. Higher values indicate greater differences between the suite of indicators used in literature and in the survey; a value of one indicates complete difference.

Within the ecological dimension, the literature focused on quantitative spatial targets such as "coverage of ecoregions" and "area of threat", and species-specific attributes such as "focal species abundance". Survey participants selected a more diverse set of indicators that generally followed trends observed in the literature (Fig. C1). The most frequently identified economic indicator from the literature was "reliability and adequacy of funding", followed by "visitor management" (Fig. C2). In the literature, "visitor management" was used to measure income-generating activities relating to effective management. According to survey respondents, it was used to measure employment and economic distribution. In contrast, the most frequently used economic indicator selected in the survey was "material style of life" and "reliability and adequacy of funding" used to measure Economic distribution, Economic/material wealth, and Employment/livelihood. The most frequently used governance indicator identified in the literature was "availability and adequacy of funding for management", followed by the "existence of a decision-making and management body", which was used to measure the existence of a management structure and its capacity (Fig. C3). Survey participants selected "levels of stakeholder participation and satisfaction in management" the most. This indicator was used to measure legitimacy, participation, and accountability in MPANs, followed closely by "level of community and stakeholder involvement". The selection of social indicators also differed between the literature and practice (Fig. C4). From the literature compiled indicators, "level of communication and information dissemination" and "quality of human health" were identified most, used to measure Community engagement and Human wellbeing, respectively. Similarly, "quality of human health" was primarily selected to measure Human wellbeing in the survey. The social indicator most frequently selected from the survey was “perceptions of MPA effects on livelihood” used to measure community engagement, conflict, and equity. Survey participants selected “values and beliefs about marine resources” and “perceptions of MPA effects on livelihood” to measure Cultural values. In the literature, this attribute was informed by the indicators “Local users’ participation in management” and “existence of a social network”.

4.4 Discussion

Evaluating MPANs along multiple (ecological, economic, governance, and social) dimensions is essential to assess whether they are meeting their objectives and how to adaptively manage them if not (Hockings et al. 2000; Pomeroy et al. 2004; Leverington et al. 2010; Gannon et al. 2017; Geldmann et al. 2021; Grorud-Colvert et al. 2021). Here, we set out to identify the indicators that are used in practice, and the attributes they measure.

The broad collection of indicators associated with attributes in practice could reflect the complexity of MPAN attributes across dimensions. These attributes may require a suite of indicators, rather than one single indicator, which – alone – provides insufficient detail for effective evaluation. These findings corroborate those of Turcu et al. (2013) who found that informing global, multidimensional MPANs will require a suite of indicators that work in concert to evaluate progress (Turcu 2013). A suite of indicators may better represent the system’s diversity better, and more accurately describe its status rather than one broad indicator (Failing & Gregory 2003; Pelletier et al. 2005; Rice & Rochet 2005; Heink & Kowarik 2010; Shin et al. 2010; Beliaeff & Pelletier 2011; Pelletier 2011; Bundy et al. 2017).

We found that the evaluation of MPANs consisted of an aggregate approach of individual MPA and network-specific indicators. We observed network-specific indicators primarily in the ecological dimension (distance between habitat patches, oceanographic parameters, proportion of species distribution covered by MPAs, size and spatial arrangement of MPAs, number of replicated species/habitats, and coverage of ecoregions). These indicators were predominantly used to evaluate network-specific attributes, such as connectivity, representativity, adequacy, and replication (Fig. 4.2a). Our findings align with academic research identified in the peer reviewed literature that focuses on ecological components of MPAN performance (Almany et al. 2009; McLeod et al. 2009; Grorud-Colvert et al. 2014; Roberts et al. 2018). There were some network-specific governance indicators identified by survey participants (existence of integrated management measures in management plans, and level of regional cooperation and coordination). We identified these as network-specific due to their alignment with the qualitative element "Integrated into wider landscape and seascape" described in Aichi Target 11 (CBD 2010).

We identified one network-specific social indicator (existence of a social network) as well. While our research on the multiple dimensions of MPANs supports greater consideration of social attributes in MPAN evaluations, we found that social attributes were still underrepresented in MPAN evaluations. Our results contribute to furthering calls to evaluate both component MPAs individually, as well as network-specific elements. The indicator expressed in our survey, for example, can be used to assess the coordination and other social network aspects of individual MPAs as well as MPANs. However, one implication might be that more capacity and funds are needed to do both (Alexander 2014; Alexander & Armitage 2015; Wenzel et al. 2019).

Differences in indicator selection based on GDP and management type could be indicative of the ability to access information, such as reports and current literature (Martin et al., 2011), and the ability of a government to provide financial capacity and support to biodiversity and fisheries management initiatives (Campbell et al. 2013). Thus, GDP and management type may limit or promote indicator use, or evaluation in general. Different types of management structures are known to influence how ecosystem services (an element of MPANs) are conceptualized and managed (Hicks et al. 2008) and could therefore influence the indicators used to evaluate these elements. Different management structures may also shape indicator use, influencing how evaluations are performed (Cudney-Bueno et al. 2009; Fox et al. 2012). Finally, differences in indicator selection based on management type may be due to where participants' roles fall within the management structure of an institution. Participants with a higher-level managerial role may have more influence over the indicators used while others who operationalize work plans may have limited agency or influence over the specific indicators used to evaluate MAPNs. Locally managed or co-managed areas may be able to use place-based understanding to account for limited financial capacity or perception of legitimacy amongst stakeholders. The age of an MPAN speaks to the legacy of how old or established it is. Time allows for benefits to accrue and management to adapt to the site-specific contexts, which could influence how indicators are used (Hockings et al. 2000; Edgar et al. 2014). Levels of protection provide for diverse activities allowable within an MPAN (IUCN et al.

2012; Grorud-Colvert et al. 2021). Therefore, we would suppose this feature would explain some differences in how indicators were used among MPANs. Our results, however, found that GDP and management structure, not level of protection, explained indicator differences. Guidance on better defining levels of protection was recently developed (Grorud-Colvert et al. 2021), and hence perhaps in the future, this might become more influential.

Studies have found that academic research and practice are not always aligned (Pullin & Knight 2009; Sunderland et al. 2009; Arlettaz et al. 2010; Cook et al. 2010; Di Marco et al. 2017; Stephenson et al. 2017; Toomey et al. 2017; Walsh et al. 2019). This research identified differences between how MPANs are evaluated from the perspective of practitioners and in the peer-reviewed literature. Evaluations in the peer-reviewed literature identified clear associations between indicators and specific attributes they measured. In contrast, survey responses implied evaluations use a suite of indicators that are more comprehensive and evenly distributed across attributes in each dimension. The distinct indicator-attribute pairs observed in the literature could be due to the nature of academic research, which relies on a clearly articulated problem to develop robust, reproducible results within a specific timeframe, often using established theory and existing frameworks (Arlettaz et al. 2010; Abdulai & Owusu-Ansah 2014). In many cases, these contexts allow for only a subset of indicators to be studied (Sunderland et al. 2009). The academic literature provides important contributions about specific indicators useful for measuring and evaluating performance. The richness and diversity of indicators selected by survey participants may allude to the complexity at a local scale that is difficult to capture in academic research (Sunderland et al., 2009). Incorporating academic and practical knowledge as we did can improve how MPAN evaluations are performed (Clark et al. 2016; Reed & Abernethy 2018; Wyborn et al. 2019; Chambers et al. 2021). The inconsistency between indicators considered in practice and identified in the literature does not diminish the potential influence of academic research on practice. It may speak to the diverse contexts that influence practitioner perspectives- what is considered according to the context (Cvitanovic et al. 2014; Hopkins et al. 2016; Aswani et al. 2017). Clark et al. (2016) underscored the importance of collaboration between researchers and practitioners when dealing with complex social-ecological dynamics as they provide different perspectives of problems and solutions. Indeed, the idea of bridging knowledge has been described as an important tool for science, especially sustainability and conservation science (Arlettaz et al. 2010; Pajaro et al. 2010; Cook et al. 2013).

Our research used a survey instrument to gather substantive expert opinion to evaluate associations between indicators and attributes to inform a broad (global) effort to understand how to best evaluate MPAN under a variety of contexts from a multidimensional perspective. Substantive expertise draws on an expert's knowledge of their field, MPAN evaluation (Martin et al. 2011). Expert opinion can be particularly useful when data are absent or incomplete (Pajaro et al. 2010), however, care needs to be taken to reduce the potential for error in judgment stemming from participants' contextual or cognitive biases such as anchoring and availability (Knol et al. 2010; Hemming et al. 2018). We endeavored to overcome some of the obstacles by framing questions in a manner that reflected current discourse in the field, providing clear definitions at the outset of every section, within each section, as well as a definition page at the start of the survey. We provided several open-ended questions, that allowed participants to add their own categories and insights. Furthermore, we performed several iterations of beta-testing the survey to substantiate the relevance and clarity of the survey instrument. Nevertheless, it is possible that participants were not overly discerning with indicator selection.

Our study found that clearly defined indicator-attribute pairs were more apparent in attributes that were only identified by survey participants (not identified in the literature). The stronger pairings for participant-identified attributes could reflect the broad contexts in which well-studied attributes (those used in existing evaluation frameworks) are measured, blurring the indicator-attribute pairings. This could imply a need to understand these attributes further and identify a set of indicators to evaluate each attribute. It is not lost on us that some of the same academic researchers whose literature was assessed were included in the practitioner category. In this study, we were looking to compare indicators that were considered in the literature and those considered in practice. While the differences between literature-based indicators and survey-based indicators was considerable, there is yet a concern that our sampling strategy may have produced bias toward academic researchers. However, since we found minimal differences in responses between solely academic research and "other" academic and practitioner responses, any sampling bias that may exist would not have much effect since participants were asked about indicators used in practice rather than personal judgement. That said, this research did not assess the quality of the indicators identified in reflecting each attribute to ensure MPAN performance. While this is a cursory examination, there is merit in looking into the quality of the indicators in measuring MPAN effectiveness. The plethora of indicators selected for each attribute could have been influenced by the aggregated process we referred to for evaluations. Rather than ask participants to differentiate about where in the process of MPAN design, implementation, monitoring, and evaluation, indicators were used, we asked participants to select indicators used during any part of MPAN evaluations – i.e., design, implementation, monitoring, or evaluation (Hockings et al. 2000; UNDP 2002; Failing & Gregory 2003; Sari et al. 2019). Requesting information at each step of the process would have added more complexity to an already complex and cumbersome survey, likely impacting the response rate (Bliss et al. 2001). Further work would benefit by differentiating how indicators are conceptualized in each step of the process for each dimension.

Results of this study showed that indicators used to evaluate MPANs attributes were highly variable across sites. In fact, every attribute was informed by a suite of indicators. While the composition of indicators was similar, leading indicators differed among attributes. This suggests that the same indicators, grouped differently, informed different attributes. These results were surprising given that indicator theory suggests the relationship between an indicator and MPAN objective should be clearly defined (Failing & Gregory 2003; Pelletier et al. 2005; Rice & Rochet 2005; Heink & Kowarik 2010; Shin et al. 2010; Beliaeff & Pelletier 2011; Pelletier 2011; Bundy et al. 2017). Following this theory, we would speculate the attributes that indicators contribute to would also be more clearly defined. Furthermore, guidance exists that offers specific indicator sets to measure individual MPA performance (Pomeroy et al., 2004; Hockings et al., 2000). Given the contribution of individual MPAs to an MPAN, the ambiguous indicator-attribute pairs were again surprising. These results correspond with Fox et al., (2014) who found limited use of indicators to evaluate socioeconomic and governance attributes when exploring indicators used to evaluate MPA performance (Fox et al 2014). The greater variability in indicators used to evaluate economic, governance, social, and MPAN-specific attributes may be linked to the limited historical use of indicators to evaluate these elements. Likewise, clearly defined indicator-attribute pairs were more apparent in attributes that were only identified by survey participants (not identified in the literature). This seems to imply that these attributes may not yet have been examined in a research context, rather than having a strong relationship with a particular set of indicators. These clearly defined indicator-attribute pairs could be a result of context specificity or emerging contributions and considerations associated with place, an interesting area of examination that can be improved upon.

4.5 Conclusion

This research represents the first comprehensive review of the indicators used to evaluate MPANs from a multidimensional perspective. Classification of the indicators that contribute to understanding individual MPAs has been done (Pomeroy et al 2004), but not MPANs. Identifying commonly used indicators to measure attributes can provide insight into the indicators used more and less consistently throughout the world. This can help inform current initiatives aiming to develop a global compendium of MPAN performance indicators that consider the multiple dimensions of MPANs. This can also provide insight for an MPAN that is interested in identifying priority indicators as a starting point or in case of limited capacity. Current discussions in the international arena are looking to identify an approach to develop a suite of feasible indicators for reporting on MPANs from an international perspective (UNEP/WCMC working group, 2022). We hope this work provides critical insight into the type of indicators used in practice and the challenges in framing headline indicators that can be used to evaluate MPANs from a global perspective.

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5. Discussion

5.1 Summary of research rationale

As human pressures on coastal and marine systems increase, so does biodiversity loss (IPBES et al. 2019). Loss of biodiversity can in turn have profound impacts on human wellbeing. MPANs are management tools that help address biodiversity decline by securing "areas of […] importance for biodiversity and ecosystem services [through] effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrating [them] into the wider landscape and seascape" (Aichi Target 11; CBD, 2010). The Convention on Biological Diversity's Aichi Target 11 describes a pathway to improve the status of biodiversity in an equitable, sustainable manner globally (CBD 2010; Hockings et al. 2015; Gannon et al. 2017; Law et al. 2018; Yates et al. 2019). When I started my dissertation research, reviews of MPAN evaluations relative to Aichi Target 11 qualitative elements were limited in the academic literature. As target 11 has drawn to an end, it is still important to reflect fully on the progress made, so that this process can provide important feedback for international guidance on biodiversity conservation. Target 11 encompassed multiple interrelated (ecological, economic, governance, and social) dimensions (Rees et al. 2018; CBD 2020), positioning MPANs as a multidimensional tool for biodiversity conservation. Moving forward in a post-2020 world may warrant a broader view of how MPANs are evaluated in the face of ongoing efforts to conserve and protect biodiversity. Using a multidimensional approach will enable insight into how international conservation goals will be met (Woodley et al., 2012). This complex approach, however, may hinder a comprehensive review of whether multiple dimensions are considered in MPAN evaluations, nor a classification of the indicators that contribute to understanding associated attributes in practice.

The purpose of this dissertation was to fill these gaps by investigating how MPANs have been or could be evaluated. The first step was to identify, from the literature, the qualitative elements assessed, and the indicators used to measure each element. I chose Aichi Target 11's qualitative elements as preliminary attributes because they are globally recognized, and reflect the most salient attributes of MPANs. Second, I wanted to elicit the understanding of experts about the attributes they consider in each dimension when measuring MPAN effectiveness. I wanted to know whether being associated with MPANs that have different objective types (such as cultural and human wellbeing objectives, biodiversity objectives) influence these considerations, and then if practitioners perceive the attributes of each dimension as important components that contribute to effectiveness. Accordingly, the focus on Aichi Target 11's qualitative elements entailed a multidimensional approach drawn from the four dimensions of sustainability (Murphy 2012; United Nations General Assembly 2017; Wyborn et al. 2019; de Alencar et al. 2020; James & Magee 2020; Stephenson et al. 2021) and social-ecological systems (McGinnis & Ostrom 2014; Hill et al. 2015; Partelow 2018) to understand what is being evaluated and with what indicators. As such I sought to identify the multiple dimensions aligned with each of the qualitative elements evaluated in the literature and the indicators used to evaluate them (Chapter two). From here, I then aimed to understand whether all the fundamental characteristics (attributes) of MPANs from each dimension were considered during MPAN evaluations in practice (Chapter three), and what indicators were used to evaluate each attribute (Chapter four). MPAN attributes were informed by the literature, in relation to MPAN design features (Pomeroy et al. 2004; Burt et al. 2014; Grorud-Colvert et al. 2014), the Aichi qualitative elements (CBD 2010; Hockings et al. 2015; Gannon et al. 2017), and overarching factors that shape social-ecological systems (McGinnis & Ostrom 2014; Hill et al. 2015; Partelow 2018). Understanding how MPANs are evaluated with regard to progress toward global goals, using a multidimensional structure, may offer insight into ways they can be improved.

This dissertation used a systematic literature review (Chapter two) and expert opinion surveys (Chapters three and four), to explore how MPANs are evaluated from a global perspective. Compiling indicators for evaluating MPANs, and how well they capture the elements of Target 11 and aligning Aichi Target 11 qualitative elements with ecological, economic, governance, and social dimensions from peer-reviewed literature (Chapter two) was useful in identifying the state of the science behind how MPANs are evaluated. Subsequently incorporating practitioners' viewpoints provided valuable insight and a greater breadth of understanding about how MPAN evaluations are conceptualized (Chapters three and four) (Reed & Abernethy 2018; Moon et al. 2019; Jarvis et al. 2020).

5.2 Key research findings

Through my research, I answered four main research questions. Below I outline the main findings for each of these questions, followed by future directions for research, outstanding challenges, and some recommendations for academics and practitioners.

Research question 1: <u>What indicators for evaluating MPANs exist</u> in the academic literature, and <u>how well are the elements of Target 11 evaluated</u>?

I employed a systematic literature review to identify how indicators were used to measure MPANs from a global perspective (reflecting the qualitative elements of Aichi

Target 11) in the peer-reviewed literature. The qualitative elements of Aichi Target 11 suggest that protected area networks follow certain qualitative standards that include human and environmental considerations (CBD 2010; Woodley et al. 2012; Hill et al. 2015; Moreaux et al. 2018; Rees et al. 2018; Yates et al. 2019). As the Aichi target achievement dates have passed, it is important to reflect on their progress. This is particularly important because ongoing efforts to provide international guidance to "galvanize urgent and transformative action by Governments and society" and "facilitate implementation" (CBD 2021a) of the post-2020 global biodiversity framework and 2030 Agenda for Sustainable Development recount the same language of Aichi Target 11 qualitative elements (2030 Action Target 3; CBD 2021 p.6). Quantitatively, progress has been made toward Aichi Target 11 (Gannon et al. 2017; Geldmann et al. 2020). While politically necessary to gain support and momentum, evaluating MPANs based on area covered is not enough to curb biodiversity and habitat loss (De Santo 2013; Barnes et al. 2018; Devillers et al. 2020). There must be concomitant efforts to evaluate MPAN quality, as proposed in Aichi Target 11 (Woodley et al. 2019).

Results from Chapter two indicate that the qualitative elements of Aichi Target 11, and the dimensions that support each element, were unevenly considered in the peer-reviewed MPAN evaluation literature. Evaluations centered on ecological and governance dimensions of effective management, largely overlooking economic and social dimensions. Furthermore, the qualitative elements of equitable management and integration into the wider land and seascape were also overlooked, assessed just two and three times (respectively). Not surprisingly, most indicators used to evaluate MPANs in the literature were the same as those used to evaluate individual MPAs. Network-specific indicators were only identified in the ecological dimension in relation to *areas of importance*, *connectivity,* and *representativity*. Interestingly, social networks and overlapping jurisdictions had limited consideration in the literature.

I found that the imbalanced evaluation of qualitative elements may be a result of limited guidance for some about their intended contributions to biodiversity conservation (Woodley et al. 2012). As such elements such as *integration, effective management, and equitable management* may require a more concerted effort to understand and evaluate. Several scholars have described the complexity of these elements to better identify how they pertain to conservation (Gannon et al., 2017; Juffe-Bignoli, 2014; Law et al., 2018; Maxwell et al., 2020; Woodley et al., 2012) which aligns with my own findings.

The complexity of *Integration into the wider land and seascape* can be seen in the variety of dimensions and attributes it is associated with both in the literature (Chapter one) and in practice (Chapters two & three). In the literature, integration into the wider land and seascape was assessed from both governance (Van Lavieren & Klaus 2013; Geijer & Jones 2015) and ecological (Bégin et al. 2016) dimensions (Chapter one Supplementary Table 2). Likewise, Gannon et al. (2017) alluded that integration into the wider land and seascape is decidedly both an ecological and a governance attribute. Integration is a two-fold process of ecological connectivity and multijurisdictional coordination and cooperation (Gannon et al. 2017). However, in several reviews of the status of Aichi Target 11, no indicators were identified to assess integration (Gannon et al., 2017; Juffe-Bignoli, 2014; Woodley et al., 2012). My literature review (Chapter two) identified three indicators used in both dimensions (one ecological, two governance). In evaluations of Aichi Target 11 success, Woodley et al., (2012) and Gannon et al. (2018) merged integration with a discussion about connectivity. These are ostensibly similar constructs, as the process of connecting between land and sea process entails integration (Álvarez-Romero et al. 2011). However, integration is not the same as connectivity, particularly when the concept of connectivity is constrained to the ecological dimension as in "ecologically connected" (CBD, 2004). Here, integration concerns integrated decision-making and governance processes taken on by organizations, actors, or stakeholders (Bacon et al. 2019).

Another element in need of clarification is that of *areas of particular importance for biodiversity conservation and ecosystem services*. Several indicators captured aspects of *areas of importance for biodiversity conservation.* However, indicators used to evaluate ecosystem services proved absent from the literature. An accepted approach to measure the suite of services provided by an ecosystem seems to be lacking (Gannon et al. 2019). Many ecosystem services do not have a comprehensive suite of indicators and what exists is often inadequate to fully represent the complexity of benefits provided to, and used by, society (McMichael et al. 2005; Brown et al. 2014).

Effective management was not as wholistically evaluated as it could be (Hockings et al. 2000; Pomeroy et al. 2004). Management is a complex process that involves understanding the background and context (biological, social, and cultural) of an area, long-term goals and how they will be achieved, and whether they were achieved (Hockings et al. 2000). Management evaluation should entail contributions from all dimensions; however economic and social dimensions were scarcely evaluated in the management evaluation literature. This is very important, as capacity and budgetary constraints are among the most important attributes for effective biodiversity conservation (Gill et al., 2017).

While Aichi Target 11 clearly differentiates effective and equitable management, reviews of global evaluations combine them. Effective management does include equity; however these are two different and essential elements of protected area management, and as such, should be treated separately (Woodley et al. 2012). *Equitable management* is a normative concept that refers to fairness in how MPAs are managed and is very difficult to measure. Its complexity stems from three components that describe equity (procedural, distributional, recognitional) each with their own intrinsic properties (Woodcock et al. 2017; Zafra-Calvo et al. 2017; Law et al. 2018). Equitable management could include one or all these components. Chapter two identified two indicators used to measure equity in the literature, one social and one governance. The indicators identified in the literature were included among the selection of indicators for both dimensions in the survey.

Based on the findings from Chapter two, I developed and implemented an online expert survey to describe how MPANs are evaluated from a multidimensional perspective. This survey was meant to augment findings from the literature, providing additional insight and opinions about how MPANs are evaluated (the attributes considered, and indicators used). I pursued the remainder of this research from a multidimensional perspective, due to the conclusion of the Strategic Plan for Biodiversity and subsequent post-2020 pursuits that may change some of the language of qualitative elements. This was appropriate as the multiple dimensions formed the foundation of Aichi Target 11. All of the attributes and indicators identified in the literature were subsequently included in the survey. Indicators and attributes that displayed a multidimensional character (e.g., the attribute *equity/social justice* considered in both governance and social dimensions, and indicators for *Integration* *into the wider land and seascape* used to assess both ecological and governance attributes) were included in the selection for both dimensions.

Research question 2: How are the attributes of ecological, social, economic and governance dimensions considered when evaluating MPANs in practice?

The variety of expected social-ecological impacts associated with MPANs underscores a need to evaluate all the ecological, economic, social, and governance dimensions involved in the MPAN process. However, little is known about how these four dimensions are considered in MPAN evaluations. To address this gap, I conducted an online survey with MPAN managers, technical staff, and academics from across the globe. The survey asked MPAN experts whether well-known attributes of MPANs identified from the literature were considered during the MPAN process, if there were attributes from the survey that were considered or perceived as important, and whether each attribute was perceived as important for success.

Attributes of the economic, governance and social dimensions were considered to a lesser degree than ecological attributes by survey respondents. However, they were much more evenly considered by survey respondents than in the literature. Participants perceived of social attributes as important to MPAN success, even if they were not considered. Identifying whether attributes were considered in MPAN processes helps distinguish where gaps exist in terms of what is being evaluated. Evaluations could be missing an invaluable element that drives successful MPAN outcomes (Halpern et al. 2013; Fox et al. 2014).

Guidance on protected area evaluations suggests the need for clearly established objectives as a prerequisite to performing an evaluation (Pomeroy et al., 2004). Since diverse objectives are often juxtaposed as vying for trade-offs among ecological, economic, governance, and social dimensions (Giakoumi et al. 2018) I wanted to see whether the consideration of attributes was shaped by objective type. The results of Chapter three revealed that MPANs with both biodiversity and socially oriented objectives considered a larger suite of attributes that included economic and social, without de-emphasizing ecological considerations. MPANs that focus solely on biological objectives were less likely to consider attributes in the economic, and social dimensions during the MPAN process. All the MPANs in this study had biodiversity objectives, approximately half had solely biodiversity objectives. Achieving a biological outcome is dependent upon attributes in these other dimensions (Pollnac et al. 2010). Understanding why an MPAN is not working to its desired potential is likely due to elements of one of these other dimensions not being met. If we do not pay attention to them, how will we know what to change? Reaching synergies between the multiple objectives of MPANs can be challenging if certain attributes are overlooked in the MPAN process (Halpern et al. 2013; Fox et al. 2014; Giakoumi et al. 2018).

Research question 3: What indicators are used to evaluate attributes of MPANs in practice?

Although MPANs are key tools used for protecting coastal and marine biodiversity, limited guidance exists to evaluate their performance, as opposed to individual MPAs. MPANs have unique properties such as connectivity, representativity, integration, and social networks that are not represented in individual MPA guidance. As with the previous research question, this work was framed around the ecological, economic, governance, and social dimensions associated with MPANs. This multidimensional framing helped form a foundational structure to categorize MPAN indicators. Using an online expert survey instrument, Chapter four asked MPAN practitioners to identify the indicators used to evaluate attributes in practice. Many MPA evaluations have utilized the framework set out in Pomeroy et al. (2004), which identified indicators based on different goals and objectives of an area. These, and indicators identified in the peer-reviewed literature relevant to Aichi Target 11 (Gannon et al., 2018) were included in the survey. According to survey results, individual indicators showed little specificity to MPAN attributes. I found that the indicators used to evaluate MPANs attributes were highly variable across sites. In fact, every attribute was informed by a suite of indicators, but the composition of indicator sets differed among attributes. This suggests that the same indicators, grouped differently, informed different attributes.

Clearly defined indicator-attribute pairs were more apparent in attributes that were only identified by survey participants (not identified in the literature). This seems to imply a limited understanding of these "emerging" attributes rather than a strong relationship between the indicator-attribute pairs. This is surprising given that indicator theory suggests the relationship between an indicator and the attributes they contribute to should be more clearly defined (Hockings et al. 2000; Pomeroy et al. 2004; Stem et al. 2005; Pelletier 2011; Bundy et al. 2017). Furthermore, Pomeroy et al. (2004) provide specific indicators associated with common MPA goals and objectives, hence evaluations that follow this guidance should be suited to aligning attributes and indicators. However, our results are similar to those found by Fox et al. (2014) when exploring indicators used to evaluate MPA performance using HIYMPAD methodology (Fox et al 2014). The complexity of MPAN attributes, spanning several dimensions, may necessitate a suite of indicators to inform one attribute. Studies have suggested a suite of indicators that work together may be most appropriate to accurately measure progress rather than one broad indicator (Rice & Rochet 2005; Turcu 2013). This trend implies that MPAN evaluations have not learned from problems that faced past analyses of individual MPAs.

Research question 4: What are the differences between the use of indicators described in the literature and in practice?

As a result of aiming to identify whether indicators used to evaluate MPANs in practice were missing from the literature, I was able to identify differences between indicator use described in the literature and described by practitioners (Toomey et al. 2017; Jarvis et al. 2020). Studies have found that academic research and practice are not always aligned (Pullin & Knight 2003; Sunderland et al. 2009; Arlettaz et al. 2010; Cook et al. 2013; Di Marco et al. 2017; Toomey et al. 2017; Walsh et al. 2019). Evaluations described in the peer-reviewed literature identified clear attribute-indicator pairs, while survey responses described a suite of indicators associated with each attribute. Some indicators used in practice did trend with those identified in the literature for certain attributes (connectivity, key habitats, key species, ecological function, management capacity, and funding for management; Chapter three). However, more indicators were used to evaluate each attribute in practice than in the literature. This inconsistency does not diminish the potential influence of academic research on practice. It may speak to the diverse contexts that influence practitioner perspectives- what is considered according to the context (Cvitanovic et al. 2014; Hopkins et al. 2016; Aswani et al. 2017).

The richness and diversity of indicators selected by survey participants may allude to the complexity inherent to specific contexts that is difficult to capture in academic research (Sunderland et al., 2009). The distinct indicator-attribute pairs observed in the literature could be due to the nature of academic research, which relies on a clearly articulated problem to develop robust, reproducible results within a specific timeframe possibly limiting a description of the variation or noise one may observe *in situ* (Arlettaz et al. 2010; Abdulai & Owusu-Ansah 2014). Nonetheless, academic literature provides important contributions about specific indicators useful for measuring and evaluating performance. Toomey et al. (2017) describe a need for reciprocal flow of information between research from academia and practice (Arlettaz et al. 2010; Toomey et al. 2017; Reed & Abernethy 2018; Wyborn et al. 2019; Jarvis et al. 2020). Results of this chapter seem to align with this because if the flow of information were unidirectional, from academia to practice, the uptake of indicators identified in the literature would be clearly observed in practice.

5.3 Research limitations

This dissertation highlights important contributions to MPAN evaluation scholarship; a bias in evaluations of Aichi Target 11 Qualitative Elements, and the multiple dimensions that underscore these elements. The discrepancy in the geographic setting of studies identified for the literature review of Chapter two should be addressed. Here, we found that evaluations took place predominantly in high-income countries (mostly Australia and the USA). The practitioner survey (Chapters three and four) was intended to fill many gaps, including that of geographic discrepancy. Translating the survey into French and Spanish aimed to improve some geographic diversity, but the number of responses in these languages was limited (5 French, 3 Spanish, and 69 English). The survey garnered information about attributes considered from MPANs that were not fully implemented in

Canada, Chile, China, Kenya, and Portugal. Translating the survey into languages for targeted regions would likely improve the response rate from additional areas.

In seeking to identify missing pieces in the multidimensional puzzle of MPAN evaluations, the methodological approach of a survey instrument contains inherent challenges and biases. These stem from the variety of information gleaned from multiple stakeholders embedded in different contexts and the perceived credibility of the insights gained (Wyborn et al. 2019). This limitation was addressed by beta testing the survey with several marine conservation researchers not associated with this project to ensure relevance and clarity of questions and time expected to complete. Additionally, I chose to use a predominantly multiple-choice style survey. While this style of survey favors conditioning respondents to select answers provided, it also reduces availability bias. Availability bias suggests survey respondents may answer solely open-ended questions with factors that are top of mind (Knol et al. 2010). Providing a multiple-choice answer followed by open-ended response categories, as we did may help reduce both issues. A major challenge to the type of survey strategy I chose to elicit is the issue of "double counting". This may have occurred as some of the same academic researchers whose literature was assessed were included in the practitioner survey. I asked respondents about their affiliation and grouped these by experts solely affiliated with an academic institution and those that were either not affiliated with an academic institution or were both a manager and academic. I determined whether there were any differences in response based on the respondent's affiliation. There were no substantial differences found between the two respondent groups (See Chapters three and four results and discussion for more detail). That said, since I found considerable differences between the indicator-attribute pairs identified in the literature and those identified in the practitioner survey, any potential bias would have minimized the differences by increasing the number of indictor-attribute pairs that aligned with the literature. Even so, I was looking to compare indicators that were considered in the literature and those considered in practice rather than the perceived importance of these indicators, where this bias may pose a greater problem. There is merit in looking into indicator quality in measuring attributes of MPAN effectiveness. It would be good to dig deeper into these potential differences in future iterations of this study.

Furthermore, the survey instrument was detailed to get at nuanced attributes and indicators, which resulted in it being long. The survey's length prevented the inclusion of certain elements that would have increased the complexity even more. These included questions regarding how practitioners perceived the alignment of qualitative elements of Target 11 and multiple dimensions of MPANs, and the management stages associated with evaluations. While valuable, this information was not included in order to keep the length of the survey manageable. Further work is needed to fully develop a suite of indicators to measure the multiple dimensions of MPANs. The reduced number of responses in the second part of the survey "Identify the indicators used to measure MPAN attributes" could reflect this complexity (Martin et al. 2011). This could also have reflected limited knowledge about the nature of evaluations from those who responded to the survey, as several of the responses to only the first section were associated with MPANs that were in the design phase or recently implemented.

In determining what an MPAN is I accepted an MPAN as indicated by the respondent if they selected the MPAN they were responding for was with a) "an individual MPA in a network" b) "an individual MPA that will become part of a network" c) "several

MPAs within a network" or d) "entire network of MPAs". Responses that included e) "one individual MPA, not associated with any MPA network" or f) "I don't know", were excluded from this research. This still may have included ad-hoc MPANs that were not designed as a network and therefore could have biased the results against including consideration for representativity and connectivity.

Finally, to answer the questions posed, this dissertation used a survey rather than other approaches such as evaluating management plans or interviews. For instance, I did not review MPAN management plans or similar documentation that may contain information about attributes of interest. Instead, I chose to implement an online survey to offer a different perspective on the attributes considered and indicators used to evaluate MPAN performance. This different approach to gathering information, engaging experts, provided valuable insight (Krueger et al., 2012). This includes perceptions of how important an attribute is for overall MPAN performance and the consideration of attributes and indicators that may have emerged during evaluation exercises and not included in a written document available for public observation. Management plans can be very difficult to access and are typically written in the language for which it will be used, translating these documents can be tedious and time-consuming. If management plans exist, they are often developed prior to implementation from a theoretical understanding of a system (Pullin et al. 2004) or a long time, up to 30 years, after designation (Mills et al. 2020). Indicators, if included in management plans, can be "preliminary" in nature (MAPP 2015). Furthermore, the practice of adaptive management, which conservation should be following, necessitates that management plans are mutable based on evidence-informed evaluations (Knight et al. 2008; Stephenson 2019). However, the effort needed to update management plans (Balmford et al. 2004) precludes adaptively revising them to reflect evidence-based knowledge (Morris & Green 2014). Another approach, in-depth interviews, may have provided more detailed information about indicators. This approach would have taken a great deal of time to get a similar sample size and may have also required assistance with translation and interpretation.

5.4 Future research directions and outstanding challenges

This dissertation was not intended to evaluate specific MPANs, nor was it intended to replace existing evaluation frameworks. Instead, it was undertaken to identify what indicators have been used to evaluate MPANs. Using both the literature and practice as information sources helped to see how much work is yet needed to fully understand MPAN performance. Using the four dimensions of sustainability and social-ecological systems to evaluate MPAN performance can help provide a more balanced evaluation of MPAN performance, given their multidimensional nature (Fox et al., 2014).

More work is needed to establish the attributes important for MPAN success (beyond the well-known ecological attributes) and develop MPAN-specific indicators (Fox et al., 2014) that measure these attributes. Determining whether a network is more than the sum of its parts (Grorud-Colvert et al. 2014) will involve more than an evaluation of the attributes considered important and the indicators that have been used. First, it will be important to establish a long-standing framework that underpins any scale (local or global) and any timeframe (e.g., pre or post-2020). A multidimensional framework based on the elements of sustainability and social-ecological systems can do this. Along this vein, better articulation of the multiple dimensions and attributes associated with international biodiversity conservation targets is warranted, particularly within the social dimension. Although social attributes were considered less frequently, they were still perceived as important to MPAN's success (see Chapter three). Perhaps if they were clarified, these elements would enjoy greater consideration. Finally, network-specific attributes and indicators need additional investigation. For example, social networks did not receive the attention necessary in evaluations to determine the impact they have on overall MPAN success, although research has indicated there is a strong influence (Alexander 2014; Wenzel et al. 2019).

Discussions are underway at present regarding how to report on management effectiveness (CBD 2021b). Currently, this is reported as whether a management evaluation has or has not been done. This style of reporting provides little information as to whether objectives, outcomes or outputs have been met (Amengual & Alvarez-Berastegui 2018; CBD 2020). Perhaps a more informative approach would include a simple multidimensional framing for effective and equitable management. Each dimension would contain the attributes of interest to a site and a set of indicators that could be used for evaluation. This may help inform where improvements are needed, and target interventions to address them. Furthermore, a multidimensional framing would be useful for future biodiversity conservation scenarios to employ a common thread through changing quantitative and qualitative elements (Campbell & Gray 2018). Entire research programs have been developed to contextualize equity in conservation (Hill et al. 2015; Friedman et al. 2018; Law et al. 2018; Moreaux et al. 2018; Zafra-Calvo & Geldmann 2020) and is only touched on here. Indeed, equity components have recently been clearly articulated in terms of their alignment to MPANs (Hill et al. 2015; Moreaux et al. 2018; Zafra-Calvo &

Geldmann 2020). Nonetheless, this research identifies equity as yet in need of stronger mainstreaming, particularly in terms of identifying indicators relevant for each component of equity within the MPAN process. A clear characterization of integration may also benefit MPAN performance evaluations. In Chapters two and three, survey participants added *Overlapping Jurisdictions* as an emergent governance attribute and added the indicator "[existence of] multi-agency leadership team" to measure the attributes *level of co-management, partnerships, enabling legislation and strategies, and participation*, all of which are associated with integrated governance.

Finally, the diversity of responses about how indicators are used to measure similar attributes under various contexts suggests a deeper exploration of individual contexts associated with MPANs. Evaluations would benefit from a better understanding of how to incorporate flexibility into the use of context-specific indicators to measure social and economic attributes. Generally, MPAN evaluations overlook attributes associated with social and economic dimensions as well as attributes that span more than one dimension, such as integration into the wider land and seascape, equitable management, and social networks.

5.5 Recommendations

Here I offer several recommendations that may positively influence a holistic approach to MPAN evaluations. Throughout this dissertation process, I found limited consideration of certain attributes in economic, governance, and social dimensions. Indeed, elements that have social-ecological ties seem to focus on the ecological component. I suggest incorporating the social components in addition to the ecological, to better understand how they might influence MPAN performance. Incorporating socially-oriented objectives together with biodiversity objectives into MPAN design appears to promote consideration of important attributes associated with overlooked dimensions (economic and social). MPANs should offer a balanced vision in terms of sustainability and should hence not omit these dimensions.

5.5.1 Recommendations for academics

- Social networks are rarely considered in the literature or practice, yet are regard as an important component of MPANs (Alexander & Armitage 2015; Alexander et al. 2018; Wenzel et al. 2019). Practitioners can contribute to identifying the social networks in their respective areas. This can help point academics toward contributing to the theory of social networks and what influences they have among diverse settings. Identifying indicators to assess social networks would help to provide a more robust understanding of what influences MPANs, and what they influence.
- Academic researchers can provide more evidence for indicator selection, collating data in systematic reviews and meta-analyses based on diverse contexts among dimensions. These reviews and analyses can get at context-specific indicator use, and describe the processes used to identify and establish indicators.

5.5.2 Recommendations for practitioners

- Practitioners trained in evaluations should explore ways to ensure these dimensions are incorporated in MPAN evaluations, even when objectives are solely biodiversity focused. This would help to provide more robust guidance in determining what influences MPANs, and what they influence.
- Funding sustainability, management capacity, overlapping jurisdictions, equity, and social networks all had limited consideration. Funding sustainability and

management capacity are well-known attributes that influence MPA and MPAN performance (Gill et al., 2017), so their limited consideration in evaluating the MPAN process is troubling.

5.5.3 Recommendations to the CBD for the next biodiversity targets and their monitoring

- Concerted efforts are occurring on the global stage to explore potential indicators for measuring MPANs from the global perspective (e.g., Aichi Target 11 qualitative elements) (Geldmann et al. 2021; UNEP-WCMC et al. 2022). A means of coalescing or translating indicators onto a universal perspective, will be imperative, especially when a diverse set of indicators is used to measure the same attribute across multiple sites. This could mean identifying headline indicators that integrate place-associated and context-specific indicators to arrive at a shared language toward common goals and objectives in diverse areas.
- Incorporating academic and practical knowledge can improve how MPAN evaluations are performed (Clark et al. 2016; Reed & Abernethy 2018; Wyborn et al. 2019; Chambers et al. 2021). Convening workshops with a diverse group of experts (e.g., academics, managers, field technicians, and community leaders) to initiate a process for incorporating information.
- Contribute to further the processes of co-producing indicators (Muhl et al. 2022) in both international and local or regional settings to help to resolve potential discrepancies.

5.6 Conclusion

Aichi Target 11's qualitative elements stem from a desire to provide global solutions for biodiversity loss. Their complexity aligns with the concept of sustainability

(Murphy 2012; United Nations General Assembly 2017; Wyborn et al. 2019; de Alencar et al. 2020; James & Magee 2020; Stephenson et al. 2021) and the concept of social-ecological systems (McGinnis & Ostrom 2014; Hill et al. 2015; Partelow 2018). The goal of this dissertation was to investigate the qualitative elements and attributes considered in MPAN evaluations and the indicators used to measure them in literature and in practice. To better represent the attributes and indicators that represent global targets, I grounded this thesis in a multidimensional context to break down the complexity.

The only indicators put forth to evaluate Aichi Target 11 have been the quantity of area designated, suggesting area protected is sufficient to curb biodiversity loss (CBD 2020). However, pressures on marine and coastal systems are increasing while biodiversity is continuing to decrease (IPBES & IPCC 2021). This dissertation aimed to offer insight into the attributes considered and the indicators used to evaluate MPANs. Results suggest that MPAN evaluations are not adequately considering the full suite of dimensions necessary to fully elucidate MPAN performance, particularly in the literature. This gap may result in an insufficient evaluation in the field when practitioners look to academic contributions to guide their work. Furthermore, a focus on biological objectives appeared to preclude consideration of important characteristics that influence the success (and failure) of MPANs in evaluations. All MPANs included biodiversity objectives, some included both biodiversity and socially-oriented objectives (human wellbeing, human health, or fisheries management). Those that included both types of objectives appeared to consider a larger suite of attributes in their evaluations and perceive these attributes to be more important to overall MPAN success. I speculate that the consideration of multiple attributes may promote objective setting which then informs how evaluations are carried out.

A key finding of this dissertation is that MPANs with diverse objectives may be better aligned to more holistically evaluate multiple dimensions of MPAN performance than MPANs with solely biodiversity objectives (Klein et al. 2008; Rice et al. 2012; Grantham et al. 2013). This assertion corresponds with increased interest, globally, in MPANs that are not solely focused on biodiversity conservation but also more broadly on sustainable use and stewardship models of conservation (FAO 2011; Akins & Bissonnette 2020). The promotion of MPANs as a primarily biodiversity tool supports biodiversity-focused primary objectives (IUCN et al. 2012) as well as biodiversity-focused research (Grorud-Colvert et al. 2021). This focus places socially oriented objectives on a secondary significance even though more of the global MPAN contains areas where some form of human use is allowed (3.6%) than not (2.4%) (Grorud-Colvert et al. 2021). Overlooking these dimensions fails to account for the myriad of direct and indirect impacts to and from other dimensions (Gurney et al. 2014; Ban et al. 2017, 2019; Gill et al. 2019).

The indicators used to evaluate MPANs in practice were much more diverse than the indicators identified and suggested in the literature. The variability of indicators in practice may be due to complex contextual factors, including wealth, capacity (based on GDP), type of management, and the level of protection provided to the network. I also saw more commonality amongst MPAN practitioners regarding the attributes being measured than the indicators used to measure each attribute (e.g., practitioners used a diverse set of indicators to measure the same attributes). Perhaps the smaller number of attributes and higher level of organization allowed for some flexibility in characterizing an attribute. The diversity of responses about how indicators were used to measure similar attributes under various contexts lead me to speculate that indicators need to reflect culturally, ecologically, economically, and linguistically relevant contexts. Therefore, future work may clarify desired attributes and a simplified system to address whether they are being met. Taking the multiple dimensions into consideration when performing evaluations will only benefit further understanding of the factors that influence MPANs and the benefits or impacts they generate. As conservation social science reiterates, academics partnering, in a meaningful way, with site-level managers, technicians, and other knowledge holders is key to achieving biodiversity conservation and a just, sustainable future.

5.7 References

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Appendices

Appendix A. Chapter 2

A1. Supplementary tables

Table A1. Key search terms used in Web of Science and Scopus (last search date 08 April 2019).

Marine Protected Area networks AND Effectiveness	"marine protected area network*" OR "marine reserve network*" OR "MPA network*" OR "no-take network*" OR "marine protected area system" OR "marine reserve system*" OR "MPA system*" OR "no-take system*" OR "LMMA network" OR "locally managed marine area network" OR "network of MPAs" OR "network of marine protected areas" OR "network of marine reserves" "effect*" OR "performance" OR "improve*" OR "success" OR "benefit" OR "enhance*" OR "impact*" OR "outcome" OR "support" OR "ecolog*" OR "abundance" OR "density" OR "size" OR "length" OR "biomass" OR "richness" OR "diversity" OR "habitat quality" OR "number" OR "social*" OR "livelihood" OR "health" OR "wellbeing" OR "well-being" OR "income" OR "employment" OR " economic*" OR "support" OR "food security" OR "conflict" OR "participation" OR "biodiversity" OR "manage*" OR "equit*" OR "represent*" OR "connect*" OR "integrate*" OR "governance" OR "adapt*"OR "touris*" OR "recreation"

Table A2. Literature used in the study showing the Aichi Target 11 qualitative elements evaluated with the associated variables and hierarchically matched indicators used to evaluate them. On the far right are the corresponding dimensions and management stages associated with each indicator.

Study	Qualitative element	Variables	Indicators	Dimension	Management stage
(Althaus et al. 2017)	Representative	Biodiversity	Proportion of species distributions covered by MPAs	Ecological	Outcome
		Deep water coral representation (proportion of species)			Output
		Species richness			
(Ardron 2008)	Connectivity	Distribution of MPAs across biogeographic regions	Distance between habitat patches	Ecological	Output
		Reserve sizes and corresponding spacing between sites	Size and spatial arrangement of Pas		Context
	Representative	Biogeographic representation of habitat within region (in and outside of MPAs)	Coverage of ecoregions	Ecological	Output
		Distribution of habitats within MPA network			
		Proportion of biogeographic provinces within MPAs			
		Habitat patch size frequency distribution			
		Proportion of biogeographic provinces within MPAs			
		Size of habitats within MPA network			

(Barr & Possingham 2013)	Representative	Area protected for all key ecological features in a region (proportion)	Coverage of ecoregions	Ecological	Outcome
		Total percent of area protected			
(Bégin et al. 2016)	Effective Management	Change in protection status of benthic cover	Area showing signs of recovery	Ecological	Output
		Change in the cover of major benthic groups	Composition and structure of the community		Outcome
	Integrated	Terrestrial sediment influence	Terrestrial sediment influence	Ecological	Context
(Berumen et al. 2012)	Connectivity	Population estimates for Chaetodon vagabundus	Focal species population structure	Ecological	Outcome
		Dispersal distance_ assessed PLD of two differing spawners (anemone fish and butterfly fish)	Species dispersal		Context
(Caselle et al. 2015)	Effective Management	Protection (MPA) status	Existence of a decision-making and management body	Governance	Input
		Change in biomass of targeted species	Focal species abundance	Ecological	Outcome
(Christie et al. 2010)	Connectivity	Dispersal trajectory	Species dispersal	Ecological	Context
		Parent-offspring pairs in neighboring MPAs			Output
(Coleman et al. 2013)	Effective management	Fish community structure - fish abundance and diversity	Composition and structure of the community	Ecological	Outcome
		Different substrate types	Habitat distribution		Context

		(occurrence)	and complexity		
(Cox et al. 2017)	Effective Management	Coral populations (change)	Focal species abundance	Ecological	Outcome
		Fish populations (change)	Focal species population structure		
		Level of enforcement	Level of enforcement	Governance	Process
(Critchley et al. 2018)	Areas of Importance	Coverage within boundaries of protected areas bird colony overlap with MPAs	Coverage of species richness hotspots	Ecological	Output
(Daru & le Roux 2016)	Effective Management	The proportion of seagrass diversity hotspots within MPAs	Habitat distribution and complexity	Ecological	Outcome
(de Loma et al. 2008)	Effective Management	Abundance of target species	Focal species abundance	Ecological	Output
		Diversity of target species	Focal species population structure		Outcome
(Edgar et al. 2009)	Effective Management	Biomass of fishes (change)	Focal species abundance	Ecological	Outcome
		Grazing pressure (change)	Extent and severity of threats		Output
(Evans et al. 2015)	Representative	Proportion of area with existing MPA compared with optimal areal coverage	Proportion of species distributions covered by MPAs	Ecological	Outcome
(Félix-hackradt et al. 2018)	Effective Management	Abundance of post-larvae, juvenile and adult fish (change)	Focal species abundance	Ecological	Outcome
(Fernandes et al. 2005)	Effective management	Threats to natural integrity minimized	Area showing signs of recovery	Ecological	Output
	Representative	Geographic diversity	Coverage of	Ecological	Context

		Fragmentation (percent change)	ecoregions		Output
		Minimum amount of protection			
		Protect uniqueness			
		Size (distance across NTA)			
		Represent all habitats			Outcome
		Numbers of replicated habitats and specie	Number of replicate habitats		
(Fischer et al. 2019)	Representative	Aerial coverage of MPAs in EEZ	Coverage of ecoregions	Ecological	Output
		Aerial coverage of MPAs within LMEs			
		Geomorphic features within MPA boundaries (number or %)			
(Foster et al. 2017)	Connectivity	Distance between habitat patches	Distance between habitat patches	Ecological	Context
	Representative	Presence/absence of a habitat within the network	Habitat distribution and complexity	Ecological	Output
(Friedlander et al. 2017)	Areas of Importance	Benthic community composition	Coverage of Key Biodiversity Areas	Ecological	Output
	Effective Management	Fish biomass	Focal species abundance	Ecological	Context
		Fish size			Outcome
(Geijer & Jones 2015)	Areas of Importance	Existence of habitats (EBSA) within network	Coverage of Key Biodiversity Areas	Ecological	Output
	Effective Management	Existence of mitigation measures to address threats	Area showing signs of recovery	Ecological	Output

		Location of migration pathways	Focal species population structure		Context
		Governance capacity	Level of governance and leadership	Governance	Process
		Existence of management structure	Existence of a decision-making and management body		Planning
		Existence of legal basis (binding, soft-law)	Level of community benefit/ assistance		Process
		Human Development Index	Material style of life	Economic	Context
		Per Capita GDP (US$)			
		Number of mortalities due to ship strikes	Extent and severity of threats	Ecological	Output
	Integrated	Regional cooperation	Level of regional cooperation and coordination	Governance	Process
(Gerhardinger et al. 2011)	Effective Management	Availability of human and financial resources	Availability and allocation of MPA administrative resources	Economic	Input
		Existing (functioning) management plans	Existence and adoption of a management plan	Governance	Planning
		Capacity of management council	Existence of a decision-making and management body		Process
		Implementation of management councils			
		Capacity building courses	Level of training provided to staff and administration		
		Personnel capacity building			Input

		Financial support	Reliability and adequacy of funding		
(Grorud-Colvert et al. 2014)	Connectivity	Foraging distributions	Species distribution	Ecological	Context
		Breeding locations coinciding with MPAs			Output
		Fish density between networked and non-networked sites			Outcome
(Guilhaumon et al. 2014)	Representative	Habitat characteristics and life history traits	Proportion of species distributions covered by MPAs	Ecological	Context
		Species distributions			
		Overall taxonomic diversity (species diversity)			Output
(Hamilton et al. 2010)	Areas of Importance	Fish community structure	Coverage of species richness hotspots	Ecological	Output
	Effective Management	Influence of contextual factors that drive biological spatial patterns	Habitat distribution and complexity		Context
(Harrison et al. 2012)	Connectivity	Dispersal distances (frequency distribution of)	Species dispersal	Ecological	Context
(Hawkins et al. 2006)	Effective Management	Change: sediment input	Area showing signs of recovery	Ecological	Output
		Change: Protection from fishing	Area under no or reduced impact	Ecological	Output
		Change: algal cover	Composition and structure of the community		
		Change: coral cover			
		Change: structural complexity			
		Change: fish biomass	Focal species abundance		Outcome

		Change: species richness	Focal species population structure		
(Horigue et al. 2014)	Effective Management	Total area protected since formalization of the MPA network	Area under no or reduced impact	Ecological	Output
		Work plan and financing	Availability and allocation of MPA admin resources	Governance	Process
		Enforcement strategies	Clearly defined enforcement procedures		
		Patrols and adjudicated documented violations			Output
		Legal bases and by-laws	Existence and adequacy of enabling legislation		Planning
		Joint activities (separate from enforcement)	Degree of interaction between managers and stakeholders		Process
		Fisheries and socioeconomic impacts monitoring	Existence and application of scientific research and input		
		Integration of MPA network management into Integrated coastal management and ridge-to-reef management	Existence of a decision-making and management body		Planning
		Management committee			Process
		Feedback system allowing members to make informed suggestions (e.g., Forum about results of monitoring	Level of community and stakeholder involvement and participation in		

		and evaluation activities, suggestion boxes	management		
		Provincial government involvement	Level of Constraint or support by external political and civil environment		
		Support from the provincial government			
		Discussions with provincial government and/or neighboring local governments to participate in the network	Level of training provided to stakeholders in participation		
		Percentage of community members that support the MPAs	Level of stakeholder support and satisfaction in management		Output
		Funding	Reliability and adequacy of funding		Input
		Incentive systems and subsidies for MPA managers and their committee members			
(Huserbråten et al. 2013)	Effective Management	Lobster movement within region	Focal species population structure	Ecological	Context
		Genetic heterogeneity within region (Skagerrak)			Outcome
		Lobster mortality/ survival within MPAs	Recruitment success within the community		Output
(Jack & Wing 2013)	Connectivity	Marine Reserve Placement	Size and spatial arrangement of Pas	Ecological	Output
		Marine Reserve Spacing: to allow for connectivity			
	Effective Management	Anthropogenic influence on MPA performance	Extent and severity of threats	Ecological	Context

		Marine Reserve Area	Area under no or reduced impact		Output
		Relative abundance of rock lobsters and blue cod	Focal species abundance		
(Jackson et al. 2018)	Areas of Importance	Presence of Cold water coral reefs (specifically Lophelia)	Coverage of Key Biodiversity Areas	Ecological	Output
	Effective Management	Trawl fishing activity of UK vessels (presence or absence of trawling within an area)	Extent and severity of threats	Ecological	Context
(Jantke et al. 2018)	Representative	Biogeographic classification	Coverage of ecoregions	Ecological	Context
		Area protected			Output
		Comparison of existing spatial patterns against optimal MPA spatial patterns			
		Mean gap in protection for achieving the 10% PA coverage target for each ecoregion and country			
		Opportunity cost of MPAs (fish catch data)	Proportion of species distributions covered by MPAs		
(Karpov et al. 2012)	Effective Management	Density response ratios	Focal species abundance	Ecological	Output
(Kay & Wilson 2012)	Effective Management	Mortality of lobster	Recruitment success within the community	Ecological	Output
(Kay et al. 2012)	Effective Management	Daily average trap yield	Type, level and return on fishing effort	Ecological	Output
		Number and size of legal-sized lobsters caught			
(Kelaher et	Areas of	Sanctuary zone area (ha)	Centers of endemism	Ecological	Output

al. 2014)	Importance		or intact wilderness areas		
	Effective Management	Fish species richness	Focal species population structure	Ecological	Output
		Proximity to estuarine sanctuary zones Buffered by Habitat Protection Zone	Habitat distribution and complexity		
		Structure of fish assemblages	Focal species population structure		Outcome
		Enforcement actions	Level of enforcement	Governance	Input
(Klein et al. 2015)	Representative	Degree of species coverage in an MPA (across a network)	Proportion of species distributions covered by MPAs	Ecological	Output
(Lathrop et al. 2017)	Effective management	Concentrations of boating activity (either moored or in transit) in MPAs	Extent and severity of threats	Ecological	Output
		Damage caused by both propeller-driven and personal watercraft–type boats to SAV habitats			Outcome
(Mason et al. 2018)	Effective Management	Size of MPA network	Area under no or reduced impact	Ecological	Output
(Mora et al. 2006)	Effective Management	Risk index of threats to coral reef	Area showing signs of recovery	Ecological	Context
		Species home ranges overlapping with MPA locations	Focal species population structure		Output
		Levels of poaching	Level of Compliance	Social	
(Mouillot et al. 2011)	Areas of Importance	Species richness	Coverage of species richness hotspots	Ecological	Outcome

		Phylogenetic diversity	Focal species population structure		Output
	Effective Management	Spatial distribution of fishing intensity	Extent and severity of threats		Context
		Spatial distribution of MPAs	Habitat distribution and complexity		Output
(Olds et al. 2013)	Connectivity	Edge- to-edge isolation distance between habitats	Distance between habitat patches	Ecological	Output
		Proximity of reefs to mangroves	Size and spatial arrangement of pas		
	Representative	Species richness and densities of harvested species, functional groups, families and individual species	Proportion of species distributions covered by MPAs		Outcome
(Ordoñez-Gauger et al. 2018)	Effective Management	Number and size of legal-sized lobsters caught	Type, level and return on fishing effort	Ecological	Outcome
	Equitable Management	Satisfaction with the overall process to implement the MPA network	Level of stakeholder support and satisfaction in management	Governance	
		Stakeholder perception of potential effects of the MPA network on livelihood	Perception MPA effects on livelihood	Social	Context
(Péron et al. 2013)	Areas of Importance	Spatio-temporal density patterns of shearwaters	Focal species abundance	Ecological	Context
(Pietri et al. 2009)	Effective Management	Information diffusion	Communication and information dissemination	Social	Process
		Presence of community environmental education programs			
		MPA compliance	Level of Compliance		

		Enforcement	Level of enforcement	Governance	Input
		Strong leadership	Level of governance and leadership		Process
		Coral condition	Composition and structure of the community	Ecological	Output
		Fish abundance	Focal species abundance		
(Pikesley et al. 2016)	Connectivity	Spatial overlap of species distributions and MPA	Species distribution	Ecological	Output
	Effective Management	Spatial overlap of vessels using trawl and dredge with MPA area	Extent and severity of threats		
(Pittman et al. 2014)	Connectivity	Adult movement within and between protected areas and unprotected areas	Species distribution	Ecological	Context
(Ponchon et al. 2017)	Areas of Importance	Spatial overlap between the MPA network and nesting sites	Coverage of species richness hotspots	Ecological	Output
	Connectivity	At-sea distribution of kittiwakes	Species distribution		
(Puckett & Eggleston 2016)	Effective Management	Oyster growth	Focal species population structure	Ecological	Output
		Proportion of larvae spawned from a reserve that successfully settled	Recruitment success within the community		Outcome
(Roberts et al. 2019)	Effective Management	MPA designation	Existence and adequacy of enabling legislation	Governance	Planning

	Representative	Distribution of Biophysical attributes	Proportion of species distributions covered by MPAs	Ecological	Context
(Roberts et al. 2018)	Effective Management	Trend in size class distribution of MPAs	Area under no or reduced impact	Ecological	Output
		Trend in the number of MPAs			
		Trend in the total area protected			
		Trend in biodiversity representation	Habitat distribution and complexity		
		Trends in pressures on the marine environment	Extent and severity of threats		Context
(Rodríguez-rodríguez et al. 2015)	Effective Management	Existence of Management measures for Threatening (damaging, disturbing, extractive & depositional activities)	Area showing signs of recovery	Ecological	Output
		Existence of management personnel on site	Availability and allocation of MPA admin resources	Governance	Process
		Existing statutory tools	Existence and adequacy of enabling legislation		Planning
		Existing Legislative & regulatory framework of MPA site	Existence of a decision-making and management body		
(Rodríguez-Rodríguez 2018)	Effective Management	Active surveillance	Availability and allocation of MPA administrative resources	Governance	Process

		Occurrence of enforcement	Level of enforcement		
		Legal designation and regulation stringency	Existence and adequacy of enabling legislation		Planning
		Management plans	Existence and adoption of a management plan		
(Rodríguez-Rodríguez et al. 2016)	Representative	Geographic distribution of MPAs in Mediterranean	Coverage of Ecoregions	Ecological	Context
(Russ et al. 2008)	Effective Management	Densities of target fishes on open and no-take reefs	Focal species abundance	Ecological	Output
(Starr et al. 2015)	Effective Management	Changes in densities and sizes of fishes	Focal species abundance	Ecological	Outcome
(Stevenson & Tissot 2013)	Effective Management	Dive operator and fisher willingness to engage	Communication and information dissemination	Social	Process
		Value orientations toward the aquarium fish trade among by fishers and dive operators	Local values and beliefs about marine resources		Context
		Perceptions regarding the effectiveness of the MPAs to alleviate conflict and enhance reef fish abundance	Perceptions of non-market and non-use value	Governance	
		Perceptions regarding threats from other stakeholders	Level of resource conflict		
		Perceived encounter rates between surveyed groups held by dive operators and fishers			Output

		Dive operator awareness about the aquarium fishery	Level of community and stakeholder involvement and participation in management		
(Terauds et al. 2006)	Effective Management	Foraging distributions	Species distribution	Ecological	Context
		Breeding locations coinciding with MPAs	Focal species population structure	Ecological	Outcome
(Thiault et al. 2019)	Effective Management	Density and biomass of fish	Focal species abundance	Ecological	Outcome
(Tissot et al. 2004)	Effective Management	Change in coral cover (over time and between sites)	Composition and structure of the community	Ecological	Output
		Density and abundance of target fish	Focal species abundance		Outcome
(Van Lavieren & Klaus 2013)	Effective Management	Resource inventory status	Area showing signs of recovery	Ecological	Output
		Threats addressed			
		Equipment	Availability and allocation of MPA admin resources	Governance	Input
		Staff numbers			
		Current budget	Reliability and adequacy of funding		
		Stakeholder satisfaction increased	Level of stakeholder support and satisfaction in management		Output
		Environmental awareness improved	Local understanding of MPA rules and regulations		
		Stakeholder awareness and concern			Process

		Legal status	Existence and adequacy of enabling legislation		Planning
		Regulations and controls			
		Management objectives addressed	Existence and adoption of a management plan		Output
		Management activities			Planning
		Management objectives			
		Management plan			
		Boundary awareness and demarcation	Local understanding of MPA rules and regulations		
		Communication stakeholders and managers	Degree of interaction between managers and stakeholders		Process
		Research	Existence and application of scientific research and input		
		Monitoring and evaluation			
		Involvement of traditional/local people	Level of community and stakeholder involvement and participation in management		
		Stakeholder involvement and participation			
		Law enforcement	Level of enforcement		
		Staff training	Level of training provided to staff and administration		
		Stakeholder participation	Level of training provided to stakeholders in		

			participation		
		Education and awareness programs	Communication and information dissemination	Social	Process
		Environmental education		Social	
		Compliance improved	Level of compliance	Social	Output
		Community welfare improved	Quality of human health	Social	
		Visitor facilities	Visitor management	Economic	Process
		Visitor facilities			
	Integrated	Integration into coastal management plan	Existence of integrated management measures in management plans	Governance	Planning
(Weeks et al. 2010)	Connectivity	Euclidean distance to the nearest MPA for each site (spacing)	Size and spatial arrangement of PAs	Ecological	Output
	Representative	Overlap of MPAs in bioregions (bioregions represented in MPAs)	Coverage of ecoregions		
		Percentage of the area of each biodiversity feature within MPAs			
(Welch et al. 2018)	Effective Management	Bycatch threat	Extent and severity of threats	Ecological	Context
		Fishery distribution	Focal species population structure		
		Species distributions			
(White et al. 2014)	Effective Management	Percent/area of each major marine and coastal habitat type in protected “no-take replenishment zones”	Area under no or reduced impact	Ecological	Output

		Percent/area of MPAs included in CTMPAS			
		CTMPAS Framework developed and adopted by Coral Triangle Countries	Level of constraint or support by external political and civil environment	Governance	Context
(Williams et al. 2009)	Effective Management	Changes in mean yellow tang density	Focal species abundance	Ecological	Outcome
(Wing & Jack 2013)	Effective Management	Changes in biodiversity, community structure and species richness	Focal species population structure	Ecological	Outcome

Table A3. Location and name of MPA networks assessed in the literature for this review, the corresponding authors.

Country or region	Specific MPAN location	Authors
Australia	Australian MPAs	(Althaus et al. 2017; Roberts et al. 2019)
	Great barrier reef	(Fernandes et al. 2005; Russ et al. 2008; Harrison et al. 2012; Barr & Possingham 2013; Roberts et al. 2018)
	Riviana lagoon (Solomon Islands), the palm islands (great barrier reef, Australia) and Moreton bay (Australia)	(Olds et al. 2013)
	Batemans marine park (NSW)	(Coleman et al. 2013; Kelaher et al. 2014)
	Eastern Australia and Tasmania	(Welch et al. 2018)
	Albatross island, Tasmania, and south Australian waters	(Mason et al. 2018)
	Port Davey, Tasmania	(Edgar et al. 2009)
	Macquarie island	(Terauds et al. 2006)
Belize	Belize barrier reef mpa network	(Cox et al. 2017)
Brazil	Santa Catarina, Sao Paulo, Bahia and Pernambuco state	(Gerhardinger et al. 2011)

	MPAs	
Coral triangle	Coral triangle mpa network (Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands, and Timor-Leste)	(White et al. 2014)
France	French Méditerranéan coast (the parc national de port cros, parc national des calanques and the parc naturel Marin du golfe du lion)	(Péron et al. 2013)
	Along the French coasts of the English Channel: Saint-Pierre-du-mont and fécamp in Normandy and boulogne-sur-mer in hauts-de-France.	(Ponchon et al. 2017)
	France_OSPAR	(Ardron 2008)
French polynesia	The plan de gestion de l'espace maritime (pgem) includes a network of eight mpas on the island of Moorea	(de Loma et al. 2008; Thiault et al. 2019)
Global	Global	(Mora et al. 2006; Klein et al. 2015; Daru & le Roux 2016; Jantke et al. 2018; Fischer et al. 2019)
Ireland	Ireland_ OSPAR	(Critchley et al. 2018)
Mediterranean	Mediterranean basin mpa network (not including black sea)	(Guilhaumon et al. 2014)
	Mediterranean mpa network (1077 MPAs from Spain, France, Italy, Greece, turkey, Egypt, Tunisia, Morocco, Lybia)	(Rodríguez-Rodríguez et al. 2016)
	Mediterranean mpa network (Adriatic sea, Aegean sea, Alboran sea, Ionian sea, Levantine basin, Tunisian plateau/gulf of sidra, western Mediterranean)	(Rodríguez-Rodríguez 2018)
	Mediterranean mpa network (Alboran sea; Balearic sea; gulf of lions; Ligurian sea; Algerian and Tunisian waters; Tyrrhenian sea; north adriatic sea; central Adriatic sea; south Adriatic sea; Ionian sea; north Aegean sea; south Aegean sea; levant sea; gulf of gabes)	(Mouillot et al. 2011)
	Specially protected areas of Mediterranean importance	(Geijer & Jones 2015)

	(spami) network	
New Zealand	Fiordland marine area (te moana o atawhenua)	(Jack & Wing 2013; Wing & Jack 2013)
Northeast Atlantic	Cold-water coral reefs off the UK and Ireland exclusive economic zones (EEZs)	(Jackson et al. 2018)
	MSDF region (portion of nw France, the republic of Ireland, and the United Kingdom)	(Foster et al. 2017)
Norway	Kvernskjær lobster reserve	(Huserbråten et al. 2013)
OSPAR	Area beyond national jurisdiction (abnj) OSPAR region	(Evans et al. 2015)
Palau	Ebiil, ngermasech, ngederrak, ngerumekaol, ngemelis, ngelukes, ileyakl beluu	(Friedlander et al. 2017)
Papua New Guinea	Kimbe bay	(Berumen et al. 2012)
Persian/Arabian gulf	173 MPAs covering 7.8% of the ROPME sea area from the gulf to the Arabian sea coast of Oman	(Van Lavieren & Klaus 2013)
Philippines	985 Philippine mpas	(Weeks et al. 2010)
	Batangas mpa and enforcement network	(Horigue et al. 2014)
	Central Visayas	(Pietri et al. 2009)
Saint Lucia	Soufriere marine management area	(Hawkins et al. 2006)
	Soufriere marine management area (smma), and the canaries-anse-la-raye marine management area (camma).	(Bégin et al. 2016)
Spain	Cabo de gata–níjar natural park	(Félix-hackradt et al. 2018)
United Kingdom	Uk "protected area networks across the channel ecosystem (panache)	(Rodríguez-rodríguez et al. 2015)
	Wales (pembrokeshire and swansea) and southwest england (Cornwall, Devon, Dorset, and Hampshire)	(Pikesley et al. 2016)
USA _ California	Año nuevo state marine conservation area (smca), and the point lobos, piedras blancas, and point buchon state marine reserves (smrs)	(Starr et al. 2015)
	California mpa network_ north coast mpas	(Ordoñez-Gauger et al. 2018)
	Channel Islands mpa network	(Hamilton et al. 2010; Karpov et al. 2012; Caselle et al. 2015)

	Santa cruz and santa rosa island, southern California bight	(Kay & Wilson 2012; Kay et al. 2012)
USA_ east coast	Barnegat bay, new jersey	(Lathrop et al. 2017)
	Pamlico sound, North Carolina, USA	(Puckett & Eggleston 2016)
USA _ Hawai'i	West Hawai'i mpa network	(Tissot et al. 2004; Williams et al. 2009; Christie et al. 2010; Stevenson & Tissot 2013; Grorud-Colvert et al. 2014)
USA _Virgin islands	Virgin Islands coral reef national monument (vicr); the virgin islands national park (vinp); hind bank marine conservation district (mcd); and Grammanik bank (gb)	(Pittman et al. 2014)

Table A4. Aichi target categories and the number of times each indicator was used to assess them.

Qualitative element	Count	Indicator
Areas of importance	1	Centers of endemism or intact wilderness areas
	1	Focal species abundance
	1	Focal species population structure
	3	Coverage of key biodiversity areas
	4	Coverage of species richness hotspots
Well-connected	1	Focal species population structure
	3	Distance between habitat patches
	4	Species dispersal
	5	Size and spatial arrangement of MPAs
	6	Species distribution
Effectively managed	1	Level of community benefit/assistance
	1	Local values and beliefs about marine resources
	1	Perceptions of non-market and non-use value
	1	Quality of human health
	1	Species distribution
	2	Clearly defined enforcement procedures
	2	Degree of interaction between managers and stakeholders
	2	Level of governance and leadership
	2	Level of resource conflict
	2	Level of stakeholder support and satisfaction in management
	2	Level of training provided to stakeholders in participation
	2	Material style of life
	2	Type, level and return on fishing effort
	2	Visitor management
	3	Existence and application of scientific research and input
	3	Level of compliance
	3	Level of constraint or support by external political and civil environment
	3	Level of training provided to staff and administration
	3	Local understanding of mpa rules and regulations
	3	Recruitment success within the community
	4	Level of community and stakeholder involvement and participation in management
	4	Reliability and adequacy of funding

	5	Area showing signs of recovery
	5	Communication and information dissemination
	5	Level of enforcement
	6	Existence and adequacy of enabling legislation
	6	Existence and adoption of a management plan
	6	Habitat distribution and complexity
	7	Availability and allocation of mpa administrative resources
	7	Existence of a decision-making and management body
	8	Composition and structure of the community
	10	Area under no or reduced impact
	11	Extent and severity of threats
	13	Focal species population structure
	15	Focal species abundance
Equitably managed	1	Level of stakeholder support and satisfaction in management
	1	Perception mpa effects on livelihood
Integrated	1	Existence of integrated management measures in management plans
	1	Level of regional cooperation and coordination
	1	Terrestrial sediment influence
Representative	1	Habitat distribution and complexity
	1	Numbers of replicated habitats and species
	11	Proportion of species distributions covered by MPAs
	23	Coverage of ecoregions

Table A5. Alignment of the indicators used in this review with existing indicator frameworks.

Indicators	This review	Pomeroy (Pomeroy et al. 2005)	Gannon (Gannon et al. 2017)	Leverington (Leverington et al. 2010)
Adequacy of infrastructure, equipment and facilities				X
Area showing signs of recovery	X	X		
Area under no or reduced human impact	X	X		
Availability and allocation of mpa administrative resources	X	X		X
Carbon sequestration			X	
Centers of endemism or intact wilderness areas	X		X	
Changes in conditions of ancestral and historical sites/ features/ monuments		X		
Clearly defined enforcement procedures	X	X		
Communication and information dissemination	X	X		X
Composition and structure of the community	X	X		
Coverage of ecoregions	X		X	
Coverage of species richness hotspots	X		X	
Degree of interaction between managers and stakeholders	X	X		
Distance between habitat patches	X		X	
Effect of park management on local community				X
Existence and activity level of community organisations		X		
Existence and adequacy of enabling legislation	X	X		X
Existence and adoption of a management plan	X	X		
Existence and application of scientific research and input	X	X		
Existence of a decision-making and management body	X	X		
Existence of integrated management measures in management plans	X			
Extent and severity of threats	X			X

Flood risk reduction			X	
Focal species abundance	X	X		
Focal species population structure	X	X		
Food web integrity		X		
Habitat distribution and complexity	X	X		
Household income distribution by source		X		
Household occupational structure		X		
Level of communities and stakeholders’ involvement in management	X	X		X
Level of community benefit/assistance	X			X
Level of compliance	X			
Level of constraint or support by external political and civil environment	X			X
Level of enforcement	X	X		X
Level of governance and leadership	X	X		X
Level of regional cooperation and coordination	X			
Level of resource conflict	X	X		
Level of stakeholder participation and satisfaction in management	X	X		
Level of training provided to staff and administration	X	X		X
Level of training provided to stakeholders in participation	X	X		X
Level of understanding of human impact son marine resources		X		
Local understanding of mpa rules and regulations	X	X		
Local values and beliefs about marine resources	X	X		
Marking and security or fencing of park boundaries				X
Material style of life	X	X		
Natural resource and cultural protection activities undertaken				X
Number of replicate habitats	X			
Coverage of key biodiversity areas	X		X	
Percent of global marine carbon stock covered by pas			X	

Perception mpa effects on livelihood	X	X		
Perceptions of non-market and non-use value	X	X		
Perceptions of seafood availability		X		
Proportion of species distributions covered by mpas	X		X	
Quality of human health	X	X		
Recruitment success within the community	X	X		
Reliability and adequacy of funding	X			X
Research and monitoring of natural/cultural management				X
Sediment retention			X	
Size and spatial arrangement of pas	X		X	
Species dispersal	X		X	
Species distribution	X		X	
Stakeholder knowledge of natural history		X		
Tenure security and issues				X
Terrestrial sediment influence	X			
Type, level and return on fishing effort	X	X		
Visitor management	X			X
Water quality			X	

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Appendix B. Chapter 3

B1. Supplementary tables

Table B1. Online platforms, Listservs, and mailing lists from various marine conservation and MPA groups used to recruit potential survey participants.

Listserv/platform	
CAMPAM	Caribbean Marine Protected Areas Managers forum.
CMPAN	California Marine Protected Areas Network
COASTNET	Coastal Resources Center and The Department of Marine Affairs at The University of Rhode Island (USA).
CORAL-LIST	Coral discussion list produced by the Coral Health and Monitoring Program.
EBM Tools	An email listserv that allows Network members to get suggestions for and share information about tools, methods, and other resources for improving coastal and marine conservation and management (hosted by OCTO).
ECOLOG-L	Listserv maintained for members of the Ecological Society of America at the University of Maryland (USA).
ELAN	Environment in Latin America Network
ENVST-L	Environmental studies discussion listserv from Brown University (USA).
Fishfolk	Fisheries information at mit.edu (USA)
INFOTERRA	Subscription list run by the U.N. Environment Program (UNEP), for the exchange of information on environmental topics.
MPA News	Global information service on planning and management of marine protected areas (MPAs) (hosted by OCTO).
OCTO	Open Communication for the Ocean. Online platform for connecting ocean professionals to information and networks. Formerly known as MARE (Marine Affairs Research and Education).

Table B2. Dimensions and attributes as described in the survey. Center column indicates attributes added by the survey respondents from open-ended survey questions. Far right column depicts aggregated (hierarchical) dimensions (those in bold denote existing dimensions).

Dimension	Emerging participant-added attributes [verbatim]	Grouped attributes
Ecological	Responsibility for conservation [Responsabilité du site pour la conservation des espèces]	Accountability
	Activities and threats within the network	Activities and threats
	Management of human pressures	
	Oil and gas	
	Seabed mining	
	Adequacy	Adequacy
	Adequacy: ensuring the MPA is an adequate size to include a full ecosystem or habitat type	
	Adequacy (size, configuration)	
	Individual sizes of MPAs	
	MPA Size	
	MPA size and spacing	
	MPA size recommendations	
	MPA spacing	
	Climate change impacts	Climate change
	Ocean warming	
	Cultural use	Cultural values and significance
	Ecological function	Ecological function
	Fonctions et structure des écosystèmes	
	Enforcement and Compliance	Enforcement and Compliance
	Illegal fishing aka Poaching	
	Habitat health	Habitat health
	Water quality indices	
	"Critical" habitat	Key Habitats
	Key ecosystems of importance	
	At risk species	Key Species
	Keystone species	
	Life history characteristics of key species	
	Including highly protected marine areas as part of the network	Levels of protection
	Levels of protection	
	Replication	Replication

	Replication	
	Replication of habitats	
	Replication of sites	
	Comprehensiveness	Representation
	Geographic diversity	
	Proportion of habitat area protected across a region	
	Rarity	
	Replication of key features	
	Area of high biodiversity or productivity [Zone de forte biodiversité ou forte productivité]	
		Resilience
		Connectivity
Governance	Accountability	Accountability
	Transparency	
	Transparency	
	Media	
	Enforcement capacity	Capacity for Monitoring, surveillance, and enforcement
	Capacity for MCS	
	Capacity/strength of management body/council	Capacity/strength of management body/council
	Leadership	
	Deliberative democracy, delegated decision making	Co-Management
	Level of co-management in the governance	
	MPA Collaborative	
	Traditional governance systems	
	Enabling legislation	Enabling legislation and strategies
	Exploitation rights	
	Policy implementation, monitoring and evaluation	
	Suit of implementation strategies	
	International responsibilities	
	Pre-empting new uses	
	Enforcement	Enforcement and Compliance
	Fairness	Equity/social Justice
	User pays	
	Funding for management	Funding for management

	Government funding	
	National Security	National Security
	Jurisdictions of different levels of government	Overlapping jurisdictions
	Overlapping jurisdictions	
	Agriculture	
	Fossil fuel industry, shipping	
	Broad local and state agency participation in planning	Participation
	Complementation/harmonization with existing relevant management plans and initiatives	
	Coordination and governance [Coordination / gouvernance à échelle ad hoc]	
	Coordination with Tribes	
	First Nations (non-participating) consultations	
	Traditional Owner participation	
	First Nations in governance partnership	Partnerships
	Traditional rights and customs	Rights and access
	Scientifically driven decision-making	Scientifically driven decision-making
	Trust	Trust
Economic	Government Dysfunction	Capacity/strength of management body/council
	Intergenerational wealth	Economic/ material wealth
	Level of development	
	Potential for improved fisheries	Employment/livelihood
	Potential for livelihoods such as marine tourism	
	Socio-economic benefit of the MPA to local community	
	Fisheries landings and values	
	Funding sustainability	Funding sustainability
	Government funding for basic services	
	Infrastructure and access	
	Cost to manage	
	Priority fishing grounds in planning process	Economic activities
	Nonmarket values	nonmarket values
	Opportunity cost	Opportunity cost

	Opportunity costs of exclusion	
		Economic distribution
Social	Fisher inclusion	Community engagement and inclusion
	Actors and users [Actores y usuarios]	
		Conflict
	Cultural connections	Cultural value and significance
	Cultural practice	
	Cultural significance	
	First Nations areas of cultural value	
	Global heritage	
	Indigenous connections to the ocean and Earth	
	Indigenous cultures	
	Indigenous values	
	Reconnecting	
	Social values	
	Ecological knowledge	Ecological knowledge
	Economic activities [Actividades económicas]	Economic activities
	Fishing activities [Activités de pêche]	
	Fossil fuel expansion	
	Important fishing grounds	
	Other developments (e.g., ports, shipping etc.)	
	Tourism	
	Tourism potential	
	Economic impact to fisheries	Economic impacts
	Economic impacts	
	Impacts on local economy	
	Impacts to industry	
	Enforcement and Compliance	Enforcement and Compliance
	Gender inclusion	Equity/social Justice
	Opportunity cost	
	Food security	Human health
	Human health	
		Human wellbeing
	Politics	Politics
	Jurisdictional aspects [Aspects juridiques]	Rights and access
	Cultural/First Nation rights	
	Fishing access	

	Resource access rights	
	Tourism access	
	Heritage / historic use	Traditional and historic uses
	Human uses (consumptive and non-consumptive)	
	Traditional use	
	Preexisting uses [Usages préexistants]	

Table B3. Location of MPANs with corresponding objectives indicated by participants and Objective groups (B, B&S). Multiple responses for the same MPAN list objectives separately. Objectives: C= Biodiversity conservation, F= Fisheries management, H= Habitat restoration and protection, E= Maintaining ecosystem services, V= Cultural values (and subsistence), W= Social wellbeing. Objectives were categorized into two levels, those with biodiversity conservation and/or Habitat restoration and protection (B) and those with a mix of Biodiversity conservation and or Habitat restoration and protection, as well as one or more of: Fisheries management, Maintaining ecosystem services, Cultural values (and subsistence), and Social wellbeing (B&S).

Location	MPAN	Objectives	Objective groups
Australia	Commonwealth network	CE	B&S
		CH	B
	Great Barrier Reef	C	B
		CE	B&S
		CE	B&S
		CEVW	B&S
		CFVW	B&S
		CFHW	B&S
	New South Whales	C	B
	Tasmania	C	B
Belize	Belize Barrier Reef Reserve System	CFE	B&S
		CFE	B&S
		FEVW	B&S
Brazil	Brazil RESEX	CF	B&S
		CHW	B&S
Canada	Arctic	CH	B
	Eastern shelf	CH	B
	Banc-des- Américains	C	B
	Laurentian Channel	CE	B&S
	Maritimes	CH	B
	Newfoundland Labrador	F	B&S
	Norther Shelf Bioregion	CFHE	B&S
		CH	B
		CHE	B&S
	Scotian Shelf	CE	B&S
Chile	Areas marinas protegidas de Chile	CFH	B&S
China	Jiaozhou Bay	CE	B&S
Croatia	Cres-Losinj	CH	B
Cuba	Sistema Nacional de Áreas Protegidas de Cuba	CFHEVW	B&S
Fiji	LMMA network	FEVW	B&S

		FHEVW	B&S
Finland	HELCOM	C	B
France	Réserves Naturelles de France	CFHEV	B&S
Indonesia	Birds Head	CFHEW	B&S
Ireland	UK _Northern Ireland	CH	B
Jamaica	Discovery Bay	CFH	B&S
Kenya	Kisite Mpunguti	CFHE	B&S
Mexico	Midriff Islands	CFH	B&S
	Veracruzano	CFHEVW	B&S
Philippines	Batangas	FHW	B&S
	Pangatalan	CFHV	B&S
	Philippines	FH	B&S
	San luis MPAN	FHE	B&S
Portugal	Portugal	CFHEVW	B&S
Scotland	Scotland	C	B
Solomon Islands	Solomon Islands	CFV	B&S
Thailand	Thailand	CH	B
UK	MCZs	C	B
	MPAn	CHE	B&S
		CH	B
		CH	B
	MPAn offshore	CFHE	B&S
		CFH	B&S
		CH	B
		CHE	B&S
	Natura 2000	CH	B
	OSPAR network	CE	B&S
		CHE	B&S
USA	California MPAN	C	B
		CFHE	B&S
		CFHEV	B&S
		CFHEVW	B&S
		CFHEVW	B&S
		CFHEVW	B&S
		CFH	B&S
		CHEV	B&S
		CHEVW	B&S
		CHEVW	B&S
		CH	B
		F	B&S

	Oregon MPAN	CW	B&S
Global	Global	CHEVW	B&S
Mediterranean	Med PAN	CH	B
West Africa	RAMPAO	C	B
		CFVW	B&S

Table B4. Affiliation and role of survey participants. Although 77 participants finished the survey, only 64 participants filled out the role and affiliation sections. Participant number indicates a number assigned to each survey participant.

	Affiliation									Role									
Participant	Federal /National government	State/ Provincial government	Indigenous government	Local/Community government	Non-government organization (NGO)	Academic institution/ University	International agency (e.g., United Nations)	Recreational groups/ tourism industry	Private	Researcher/Academic	Project manager	Project facilitator	Habitat or species specialist	Policy analyst	Monitoring technician	Communications	Community liaison	Community leader	Other
1	X					X				X									
2					X	X				X									X
3						X				X									
4		X				X				X			X				X		
5						X				X									
6						X				X									
7	X									X	X	X	X						X
8						X				X									
9						X				X									
10					X	X				X			X						
12						X				X									
13					X	X				X		X		X					
14						X				X									
15							X							X					
16							X			X	X	X		X					
17	X					X				X			X						

18		X				X				X		X	X			X			
19						X				X			X						
20						X				X									
21					X														X
22	X					X				X	X								
23		X								X	X					X			X
24						X				X									
25						X				X									
26						X				X									
27						X				X	X								
28						X				X									
29						X				X									
30					X														X
31	X									X	X		X						
32						X				X									
58						X				X	X				X				
69						X				X									
75					X					X	X		X		X	X			
79						X				X			X						
80					X	X				X			X						X
96		X									X								
97		X								X	X	X	X			X			
98					X														X
99					X									X					
100						X				X									
101					X					X	X	X	X	X	X	X	X	X	
102						X				X									
103		X										X							
104						X				X									
105					X					X		X			X				
106						X				X									
107		X									X				X			X	
108					X					X									
109	X																		X
110	X																		X
111					X								X				X		X
112	X									X									
113	X													X					
115					X					X	X				X				

116	X																		X
117																			X
118						X				X		X							
119						X				X			X						
141	X									X									
150	X									X									
151	X	X							X	X	X		X	X	X	X			
Tot	13	8	0	0	14	34	2	0	1	48	14	9	15	7	7	6	3	2	12

Table B5. Shannon diversity and evenness of attributes for each dimension assessed among the two MPAN objective types (Biodiversity only (B) and Biodiversity and socially-oriented (B&S) objectives

Dimension	MPAN objective type	Attribute richness S	Attribute abundance N	Shannon diversity H’	Pileau evenness J’
Ecological	B	7	163	1.89	0.97
	B&S	6	164	1.76	0.98
Economic	B	4	37	1.09	0.79
	B&S	4	56	1.27	0.91
Social	B	6	59	1.56	0.87
	B&S	6	123	1.70	0.95
Governance	B	4	76	1.25	0.90
	B&S	4	106	1.36	0.98

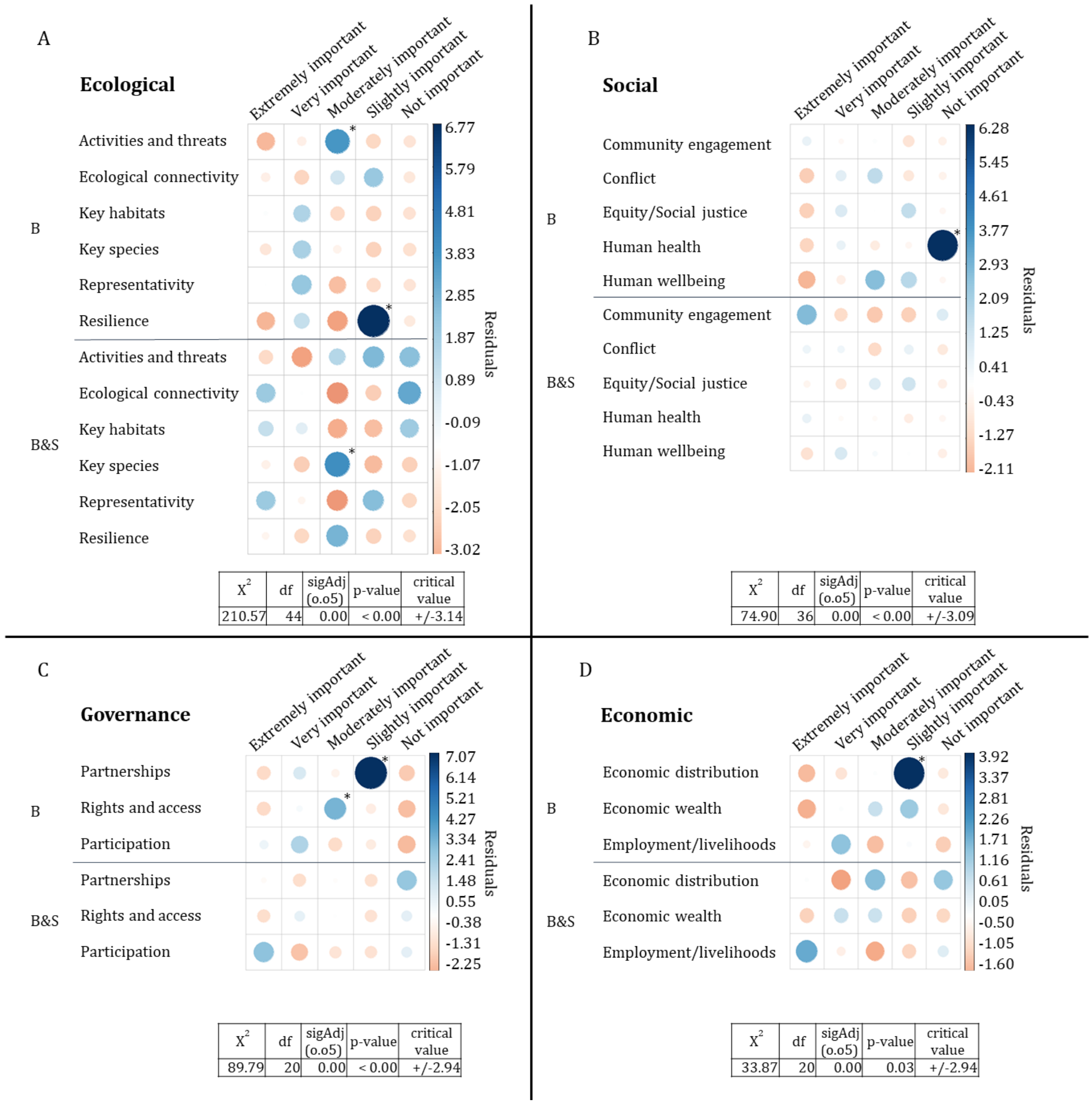
Table B6. Permutational multivariate analysis of variance (PERMANOVA) output for assessing the relationship between types of MPAN objectives, biodiversity only (B) or biodiversity with socially-oriented objectives (B&S), on the attributes considered (yes or no) among all dimensions (social, ecological, economic, governance). The significant PERMANOVA was followed with a multilevel pattern analysis to determine which attributes were associated with each group (B, BS, or both). Results indicated there was a slight difference between attributes selected for these two MPAN types. Partnerships, Economic distribution, and Human wellbeing were found statistically more often in the BS network type.

PERMANOVA	R^2	Df	Significance
Attribute | Network type	0.03	1	<0.05
Multilevel pattern analysis			
Network type B&S | Partnerships	0.32		0.02
Network type B&S | Human wellbeing	0.26		0.04
Network type B&S | Economic distribution	0.25		0.07

Table B7. Ordinal Chi square test for independence on all factors. Total frequency of importance levels selected by participants for each dimension. Groupwise p-values and adjusted p-values

Asymptotic Generalized Cochran-Mantel-Haenszel Test stratified by Dimension					**All factors**	chi-square	df	**Df**	**p-value**
						33.80		4	<0.001
Dimension	Objective	Not important	Slightly important	Moderately important	Very important	Extremely important		Group p.	Group adj.p
Ecological	B	0	5	25	69	56		0.04	0.05
	B&S	0	2	20	57	83			
Economic	B	0	4	12	15	4		0.01	0.03
	B&S	0	1	9	19	20			
Governance	B	0	1	12	32	27		0.04	0.05
	B&S	1	0	7	31	50			
Social	B	1	2	14	20	17		0.02	0.03
	B&S	0	5	13	31	59			

B2. Supplementary figures



A (Ecological)

X^2	df	sigAdj (0.05)	p-value	critical value
210.57	44	0.00	< 0.00	+/-3.14

B (Social)

X^2	df	sigAdj (0.05)	p-value	critical value
74.90	36	0.00	< 0.00	+/-3.09

C (Governance)

X^2	df	sigAdj (0.05)	p-value	critical value
89.79	20	0.00	< 0.00	+/-2.94

D (Economic)

X^2	df	sigAdj (0.05)	p-value	critical value
33.87	20	0.00	0.03	+/-2.94

Figure B1. Correlograms of the differences between the expected and observed values (residuals) across perceived levels of importance for each dimension, panel A= Ecological, panel B= Social, panel C= Governance, panel D= Economic. Ordinal Chi Square test for independence showing association between the levels of importance for each attribute among the MPAN objective types (biodiversity (B) and biodiversity and socially-oriented (B&S) objectives). Corresponding critical cut-off values are indicated. Critical values indicate the contribution of a cell to the resulting chi-square value Numbers larger and smaller than the critical cut-off value are considered significant (shown with an asterisk in the cell). Positive values (colored blue, indicate that observed values are greater than expected, negative values (colored pink) indicate that observed values are less than expected.[i]

Appendix C. Chapter 4

C1. Supplementary tables

Table C1. Survey responses, including the name, location (Country or region) and features of interest in our analyses. GDP in USD, GDP Code (GDP binned for analyses), Age of the MPAN, Level of Protection[1], Management structure (F= managed by federal /national government, L= managed by local/community or Indigenous government, P = managed by state/ provincial government, N= managed by non-government organization (NGO), z= no response), Number of MPAs in the network, MPAN objective type[2], Attributes considered in the MPAN evaluation (E= ecological, M= economic, G= governance, S= social) , and respondent affiliation (M=mix of academic, management, local expert, A=solely academic affiliation).

Response	Name of MPAN	Country or region	GDP ($USD)	GDP Code	Age of MPAN	Level of protection	Management structure	Number of MPAs	MPAN Objective type	Attributes considered	Respondent affiliation
7	Gulf; Scotian Shelf; NL Shelves Networks	Canada	$1,736,425,629,520	f	1	FHLM	F	10	B	GES	M
9	Channel Islands MPA network	United States	$22,675,000,000,000	h	41	FHLM	P	16	B&S	GEMS	A
10	Eastport, Gilbert Bay MPAs	Canada	$1,736,425,629,520	f	1	HL	LF	4	BS&	GEMS	M
13	Natura 2000, Cres-Losinj	Croatia	$60,415,553,039	b	7	M	P	7	B	E	M
16	Birds Head Seascape MPA	Indonesia	$1,119,190,780,75	d	17	M	LPN	10	B&S	GEM	M

[1] Level of protection includes F = Fully protected, H = highly protected, M= moderately protected, L= Lightly protected, based on MPA guide (Grorud-Colvert et al., 2021).

[2] Objective types follow Chapter two objective classification B = Biodiversity only, and BS = biodiversity and socially oriented objectives.

	network in West Papua, Indonesia		3							S	
17	UK and Ireland offshore deep-water Nature Conservation MPAs	United Kingdom	$2,827,113,184,696	g	9	H	F	11	B&S	GES	A
18	Réserves Naturelles de France	France	$2,715,518,274,227	g	21	F	N	12	B&S	GES	M
19	Parque Nacional Sistema Arrecifal Veracruzano y la red propuesta	Mexico	$1,258,286,717,125	e	1	FHLM	z	3	BS	GEMS	M
25	Tasmanian MPA network	Australia	$1,392,680,589,329	e	29	F	FP	7	B	GEMS	A
26	Scottish MPA Network	United Kingdom	$2,827,113,184,696	g	7	M	z	10	B	GES	A
27	Midriff Islands	Mexico	$1,258,286,717,125	e	3	FH	LFN	10	B&S	GES	M
30	HELCOM MPA network	Finland	$268,761,201,365	c	15	H	z	10	B	GES	M
31	Sistema Nacional de Áreas Protegidas de Cuba	Cuba	$100,023,000,000	b	26	FHLM	FPN	62	B&S	GEMS	M
32	Scotian Shelf Bioregion MPA Network	Canada	$1,736,425,629,520	f	1	FHLM	F	10	B	GEMS	A
69	RESEX areas in Brazil	Brazil	$1,839,758,040,766	e	38	FHLM	FLP	10	B&S	GS	A
75	Oregon Marine Reserves	United States	$22,675,000,000,000	h	9	FHLM	L	5	B&S	GEMS	M
79	European Natura 2000 special areas of conservation	United Kingdom	$2,827,113,184,696	g	23	HL	F	10	B	GE	M
80	MPA network in the northern shelf bioregion	Canada	$1,736,425,629,520	f	1	FHLM	FLP	10	B	GEMS	M
97	UK Offshore MPA Network	United Kingdom	$2,827,113,184,696	g	18	FHLM	LFP	10	B&S	GEMS	A
98	Belize Marine Reserve Network	Belize	$1,879,613,600	a	25	FHLM	FN	5	B&S	GEMS	M

99	Global MPA network	Global	NA	h	1	FHLM	FLPN	50	B&S	GEMS	A
100	NSW Marine Parks Australia	Australia	$1,392,680,589,329	e	23	FHLM	P	7	B	GEMS	A
102	Laurentian Channel MPA/NL Bioregion MPA network (conservation network)	Canada	$1,736,425,629,520	f	1	HL	F	10	B	GEMS	A
105	San Luis Marine Protected Area Network	Philippines	$376,795,508,680	d	4	FHLM	L	4	B&S	GEMS	M
108	Batangas MPA Network	Philippines	$376,795,508,680	d	13	L	LPN	10	B&S	GEMS	A
109	Marine Conservation Zones in the UK	United Kingdom	$2,827,113,184,696	g	9	L	P	10	B	ES	M
110	MedPAN	Mediterranean	$934,095,754,438	e	13	FHLM	N	10	B	GEMS	M
112	Thailand's MPAs	Thailand	$543,649,976,166	d	20	F	F	10	B	GEMS	A
113	Federal system of MPAs in Brazil	Brazil	$1,839,758,040,766	e	31	FHLM	LF	10	B&S	GES	A
115	Glovers Reef Marine Reserve	Belize	$1,879,613,600	a	28	FHLM	LFN	10	B&S	GES	M
117	UK Marine Protected Area network	United Kingdom	$2,827,113,184,696	g	12	FHLM	FN	10	B	GEMS	M
118	Solomon Islands	Solomon Islands	$1,425,074,226	a	14	L	LFN	10	B&S	GEMS	M
119	Canada's Maritimes Marine Conservation Areas Network	Canada	$1,736,425,629,520	f	1	HL	F	7	B	GEMS	M
150	PNSACV; PMPLS (Portuguese MPAs)	Portugal	$237,686,075,635	c	1	FHLM	F	7	B&S	E	A
152	RAMPAO	West Africa	$23,578,084,052	a	14	FHLM	FN	10	B&S	GEMS	A

153	OSPAR_ Celtic Seas	United Kingdom	$2,827,113,184,696	g	11	L	LFN	10	B	GEMS	M
156	Commonwealth Marine Reserves Network	Australia	$1,392,680,589,329	e	31	FHLM	FP	10	B	GEMS	A
158	Great Barrier Reef	Australia	$1,392,680,589,329	e	15	FHLM	FLP	10	B	GEMS	M
160	California's Statewide Marine Protected Area Network	United States	$22,675,000,000,000	h	12	FHLM	LPN	10	B&S	GEMS	M

Table C2. Indicators selected by survey participants. Center column includes all indicators selected and added by participants. We condensed some indicators into headline indicator groups. Column on right consists of the final set of headline indicators used in this analysis. Indicators not initially included in the survey (added by participants) are indicated in italics.

Dimension	All indicators	Consolidated indicators
Ecological	Area showing signs of recovery	Area showing signs of recovery
	Area under no or reduced human impact	Area under no or reduced human impact
	Centers of endemism or intact wilderness areas	Centers of endemism or intact wilderness areas
	Composition and structure of the community	Composition and structure of the community
	Coverage of ecoregions	Coverage of ecoregions
	Coverage of key biodiversity areas	Coverage of key biodiversity areas
	Coverage of species richness hotspots	Coverage of species richness hotspots
	Distance between habitat patches	Distance between habitat patches
	Extent and severity of threats	Extent and severity of threats
	Industry e.g., shipping, oil, gas etc. effects	Extent and severity of threats
	Non-native species (Existence/ coverage/ number)	Extent and severity of threats
	Water quality	Extent and severity of threats
	Focal species abundance	Focal species abundance
	Focal species population structure	Focal species population structure
	Food web integrity	Food web integrity
	Habitat distribution and complexity	Habitat distribution and complexity
	Number of replicated species/habitats	Number of replicated species/habitats
	Hydrodynamics (tides, waves, currents)	Oceanographic parameters
	Oceanographic considerations	Oceanographic parameters
	Oceanographic	Oceanographic parameters
	Proportion of species distribution covered by MPAs	Proportion of species distribution covered by MPAs
	Recruitment success within the community	Recruitment success within the community
	Reproductive potential	Recruitment success within the community

	Size and spatial arrangement of PAs	Size and spatial arrangement of PAs
	Species dispersal	Species dispersal
	Species distribution	Species distribution
	Type, level and return on fishing effort	Type, level and return on fishing effort
	Size of exploited fish species	Size of exploited fish species
	Biomass	Biomass
Economic	Existence of capacity building	Existence of capacity building initiatives
	Number of employment opportunities	Employment opportunities provided by MPAs
	Number of people employed by MPAs	
	Economic contribution of fishing	Revenue from fisheries and other sources of income
	Economic contribution of tourism	
	Amount of revenue from fisheries and other sources of income	
	Reliability and adequacy of funding	Reliability and adequacy of funding
	Visitor management	Visitor management
	Material style of life	Material style of life
Governance	Level of constraint or support by external political and civil environment	Level of constraint or support by external political and civil environment
	Existence of clearly defined enforcement procedures	Clearly defined enforcement procedures
	Level of stakeholder participation & satisfaction in management	Level of stakeholder participation & satisfaction in management
	Degree of interaction between managers and stakeholders	Degree of interaction between managers and stakeholders
	Availability and allocation of MPA administrative resources	Availability and allocation of MPA administrative resources (secured funding)
	Adequacy of funding for management	
	Amount of funding per unit area	
	Existence of integrated management measures in	Existence of integrated management measures in management plans

	management plans	
	Level of community and stakeholder involvement	Level of community and stakeholder involvement
	Level of enforcement	Level of enforcement
	Existence and adoption of a management plan	Existence and adoption of a management plan
	Number of policies/statutory acts passed	
	Level of regional cooperation and coordination	Level of regional cooperation and coordination
	Level of resource conflict	Level of resource conflict
	Local understanding of MPA rules and regulations	Local understanding of MPA rules and regulations
	Existence and adequacy of enabling legislation	Existence and adequacy of enabling legislation
	Existence of a decision making and management body	Existence of a decision making and management body
	Level of governance and leadership	Level of governance and leadership
	Existence of multi-agency leadership Team	
	Level of training provided to staff and administration	Level of training provided to staff and administration
	Level of community benefit/assistance	Level of community benefit/assistance
	Existence and application of scientific research and input	Existence and application of scientific research and input
	Level of training provided to stakeholders in participation	Level of training provided to stakeholders in participation
Social	Level of communication and information dissemination	Level of communication and information dissemination
	Level of compliance	Level of compliance
	Level of resource conflict	Level of resource conflict
	Level of equity	Level of equity
	Perceptions of MPA effects on livelihood	Perceptions of MPA effects on livelihood
	Access to resources	Access to resources
	Quality of human health	Quality of human health
	Level of maternal health and child malnutrition	
	Values and beliefs about marine resources	Values and beliefs about marine resources

	Extent of traditional practices	
	Level of governance and leadership	Level of governance and leadership
	Existence of multi-agency leadership Team	
	Level of local users' participation in management	
	Existence of community collaboratives	
	Number of community leaders	
	Existence of social network	Existence of social network
	Level of community participation and leadership	Level of community participation and leadership

Table C3. Count and dominance of indicators and associated attributes organized by Leading indicators as calculated by dominance for each attribute and dimension. Dominance was calculated as the total number of times an indicator is used to measure an attribute (d) / total number of attributes the indicator measures (e) /number of times the attributes is measured (i).

Dimension	Attribute	Indicator	Count	Dominance
Ecological	Accountability	Proportion of species distribution covered by MPAs	1	0.008
		Food web integrity	1	0.008
		Coverage of ecoregions	1	0.008
		Centers of endemism or intact wilderness areas	1	0.008
		Type, level and return on fishing effort	1	0.007
		Species distribution	1	0.007
		Recruitment success within the community	1	0.007
		Coverage of species richness hotspots	1	0.007
		Coverage of key biodiversity areas	1	0.007
		Species dispersal	1	0.006
		Focal species abundance	1	0.006
		Focal species population structure	1	0.006

	Activities and threats	Extent and severity of threats	24	0.018
		Area under no or reduced human impact	21	0.012
		Type, level and return on fishing effort	20	0.011
		Size and spatial arrangement of PAs	11	0.007
		Area showing signs of recovery	11	0.007
		Habitat distribution and complexity	5	0.004
		Food web integrity	6	0.004
		Centers of endemism or intact wilderness areas	6	0.004
		Recruitment success within the community	6	0.003
		Oceanographic parameters	2	0.003
		Distance between habitat patches	5	0.003
		Species dispersal	5	0.003
		Coverage of ecoregions	4	0.002
		Composition and structure of the community	4	0.002
		Number of replicated species/habitats	3	0.002
		Species distribution	3	0.002
		Coverage of species richness hotspots	3	0.002
		Coverage of key biodiversity areas	3	0.002
		Focal species population structure	3	0.001
		Proportion of species distribution covered by MPAs	2	0.001
		Focal species abundance	2	0.001
	Adequacy	Size and spatial arrangement of PAs	6	0.010
		Habitat distribution and complexity	4	0.008
		Proportion of species distribution covered by	4	0.007

		MPAs		
		Coverage of ecoregions	4	0.007
		Coverage of key biodiversity areas	4	0.006
		Distance between habitat patches	3	0.005
		Type, level and return on fishing effort	3	0.005
		Recruitment success within the community	3	0.005
		Species dispersal	3	0.004
		Number of replicated species/habitats	2	0.004
		Extent and severity of threats	2	0.004
		Composition and structure of the community	2	0.003
		Centers of endemism or intact wilderness areas	2	0.003
		Area showing signs of recovery	2	0.003
		Species distribution	2	0.003
		Coverage of species richness hotspots	2	0.003
		Area under no or reduced human impact	2	0.003
		Focal species abundance	2	0.003
		Focal species population structure	2	0.003
		Food web integrity	1	0.002
	Connectivity	Distance between habitat patches	20	0.011
		Size and spatial arrangement of PAs	16	0.008
		Species dispersal	17	0.007
		Habitat distribution and complexity	11	0.007
		Food web integrity	11	0.006
		Species distribution	11	0.005
		Recruitment success within the community	11	0.005
		Number of replicated species/habitats	7	0.004

		Coverage of ecoregions	8	0.004
		Coverage of key biodiversity areas	8	0.004
		Proportion of species distribution covered by MPAs	7	0.004
		Area showing signs of recovery	7	0.004
		Area under no or reduced human impact	7	0.003
		Extent and severity of threats	5	0.003
		Composition and structure of the community	6	0.003
		Centers of endemism or intact wilderness areas	6	0.003
		Oceanographic parameters	2	0.003
		Type, level and return on fishing effort	5	0.002
		Coverage of species richness hotspots	5	0.002
		Focal species abundance	5	0.002
		Focal species population structure	4	0.002
		Size of exploited fish species	1	0.001
	Cultural use	Type, level and return on fishing effort	1	0.042
		Focal species population structure	1	0.036
	Ecological function	Composition and structure of the community	1	0.023
		Recruitment success within the community	1	0.021
		Species dispersal	1	0.019
		Focal species population structure	1	0.018
	Enforcement and Compliance	Extent and severity of threats	1	0.007
		Size and spatial arrangement of PAs	1	0.006
		Proportion of species distribution covered by	1	0.006

		MPAs		
		Food web integrity	1	0.006
		Coverage of ecoregions	1	0.006
		Composition and structure of the community	1	0.006
		Area showing signs of recovery	1	0.006
		Type, level and return on fishing effort	1	0.005
		Species distribution	1	0.005
		Recruitment success within the community	1	0.005
		Coverage of species richness hotspots	1	0.005
		Coverage of key biodiversity areas	1	0.005
		Area under no or reduced human impact	1	0.005
		Species dispersal	1	0.005
		Focal species abundance	1	0.005
		Focal species population structure	1	0.004
	Habitat health	water quality	1	0.071
		Extent and severity of threats	2	0.016
		Food web integrity	2	0.013
		Area showing signs of recovery	2	0.013
		Size and spatial arrangement of PAs	1	0.006
		Type, level and return on fishing effort	1	0.006
		Recruitment success within the community	1	0.006
		Coverage of species richness hotspots	1	0.006
		Coverage of key biodiversity areas	1	0.006
		Area under no or reduced human impact	1	0.006
		Focal species abundance	1	0.005
	Key Habitats	Habitat distribution and complexity	26	0.009

		Centers of endemism or intact wilderness areas	25	0.007
		Area showing signs of recovery	23	0.006
		Number of replicated species/habitats	18	0.006
		Coverage of key biodiversity areas	23	0.006
		Area under no or reduced human impact	23	0.006
		Composition and structure of the community	20	0.005
		Distance between habitat patches	17	0.005
		Size and spatial arrangement of PAs	18	0.005
		Food web integrity	15	0.004
		Recruitment success within the community	16	0.004
		Extent and severity of threats	11	0.004
		Coverage of ecoregions	13	0.004
		Coverage of species richness hotspots	14	0.004
		Type, level and return on fishing effort	12	0.003
		Species dispersal	13	0.003
		Focal species abundance	13	0.003
		Species distribution	11	0.003
		Proportion of species distribution covered by MPAs	10	0.003
		Focal species population structure	9	0.002
		Size of exploited fish species	1	0.001
		Oceanographic parameters	1	0.001
	Key Species	Species distribution	29	0.007
		Number of replicated species/habitats	21	0.006
		Focal species abundance	30	0.006
		Focal species population structure	31	0.006

		Proportion of species distribution covered by MPAs	22	0.005
		Species dispersal	24	0.005
		Food web integrity	20	0.005
		Recruitment success within the community	21	0.005
		Coverage of species richness hotspots	21	0.005
		Composition and structure of the community	19	0.005
		Centers of endemism or intact wilderness areas	19	0.005
		Type, level and return on fishing effort	20	0.005
		Extent and severity of threats	14	0.004
		Area showing signs of recovery	15	0.004
		Coverage of key biodiversity areas	14	0.003
		Distance between habitat patches	11	0.003
		Area under no or reduced human impact	13	0.003
		Habitat distribution and complexity	8	0.002
		Size and spatial arrangement of PAs	9	0.002
		Reproductive potential	1	0.001
		Coverage of ecoregions	5	0.001
	Levels of protection	Number of replicated species/habitats	1	0.007
		Habitat distribution and complexity	1	0.007
		Distance between habitat patches	1	0.006
		Size and spatial arrangement of PAs	1	0.005
		Proportion of species distribution covered by MPAs	1	0.005
		Coverage of ecoregions	1	0.005

		Composition and structure of the community	1	0.005
		Centers of endemism or intact wilderness areas	1	0.005
		Area showing signs of recovery	1	0.005
		Type, level and return on fishing effort	1	0.005
		Species distribution	1	0.005
		Coverage of species richness hotspots	1	0.005
		Coverage of key biodiversity areas	1	0.005
		Area under no or reduced human impact	1	0.005
		Species dispersal	1	0.005
		Focal species abundance	1	0.005
		Focal species population structure	1	0.004
	Ocean warming	Distance between habitat patches	1	0.050
		Species dispersal	1	0.038
	Replication	Number of replicated species/habitats	4	0.016
		Habitat distribution and complexity	2	0.008
		Distance between habitat patches	2	0.007
		Size and spatial arrangement of PAs	2	0.006
		Proportion of species distribution covered by MPAs	2	0.006
		Coverage of ecoregions	2	0.006
		Species distribution	2	0.006
		Coverage of key biodiversity areas	2	0.006
		Food web integrity	1	0.003
		Composition and structure of the community	1	0.003
		Centers of endemism or intact wilderness areas	1	0.003
		Area showing signs of	1	0.003

		recovery		
		Recruitment success within the community	1	0.003
		Coverage of species richness hotspots	1	0.003
		Area under no or reduced human impact	1	0.003
		Species dispersal	1	0.003
		Focal species abundance	1	0.003
		Focal species population structure	1	0.003
	Representation	Habitat distribution and complexity	24	0.009
		Number of replicated species/habitats	23	0.008
		Proportion of species distribution covered by MPAs	27	0.008
		Coverage of ecoregions	26	0.008
		Coverage of key biodiversity areas	21	0.006
		Composition and structure of the community	18	0.005
		Species distribution	19	0.005
		Coverage of species richness hotspots	19	0.005
		Size and spatial arrangement of PAs	17	0.005
		Centers of endemism or intact wilderness areas	16	0.005
		Area under no or reduced human impact	16	0.004
		Distance between habitat patches	11	0.004
		Focal species abundance	12	0.003
		Extent and severity of threats	8	0.003
		Species dispersal	11	0.003
		Area showing signs of recovery	9	0.003
		Food web integrity	6	0.002
		Type, level and return on fishing effort	6	0.002

		Recruitment success within the community	6	0.002
		Focal species population structure	6	0.001
		Size of exploited fish species	1	0.001
	Resilience	Extent and severity of threats	11	0.009
		Area showing signs of recovery	12	0.008
		Food web integrity	9	0.006
		Number of replicated species/habitats	7	0.006
		Area under no or reduced human impact	9	0.006
		Size and spatial arrangement of PAs	8	0.005
		Type, level and return on fishing effort	8	0.005
		Recruitment success within the community	8	0.005
		Composition and structure of the community	7	0.005
		Coverage of key biodiversity areas	7	0.004
		Species dispersal	7	0.004
		Size of exploited fish species	2	0.004
		Reproductive potential	1	0.004
		Oceanographic parameters	2	0.004
		Centers of endemism or intact wilderness areas	5	0.003
		Habitat distribution and complexity	4	0.003
		Coverage of species richness hotspots	5	0.003
		Proportion of species distribution covered by MPAs	4	0.003
		Focal species population structure	5	0.003
		Species distribution	4	0.002
		Distance between habitat	3	0.002

		patches		
		Coverage of ecoregions	3	0.002
		Focal species abundance	3	0.002
Governanc e	Accountability	Level of training provided to staff and administration	3	0.006
		Level of resource conflict	3	0.006
		Level of governance and leadership	3	0.006
		Level of constraint or support by external political and civil environment	3	0.005
		Level of community benefit/assistance	3	0.005
		Level of community and stakeholder involvement	3	0.005
		Existence of integrated management measures in management plans	3	0.005
		Existence of a decision making and management body	3	0.005
		Existence and adoption of a management plan	3	0.005
		Level of regional cooperation and coordination	3	0.005
		Level of enforcement	3	0.005
		Availability and allocation of MPA administrative resources (secured funding)	3	0.005
		Level of stakeholder participation & satisfaction in management	3	0.004
		Degree of interaction between managers and stakeholders	3	0.004
		Clearly defined enforcement procedures	3	0.004
		Level of training provided to stakeholders in participation	2	0.004
		Existence and adequacy of enabling legislation	2	0.004

		Local understanding of MPA rules and regulations	2	0.003
		Existence and application of scientific research and input	1	0.002
	Capacity for Monitoring, surveillance, and enforcement	Level of enforcement	2	0.010
		Availability and allocation of MPA administrative resources (secured funding)	2	0.010
		Clearly defined enforcement procedures	2	0.010
		Level of training provided to staff and administration	1	0.006
		Level of resource conflict	1	0.006
		Level of constraint or support by external political and civil environment	1	0.006
		Level of community benefit/assistance	1	0.006
		Level of community and stakeholder involvement	1	0.006
		Existence of integrated management measures in management plans	1	0.006
		Local understanding of MPA rules and regulations	1	0.005
		Level of regional cooperation and coordination	1	0.005
		Level of stakeholder participation & satisfaction in management	1	0.005
		Degree of interaction between managers and stakeholders	1	0.005
	Capacity/strength of management body/council	Level of training provided to staff and administration	2	0.008
		Level of governance and leadership	2	0.008
		Existence and application of scientific research and input	2	0.008
		Level of community and	2	0.007

		stakeholder involvement		
		Existence of a decision making and management body	2	0.007
		Degree of interaction between managers and stakeholders	2	0.006
		Clearly defined enforcement procedures	2	0.006
		Level of training provided to stakeholders in participation	1	0.004
		Level of resource conflict	1	0.004
		Existence and adequacy of enabling legislation	1	0.004
		Level of constraint or support by external political and civil environment	1	0.003
		Level of community benefit/assistance	1	0.003
		Existence of integrated management measures in management plans	1	0.003
		Existence and adoption of a management plan	1	0.003
		Local understanding of MPA rules and regulations	1	0.003
		Level of regional cooperation and coordination	1	0.003
		Level of enforcement	1	0.003
		Availability and allocation of MPA administrative resources (secured funding)	1	0.003
		Level of stakeholder participation & satisfaction in management	1	0.003
	Co-Management	Existence and application of scientific research and input	3	0.008
		Level of community and stakeholder involvement	3	0.007
		Existence of a decision	3	0.007

		making and management body		
		Existence and adoption of a management plan	3	0.007
		Local understanding of MPA rules and regulations	3	0.006
		Level of stakeholder participation & satisfaction in management	3	0.006
		Degree of interaction between managers and stakeholders	3	0.006
		Level of resource conflict	2	0.005
		Existence and adequacy of enabling legislation	2	0.005
		Level of constraint or support by external political and civil environment	2	0.005
		Level of community benefit/assistance	2	0.005
		Level of regional cooperation and coordination	2	0.004
		Availability and allocation of MPA administrative resources (secured funding)	2	0.004
		Clearly defined enforcement procedures	2	0.004
		Level of training provided to stakeholders in participation	1	0.003
		Level of governance and leadership	1	0.003
		Existence of integrated management measures in management plans	1	0.002
		Level of enforcement	1	0.002
	Enabling legislation and strategies	Existence of integrated management measures in management plans	4	0.011
		Existence and adoption of a management plan	3	0.009
		Level of governance and	2	0.006

		leadership		
		Existence and application of scientific research and input	2	0.006
		Existence and adequacy of enabling legislation	2	0.006
		Level of constraint or support by external political and civil environment	2	0.006
		Level of community and stakeholder involvement	2	0.006
		Local understanding of MPA rules and regulations	2	0.005
		Availability and allocation of MPA administrative resources (secured funding)	2	0.005
		Level of stakeholder participation & satisfaction in management	2	0.005
		Clearly defined enforcement procedures	2	0.005
		Level of training provided to staff and administration	1	0.003
		Level of resource conflict	1	0.003
		Level of community benefit/assistance	1	0.003
		Existence of a decision making and management body	1	0.003
		Level of regional cooperation and coordination	1	0.003
		Level of enforcement	1	0.003
		Degree of interaction between managers and stakeholders	1	0.002
	Equity/social Justice	Level of resource conflict	2	0.011
		Existence and adequacy of enabling legislation	2	0.011
		Level of training provided to stakeholders in participation	1	0.005
		Level of training provided	1	0.005

		to staff and administration		
		Level of governance and leadership	1	0.005
		Existence and application of scientific research and input	1	0.005
		Level of constraint or support by external political and civil environment	1	0.005
		Level of community benefit/assistance	1	0.005
		Level of community and stakeholder involvement	1	0.005
		Existence of a decision making and management body	1	0.005
		Existence and adoption of a management plan	1	0.005
		Local understanding of MPA rules and regulations	1	0.004
		Level of regional cooperation and coordination	1	0.004
		Availability and allocation of MPA administrative resources (secured funding)	1	0.004
		Level of stakeholder participation & satisfaction in management	1	0.004
		Degree of interaction between managers and stakeholders	1	0.004
		Clearly defined enforcement procedures	1	0.004
	Funding for management	Level of constraint or support by external political and civil environment	11	0.031
		Availability and allocation of MPA administrative resources (secured funding)	4	0.010
		Level of enforcement	2	0.005
		Level of training provided	1	0.003

		to stakeholders in participation		
		Level of training provided to staff and administration	1	0.003
		Level of resource conflict	1	0.003
		Level of governance and leadership	1	0.003
		Existence and adequacy of enabling legislation	1	0.003
		Level of community benefit/assistance	1	0.003
		Level of community and stakeholder involvement	1	0.003
		Existence of integrated management measures in management plans	1	0.003
		Existence of a decision making and management body	1	0.003
		Existence and adoption of a management plan	1	0.003
		Local understanding of MPA rules and regulations	1	0.003
		Level of regional cooperation and coordination	1	0.003
		Level of stakeholder participation & satisfaction in management	1	0.002
		Degree of interaction between managers and stakeholders	1	0.002
		Clearly defined enforcement procedures	1	0.002
	Overlapping jurisdictions	Availability and allocation of MPA administrative resources (secured funding)	2	0.012
		Level of training provided to stakeholders in participation	1	0.007
		Level of training provided to staff and administration	1	0.007
		Existence and application of scientific research and	1	0.007

		input		
		Existence and adequacy of enabling legislation	1	0.007
		Existence of integrated management measures in management plans	1	0.006
		Existence of a decision making and management body	1	0.006
		Local understanding of MPA rules and regulations	1	0.006
		Level of regional cooperation and coordination	1	0.006
		Level of enforcement	1	0.006
		Level of stakeholder participation & satisfaction in management	1	0.005
		Degree of interaction between managers and stakeholders	1	0.005
		Clearly defined enforcement procedures	1	0.005
	Participation	Level of community and stakeholder involvement	47	0.006
		Level of governance and leadership	41	0.006
		Level of stakeholder participation & satisfaction in management	51	0.006
		Level of resource conflict	37	0.005
		Degree of interaction between managers and stakeholders	46	0.005
		Level of training provided to stakeholders in participation	34	0.005
		Level of regional cooperation and coordination	40	0.005
		Existence and application of scientific research and input	33	0.005
		Level of community	36	0.005

		benefit/assistance		
		Existence and adoption of a management plan	36	0.005
		Local understanding of MPA rules and regulations	39	0.005
		Existence of a decision making and management body	35	0.005
		Level of training provided to staff and administration	30	0.004
		Existence and adequacy of enabling legislation	28	0.004
		Level of constraint or support by external political and civil environment	30	0.004
		Existence of integrated management measures in management plans	30	0.004
		Level of enforcement	30	0.004
		Availability and allocation of MPA administrative resources (secured funding)	25	0.003
		Clearly defined enforcement procedures	25	0.003
	Partnerships	Availability and allocation of MPA administrative resources (secured funding)	32	0.006
		Level of governance and leadership	26	0.006
		Existence and application of scientific research and input	26	0.006
		Level of regional cooperation and coordination	31	0.006
		Existence and adoption of a management plan	27	0.006
		Level of community and stakeholder involvement	26	0.005
		Degree of interaction between managers and stakeholders	30	0.005
		Level of training provided	23	0.005

		to staff and administration		
		Existence of a decision making and management body	25	0.005
		Level of training provided to stakeholders in participation	22	0.005
		Existence of integrated management measures in management plans	22	0.005
		Local understanding of MPA rules and regulations	22	0.004
		Level of enforcement	22	0.004
		Level of stakeholder participation & satisfaction in management	23	0.004
		Level of constraint or support by external political and civil environment	19	0.004
		Level of resource conflict	16	0.004
		Existence and adequacy of enabling legislation	16	0.004
		Level of community benefit/assistance	17	0.003
		Clearly defined enforcement procedures	17	0.003
	Rights and access	Level of resource conflict	26	0.009
		Existence and adequacy of enabling legislation	21	0.007
		Local understanding of MPA rules and regulations	24	0.007
		Existence and adoption of a management plan	22	0.007
		Level of enforcement	23	0.007
		Clearly defined enforcement procedures	24	0.006
		Level of community benefit/assistance	18	0.006
		Level of constraint or support by external political and civil environment	16	0.005

		Existence of a decision making and management body	15	0.005
		Level of stakeholder participation & satisfaction in management	17	0.005
		Existence and application of scientific research and input	11	0.004
		Level of community and stakeholder involvement	12	0.004
		Availability and allocation of MPA administrative resources (secured funding)	13	0.004
		Degree of interaction between managers and stakeholders	11	0.003
		Existence of integrated management measures in management plans	9	0.003
		Level of governance and leadership	7	0.002
		Level of training provided to stakeholders in participation	6	0.002
		Level of training provided to staff and administration	6	0.002
		Level of regional cooperation and coordination	6	0.002
	Scientifically driven decision-making	Existence and application of scientific research and input	1	0.010
		Existence of integrated management measures in management plans	1	0.009
		Existence of a decision making and management body	1	0.009
		Existence and adoption of a management plan	1	0.009
		Local understanding of MPA rules and regulations	1	0.008
		Level of enforcement	1	0.008

		Availability and allocation of MPA administrative resources (secured funding)	1	0.008
		Level of stakeholder participation & satisfaction in management	1	0.008
		Degree of interaction between managers and stakeholders	1	0.008
		Clearly defined enforcement procedures	1	0.008
Economic	Capacity/strength of management body/council	Material style of life	1	0.083
		Visitor management	1	0.071
	Economic activities	Perceptions of MPA effects on livelihood	2	0.286
		Level of resource conflict	1	0.071
		Reliability and adequacy of funding	2	0.057
		Material style of life	1	0.024
		Visitor management	1	0.020
	Economic distribution	Reliability and adequacy of funding	7	0.082
		Material style of life	6	0.059
		Visitor management	4	0.034
	Economic/ material wealth	Reliability and adequacy of funding	4	0.073
		Visitor management	4	0.052
		Material style of life	2	0.030
		Employment opportunities	1	0.030
	Employment/livelihood	Material style of life	16	0.063
		Visitor management	15	0.051
		Reliability and adequacy of funding	9	0.043
		Employment opportunities	2	0.016
	Funding sustainability	Level of resource conflict	1	0.100
		Reliability and adequacy of funding	2	0.080
		Visitor management	2	0.057
	Opportunity cost	Revenue from fisheries and other sources of income	1	0.250
		Employment opportunities	1	0.083
		Material style of life	1	0.042

		Visitor management	1	0.036
	Economic impacts	Number of tourists	1	0.077
		Perceptions of MPA effects on livelihood	4	0.034
		Level of compliance	2	0.014
		Level of governance and leadership	1	0.008
		Values and beliefs about marine resources	1	0.007
		Level of resource conflict	1	0.007
		Level of communication and information dissemination	1	0.007
Social	Community engagement and inclusion	Perceptions of MPA effects on livelihood	23	0.017
		Level of communication and information dissemination	28	0.017
		Level of governance and leadership	25	0.017
		Values and beliefs about marine resources	24	0.015
		Level of compliance	23	0.014
		Level of resource conflict	14	0.009
		Quality of human health	7	0.006
		Existence of a social network	2	0.005
		Access to resources	1	0.002
	Conflict	Level of resource conflict	24	0.021
		Perceptions of MPA effects on livelihood	17	0.018
		Level of compliance	19	0.016
		Values and beliefs about marine resources	15	0.013
		Level of communication and information dissemination	13	0.011
		Level of governance and leadership	11	0.010
		Quality of human health	3	0.004
	Cultural value and significance	Extent of traditional practices	2	0.056
		Values and beliefs about	4	0.020

		marine resources		
		Perceptions of MPA effects on livelihood	3	0.019
		Quality of human health	2	0.014
		Level of governance and leadership	2	0.011
		Level of communication and information dissemination	2	0.010
		Level of resource conflict	1	0.005
		Level of compliance	1	0.005
	Customary rights	Quality of human health	1	0.013
		Level of governance and leadership	1	0.010
		Values and beliefs about marine resources	1	0.009
		Level of resource conflict	1	0.009
		Level of communication and information dissemination	1	0.009
	Enforcement and Compliance	Level of governance and leadership	1	0.003
		Values and beliefs about marine resources	1	0.002
		Level of resource conflict	1	0.002
		Level of compliance	1	0.002
		Level of communication and information dissemination	1	0.002
	Equity/social Justice	Perceptions of MPA effects on livelihood	12	0.023
		Level of governance and leadership	11	0.019
		Level of compliance	9	0.014
		Level of resource conflict	7	0.011
		Level of communication and information dissemination	7	0.011
		Quality of human health	5	0.011
		Values and beliefs about marine resources	4	0.006
	Human health	Quality of human health	4	0.033
		Extent of traditional	1	0.033

		practices		
		Existence of a social network	1	0.022
		Level of governance and leadership	2	0.013
		Values and beliefs about marine resources	2	0.012
		Level of communication and information dissemination	2	0.012
		Perceptions of MPA effects on livelihood	1	0.007
		Level of resource conflict	1	0.006
		Level of compliance	1	0.006
	Human wellbeing	Quality of human health	13	0.031
		Perceptions of MPA effects on livelihood	9	0.019
		Level of resource conflict	8	0.014
		Values and beliefs about marine resources	7	0.012
		Level of governance and leadership	5	0.009
		Level of compliance	5	0.009
		Level of communication and information dissemination	4	0.007
		Existence of a social network	1	0.006
		Access to resources	1	0.006
	Opportunity cost	Access to resources	1	0.028
		Level of resource conflict	1	0.008
		Level of compliance	1	0.008
	Rights and access	Perceptions of MPA effects on livelihood	1	0.007
		Values and beliefs about marine resources	1	0.006
		Level of compliance	1	0.006
		Level of communication and information dissemination	1	0.006
	Traditional and historic uses	Quality of human health	4	0.025
		Perceptions of MPA effects on livelihood	4	0.022

		Values and beliefs about marine resources	4	0.018
		Level of communication and information dissemination	3	0.014
		Level of resource conflict	2	0.009
		Level of compliance	2	0.009
		Level of governance and leadership	1	0.005

Table C4. Pairwise comparisons of the features associated with differences in the composition of MPAN indicator- attribute pairs among MPANs. GDP codes represent groups of countries grouped by similar GDP: a (Belize, Solomon Islands), b (Croatia, West Africa, Cuba), c (Portugal, Finland, d-Philippines, Thailand), e (Mexico, Indonesia, Australia), f (Canada, Brazil), g (UK, France), h (USA). Management codes are represented as; a (NA), F (managed by federal government), L (under local or community-based management), P (provincially managed), N (managed by an NGO). P. adjust refers to adjusted p values using Benjamini-Hochberg correction for multiple comparisons.

Ecological_ GDP	Df	SS	F. Model	R^2	p. value	p. adjusted
e vs a	1	0.652240458	2.467324403	0.215161298	0.008	0.224
g vs a	1	0.636040454	2.1377215	0.191935263	0.017	0.459
e vs c	1	0.351549794	1.751852058	0.17964301	0.029	0.754
e vs f	1	0.392693807	1.404408083	0.097498493	0.036	0.9
h vs a	1	0.514500264	1.407072359	0.219612372	0.059	1
g vs f	1	0.419746891	1.387196907	0.096418845	0.083	1
f vs a	1	0.455165453	1.24516492	0.134682824	0.084	1
c vs a	1	0.608944584	2.041704613	0.404963156	0.1	1
f vs c	1	0.409843439	1.334005151	0.160067714	0.109	1
d vs c	1	0.395219548	1.507045795	0.334375523	0.2	1
d vs a	1	0.426237373	1.092552363	0.21453925	0.2	1

g vs b	1	0.335297872	1.121151958	0.110773157	0.232	1
d vs e	1	0.288530112	1.143374566	0.11272132	0.259	1
g vs c	1	0.304545931	1.279597035	0.137893599	0.265	1
e vs b	1	0.330435563	1.24277688	0.121332027	0.274	1
d vs g	1	0.324806938	1.137557078	0.11221215	0.285	1
e vs h	1	0.284240896	1.119547103	0.100682797	0.297	1
c vs b	1	0.435913007	1.439351908	0.324225684	0.3	1
h vs c	1	0.300614827	1.140324157	0.221838958	0.4	1
h vs b	1	0.380695997	1.033339144	0.171271516	0.427	1
b vs a	1	0.397689945	0.945565412	0.191194602	0.5	1
d vs b	1	0.338820289	0.860866759	0.177101493	0.7	1
f vs h	1	0.294536105	0.859513157	0.087176024	0.714	1
f vs b	1	0.300342582	0.817767058	0.092740832	0.765	1
g vs h	1	0.216959191	0.764609168	0.071029905	0.804	1
d vs f	1	0.299445065	0.850588957	0.096105351	0.807	1
d vs h	1	0.266792025	0.775445663	0.134265944	0.846	1
g vs e	1	0.181902135	0.75156982	0.050948464	0.861	1
Economic_ Management	Df	SS	F. Model	R^2	p. value	p. adjusted
a vs FLP	1	0.37755102	0.966530612	0.325811778	1	1
a vs FN	1	0.302861111	0.863775005	0.223557273	0.6	1
a vs FPN	1	0.286666667	0.573333333	0.36440678	1	1
a vs L	1	0.380562642	0.87753268	0.304960109	1	1

a vs LFN	1	0.287414966	0.610843373	0.169169169	1	1
a vs LFP	1	0.5	1	0.5	1	1
a vs LPN	1	0.402374654	1.032628814	0.256068401	0.5	1
a vs N	1	0.314814815	0.62962963	0.386363636	1	1
a vs P	1	0.203703704	0.407407407	0.289473684	1	1
F vs a	1	0.262037037	0.900795756	0.230926153	0.7	1
F vs FLP	1	0.402841742	1.848081055	0.381198465	0.1	1
F vs FN	1	0.22401148	0.969159102	0.19503483	0.6	1
F vs FP	1	0.274537037	0.943766578	0.239305892	0.6	1
F vs FPN	1	0.210439815	1.12931677	0.360882855	0.5	1
F vs L	1	0.478845427	1.941180977	0.392857697	0.1	1
F vs LFN	1	0.282342451	0.879400405	0.180227145	0.5	1
F vs LFP	1	0.656828704	3.52484472	0.637998876	0.25	1
F vs LPN	1	0.556389466	2.136535551	0.34816641	0.1	1
F vs N	1	0.408564815	2.192546584	0.522962963	0.5	1
F vs P	1	0.137731481	0.739130435	0.26984127	0.75	1
FLP vs FN	1	0.304684209	1.097137436	0.267781458	0.4	1
FLP vs FPN	1	0.299296107	1.064163937	0.515542355	0.6667	1
FLP vs L	1	0.484343506	1.493511538	0.42751012	0.3333	1
FLP vs LFN	1	0.186696712	0.469553377	0.135335395	1	1
FLP vs LFP	1	0.572916667	2.037037037	0.670731707	0.3333	1
FLP vs LPN	1	0.447860244	1.413950977	0.32033681	0.3	1
FLP vs N	1	0.409651361	1.456538171	0.592923077	0.6667	1

FLP vs P	1	0.228426871	0.812184429	0.448179786	0.6667	1
FN vs FPN	1	0.163760275	0.59346872	0.228832033	0.75	1
FN vs LFN	1	0.271109405	0.741019719	0.156299649	0.7	1
FN vs LFP	1	0.389809028	1.412671448	0.413948858	0.25	1
FN vs LPN	1	0.214974044	0.70433846	0.149721043	0.6	1
FN vs N	1	0.250920139	0.909336857	0.312558119	0.5	1
FN vs P	1	0.08453125	0.306342016	0.132825927	1	1
FP vs a	1	0.277777778	0.555555556	0.217391304	1	1
FP vs FLP	1	0.241292693	0.617709293	0.235973221	1	1
FP vs FN	1	0.25725	0.73368984	0.196505299	0.8	1
FP vs FPN	1	0.314814815	0.62962963	0.386363636	1	1
FP vs L	1	0.271111111	0.625150327	0.238138868	1	1
FP vs LFN	1	0.302052295	0.641952106	0.176265939	1	1
FP vs LFP	1	0.5	1	0.5	1	1
FP vs LPN	1	0.386602419	0.99215195	0.248525598	0.5	1
FP vs N	1	0.203703704	0.407407407	0.289473684	1	1
FP vs P	1	0.166666667	0.333333333	0.25	1	1
FPN vs LFN	1	0.244608844	0.536679104	0.211567598	1	1
FPN vs P	1	0.222222222		1		
L vs FN	1	0.355896542	1.161514517	0.279108606	0.3	1
L vs FPN	1	0.213199169	0.580375514	0.367238994	1	1
L vs LFN	1	0.455465986	1.068406915	0.262610633	0.4	1
L vs LFP	1	0.54421768	1.481481481	0.59701492	0.333	1

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L vs LPN	1	0.305921714	0.885592949	0.227917067	0.7	1
L vs N	1	0.18505102	0.50375	0.334995844	1	1
L vs P	1	0.239032502	0.650699588	0.39419625	1	1
LFP vs FPN	1	0.5		1		
LFP vs LFN	1	0.463515094	1.016965951	0.337082343	0.5	1
LFP vs P	1	0.5		1		
LPN vs FPN	1	0.193371914	0.57810842	0.224237435	0.75	1
LPN vs LFN	1	0.431914898	1.09307763	0.214620257	0.5	1
LPN vs LFP	1	0.396365741	1.184982699	0.372053104	0.5	1
LPN vs N	1	0.361540218	1.080867641	0.350832222	0.5	1
LPN vs P	1	0.275498394	0.823635336	0.291693239	0.75	1
N vs FPN	1	0.347222222		1		
N vs LFN	1	0.463515094	1.016965951	0.337082343	0.5	1
N vs LFP	1	0.5		1		
N vs P	1	0.055555556		1		
P vs LFN	1	0.273844955	0.600824005	0.231012942	1	1
Economic_ GDP	Df	SS	F. Model	R^2	p. value	p. adjusted
e vs f	1	0.512979652	1.472756402	0.155472846	0.127	1
e vs g	1	0.481625393	1.267413159	0.136760187	0.169	1
f vs g	1	0.372576111	1.31967952	0.248075004	0.2	1
d vs h	1	0.40315449	1.245025471	0.199362753	0.266	1
e vs b	1	0.463876709	1.195568394	0.145879863	0.272	1
d vs e	1	0.45530020	1.13225544	0.12398420	0.275	1

		9		6		
d vs f	1	0.474276397	1.452403992	0.266378646	0.3	1
g vs a	1	0.438425401	1.4395929	0.324262366	0.3	1
e vs h	1	0.376916969	1.094494287	0.108424876	0.334	1
e vs a	1	0.380576409	1.036245557	0.128946478	0.387	1
d vs a	1	0.370730453	1.019858491	0.253705073	0.4	1
h vs g	1	0.312496213	1.083423049	0.178094313	0.452	1
h vs a	1	0.214956276	0.883711217	0.180950752	0.5333	1
f vs h	1	0.194189195	0.816869087	0.140431059	0.644	1
b vs a	1	0.247437642	0.839384615	0.29562202	0.6667	1
f vs b	1	0.223882464	0.834119417	0.217551757	0.7	1
h vs b	1	0.219672514	0.785881115	0.16420824	0.7333	1
d vs g	1	0.26760076	0.686272338	0.146443119	0.8	1
d vs b	1	0.219184093	0.532146741	0.150658163	0.8	1
f vs a	1	0.119518519	0.543189788	0.153305304	0.9	1
g vs b	1	0.046425684	0.131546181	0.042006783	1	1
Economic_ Age	**Df**	**SS**	**F. Model**	**R^2**	**p. value**	**p. adjusted**
13 vs 33	1	0.602525981	1.891202541	0.212704922	0.111	1
1 vs 4	1	0.604099125	1.779437104	0.262475642	0.152	1
1 vs 13	1	0.421900943	1.353981231	0.109598777	0.172	1
4 vs 13	1	0.424330974	1.243388435	0.134516519	0.237	1
28 vs 33	1	0.592592593	2.666666667	0.727272727	0.3333	1
1 vs 33	1	0.58954157	1.969332523	0.32990833	0.333	1

		2			3	
18 vs 1	1	0.364988257	1.033317344	0.146917492	0.389	1
8 vs 13	1	0.4000882	1.255792855	0.152110509	0.47	1
18 vs 8	1	0.467062114	1.013287299	0.336273046	0.5	1
1 vs 8	1	0.362925926	1.212334911	0.232589604	0.5	1
18 vs 28	1	0.342611678	0.898380849	0.230449739	0.6	1
18 vs 13	1	0.270732594	0.773022611	0.079097598	0.614	1
28 vs 4	1	0.390625	1.081730769	0.351014041	0.6667	1
28 vs 8	1	0.287407407	1.293333333	0.563953488	0.6667	1
28 vs 23	1	0.074074074	0.333333333	0.25	0.6667	1
1 vs 23	1	0.152462963	0.509294485	0.112943275	0.6667	1
1 vs 38	1	0.152462963	0.509294485	0.112943275	0.6667	1
18 vs 4	1	0.45925	0.968967033	0.244135823	0.7	1
18 vs 33	1	0.443142361	0.961393597	0.324642289	0.75	1
28 vs 1	1	0.174416586	0.614287106	0.109414979	0.763	1
13 vs 23	1	0.172096875	0.540175956	0.071639702	0.864	1
13 vs 38	1	0.172096875	0.540175956	0.071639702	0.903	1
28 vs 13	1	0.113476505	0.370175781	0.044225568	0.967	1
18 vs 23	1	0.241788903	0.524558976	0.207782421	1	1
18 vs 38	1	0.241788903	0.524558976	0.207782421	1	1
28 vs 38	1	0.074074074	0.333333333	0.25	1	1
4 vs 8	1	0.411564626	0.823129252	0.451492537	1	1
4 vs 23	1	0.31481481	0.62962963	0.38636363	1	1

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4 vs 33	1	0.5	1	0.5	1	1
4 vs 38	1	0.31481481 5	0.62962963	0.38636363 6	1	1
8 vs 23	1	0.32		1		
8 vs 33	1	0.36734693 9		1		
8 vs 38	1	0.32		1		
23 vs 33	1	0.5		1		
23 vs 38	1	0				
33 vs 38	1	0.5		1		

Table C5. Multivariate dissimilarity between suite of indicators associated with each attribute in the literature and survey (Bray-Curtis distance). A dissimilarity of 1 means a) that a completely different suite of indicators was used to evaluate the attribute between the literature and survey or b) that the attribute was not identified in one of the groups.

Dimension	Attribute	Dissimilarity
	Accountability	1.00
	Cultural use	1.00
	Enforcement and Compliance	1.00
	Habitat health	1.00
	Number of MPAs	1.00
	Ocean warming	1.00
	Rarity	1.00
	Replication	1.00
Ecological	Adequacy	0.93
	Resilience	0.92
	Levels of protection	0.82
	Activities and threats	0.73
	Representation	0.72
	Ecological function	0.61
	Key Species	0.57
	Key Habitats	0.55
	Connectivity	0.52
	Capacity/strength of management body/council	1.00
	Economic activities	1.00
Economic	Economic distribution	1.00
	Employment/livelihood	1.00
	Opportunity cost	1.00

	Economic/ material wealth	0.82
	Funding sustainability	0.31
Governance	Partnerships	0.90
	Scientifically driven decision-making	0.90
	Participation	0.87
	Accountability	0.82
	Integrated management strategies	0.75
	Capacity/strength of management body/council	0.67
	Enabling legislation and strategies	0.65
	Funding for management	0.57
Social	Cultural value and significance	1.00
	Human wellbeing	0.75
	Community engagement and inclusion	0.71
	Enforcement and Compliance	0.60
	Conflict	0.60

Table C6. Shannon diversity and evenness among indicators from the literature and survey in each dimension.

Dimension	Sample (dataset)	Abundance	Richness	Shannon Diversity (H’)	Pileau evenness (J’)
Ecological	Literature	143	20	2.70	0.90
	Survey	2314	27	3.03	0.92
Economic	Literature	9	3	1.00	0.91
	Survey	105	5	1.33	0.82
Governance	Literature	64	19	2.74	0.93
	Survey	1631	19	2.94	1.00
Social	Literature	15	7	1.81	0.93
	Survey	520	10	1.86	0.81

Table C7. Indicator and attribute abbreviations for each dimension corresponding to NMDS bi-plots. Attribute codes are symbolized by alphabetical letters. Indicators are represented by numbers.

Ecological		Economic		Governance		Social	
Code	Attribute	Code	Attribute	Code	Attribute	Code	Attribute
AQ	Adequacy	ED	Economic distribution	AC	Accountability	CE	Community engagement and inclusion
AT	Activities and threats	EW	Economic/ material wealth	CP	Capacity/ strength of management body	C	Conflict
C	Connectivity	EP	Employment/ livelihood	CMG	Co-Management	CV	Cultural value and significance
H	Habitat health	FS	Funding sustainability	COM	Coordinated management	EQ	Equity/ Social Justice
KH	Key Habitats	OC	Opportunity cost	EL	Enabling legislation and strategies	HuH	Human health
KS	Key Species	EA	Economic activities	EQ	Equity/ social Justice	HuW	Human wellbeing
RC	Replication	EI	Economic impacts	FM	Funding for management	TU	Traditional and historic uses
RR	Representation			IM	Integrated management strategies		
RS	Resilience			PN	Participation		
				PT	Partnerships		
				RA	Rights and access		
Code	Indicator	Code	Indicator	Code	Indicator	Code	Indicator
1	Area showing signs of recovery	1	Employment opportunities	1	Availability and allocation of MPA administrative resources	1	Access to resources

					(secured funding)		
2	Area under no or reduced human impact	3	Material style of life	2	Clearly defined enforcement procedures	2	Existence of a Social network
3	Species biomass	2	Reliability and adequacy of funding	3	Degree of interaction between managers and stakeholders	3	Extent of traditional practices
4	Centers of endemism or intact wilderness areas	4	Revenue from fisheries and other sources of income	4	Existence of integrated management measures in management plans	4	Level of communication and information dissemination
5	Composition and structure of the community	5	Visitor management	5	Existence and adequacy of enabling legislation	5	Level of compliance
6	Coverage of ecoregions	6	Perceptions of MPA effects on livelihood	6	Existence and adoption of a management plan	6	Level of governance and leadership
7	Coverage of key biodiversity areas			7	Existence and application of scientific research and input	7	Level of resource conflict
8	Coverage of species richness hotspots			8	Existence of a decision making and management body	8	Perceptions of MPA effects on livelihood
9	Distance between habitat patches			9	Level of community benefit/assistance	9	Quality of human health
10	Extent and severity of threats			10	Level of constraint or support by	10	Values and beliefs about

				external political and civil environment		marine resources
11	Focal species abundance		11	Level of enforcement		
12	Focal species population structure		12	Level of governance and leadership		
13	Food web integrity		13	Level of resource conflict		
14	Habitat distribution and complexity		14	Level of stakeholder participation & satisfaction in management		
15	Existence of industrial activities		15	Level of training provided to staff and administration		
16	Presence of non-native species		16	Level of training provided to stakeholders in participation		
17	Number of replicated species/habitats		17	Local understanding of MPA rules and regulations		
18	Oceanographic parameters		18	Level of regional cooperation and coordination		
19	Proportion of species distribution covered by MPAs		19	Level of community and stakeholder involvement		
20	Recruitment					

	success within the community			
21	Reproductive potential			
22	Size and spatial arrangement of PAs			
23	Size of exploited fish species			
24	Species dispersal			
25	Species distribution			
26	Type, level and return on fishing effort			
27	Water quality			

C2. Supplementary figures

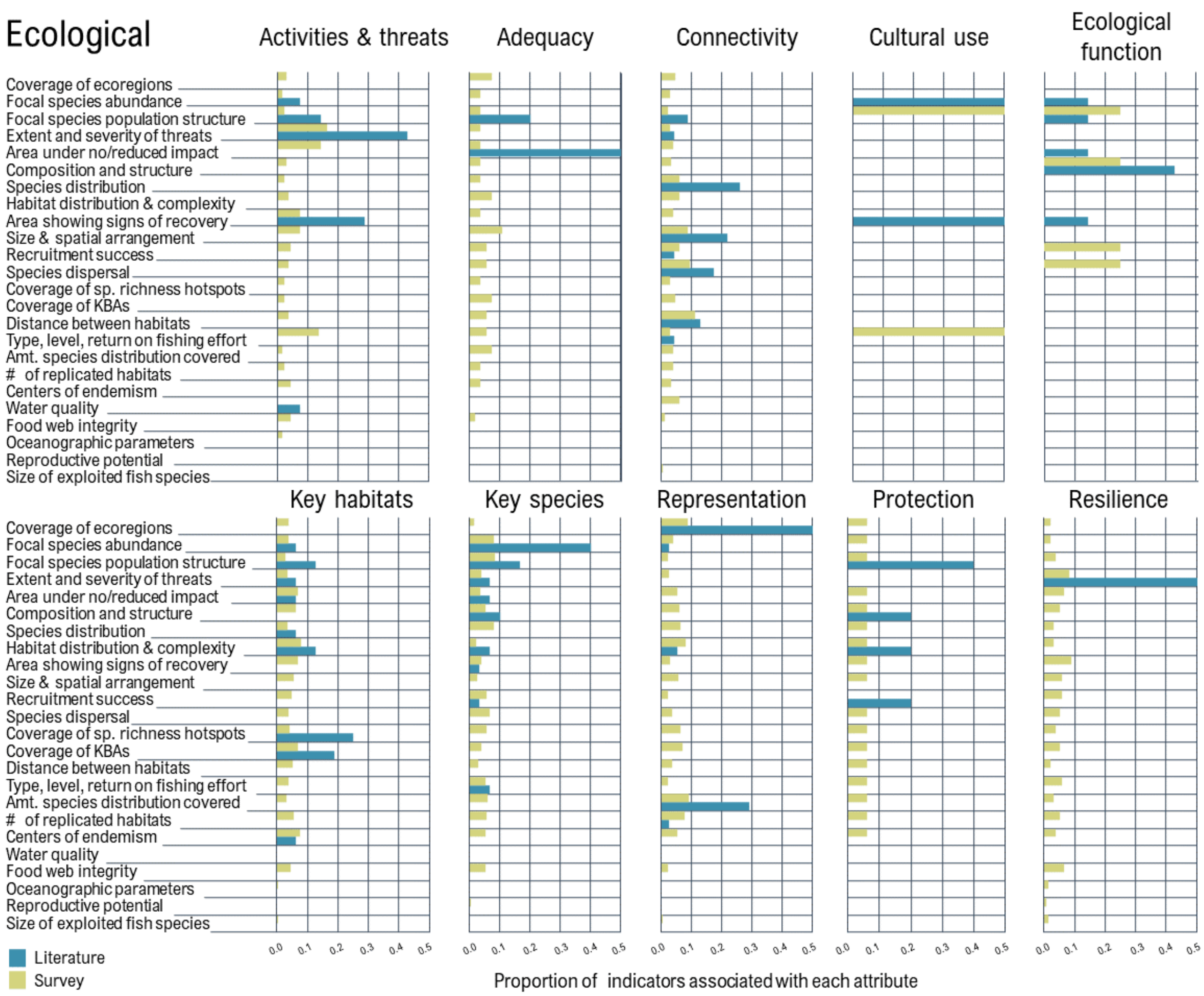

Figure C1 Proportion of indicators associated with attributes in the ecological dimension showing the difference between indicators found in the literature (blue) and those Identified by survey participants (green) as important or used in the evaluation of MPANs.

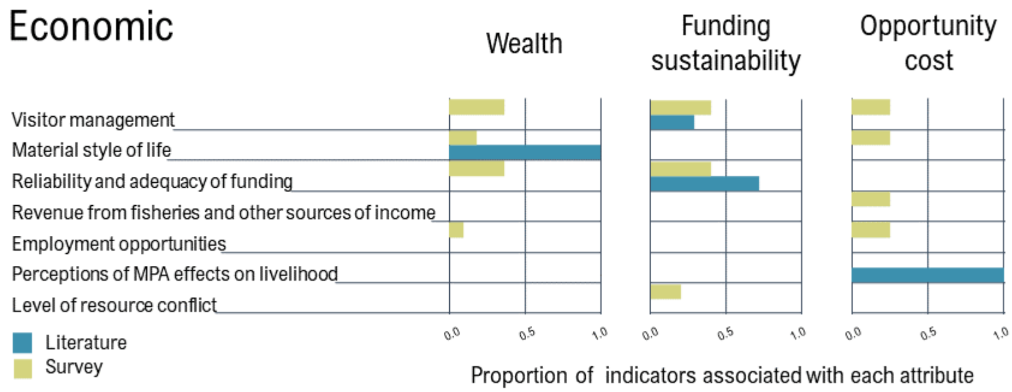

Figure C2. Proportion of indicators associated with attributes in the economic dimension showing the difference between indicators found in the literature (blue) and those identified by survey participants (green) as important or used in the evaluation of MPANs.

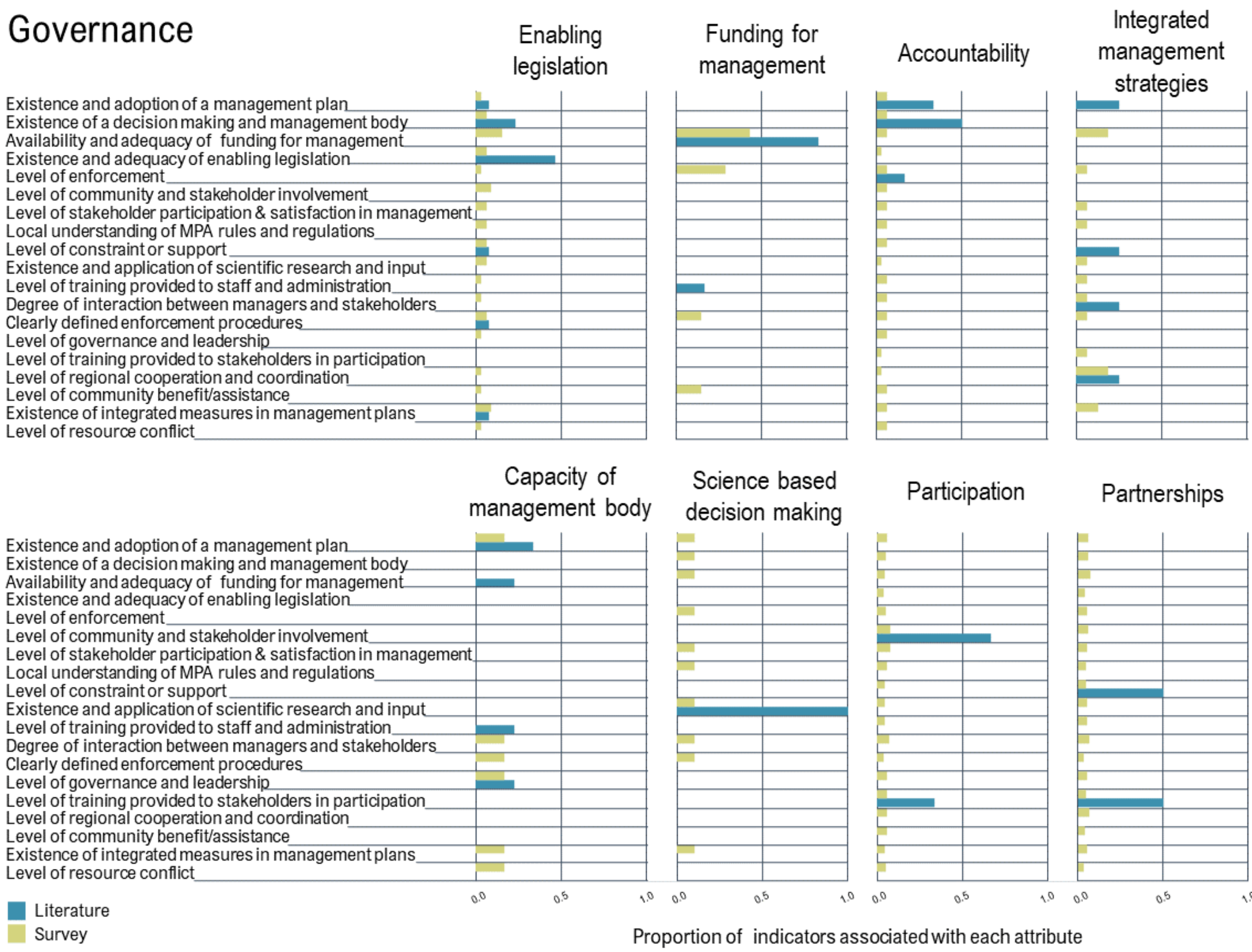

Figure C3. Proportion of indicators associated with attributes in the governance dimension showing the difference between indicators found in the literature (blue) and those identified by survey participants (green) as important or used in the evaluation of MPANs.

Figure C4. Proportion of indicators associated with attributes in the social dimension showing the difference between indicators found in the literature (blue) and those identified by survey participants (green) as important or used in the evaluation of MPANs.

Appendix D. Ethics documentation

This proposal for research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's and the University of Victoria's ethics policies. For questions relating to the ethical process of this research you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 709-864-2861 or the University of Victoria Human Research Ethics Office at 250-472-4545 or via email at ethics@uvic.ca.

D1. Approval documentation

Ethics approval Memorial University of Newfoundland

MEMORIAL UNIVERSITY

Interdisciplinary Committee on
Ethics in Human Research (ICEHR)

St. John's, NL Canada A1C 5S7
Tel: 709 864-2561 icehr@mun.ca
www.mun.ca/research/ethics/humans/icehr

ICEHR Number:	**20200830-AR**
Approval Period:	November 21, 2019 – November 30, 2020
Funding Source:	NSERC [RGCS# 20152073]
Responsible Faculty:	Dr. Rodolphe Devillers Geography
Title of Project:	*MPA networks: Identifying and categorizing indicators of effectiveness*

November 21, 2019

Mrs. Mary Elizabeth Miller
Department of Geography
Faculty of Humanities and Social Sciences
Memorial University of Newfoundland

Dear Mrs. Miller:

Thank you for your correspondence of October 15, 2019 addressing the issues raised by the Interdisciplinary Committee on Ethics in Human Research (ICEHR) concerning the above-named research project. ICEHR has re-examined the proposal with the clarification and revisions submitted, and is satisfied that the concerns raised by the Committee have been adequately addressed. In accordance with the *Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans (TCPS2)*, the project has been granted *full ethics clearance* to November 30, 2020. ICEHR approval applies to the ethical acceptability of the research, as per Article 6.3 of the *TCPS2*. Researchers are responsible for adherence to any other relevant University policies and/or funded or non-funded agreements that may be associated with the project.

The *TCPS2* **requires** that you submit an Annual Update to ICEHR before November 30, 2020. If you plan to continue the project, you need to request renewal of your ethics clearance and include a brief summary on the progress of your research. When the project no longer involves contact with human participants, is completed and/or terminated, you are required to provide an annual update with a brief final summary and your file will be closed. If you need to make changes during the project which may raise ethical concerns, you must submit an Amendment Request with a description of these changes for the Committee's consideration prior to implementation. If funding is obtained subsequent to approval, you must submit a Funding and/or Partner Change Request to ICEHR before this clearance can be linked to your award.

All post-approval event forms noted above can be submitted from your Researcher Portal account by clicking the *Applications: Post-Review* link on your Portal homepage. We wish you success with your research.

Yours sincerely,

Kelly Blidook, Ph.D.
Vice-Chair, Interdisciplinary Committee on
Ethics in Human Research

KB/bc

cc: Supervisor – Dr. Rodolphe Devillers, Department of Geography
Director, Research Grant and Contract Services

Ethics approval University of Victoria

University of Victoria

Office of Research Services | Human Research Ethics Board
Michael Williams Building Rm B202 PO Box 1700 STN CSC Victoria BC V8W 2Y2 Canada
T 250-472-4545 | F 250-721-8960 | uvic.ca/research | ethics@uvic.ca

Certificate of Approval - Annual Renewal

PRINCIPAL INVESTIGATOR	**Natalie Ban** (Supervisor)	**ETHICS PROTOCOL NUMBER** Expedited review - delegated	**19-0363**
PRINCIPAL APPLICANT	**Mairi Miller** **PhD student**	ORIGINAL APPROVAL DATE	16-Oct.-2019
UVIC DEPARTMENT	**Environmental Studies ENVI**	APPROVED ON	05-Oct.-2021
		APPROVAL EXPIRY DATE	15-Oct.-2022

PROJECT TITLE **Marine Protected Area (MPA) networks: Identifying and categorizing indicators of effectiveness**

RESEARCH TEAM MEMBERS
Gerald Singh - Supervisor, Memorial University of Newfoundland

DECLARED PROJECT FUNDING
Natural Sciences and Engineering Research Council, Memorial University of Newfoundland

DOCUMENTS INCLUDED IN THIS APPROVAL
Data Collection 1_ Survey Questions.pdf - 16-Sep.-2019
Data Collection 2_ Interview Questions.pdf - 16-Sep.-2019
Draft email listserve and tweet recruitment_Final1015UVic.docx - 15-Oct.-2019
Ethics_Information letter and Implied Consent Form_Online_ Revised1202.pdf - 05-Dec.-2019
Consent_ Participant Telephone Consent form_Revised 1202.pdf - 05-Dec.-2019
tcps2_core_certificate_MCMM.pdf - 30-Sep.-2020

CONDITIONS OF APPROVAL

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Modifications
To make any changes to the approved research procedures in your study, please submit a “Request for Modification” form. You must receive ethics approval before proceeding with your modified protocol.

Renewals
Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a “Request for Renewal” form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

Project Closures
When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a “Notice of Project Completion” form.

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropiate standards of etchis as outlines by the University of Victoria Research Regulations Involving Human Participants.

Rachael Scarth

Dr. Rachael Scarth
Associate VP Research Operations

D2. Survey recruitment

Email recruitment

Email in English

Subject: Invitation to participate in research about MPA network indicators
Dear {{First name}};

My name is Mairi Miller-Meehan, I am a PhD student at Memorial University of Newfoundland, Canada. Yes, I'm a real person emailing you. As part of my PhD research, supervised by Natalie Ban of the University of Victoria and Gerald Singh of Memorial University, I'm conducting a survey (MPA.network.effectiveness_Survey) about indicators used to assess MPA networks in reaching Aichi Target 11.

I've identified you as a possible participant because of your experience in monitoring, managing or evaluating MPA networks **based on your research focus/based on your work with, particularly a paper you authored entitled: {{Title}}.** The survey takes about 20 minutes, and responses are confidential. Your participation will help to develop a comprehensive set of indicators to assess MPA network effectiveness.

If you have any questions about me or my project, please contact me by email at mcmiller@mun.ca, or by phone at +1-250-858-8313.

Please do share the survey link (MPA.network.effectiveness_Survey) with others who are familiar with MPA networks, including managers, researchers, technicians, project partners, community organizers.
Thank-you in advance for considering our request.
Sincerely,
Mairi Miller-Meehan, PhD Student

This proposal for research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's and the University of Victoria's ethics policies. For questions relating to the ethical process of this research you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 709-864-2861 or the University of Victoria Human Research Ethics Office at 250-472-4545 or via email at ethics@uvic.ca.

MPA.network.effectiveness_Survey

*This message will change in a very small way for Organisation affiliations

Email en Français

Invitation à participer à la recherche sur les indicateurs du réseau d'AMP
Cher {{First Name}};

Je m'appelle Mairi Miller-Meehan, je suis étudiante au doctorat à la Memorial University of Newfoundland, Canada. Oui, je suis une vraie personne qui vous envoie un e-mail. Dans le cadre de ma recherche de doctorat, supervisée par Natalie Ban de l'Université de Victoria et Gerald Singh de l'Université Memorial, je mène une enquête sur les indicateurs utilisés pour évaluer les réseaux d'AMP pour atteindre l'objectif d'Aichi 11. (MPA.network.effectiveness_Survey)

Je vous ai identifié comme un participant possible en raison de votre expérience dans le suivi, la gestion ou l'évaluation des réseaux d'AMP en fonction de votre objectif de recherche, en particulier un article que vous avez rédigé et intitulé: {{Title}}/ ..en fonction de votre travail avec {{l' organisation}}. L'enquête dure environ 20 minutes et les réponses sont confidentielles. Votre participation contribuera à développer un ensemble complet d'indicateurs pour évaluer l'efficacité du réseau d'AMP.

Si vous avez des questions sur moi ou mon projet, veuillez me contacter par courriel à mcmiller@mun.ca, ou par téléphone au + 1-250-858-8313.

Veuillez partager le lien de l'enquête (MPA.network.effectiveness_Survey) avec d'autres qui connaissent les réseaux d'AMP, y compris les gestionnaires, les chercheurs, les techniciens, les partenaires de projet, les organisateurs communautaires.

Merci d'avance d'avoir pris en compte notre demande.
Cordialement,
Mairi Miller-Meehan, étudiante au doctorat

Cette proposition de recherche a été examinée par le comité interdisciplinaire d'éthique de la recherche humaine et jugée conforme aux politiques d'éthique de l'Université Memorial et de l'Université de Victoria. Pour toute question relative au processus éthique de cette recherche, vous pouvez contacter le président de l'ICEHR à icehr@mun.ca ou par téléphone au 709-864-2861 ou au Bureau d'éthique de la recherche humaine de l'Université de Victoria au 250-472-4545 ou via envoyez un courriel à ethics@uvic.ca.

(MPA.network.effectiveness_Survey)

Ce message changera très peu pour les co-auteurs et les affiliations organisationnelles

Correo electrónico en Español

Invitación a participar en una investigación sobre indicadores de la red de AMP
Estimado {{First name}};

Mi nombre es Mairi Miller-Meehan, soy estudiante de doctorado en Memorial University of Newfoundland, Canadá. Sí, soy una persona real que te envía un correo electrónico. Como parte de mi investigación de doctorado, supervisada por Dra. Natalie Ban de University of Victoria y Gerald Singh de Memorial University, estoy realizando una encuesta sobre los indicadores utilizados para evaluar las redes de áreas marinas protegidas (AMPs) para alcanzar la meta 11 de Aichi. (MPA.network.effectiveness_Survey)

Lo identifiqué como un posible participante debido a su experiencia en el monitoreo, gestión o evaluación de redes de AMPs en función de su enfoque de investigación, particularmente en un artículo que escribió, titulado: {{Title}}/…en función de su trabajo con {{la organización}}. La encuesta lleva unos 20 minutos y las respuestas son confidenciales. Su participación ayudará a desarrollar un conjunto integral de indicadores para evaluar la efectividad de la red de AMPs.

Si tiene alguna pregunta sobre mí o mi proyecto, comuníquese conmigo por correo electrónico a mcmiller@mun.ca, o por teléfono al + 1-250-858-8313.

Comparta el enlace de la encuesta (MPA.network.effectiveness_Survey) con otras personas que estén familiarizadas con las redes de AMP, incluidos gestores, investigadores, técnicos, socios de proyectos, y organizadores comunitarios.

Gracias de antemano por considerar nuestra solicitud.

Sinceramente,
Mairi Miller-Meehan, estudiante de doctorado

Esta propuesta de investigación ha sido revisada por el Comité Interdisciplinario de Ética en Investigación Humana, la cual cumple con las políticas de ética de Memorial University y University of Victoria. Para preguntas relacionadas con el proceso ético de esta investigación, puede comunicarse con el presidente del ICEHR a icehr@mun.ca o por teléfono al 709-864-2861 o la Oficina de Ética de Investigación Humana de la Universidad de Victoria al 250-472-4545 o vía correo electrónico a ethics@uvic.ca.
(MPA.network.effectiveness_Survey)

Este mensaje cambiará de forma muy pequeña para Coautores/as y las afiliaciones de organizaciones

Social media recruitment

Twitter in English

Are you a #manager, #researcher, #programleader, #fieldtechnician, or #marineconservation #specialist who has worked in #MPAnetwork #marineprotectedareas networks? We want your input! Please take this short survey about #MPA networks and #indicators of effectiveness
MPA.network.effectiveness_Survey
Please take our survey about #MPA networks and #indicators of effectiveness in reaching #Aichitarget 11 @MarineCons @seamap @JoachimClaudet and @YogiGerBear MPA.network.effectiveness_Survey
Twitter en Español

Por favor RT: ¿Es usted un #gestor, #director de un área marina protegida (AMP), #investigador, #coordinador comunitario #líder un programa #técnico de campo # líder comunitario #especialista en #conservación marina que ha trabajado en #redes AMP o redes de #áreasmarinasprotegidas?
Por favor ¡Queremos tu opinión! Realiza esta breve encuesta sobre las redes de AMPs y sus indicadores de efectividad.
MPA.network.effectiveness_Survey?Q_Language=ES
Twitter en Français

S'il vous plaît RT: Etes-vous un #directeur #spécialiste #chercheur #chefdeprogramme, #techniciendeterrain #spécialiste de la #conservationmarine qui a travaillé dans un #réseaud'AMP ou des #réseauxd'airesmarinesprotégées?
Nous voulons votre avis! Veuillez répondre à cette brève enquête sur les #réseauxd'AMP et les indicateurs d'efficacité
MPA.network.effectiveness_Survey?Q_Language=FR
Linked-in/ Facebook

Hello, my name is Mairi Meehan; I am a doctoral student at Memorial University of Newfoundland, Canada. We are reaching out to individuals familiar with management, implementation, general functioning, and assessment of MPA networks to document their experience in evaluating what makes MPA networks work. Please take our survey-available in French, Spanish and English.https://mun.az1.qualtrics.com/jfe/form/SV_2h2l5KYkb0vSzm5

Please do share the survey link with others who are familiar with MPA networks, including managers, researchers, technicians, project partners, community organizers. We would like to collect as much information from around the world to ensure a balanced representation of the indicators used to monitor and evaluate the effectiveness of MPA networks.
If you have any questions please do not hesitate to contact me.
Thank you in advance for considering participating in and/or passing along this study.

List serve in English

Good morning all,
My name is Mairi Miller-Meehan, I am a doctoral student at Memorial University of Newfoundland, Canada. I am investigating the indicators used to assess MPA networks to achieve the Aichi Target 11. This research is supervised by Gerald Singh from Memorial University and Natalie Ban from the University of Victoria, Canada.
We invite individuals who are familiar with MPA networks, including managers, researchers, technicians, project partners and community organizers, to document their experience in evaluating what makes MPA networks work. We aim to develop a set of indicators to comprehensively assess MPA network effectiveness. We would like to collect as much information from around the world to ensure a balanced representation of the indicators used to monitor and evaluate the effectiveness of the MPA network.
The survey takes approximately 20 minutes and responses are confidential and anonymous, unless you wish to provide your contact information (we will not track your IP address or any personally identifying information).
https://mun.az1.qualtrics.com/jfe/form/SV_2h2l5KYkb0vSzm5

List serve en Español

Buenos días a todos,

Mi nombre es Mairi Miller-Meehan, soy estudiante de doctorado en la Memorial University of Newfoundland, Canadá. Estoy investigando los indicadores utilizados para evaluar las redes de AMP para lograr el Objetivo Aichi 11. Esta investigación es supervisada por Gerald Singh de la Universidad Memorial y Natalie Ban de la Universidad de Victoria, Canadá.

Invitamos a quienes estén familiarizados con las redes de AMP, incluidos gerentes, investigadores, técnicos, socios de proyectos y organizadores comunitarios, a documentar su experiencia en la evaluación de lo que hace que funcionen las redes de AMP. Nuestro objetivo es desarrollar un conjunto de indicadores para evaluar exhaustivamente la efectividad de la red de AMP. Nos gustaría recopilar tanta información de todo el mundo para garantizar una representación equilibrada de los indicadores utilizados para monitorear y evaluar la efectividad de la red de AMP.

La encuesta toma aproximadamente 20 minutos y las respuestas son confidenciales y anónimas, a menos que desee proporcionar su información de contacto (no rastrearemos su dirección IP ni ninguna información de identificación personal).

List serve en Français

Bonjour à tous,

Je m'appelle Mairi Miller-Meehan, je suis doctorante à la Memorial University of Newfoundland, Canada. Je mène une enquête sur les indicateurs utilisés pour évaluer les réseaux d'AMP pour atteindre l'objectif d'Aichi 11. Cette recherche est supervisée par Gerald Singh de l'Université Memorial et Natalie Ban de l'Université de Victoria, Canada.

Nous invitons les personnes qui connaissent les réseaux d'AMP, y compris les gestionnaires, les chercheurs, les techniciens, les partenaires de projet et les organisateurs communautaires, à documenter leur expérience dans l'évaluation de ce qui fait fonctionner les réseaux d'AMP. Notre objectif est de développer un ensemble d'indicateurs pour évaluer de manière globale l'efficacité du réseau d'AMP. Nous aimerions collecter autant d'informations du monde entier pour assurer une représentation équilibrée des indicateurs utilisés pour suivre et évaluer l'efficacité du réseau d'AMP.

L'enquête dure environ 20 minutes et les réponses sont confidentielles et anonymes, sauf si vous souhaitez fournir vos informations de contact (nous ne suivrons pas votre adresse IP ou toute information d'identification personnelle). Votre participation contribuera à développer un ensemble complet d'indicateurs pour évaluer l'efficacité du réseau d'AMP.

D3. Survey instrument

Survey in English

Assessing MPA Network Effectiveness

Start of Block: Consent
Please chose your preferred language
Por favor elija su idioma preferido
Veuillez choisir votre langue préférée

Q1
You are invited to take part in a research project to identify indicators specific to marine protected area (MPA) networks. This project is being conducted by Mairi Meehan, as part of a PhD thesis at Memorial University of Newfoundland and visiting research student at the University of Victoria, Canada.
Purpose:
The purpose of the survey is to identify indicators that can help evaluate MPA networks. This study will add to the growing body of literature measuring MPA network effectiveness. Definitions and examples can be viewed where blue text is present by hovering your cursor over the highlighted word.
What you will do in this study:
As an expert (e.g., manager, academic, researcher, facilitator, field technician, specialist) in MPA network design, implementation, monitoring, or evaluation you are invited to document your experience using indicators to monitor and evaluate MPA network effectiveness. Names and contact information of willing participants will be requested for a follow-up interview.
Length of Time:
This survey will take about 15-20 minutes of your time.
Withdrawal:
Participation in this study is voluntary and is not a work requirement. You may skip any questions that you do not wish to answer. You can withdraw your participation at any time by closing your browser window or navigating away from this page prior to submitting the survey, without having to give a reason and that doing so will not affect you now or in the future.
Benefits and Risks:
You may indirectly benefit from participating in this study by advancing knowledge of the effectiveness of marine conservation initiatives. There are minimal risks associated with this research, as participation in this survey will remain confidential.
Data and Results:
This survey will be administered through Qualtrics, this site will not record any personal information or contact associations. Any personal identifying information provided by you at the end of the survey will remain confidential and will be anonymized in the analysis and dissemination of results; each participant will have an associated research code that will be used in data analysis and results will be presented in aggregate form,

thereby protecting anonymity.
Names and contact information associated with codes will be kept in a separate secure location on a password protected, encrypted hard drive accessible solely to the researcher. Data will be stored in a password-protected computer for a minimum of five years, as required by Memorial University's policy on Integrity in Scholarly Research. Results of this research will be shared with participants who wish to receive information on research findings. In this case, respondents will be asked for contact information that is independent from survey responses. Survey responses will remain confidential. Upon completion, the dissertation of Mairi Meehan will be available at Memorial University's Queen Elizabeth II Library, online at:
http://collections.mun.ca/cdm/search/collection/theses.
Questions:
This proposal for research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's and the University of Victoria's ethics policies. For questions relating to the ethical process of this research you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at +1-709-864-2861 or the University of Victoria Human Research Ethics Office at +1-250-472-4545 or via email at ethics@uvic.ca. Questions about this research can be directed to: Mairi Meehan, PhD Candidate Department of Geography, Memorial University of Newfoundland, Canada mcmiller@mun.ca. Under the supervision of: Professors Gerald Singh geralds@mun.ca and Natalie Ban nban@uvic.ca.
By completing this survey you agree that: You have read the information about the research. You have been advised that you may ask questions about this study and receive answers prior to continuing. You are satisfied that any questions you had have been addressed. You understand what the study is about and what you will be doing. You understand that you are free to withdraw participation from the study. You understand that if you chose to remain anonymous, your data cannot be removed once you submit this survey. Should you submit your personal contact for follow-up interview, you have the right to withdraw and you may request the removal of your data from the study by contacting the researcher before June 1 2020. By consenting to this online survey, you do not give up your legal rights and do not release the researchers from their professional responsibilities.
Clicking yes below and submitting this survey constitutes consent and implies your agreement to the above statements. Thank you for considering participating in this study. Do you consent to these terms?

☐ Yes

☐ No

Skip To: End of Survey If Q1 != Yes

Q2 For the purpose of this survey, we will use the following definitions: Marine Protected Area Network (or system of MPAs) is considered an organized collection of individual MPAs designed to operate “cooperatively and synergistically, at various spatial scales, and with a range of protection levels..." (IUCN-WCPA 2008).

Effectiveness is considered the degree to which MPA networks achieve their objectives related to the Convention on Biological Diversity's Aichi Target 11.

Convention on Biological Diversity's Aichi Target 11 states: "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, and integrated into the wider landscape and seascape" (UNEP-CBD 2011).

A dimension is the context or characteristic of interest related to the objectives. Dimensions will be measured by a suite of indicators.

An indicator is a qualitative or quantitative variable (social, environmental, etc) used to measure the status or change over time of a particular characteristic of interest due to MPA network implementation. Indicators in this study are high-level and may encompass the more site-specific indicators or metrics that you use.

Specific indicators in this survey have been identified from a global review of peer reviewed literature on MPA network effectiveness. We anticipate that you will find gaps in this list and hope you will add those you feel are missing from this list.

End of Block: Consent

Start of Block: Dimensions

Q3 We first would like to gather some background on the MPA network you are familiar with, including the objectives and dimensions your MPA network covers. Your collaboration is also valuable for MPAs that in the future will become a network.

MPAs have ecological, social, economic, and governance characteristics important for their performance. **Dimensions** are these characteristics of interest that will be measured by a suite of indicators.

Q4 Is your work related to an individual MPA that is part of a network or an entire MPA network / system of MPAs? (Required)
Individual MPA in a network
Individual MPA that *will become* part of a network
Part of an MPA network (several MPAs within the network)
Entire network of MPAs

One individual MPA, not associated with any MPA network
I don't know
Other ____

Q5 What is the name of the MPA network or MPA(s) in the network you are most familiar with?
____
____
____

Q6 What is (are) the objective(s) of this MPA network? (Select all that apply, any unselected objective will be treated as "Not an objective")

	Importance of this objective			
	Primary	Secondary	Not an objective	I don't know
Biodiversity conservation	☐	☐	☐	☐
Fisheries management	☐	☐	☐	☐
Habitat restoration and protection	☐	☐	☐	☐
Maintaining ecosystem services	☐	☐	☐	☐
Cultural values (and subsistence)	☐	☐	☐	☐
Social wellbeing	☐	☐	☐	☐
Scientific research	☐	☐	☐	☐
Contribution to global initiatives (CBD Aichi, SDGs)	☐	☐	☐	☐
Other (Please enter text)	☐	☐	☐	☐

Q7 Please indicate whether the ecological dimensions below have been considered in the design, implementation, or monitoring of this MPA network. Please also note your opinion about the importance of each dimension to MPA network effectiveness, even if it was not considered in the design.

Answering "Yes" in this section will be reflected in following sections when selecting indicators used to assess these dimensions. Any "other" dimension you enter will also show up in the next section.
Any unselected dimensions will be treated as "Not considered" and "Not important"

"Extremely important" means this dimension is critical for the network to succeed. "Not important" means it is of no use for success.

	Was this considered in network design, implementation or monitoring?			How important is this dimension to MPA network effectiveness?				
	Yes	No	I don't know	1 Not important	2 Slightly important	3 Moderately important	4 Very important	5 Extremely important
Ecological connectivity	☐	☐	☐	☐	☐	☐	☐	☐
Representativity (a representative sample of the full range of ecosystems, including biotic and habitat diversity of those marine ecosystems).	☐	☐	☐	☐	☐	☐	☐	☐
Key habitats of importance	☐	☐	☐	☐	☐	☐	☐	☐

Key species of importance	☐	☐	☐	☐	☐	☐	☐	☐
Resilience (ability to recover from a negative impact/stress)	☐	☐	☐	☐	☐	☐	☐	☐
Activities and threats adjacent to the network	☐	☐	☐	☐	☐	☐	☐	☐
Other ecological dimension?	☐	☐	☐	☐	☐	☐	☐	☐
Other ecological dimension?	☐	☐	☐	☐	☐	☐	☐	☐
Other ecological dimension?	☐	☐	☐	☐	☐	☐	☐	☐

Q8 Please indicate whether the social dimensions below have been considered in the design, implementation, or monitoring of this MPA network. Please also note your opinion about the importance of each dimension to MPA network effectiveness, even if it was not considered in the design.
Answering "Yes" in this section will be reflected in following sections when selecting indicators used to assess these dimensions. Any "other" dimension you enter will also show up in the next section.
Any unselected dimensions will be treated as "Not considered" and "Not important"
"Extremely important" means this dimension is critical for the network to succeed. "Not important" means it is of no use for success.

	Was this considered in network design, implementation or monitoring?			How important is this dimension to MPA network effectiveness?				
	Yes	No	I don't know	1 Not important	2 Slightly important	3 Moderately important	4 Very important	5 Extremely important
Community engagement	☐	☐	☐	☐	☐	☐	☐	☐
Equity/ social justice	☐	☐	☐	☐	☐	☐	☐	☐
Conflict	☐	☐	☐	☐	☐	☐	☐	☐
Human health	☐	☐	☐	☐	☐	☐	☐	☐
Human wellbeing	☐	☐	☐	☐	☐	☐	☐	☐
Other social dimension?	☐	☐	☐	☐	☐	☐	☐	☐

Other social dimension?	☐	☐	☐	☐	☐	☐	☐	☐
Other social dimension?	☐	☐	☐	☐	☐	☐	☐	☐

Q9 Please indicate whether the governance dimensions below have been considered in the design, implementation, or monitoring of this MPA network. Please also note your opinion about the importance of each dimension to MPA network effectiveness, even if it was not considered in the design.
Answering "Yes" in this section will be reflected in following sections when selecting indicators used to assess these dimensions. Any "other" dimension you enter will also show up in the next section.
Any unselected dimensions will be treated as "Not considered" and "Not important"

"Extremely important" means this dimension is critical for the network to succeed. "Not important" means it is of no use for success.

	Was this considered in network design, implementation or monitoring?			How important is this dimension to MPA network effectiveness?				
	Yes	No	I don't know	1 Not important	2 Slightly important	3 Moderately important	4 Very important	5 Extremely important
Institutional/ social partnerships		☐	☐	☐	☐	☐	☐	☐
Stakeholder participation		☐	☐	☐	☐	☐	☐	☐
Rights and access		☐	☐	☐	☐	☐	☐	☐

Other governance dimension?	☐	☐	☐	☐	☐	☐	☐
Other governance dimension?	☐	☐	☐	☐	☐	☐	☐
Other governance dimension?	☐	☐	☐	☐	☐	☐	☐

Q10 Please indicate whether the economic dimensions below have been considered in the design, implementation, or monitoring of this MPA network. Please also note your opinion about the importance of each dimension to MPA network effectiveness, even if it was not considered in the design.
Answering "Yes" in this section will be reflected in following sections when selecting indicators used to assess these dimensions. Any "other" dimension you enter will also show up in the next section.
Any unselected dimensions will be treated as "Not considered" and "Not important"

"Extremely important" means this dimension is critical for the network to succeed. "Not important" means it is of no use for success.

	Was this considered in network design, implementation or monitoring?			How important is this dimension to MPA network effectiveness?				
	Yes	No	I don't know	1 Not important	2 Slightly important	3 Moderately important	4 Very important	5 Extremely important
Employment/livelihoods	☐	☐	☐	☐	☐	☐	☐	☐

Economic distribution (distribution of money among people)	☐	☐	☐	☐	☐	☐	☐	☐
Economic/material wealth	☐	☐	☐	☐	☐	☐	☐	☐
Other economic dimension?	☐	☐	☐	☐	☐	☐	☐	☐
Other economic dimension?	☐	☐	☐	☐	☐	☐	☐	☐
Other economic dimension?	☐	☐	☐	☐	☐	☐	☐	☐

End of Block: Dimensions

[ii]Start of Block: Indicators

Q11 This section aims to explore the use of indicators in assessing MPA network success. We anticipate that you will find gaps in this list and hope you will identify additional important indicators you feel are missing.

Please match the indicator in the left column with the dimensions considered important for this MPA network. The indicators listed in this section are considered high-level (general) indicators and may encompass site-specific indicators or metrics that you use. If you do not see an appropriate indicator category, please use the "Other" category to name the indicator(s).

Display This Question: If Q7#1 [Yes] (Count) >= 1

Q12

Please match the ecological indicators with each ecological dimension considered in the design, implementation or monitoring of this MPA network.

The ecological dimensions you selected are listed across the top of the following chart. Ecological- related indicators are listed down the left side, with an option to add more at the bottom.

	Ecological dimension	Ecological dimension	Ecological dimension	Ecological dimension	Ecological dimension	Ecological dimension	Ecological Dimension
	Connectivity	Representation	Key Habitats	Key Species	Resilience	Adjacent activities and threats	Choice Text
Area under no or reduced human impact	☐	☐	☐	☐	☐	☐	☐
Area showing signs of recovery	☐	☐	☐	☐	☐	☐	☐
Habitat distribution and complexity	☐	☐	☐	☐	☐	☐	☐

Distance between habitat patches	☐	☐	☐	☐	☐	☐	☐
Centers of endemism or intact wilderness areas	☐	☐	☐	☐	☐	☐	☐
Number of replicated species/habitats	☐	☐	☐	☐	☐	☐	☐
Focal species abundance	☐	☐	☐	☐	☐	☐	☐
Species distribution	☐	☐	☐	☐	☐	☐	☐
Species dispersal	☐	☐	☐	☐	☐	☐	☐
Proportion of species distribution covered by MPAs	☐	☐	☐	☐	☐	☐	☐
Size and spatial arrangement of PAs	☐	☐	☐	☐	☐	☐	☐
Coverage of ecoregions	☐	☐	☐	☐	☐	☐	☐
Coverage of key biodiversity areas	☐	☐	☐	☐	☐	☐	☐
Coverage of species richness hotspots	☐	☐	☐	☐	☐	☐	☐

Composition and structure of the community	☐	☐	☐	☐	☐	☐	☐
Focal species population structure	☐	☐	☐	☐	☐	☐	☐
Food web integrity	☐	☐	☐	☐	☐	☐	☐
Recruitment success within the community	☐	☐	☐	☐	☐	☐	☐
Type, level and return on fishing effort	☐	☐	☐	☐	☐	☐	☐
Extent and severity of threats	☐	☐	☐	☐	☐	☐	☐
None	☐	☐	☐	☐	☐	☐	☐
Other indicator not listed above (e.g., oceanographic currents, pollution, habitat resilience)	☐	☐	☐	☐	☐	☐	☐
Other ecological indicator not listed above	☐	☐	☐	☐	☐	☐	☐

Other ecological indicator not listed above	☐	☐	☐	☐	☐	☐	☐

Display This Question If Q8#1 [Yes] (Count) >= 1
Q13 Please match the social indicators with each social dimension considered in the design, implementation or monitoring of this MPA network.
The social dimensions you selected are listed across the top of the following chart. Social-related indicators are listed down the side to the left, with an option to add more at the bottom.

	Community engagement	Equity/social Justice	Conflict	Human health	Human wellbeing	Choice Text Entry_(3)
Quality of human health	☐	☐	☐	☐	☐	☐
Values and beliefs about marine resources	☐	☐	☐	☐	☐	☐
Perceptions of MPA effects on livelihood	☐	☐	☐	☐	☐	☐
Level of resource conflict	☐	☐	☐	☐	☐	☐
Level of governance and leadership	☐	☐	☐	☐	☐	☐
Level of compliance	☐	☐	☐	☐	☐	☐

Level of communication and information dissemination	☐	☐	☐	☐	☐	☐
None	☐	☐	☐	☐	☐	☐
Other (e.g., leadership, social networks, access to resource, equity)	☐	☐	☐	☐	☐	☐
Other social indicator	☐	☐	☐	☐	☐	☐
Other social indicator	☐	☐	☐	☐	☐	☐

Display This Question: If Q9#1 [Yes] (Count) >= 1
Q14 Please match the governance indicators with each governance dimension considered in the design, implementation or monitoring of this MPA network.
The governance dimensions you selected are listed across the top of the following chart. Governance-related indicators are listed down the side to the left, with an option to add more at the bottom.

	Partnerships	Participation	Rights and access	Choice Text Entry Value
Availability and allocation of MPA administrative resources (secured funding)	☐	☐	☐	☐
Level of enforcement	☐	☐	☐	☐
Clearly defined enforcement procedures	☐	☐	☐	☐
Local understanding of MPA rules and regulations	☐	☐	☐	☐
Existence and adequacy of enabling legislation	☐	☐	☐	☐
Existence and adoption of a management plan	☐	☐	☐	☐
Existence and application of scientific research and input	☐	☐	☐	☐
Existence of a decision-making and management body	☐	☐	☐	☐

Degree of interaction between managers and stakeholders	☐	☐	☐	☐
Level of regional cooperation and coordination	☐	☐	☐	☐
Existence of integrated management measures in management plans	☐	☐	☐	☐
Level of community and stakeholder involvement	☐	☐	☐	☐
Level of governance and leadership	☐	☐	☐	☐
Level of constraint or support by external political and civil environment	☐	☐	☐	☐
Level of community benefit/assistance	☐	☐	☐	☐
Level of resource conflict	☐	☐	☐	☐
Level of stakeholder participation & satisfaction in management	☐	☐	☐	☐
Level of training provided to staff and administration	☐	☐	☐	☐
Level of training provided to stakeholders in participation	☐	☐	☐	☐
None	☐	☐	☐	☐

Other (e.g., regional cooperation, government involvement / support, collaborative working groups)	☐	☐	☐	☐
Other governance indicator	☐	☐	☐	☐
Other governance indicator	☐	☐	☐	☐

Display This Question: If Q10#1 [Yes] (Count) >= 1

Q15 Please match the following economic indicators with each economic dimension considered in the design, implementation and monitoring of this MPA network.
The economic dimensions you selected are listed across the top of the following chart. Economic-related indicators are listed down the side to the left, with an option to add more at the bottom.

	Employment/livelihood	Economic distribution	Economic/ material wealth	Choice Text Entry
Reliability and adequacy of funding	☐	☐	☐	☐
Material style of life	☐	☐	☐	☐
Visitor management	☐	☐	☐	☐
None	☐	☐	☐	☐

Other (e.g., financing, capacity building, employment opportunities)	☐	☐	☐	☐
Other economic indicator	☐	☐	☐	☐
Other economic indicator	☐	☐	☐	☐

Q16 Are there any other indicators not mentioned above that you would find useful in assessing MPA network effectiveness? Please explain (Optional)

____
____
____

Q17 To what extent do you agree or disagree that current monitoring and evaluation allows assessment of whether the network is meeting its objectives.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	There is no monitoring plan
The monitoring currently being done allows us to assess if the network is achieving its objectives	☐	☐	☐	☐	☐	☐

Q17a In your opinion, what are the most important factors in the success of an MPA network? (please limit to maximum of three)

____
____
____

End of Block: Indicators

Start of Block: Demographics

Q18 In this section we will ask a few more questions about the network in which you work

Q19 What level(s) of protection exist in the network? (Select all that apply)

- ▢ **Fully Protected**: no extractive or destructive activities are allowed, and all impacts are minimized
- ▢ **Highly Protected**: only light extractive activities are allowed, and other impacts are minimized to the extent possible
- ▢ **Lightly Protected**: some protection exists but moderate to significant extraction and impacts are allowed
- ▢ **Minimally Protected:** extensive extraction and other impacts are allowed while still providing some conservation benefit to the area
- ▢ Other (Please enter text)____

Q20 What is the management structure of this MPA network? (if co-managed, please select all involved groups)

- ▢ Indigenous or community
- ▢ Federal government

- [ ] Municipal
- [ ] Provincial
- [ ] Non-government organisation (NGO)
- [ ] Private
- [ ] Other ____

Q21 What is your affiliation? (Select all that apply)

- [ ] Federal/National government
- [ ] State/ Provincial government
- [ ] Indigenous government
- [ ] Local/Community government
- [ ] Non-governmental (NGO)
- [ ] Academic institution/ University
- [ ] International agency (e.g., United Nations)
- [ ] Recreational groups/ tourism industry
- [ ] Private

☐ Other ____

Q22 In what capacity do you know/work in the MPA network? (Select all that apply)

☐ Researcher/Academic

☐ Project manager

☐ Project facilitator

☐ Habitat or species specialist

☐ Policy analyst

☐ Monitoring technician

☐ Communications

☐ Community liaison

☐ Community leader

☐ Other (please enter text)____

Q23 How many individual MPAs are/will be in the network?

- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6-8
- ☐ 9-10
- ☐ more than 10

Q24 In what year was the MPA network established?
Don't know

- ☐ Post-2020
- ☐ 2020
- ☐ 2019
- ☐ 2018
- ☐ 2017
- ☐ 2016

- ☐ 2015
- ☐ 2014
- ☐ 2013
- ☐ 2012
- ☐ 2011
- ☐ 2010
- ☐ 2009
- ☐ 2008
- ☐ 2007
- ☐ 2006
- ☐ 2005
- ☐ 2004
- ☐ 2003
- ☐ 2002
- ☐ 2001
- ☐ 2000

- ☐ 1999
- ☐ 1998
- ☐ 1997
- ☐ 1996
- ☐ 1995
- ☐ 1994
- ☐ 1993
- ☐ 1992
- ☐ 1991
- ☐ 1990
- ☐ Before 1990

Q25 In what country or countries is the MPA network located?

____

End of Block: Demographics

Start of Block: End

Q26 Thank you for taking this survey, we will ask two final questions about future engagement with this project.

Q27 Would you be willing to take part in a 10 min follow up interview, if necessary, in two weeks via Skype?

☐ Yes

☐ No

Display This Question:
If Q27 = Yes

Q28 Please enter your email address for follow-up interview

____

Q29 Would you like to receive a summary of the results from this survey?

☐ Yes

☐ No

Display This Question:
If Q29 = Yes
And Q27 = No

Q30 Please enter your email address to receive a summary of the survey results

____

End of Block: End

Survey en Français

Evaluation de l'efficacité des réseaux d'AMPs

Bloc: Consentement
Please chose your preferred language
Por favor elija su idioma preferido
Veuillez choisir votre langue préférée

Q1
Vous êtes invités à prendre part à un projet de recherche pour identifier et valider des indicateurs spécifiques aux réseaux d'aires marines protégées (AMPs). Ce projet est mené par Mairi Meehan, dans le cadre d'une thèse de doctorat à Memorial University of Newfoundland, et comme étudiante-chercheuse invitée à l'University of Victoria, Canada.
But:
Le but de cette enquête est d'identifier des indicateurs qui pourront aider à l'évaluation des réseaux d'AMPs. Cette étude ajoutera à une documentation de plus en plus abondante mesurant l'efficacité des réseaux d'AMPs.
Lorsque le texte est bleu, vous pouvez passer votre curseur sur le mot souligné pour consulter des définitions et des exemples.
Ce que vous allez faire dans cette étude:
Comme expert (p. ex. gestionnaire, universitaire, chercheur(se), facilitateur(trice), technicien(ne) sur terrain, spécialiste) en conception, réalisation, suivi ou évaluation de réseaux d'AMPs, vous êtes invités à documenter votre expérience dans l'utilisation d'indicateurs pour suivre et évaluer l'efficacité des réseaux d'AMPs.
Durée
Ce questionnaire vous prendra environ 15 à 20 minutes.
Retrait:
Votre participation dans cette étude est volontaire et n'est pas une exigence de travail. Vous pouvez ignorer les questions que préférez ne pas répondre. Vous pouvez retirez votre participation en tout temps en fermant votre fenêtre de navigateur ou changeant de page avant de soumettre le questionnaire, sans donner de raisons et sans conséquences immédiates ou à l'avenir.
Avantages et risques:
Votre participation dans ce questionnaire pourrait vous bénéficier en faisant progresser les connaissances au sujet de l'efficacité d'initiatives en conservation marine. Il y a peu de risques associés à cette recherche, puisque votre participation dans ce questionnaire demeurera confidentielle.
Données et résultats:
Ce questionnaire sera administré par Qualtrics et ce site n'enregistre aucune information personnelle ou associations de contacts. Toute information d'indentification personnelle que vous fournissez à la fin du questionnaire demeurera confidentielle et sera dépersonnalisé lors de l'analyse et de la diffusion des résultats. Chaque participant aura

un code de recherche qui lui est associé, et qui sera utilisé lors de l'analyse des données. Les résultats seront présentés sous forme agrégée, protégeant l'anonymat.
Noms et coordonnés associés avec les codes resteront en un lieu séparé et sûr, sur un disque dur crypté, protégé par un mot de passe, et seulement accessible par le/la chercheur(se). Les données seront stockées sur un ordinateur protégé d'un mot de passe, pour un minimum de cinq ans, requis par la politique sur l'intégrité en recherche universitaire de Memorial University of Newfoundland. Les résultats de cette recherche seront partagés avec les participants qui désirent recevoir de l'information sur ses conclusions. Dans ce cas, les répondants seront demandés pour des coordonnés indépendantes de leurs réponses au questionnaire. Les réponses au questionnaire resteront confidentielles. Dès l'achèvement, la thèse de Mairi Meehan sera disponible en ligne à la bibliothèque Queen Elizabeth II de Memorial University of Newfoundland: http://collections.mun.ca/cdm/search/collection/theses.

Questions:
Cette proposition de recherche a été révisée par le comité interdisciplinaire d'étique sur la recherche humaine et a été déterminé d'être conforme avec les politiques d'éthique de l'University of Victoria. Pour des questions reliées au processus d'étique de cette recherche, veuillez contacter le/la président(e) du comité (ICEHR) à icehr@mun.ca ou par téléphone au +1-709-864-2861. Vous pouvez aussi contacter le bureau de l'étique de la recherche à l'University of Victoria au +1-250-472-4545 ou par e-mail à ethics@uvic.ca. Pour des questions concernant la recherche, veuillez contacter Mairi Meegan, candidate au doctorat au département de géographie à Memorial University of Newfoundland, Canada, mcmiller@mun.ca. Sous supervision de: professeur(e)s Gerald Singh geralds@mun.ca et Natalie Ban nban@uvic.ca.

En remplissant ce questionnaire, vous acceptez que: Vous avez lu l'information concernant cette recherche. Vous avez été informés de pouvoir poser des questions concernant cette étude et de recevoir ces réponses avant de continuer. Vous êtes satisfait(e)s que toutes vos questions ont été adressées. Vous comprenez de quoi cette recherche s'agit et ce que vous allez faire. Vous comprenez que vous pouvez retirer votre participation de cette étude. Vous comprenez que si vous choisissez de rester anonymat, vos données ne pourront pas être supprimées une fois le questionnaire soumis. Si vous soumettez vos coordonnés personnelles pour une entrevue de suivi, vous avez le droit de vous retirer et vous pouvez demander que vos données soient éliminées de l'étude en contactant le/la chercheur(euse) avant le 4 avril 2020. En acceptant de faire ce questionnaire en ligne, vous ne renoncez pas vos droits légaux et ne libérez pas les chercheurs(euses) de leurs responsabilités professionnelles.

En cliquant oui ci-dessous et en soumettant ce questionnaire, cela consiste de votre consentement et implique votre accord avec les déclarations susmentionnées. Merci de considérer votre participation dans cette étude. Acceptez-vous ces conditions ?

☐ Oui

☐ Non

Q2 Aux fins de ce questionnaire, nous utiliserons les définitions ci-dessous: Réseau d'aires marines protégées (ou système d'AMPs) est considéré comme étant une collection organisée d'AMPs individuelles conçues pour fonctionner « en coopération et en synergie à diverses échelles spatiales et avec plusieurs niveaux de protection… » (CMAP/IUCN 2008).

L'efficacité est considérée comme la mesure dans laquelle les réseaux d'AMPs atteignent leurs buts relatifs à l'objectif 11 d'Aichi de la convention sur la diversité biologique.

L'objectif 11 d'Aichi de la convention sur la diversité biologique indique que: « D'ici à 2020, au moins 17% des zones terrestres et d'eaux intérieures et 10% des zones marines et côtières, y compris les zones qui sont particulièrement importantes pour la diversité biologique et les services fournis par les écosystèmes, sont conservées au moyen de réseaux écologiquement représentatifs et bien reliés d'aires protégées gérées efficacement et équitablement et d'autres mesures de conservation effectives par zone, et intégrées dans l'ensemble du paysage terrestre et marin » (UNEP-CBD 2011).

Un indicateur est une variable (sociale, environnementale, etc.) qualitative ou quantitative utilisée afin de mesurer le statu ou l'évolution dans le temps d'une caractéristique d'intérêt particulière, due à la mise en oeuvre d'un réseau d'AMPs. Les indicateurs dans cette étude sont de haut niveau et peuvent comprendre autre indicateurs ou mesures que vous utilisez, qui sont plus spécifiques au site.

Les indicateurs spécifiques à ce questionnaire on été identifiés à partir d'une révision globale de littérature évaluée par des paires, sur l'efficacité des réseaux d'AMPs. Nous prévoyons que vous trouverez des lacunes dans cette liste et espérons que vous ajouterez ceux qui en semblent absents.

Bloc: dimensions

Q3 Nous voulons tout d'abord recueillir quelques informations sur le réseau d'AMPs dont vous êtes familier, incluant les objectifs et dimensions couverts par votre réseau d'AMPs. Les AMPs ont des caractéristiques écologiques, sociales, économiques et gouvernementales importantes pour leur performance. Les **dimensions** sont des caractéristiques d'intérêt qui seront mesurés par une série d'indicateurs.

Q4 Votre travail est-il relié à une AMP individuelle faisant partie d'un réseau, ou d'un réseau d'AMPs entier/système d'AMPs? (Requis)

AMP individuelle dans un réseau

AMP individuelle qui *fera* partie d'un réseau

Faisant partie d'un réseau d'AMPs (plusieurs AMPs dans le réseau)

Réseaux d'AMPs en entier

Une AMP individuelle, associée à aucun réseau d'AMPs

☐ Je ne sais pas

☐ Autre

Q5 Quel est le nom du réseau d'AMPs ou de l'AMP(s) dans le réseau avec lequel vous êtes le plus familier?

Q6 Quel(s) est (sont) l'(les) objectif(s) de ce réseau d'AMPs? (Sélectionnez tous ceux qui s'appliquent, tous ceux non-sélectionnés seront traités comme « pas un objectif »

Importance de cet objectif				
	Primaire	Secondaire	Pas un objectif	Je ne sais pas
Conservation de la biodiversité	☐	☐	☐	☐
Gestion des pêches	☐	☐	☐	☐
Restauration et protection d'habitat	☐	☐	☐	☐
Préservation de services écosystémiques	☐	☐	☐	☐
Ressources culturelles (et subsistance)	☐	☐	☐	☐
Bien-être social	☐	☐	☐	☐
Recherche scientifique	☐	☐	☐	☐
Contribution aux initiatives globales (cdb, aichi, odds)	☐	☐	☐	☐
Autre (saisissez un texte)	☐	☐	☐	☐

Q7 Veuillez indiquez si les dimensions écologiques ci-dessous ont été prises en considération lors de la conception, la réalisation ou le suivi de ce réseau d'AMPs. S'il vous plaît aussi noter votre opinion sur l'importance de chaque dimension dans l'efficacité du réseau d'AMPs, même si elle n'a pas été prise en considération lors de la conception.
Répondre « oui » dans cette section sera reflété dans des sections suivantes, lors de la sélection d'indicateurs utilisés pour évaluer ces dimensions. « Autres » dimensions que vous entrez se montrons aussi dans la prochaine section.
Toutes dimensions non-sélectionnées seront traitées comme « non-considéré » et « pas important ».
« Extrêmement importants » indique que cette dimension est essentielle pour la réussite du réseau. « Pas important » indique que c'est inutile pour son succès.

	Est ce que cela a été considéré lors de la conception, la réalisation ou le suivi du réseau?			Quelle est l'importance de cette dimension pour l'efficacité du réseau d'amps?				
	Oui	Non	Je ne sais pas	1 pas important	2 un peut important	3 modérément important	4 très important	5 extrêmement important
Connectivité écologique	☐	☐	☐	☐	☐	☐	☐	☐
Représentation (un échantillon représentatif d'une gamme complète d'écosystèmes, incluant la diversité biotique et d'habitats, de ces écosystèmes marins)	☐	☐	☐	☐	☐	☐	☐	☐
Habitats clés d'importances	☐	☐	☐	☐	☐	☐	☐	☐

Espèces clés d'importances	☐	☐	☐	☐	☐	☐	☐	☐
Résilience (capacité de récupération suite à un impact/stress négatif)	☐	☐	☐	☐	☐	☐	☐	☐
Activités et menaces adjacentes au réseau	☐	☐	☐	☐	☐	☐	☐	☐
Autre dimension écologique?	☐	☐	☐	☐	☐	☐	☐	☐
Autre dimension écologique?	☐	☐	☐	☐	☐	☐	☐	☐
Autre dimension écologique?	☐	☐	☐	☐	☐	☐	☐	☐

Q8 Veuillez indiquez si les dimensions sociales ci-dessous ont été prises en considération lors de la conception, la réalisation ou le suivi de ce réseau d'AMPs. S'il vous plaît aussi noter votre opinion sur l'importance de chaque dimension dans l'efficacité du réseau d'AMPs, même si elle n'a pas été prise en considération lors de la conception.
Répondre « oui » dans cette section sera reflété dans des sections suivantes, lors de la sélection d'indicateurs utilisés pour évaluer ces dimensions. « Autres » dimensions que vous entrez se montrons aussi dans la prochaine section.
Toutes dimensions non-sélectionnées seront traitées comme « non-considéré » et « pas important ».
« Extrêmement important » indique que cette dimension est essentielle pour la réussite du réseau. « Pas important » indique que c'est inutile pour son succès.

	Est ce que cela a été considéré lors de la conception, la réalisation ou le suivi du réseau?			Quelle est l'importance de cette dimension pour l'efficacité du réseau d'amps?				
	Oui	Non	Je ne sais pas	1 pas important	2 un peut important	3 modérément important	4 très important	5 extrêmement important
Engagement communautaire	☐	☐	☐	☐	☐	☐	☐	☐
Équité/justice sociale	☐	☐	☐	☐	☐	☐	☐	☐
Confli	☐	☐	☐	☐	☐	☐	☐	☐
Santé humaine	☐	☐	☐	☐	☐	☐	☐	☐
Bien-être humain	☐	☐	☐	☐	☐	☐	☐	☐
Autre dimension sociale?	☐	☐	☐	☐	☐	☐	☐	☐
Autre dimension sociale?	☐	☐	☐	☐	☐	☐	☐	☐

Autre dimension sociale?	☐	☐	☐	☐	☐	☐	☐	☐

Q9 Veuillez indiquez si les dimensions gouvernementales ci-dessous ont été prises en considération lors de la conception, la réalisation ou le suivi de ce réseau d'AMPs. S'il vous plaît aussi noter votre opinion sur l'importance de chaque dimension dans l'efficacité du réseau d'AMPs, même si elle n'a pas été prise en considération lors de la conception.
Répondre « oui » dans cette section sera reflété dans des sections suivantes, lors de la sélection d'indicateurs utilisés pour évaluer ces dimensions. « Autres » dimensions que vous entrez se montrons aussi dans la prochaine section.
Toutes dimensions non-sélectionnées seront traitées comme « non-considéré » et « pas important ».
« Extrêmement important » indique que cette dimension est essentielle pour la réussite du réseau. « Pas important » indique que c'est inutile pour son succès.

	Est ce que cela a été considéré lors de la conception, la réalisation ou le suivi du réseau?			Quelle est l'importance de cette dimension pour l'efficacité du réseau d'amps?				
	Oui	Non	Je ne sais pas	1 pas important	2 un peut important	3 modérément important	4 très important	5 extrêmement important
Partenariats institutionnels/sociaux	☐	☐	☐	☐	☐	☐	☐	☐
Participation de détenteurs de droits ou de parties prenantes	☐	☐	☐	☐	☐	☐	☐	☐
Droits et accès	☐	☐	☐	☐	☐	☐	☐	☐

Autre dimension gouvernementale?	☐	☐	☐	☐	☐	☐	☐	☐
Autre dimension gouvernementale?	☐	☐	☐	☐	☐	☐	☐	☐
Autre dimension gouvernementale?	☐	☐	☐	☐	☐	☐	☐	☐

Q10 Veuillez indiquez si les dimensions économiques ci-dessous ont été prises en considération lors de la conception, la réalisation ou le suivi de ce réseau d'AMPs. S'il vous plaît aussi noter votre opinion sur l'importance de chaque dimension dans l'efficacité du réseau d'AMPs, même si elle n'a pas été prise en considération lors de la conception.
Répondre « oui » dans cette section sera reflété dans des sections suivantes, lors de la sélection d'indicateurs utilisés pour évaluer ces dimensions. « Autres » dimensions que vous entrez se montrons aussi dans la prochaine section.
Toutes dimensions non-sélectionnées seront traitées comme « non-considéré » et « pas important ».
« Extrêmement important » indique que cette dimension est essentielle pour la réussite du réseau. « Pas important » indique que c'est inutile pour son succès.

	Est ce que cela a été considéré lors de la conception, la réalisation ou le suivi du réseau?			Quelle est l'importance de cette dimension pour l'efficacité du réseau d'amps?				
	Oui	Non	Je ne sais pas	1 pas important	2 un peut important	3 modérément important	4 très important	5 extrêmement important
Emplois/moyens de subsistance	☐	☐	☐	☐	☐	☐	☐	☐

Distribution economique (distribution d'argent parmi les personnes)	☐	☐	☐	☐	☐	☐	☐	☐
Richesse économique/matérielle	☐	☐	☐	☐	☐	☐	☐	☐
Autre dimension économique?	☐	☐	☐	☐	☐	☐	☐	☐
Autre dimension économique?	☐	☐	☐	☐	☐	☐	☐	☐
Autre dimension économique?	☐	☐	☐	☐	☐	☐	☐	☐

Bloc: Indicateurs

Q11 Cette section vise à explorer l'utilisation d'indicateurs afin d'évaluer le succès des réseaux d'AMPs. Nous prévoyons que vous trouverez des lacunes dans cette liste et espérons que vous ajouterez les indicateurs qui en semblent absents.

Veuillez faire correspondre l'indicateur dans la colonne de gauche avec les dimensions considérées importantes pour ce réseau d'AMPs. Les indicateurs listés dans cette section sont considérés de haut-niveau et peuvent comprendre autres indicateurs ou mesures que vous utilisez, qui sont spécifiques au site. Si vous ne trouvez pas une catégorie d'indicateurs adéquate, veuillez utiliser la catégorie « autre » pour nommer l'indicateur.

Q12 Veuillez faire correspondre les indicateurs écologiques avec chaque dimension écologique considérée dans la conception, la réalisation ou le suivi de ce réseau d'AMPs.

Les dimensions écologiques que vous avez sélectionnées sont listées dans la rangée du haut de ce tableau. Les indicateurs pertinents à l'écologie sont listés dans la colonne de gauche avec une option d'en ajouter au bas du tableau.

	Dimension écologique	Dimension écologique	Dimension écologique	Dimension écologique	Dimension écologique	Dimension écologique	Dimension écologique
	Connectivité	Représentation	Habitats clés	Espèces clés	Résilience	Activités et menaces adjacentes	Choice text entry
Aucun impact humain ou impact humain moindre sur la région	☐	☐	☐	☐	☐	☐	☐
Région démontre des signes de rétablissement	☐	☐	☐	☐	☐	☐	☐

Distribution et complexité d’habitats	☐	☐	☐	☐	☐	☐	☐
Distance entre parcelles d’habitat	☐	☐	☐	☐	☐	☐	☐
Centres d’endémismes ou régions sauvages intactes	☐	☐	☐	☐	☐	☐	☐
Nombre d’espèces/habitats reproduits	☐	☐	☐	☐	☐	☐	☐
Abondance des espèces focales	☐	☐	☐	☐	☐	☐	☐
Distribution d’espèces	☐	☐	☐	☐	☐	☐	☐
Dispersion d’espèces	☐	☐	☐	☐	☐	☐	☐

Proportion de la distribution d'espèces couverte par les amps	☐	☐	☐	☐	☐	☐	☐
Taille et disposition spatiale des aps	☐	☐	☐	☐	☐	☐	☐
Couverture des écorégions	☐	☐	☐	☐	☐	☐	☐
Couverture des zones de biodiversité clés	☐	☐	☐	☐	☐	☐	☐
Couverture des hotspots de richesse d'espèces	☐	☐	☐	☐	☐	☐	☐
Composition et structure de la communauté	☐	☐	☐	☐	☐	☐	☐

Structure de la population d’espèce prioritaire	☐	☐	☐	☐	☐	☐	☐
Intégrité du réseau trophique	☐	☐	☐	☐	☐	☐	☐
Recrutement réussi au sein de la communauté	☐	☐	☐	☐	☐	☐	☐
Type, niveau et rendements des efforts de peche	☐	☐	☐	☐	☐	☐	☐
Étendue et sévérité des menaces	☐	☐	☐	☐	☐	☐	☐
Aucun	☐	☐	☐	☐	☐	☐	☐
Autre indicateur non-listé ci-dessus (p.ex. Courant océanographique, pollution, résilience d’habitat)	☐	☐	☐	☐	☐	☐	☐

Autre indicateur écologique non-listé ci-dessus	☐	☐	☐	☐	☐	☐	☐
Autre indicateur écologique non-listé ci-dessus	☐	☐	☐	☐	☐	☐	☐

Q13 Veuillez faire correspondre les indicateurs sociaux avec chaque dimension sociale considérée dans la conception, la réalisation ou le suivi de ce réseau d'AMPs.
Les dimensions sociales que vous avez sélectionnées sont listées dans la rangée du haut de ce tableau. Les indicateurs sociaux sont listés dans la colonne de gauche avec l'option d'en ajouter au bas du tableau.

	Engagement communautaire	Équité/justice sociale	Conflit	Santé humaine	Bien-être humain	Choice text entry
Qualité de la santé humaine	☐	☐	☐	☐	☐	☐
Valeurs et croyances au sujet des ressources marines	☐	☐	☐	☐	☐	☐
Perceptions de l'effet des amps sur le moyen de subsistance	☐	☐	☐	☐	☐	☐

Niveau de conflit de ressources	☐	☐	☐	☐	☐	☐
Niveau de gouvernance et de leadership	☐	☐	☐	☐	☐	☐
Niveau de conformité	☐	☐	☐	☐	☐	☐
Niveau de communication et diffusion d’information	☐	☐	☐	☐	☐	☐
Aucun	☐	☐	☐	☐	☐	☐
Autre (p.ex. Leadership, réseaux sociaux, accès à la ressource, équité)	☐	☐	☐	☐	☐	☐
Autre indicateur social	☐	☐	☐	☐	☐	☐
Autre indicateur social	☐	☐	☐	☐	☐	☐

Q14 Veuillez faire correspondre les indicateurs gouvernementaux avec chaque dimension gouvernementale considérée dans la conception, la réalisation ou le suivi de ce réseau d'AMPs.
Les dimensions gouvernementales que vous avez sélectionnées sont listées dans la rangée du haut de ce tableau. Les indicateurs gouvernementaux sont listés dans la colonne de gauche avec l'option d'en ajouter au bas du tableau.

	Partenariats	Participation	Droits et accès	Choice text entry
Disponibilité et répartition des ressources administratives de l'amp (financement sûr)	☐	☐	☐	☐
Niveau d'application de la loi	☐	☐	☐	☐
Application de la loi et procédures clairement définies	☐	☐	☐	☐
Compréhension locale des règles et règlementations de l'amp	☐	☐	☐	☐
Existence and suffisance des lois habilitantes	☐	☐	☐	☐
Existence et adoption d'un plan de gestion	☐	☐	☐	☐

Existence et application de la recherche et contribution scientifique	☐	☐	☐	☐
Existence d'un organe de décision et de gestion	☐	☐	☐	☐
Niveau d'interaction entre gestionnaires et partie prenantes	☐	☐	☐	☐
Niveau de coopération et coordination régionale	☐	☐	☐	☐
Existence de mesures de gestion intégrées dans les plans de gestion	☐	☐	☐	☐
Niveau d'implication communautaire et des parties prenantes	☐	☐	☐	☐
Niveau de gouvernance et de leadership	☐	☐	☐	☐
Niveau de contrainte ou de soutient de l'environnement politique et civil externe	☐	☐	☐	☐
Niveau d'avantage/d'assistance communautaire	☐	☐	☐	☐

Niveau de conflit de ressources	☐	☐	☐	☐
Niveau de participation et satisfaction dans la gestion, des partie prenantes	☐	☐	☐	☐
Niveau de formation fournie aux employés et à l'administration	☐	☐	☐	☐
Niveau de formation fournie aux parties prenantes dans la participation	☐	☐	☐	☐
Aucun	☐	☐	☐	☐
Autre (p.ex. Coopération régionale, implication/appui gouvernemental, groupes de travail collaboratifs)	☐	☐	☐	☐
Autre indicateur gouvernemental	☐	☐	☐	☐
Autre indicateur gouvernemental	☐	☐	☐	☐

Q15 Veuillez faire correspondre les indicateurs économiques avec chaque dimension économique considérée dans la conception, la réalisation ou la surveillance de ce réseau d'AMPs.
Les dimensions économiques que vous avez sélectionnées sont listées dans la rangée du haut de ce tableau. Les indicateurs économiques sont listés dans la colonne de gauche avec une option d'en ajouter au bas du tableau.

	Emploi/moyen de subsistance	Distribution économique	Richesse économique/matérielle	Choice text entry
Financement fiable et adéquat	☐	☐	☐	☐
Style de vie matérielle	☐	☐	☐	☐
Gestion des visiteurs	☐	☐	☐	☐
Aucun	☐	☐	☐	☐
Autre (p. Ex. Financement, renforcement des capacités, opportunités d'emplois)	☐	☐	☐	☐
Autre indicateur économique	☐	☐	☐	☐

Autre indicateur économique	☐	☐	☐	☐

Q16 Est ce qu'il y a autres indicateurs que vous trouvez utiles dans l'évaluation de l'efficacité du réseau d'AMPs? Veuillez expliquer (facultatif).

Q17 À quel point êtes vous en accord ou en désaccord que le suivi et l'évaluation actuel permet d'évaluer si un réseau répond aux objectifs.

	Tout a fait en désaccord	Plutôt en désaccord	Ni en désaccord, ni en accord	Plutôt en accord	Tout a fait en accord	Il n'y a aucun plan de suivi
Le suivi actuel permet d'évaluer si le réseau atteint ses objectifs	☐	☐	☐	☐	☐	☐

Bloc: Données démographiques
Q18 Dans cette section nous vous demanderons quelques questions de plus au sujet du réseau dans lequel vous travaillez.
Q19 Quel(s) niveau(x) de protection existe-t-il dans ce réseau? (Sélectionnez toutes les réponses applicables)

- ☐ **Protection entière:** aucune activité d'extraction ou de destruction n'est permise, et tous les impacts sont minimisés
- ☐ **Protection élevé:** seulement des faibles activités d'extraction sont permises, autres impacts sont minimisés autant que possible
- ☐ **Protection faible:** un peu de protection existe mais avec extraction modérée ou importante, et les impacts sont permis
- ☐ **Protection minime:** extraction vaste et autres impacts sont permis, tout en offrant quelques avantages de conservation à la région
- ☐ Autre (veuillez saisir un texte)

Q20 Quelle est la structure de gestion de ce réseau d'AMPs? (Si cogéré, sélectionnez tous ceux qui s'appliquent)

- ☐ Autochtone ou communautaire
- ☐ Gouvernement fédéral
- ☐ Municipal
- ☐ Provincial
- ☐ Organisme non-gouvernemental (ONG)
- ☐ Privé
- ☐ Autre

Q22 Quelle est votre appartenance? (Sélectionnez toutes les réponses applicables)

- ☐ Gouvernement fédéral/national
- ☐ Gouvernement de l'état
- ☐ Gouvernement autochtone
- ☐ Gouvernement local/communautaire

- ☐ Non-gouvernemental (ONG)
- ☐ Institution académique/université
- ☐ Agence internationale (p. ex. Nations Unis)
- ☐ Groupe récréatif/secteur touristique
- ☐ Privé
- ☐ Autre

Q21 À quel titre travaillez-vous dans, ou dans quelle mesure connaissez-vous le réseau d'AMPs?

- ☐ Chercheur(euse)/universitaire
- ☐ Gestionnaire de projet
- ☐ Facilitateur(trice) de projet
- ☐ Spécialiste d'habitat ou d'espèces
- ☐ Analyste politique
- ☐ Technicien(ne) de suivi
- ☐ Communications
- ☐ Autre (Veuillez saisir un texte)

Q23 Combien d'AMPs il-y-a t'il/aura-t-il dans ce réseau?

- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6-8
- ☐ 9-10
- ☐ plus que 10

Q24 En quelle année ce réseau d'AMPs a-t-il été établi?

- ☐ Je ne sais pas
- ☐ Après 2020
- ☐ 2020
- ☐ 2019
- ☐ 2018
- ☐ 2017
- ☐ 2016
- ☐ 2015
- ☐ 2014
- ☐ 2013
- ☐ 2012
- ☐ 2011
- ☐ 2010
- ☐ 2009
- ☐ 2008
- ☐ 2007
- ☐ 2006
- ☐ 2005
- ☐ 2004
- ☐ 2003
- ☐ 2002
- ☐ 2001
- ☐ 2000
- ☐ 1999

☐ 1998

☐ 1997

☐ 1996

☐ 1995

☐ 1994

☐ 1993

☐ 1992

☐ 1991

☐ 1990

☐ Avant 1990

Q25 Dans quel(s) pays se situ(ent) ce réseau d'AMPs?

Bloc : Fin

Q26 Merci pour votre participation dans ce questionnaire. Nous avons deux dernières questions au sujet d'engagements futurs avec ce projet.

Q27 Seriez vous prêt(e)s à prendre part à une entrevue de suivie de 10 minutes via Skype, si ce l'est nécessaire, dans deux semaines?

☐ Oui

☐ Non

Q28 Veuillez inscrire votre adresse électronique pour l'entrevue de suivi

Q29 Voulez-vous recevoir un résumé des résultats de cette enquête?

☐ Oui

☐ Non

Q30 Veuillez entrer votre adresse électronique pour recevoir un résumé des résultats de cette enquête

Survey en Español

Evaluación de la efectividad de redes de Áreas Marinas Protegidas

Bloque: Consentimien
Please chose your preferred language
Por favor elija su idioma preferido
Veuillez choisir votre langue préférée

Q1
Usted está invitado a participar en un proyecto de investigación para identificar indicadores específicos de las redes de áreas marinas protegidas (AMPs). Este proyecto lo lleva a cabo Mairi Meehan, como parte de una tesis doctoral en Memorial University of Newfoundland, quién a su vez es estudiante visitante de investigación en la University of Victoria, Canadá.

Propósito:
El propósito de la encuesta es identificar indicadores que puedan ayudar a evaluar las redes de AMP. Este estudio se sumará al creciente cuerpo de literatura que mide la efectividad de la red de AMP. Definiciones y ejemplos pueden ser observadas en donde el texto azul esta presente, al pasar el cursor sobre la palabra esta se destacará.

Lo que usted realizará en este estudio:
Como experto (por ejemplo, gestor, académico, investigador, facilitador, técnico de campo, especialista) en diseño, implementación, monitoreo o evaluación de redes de AMP, está invitado a documentar su experiencia utilizando indicadores para monitorear y evaluar la efectividad de las redes de AMP. Los nombres y la información de contacto de los participantes dispuestos a continuar participando se solicitarán para una entrevista de seguimiento.

Tiempo de duración:
Esta encuesta tomará alrededor de 15 a 20 minutos de su tiempo.

Renuncia a la encuesta:
La participación en este estudio es voluntaria y no es un requisito de trabajo. Puede omitir cualquier pregunta que no desee responder. Puede retirarse de la encuesta en cualquier momento cerrando la ventana de su navegador. También, puede navegar fuera de esta página antes de enviar la encuesta. Usted no tiene que dar ninguna razón por renunciar a la encuesta, esto no lo afectará ahora o en el futuro.

Beneficios y riesgos:
Puede beneficiarse indirectamente de participar en este estudio al avanzar en el conocimiento de la efectividad de las iniciativas de conservación marina. Hay riesgos mínimos asociados con esta investigación porque la participación en esta encuesta seguirá siendo confidencial.

Datos y Resultados:
Esta encuesta se administrará a través de Qualtrics, este sitio no registrará ninguna información personal o asociaciones de contacto. Cualquier información de identificación personal proporcionada por usted al final de la encuesta permanecerá confidencial y será utilizada anónimamente en el análisis y difusión de resultados; cada participante tendrá un

código de investigación asociado que se utilizará en el análisis de datos y los resultados se presentarán en forma agregada, protegiendo así el anonimato.
Los nombres y la información de contacto asociados con los códigos se mantendrán separadamente en una ubicación segura en un disco duro encriptado, protegido con contraseña, accesible únicamente por el investigador (Mairi). Los datos se almacenarán en una computadora protegida por contraseña durante un mínimo de cinco años, como lo solicita las regulaciones de Integridad en la Investigación Académica de Memorial University. Los resultados de esta investigación se compartirán con los participantes que deseen recibir información sobre los resultados de la investigación. En este caso, se solicitará a los encuestados información de contacto que sea independiente de las respuestas de la encuesta. Las respuestas a la encuesta serán confidenciales. Al finalizar, la tesis doctoral de Mairi Meehan, esta estará disponible en la Biblioteca Queen Elizabeth II de Memorial University, el sitio web es:
http://collections.mun.ca/cdm/search/collection/theses.
Preguntas:
Esta propuesta de investigación ha sido revisada por el Comité Interdisciplinario de Ética en Investigación Humana y se encontró que esta cumple con las políticas de ética de Memorial University y University of Victoria. Para preguntas relacionadas con el proceso ético de esta investigación, puede comunicarse con el director del ICEHR en icehr@mun.ca o por teléfono al + 1-709-864-2861 o la Oficina de Ética de Investigación Humana de University of Victoria al + 1-250-472-4545 o por correo electrónico a ethics@uvic.ca. Para preguntas sobre esta investigación pueden contactarse con: Mairi Meehan, PhD Candidate Department of Geography, Memorial University of Newfoundland, Canadá mcmiller@mun.ca. Ella esta bajo la supervisión de los profesores: Gerald Singh geralds@mun.ca y Natalie Ban nban@uvic.ca.
Al completar esta encuesta, usted de acuerdo que: Ha leído la información sobre la investigación. Se le ha informado que puede hacer preguntas sobre este estudio y recibir respuestas antes de continuar. Está conforme de cualquier pregunta que haya tenido que ser abordada. Entiende de qué se trata el estudio y qué hará. Usted comprende que es libre de retirar su participación en el estudio. Entiende de qué se trata el estudio y qué hará. Usted comprende que es libre de retirar su participación en el estudio. Entiende que sí elige permanecer en el anonimato, sus datos no pueden removidos una vez que usted envíe esta encuesta. Si envía su contacto personal para una entrevista de seguimiento, tiene derecho a retirarse y poder solicitar la eliminación de sus datos del estudio contactando al investigador antes del 4 de abril de 2020. Al dar su consentimiento para esta encuesta en línea, no da sus derechos legales y no esta dando cuenta de sus responsabilidades profesionales a los investigadores.
Haciendo clic en Sí a continuación, usted estará aceptando el consentimiento de realizar esta encuesta, lo que implica la aceptación de las declaraciones anteriores.
Gracias por considerar participar en este estudio.
¿Aceptas estos términos?

- ☐ Si
- ☐ No

Q2
Para el propósito de esta encuesta, usaremos las siguientes definiciones: **Red de áreas marinas protegidas** (o sistema de áreas marinas protegidas) se considera un conjunto organizado de áreas marinas protegidas (AMPs) individuales, diseñadas para operar "cooperativa y sinérgicamente, a varias escalas espaciales, y con una gama de niveles de protección ... "(UICN-WCPA 2008).
La efectividad se considera el grado en que las redes de AMP logran sus objetivos relacionados con la Convention on Biological Diversity's Aichi Target 11 (Organismo perteneciente a Naciones Unidas).
Convention on Biological Diversity's AICHI Meta 11 indica: "Para 2020, al menos el 17% de las zonas terrestres y de las aguas interiores y el 10% de las zonas marinas y costeras, especialmente las que revisten particular importancia para la diversidad biológica y los servicios de los ecosistemas, se habrán conservado por medio de sistemas de áreas protegidas administrados de manera eficaz y equitativa, ecológicamente representativos y bien conectados, y de otras medidas de conservación eficaces basadas en áreas, y estas estarán integradas a los paisajes terrestres y marinos más amplios."(UNEP-CBD 2011)."
Una dimensión es el contexto o característica de interés relacionada con los objetivos de una red de AMPs. Las dimensiones se medirán mediante un conjunto de indicadores.
Un indicador es una variable cualitativa o cuantitativa (social, ambiental, etc.) utilizada para medir el estado o el cambio a lo largo del tiempo de una característica de particular interés debido a la implementación de la red de áreas marinas protegidas. Los indicadores en este estudio son de alto nivel y pueden abarcar los indicadores o métricas más específicos del sitio en que utilice.
Los indicadores específicos en esta encuesta se han identificado a partir de una revisión global de literatura revisada por pares sobre la efectividad de las redes de áreas marinas protegidas. Anticipamos que encontrará vacíos en esta lista de opciones y esperamos que agregue los indicadores que considera que faltan en esta lista.

Bloque: Dimensiones
Q3 Primero nos gustaría reunir algunos antecedentes sobre la red de áreas marinas protegidas (AMPs) con la que está familiarizado, incluidos los objetivos y dimensiones que cubre su red AMPs. Probablemente, también puede existir el caso que usted esta vinculado a un área marina protegida que en un futuro será una red AMPs, si este es el caso igual su colaboración es valiosa.
Las AMPs tienen características ecológicas, sociales, económicas y de gobernanza importantes para su desempeño. Las dimensiones son estas características de interés que se medirán mediante un conjunto de indicadores.
Q4 ¿Su trabajo está relacionado con un área marina protegida (AMP) individual que forma parte de una red o usted trabaja vinculado a una red completa de áreas marinas protegidas (AMPs)? (Requerida)
▢ En un AMP individual en una red
▢ En un AMP individual que *llegará a formar parte* de una red

▢ Parte de una red de AMPs (varias AMPs dentro de la red)
▢ En una Red completa de AMPs
▢ En un AMP individual, no asociado con ninguna red de AMPs
▢ No lo sé
▢ Otro

Q5 ¿Cuál es el nombre de la red de áreas marinas protegidas o del área marina protegida que es parte de una red con la que usted está más familiarizado?

____

____

____

Q6 ¿Cuáles son los objetivos de la red de áreas marinas protegidas? (Seleccione todas las opciones que correspondan, cualquier objetivo no seleccionado se tratará como "No es un objetivo")

	Importancia de este objetivo			
	Primario	Secundario	No objetivo	No lo sé
Conservación de la biodiversidad	☐	☐	☐	☐
Manejo de pesquerías	☐	☐	☐	☐
Restauración y protección del hábitat	☐	☐	☐	☐
Mantención de los servicios ecosistémicos	☐	☐	☐	☐
Valores culturales (y subsistencia)	☐	☐	☐	☐
Bienestar Social	☐	☐	☐	☐
Investigación científica	☐	☐	☐	☐
Contribución a iniciativas globales (CBD Aichi, SDGs	☐	☐	☐	☐
Otro (Por favor ingrese el texto)	☐	☐	☐	☐

Q7
Por favor, indique si las dimensiones ecológicas a continuación se han considerado en el diseño, implementación o monitoreo de la red de áreas marinas protegidas (AMPs). Por favor, tenga en cuenta también su opinión sobre la importancia de cada dimensión para la efectividad de la red de AMPs, incluso sí no se tuvo en cuenta en el diseño.
Respondiendo “Si” en esta sección, esta se reflejará en las siguientes secciones donde podrá seleccionar los indicadores utilizados para evaluar estas dimensiones. Cualquier “otra” dimensión que ingrese también aparecerá en la siguiente sección. Cualquier dimensión no seleccionada será tratada como “No considerada” y “No importante”.
“Extremadamente importante" significa que esta dimensión es crítica para que la red tenga éxito. “No importante” significa que no sirve para el éxito.

	¿Se consideró esto en el diseño, implementación o monitoreo de la red?			¿Qué importancia tiene esta dimensión para la efectividad de la red de áreas marinas protegidas?				
	Si	No	No lo sé	1 No importante	2 Ligeramente importante	3 Moderadamente importante	4 Muy importante	5 Extremadamente importante
Conectividad ecológica	☐	☐	☐	☐	☐	☐	☐	☐
Representatividad (una muestra representativa de la gama completa de ecosistemas, incluida la diversidad biótica y de hábitat de	☐	☐	☐	☐	☐	☐	☐	☐

esos ecosistemas marinos).								
Hábitats clave de importancia	☐	☐	☐	☐	☐	☐	☐	☐
Especies clave de importancia	☐	☐	☐	☐	☐	☐	☐	☐
Resiliencia (capacidad de recuperarse de un impacto/ estrés negativo)	☐	☐	☐	☐	☐	☐	☐	☐
Actividades y amenazas adyacentes a la red	☐	☐	☐	☐	☐	☐	☐	☐
¿Otra dimensión ecológica?	☐	☐	☐	☐	☐	☐	☐	☐
¿Otra dimensión ecológica?	☐	☐	☐	☐	☐	☐	☐	☐
¿Otra dimensión ecológica?	☐	☐	☐	☐	☐	☐	☐	☐

Q8
Por favor, indique si las dimensionales sociales a continuación se han considerado en el diseño, implementación o monitoreo de la red de áreas marinas protegidas (AMPs). Por favor, tenga en cuenta también su opinión sobre la importancia de cada dimensión para la efectividad de la red de AMPs, incluso sí no se tuvo en cuenta en el diseño.
Respondiendo “Si” en esta sección, esta se reflejará en las siguientes secciones donde podrá seleccionar los indicadores utilizados para evaluar estas dimensiones. Cualquier “otra” dimensión que ingrese también aparecerá en la siguiente sección. Cualquier dimensión no seleccionada será tratada como “No considerada” y “No importante”.
“Extremadamente importante" significa que esta dimensión es crítica para que la red tenga éxito. “No importante” significa que no sirve para el éxito.

	¿Se consideró esto en el diseño, implementación o monitoreo de la red?			¿Qué importancia tiene esta dimensión para la efectividad de la red de áreas marinas protegidas?				
	Si	No	No lo sé	1 No importante	2 Ligeramente importante	3 Moderadamente importante	4 Muy importante	5 Extremadamente importante
Participación de la comunidad	☐	☐	☐	☐	☐	☐	☐	☐
Equidad / justicia social	☐	☐	☐	☐	☐	☐	☐	☐
Conflictos	☐	☐	☐	☐	☐	☐	☐	☐
Salud humana	☐	☐	☐	☐	☐	☐	☐	☐

Bienestar humano	☐	☐	☐	☐	☐	☐	☐	☐
¿Otra dimensión social?	☐	☐	☐	☐	☐	☐	☐	☐
¿Otra dimensión social?	☐	☐	☐	☐	☐	☐	☐	☐
¿Otra dimensión social?	☐	☐	☐	☐	☐	☐	☐	☐

Q9
Por favor, indique si las dimensiones de gobernanza a continuación se han considerado en el diseño, implementación o monitoreo de la red de áreas marinas protegidas (AMPs). Por favor, tenga en cuenta también su opinión sobre la importancia de cada dimensión para la efectividad de la red de AMPs, incluso sí no se tuvo en cuenta en el diseño.
Respondiendo "Si" en esta sección, esta se reflejará en las siguientes secciones donde podrá seleccionar los indicadores utilizados para evaluar estas dimensiones. Cualquier "otra" dimensión que ingrese también aparecerá en la siguiente sección. Cualquier dimensión no seleccionada será tratada como "No considerada" y "No importante".
"Extremadamente importante" significa que esta dimensión es crítica para que la red tenga éxito. "No importante" significa que no sirve para el éxito.

	¿Se consideró esto en el diseño, implementación o monitoreo de la red?			¿Qué importancia tiene esta dimensión para la efectividad de la red de áreas marinas protegidas?				
	Si	No	No lo sé	1 No importante	2 Ligeramente importante	3 Moderadamente importante	4 Muy importante	5 Extremadamente importante
Colaboración institucionales / sociales	☐	☐	☐	☐	☐	☐	☐	☐
participación de los interesados	☐	☐	☐	☐	☐	☐	☐	☐
Derechos y acceso	☐	☐	☐	☐	☐	☐	☐	☐
¿Otra dimensión de	☐	☐	☐	☐	☐	☐	☐	☐

gobernanza?								
¿Otra dimensión de gobernanza?	☐	☐	☐	☐	☐	☐	☐	☐
¿Otra dimensión de gobernanza?	☐	☐	☐	☐	☐	☐	☐	☐

Q 10
Por favor, indique si las dimensiones económicas a continuación se han considerado en el diseño, implementación o monitoreo de la red de áreas marinas protegidas (AMPs). Por favor, tenga en cuenta también su opinión sobre la importancia de cada dimensión para la efectividad de la red de AMPs, incluso sí no se tuvo en cuenta en el diseño.
Respondiendo "Si" en esta sección, esta se reflejará en las siguientes secciones donde podrá seleccionar los indicadores utilizados para evaluar estas dimensiones. Cualquier "otra" dimensión que ingrese también aparecerá en la siguiente sección. Cualquier dimensión no seleccionada será tratada como "No considerada" y "No importante".
"Extremadamente importante" significa que esta dimensión es crítica para que la red tenga éxito. "No importante" significa que no sirve para el éxito.

	¿Se consideró esto en el diseño, implementación o monitoreo de la red?			¿Qué importancia tiene esta dimensión para la efectividad de la red de áreas marinas protegidas?				
	Si	No	No lo sé	1 No importante	2 Ligeramente importante	3 Moderadamente importante	4 Muy importante	5 Extremadamente importante
Empleo / medios de subsistencia	☐	☐	☐	☐	☐	☐	☐	☐
Distribución económica (distribución de dinero entre personas)	☐	☐	☐	☐	☐	☐	☐	☐
Riqueza económica y/o material	☐	☐	☐	☐	☐	☐	☐	☐

¿Otra dimensión económica?	☐	☐	☐	☐	☐	☐	☐
¿Otra dimensión económica?	☐	☐	☐	☐	☐	☐	☐
¿Otra dimensión económica?	☐	☐	☐	☐	☐	☐	☐

Q11
Esta sección tiene como objetivo explorar el uso de indicadores en la evaluación de la efectividad de una red de áreas marinas protegidas (AMPs). Anticipamos que encontrará vacíos en esta lista y esperamos que identifique indicadores importantes adicionales que usted considere que faltan.
Por favor, haga coincidir el indicador en la columna izquierda con las dimensiones consideradas importantes para esta red de AMPs. Los indicadores enumerados en esta sección se consideran indicadores generales y pueden abarcar indicadores o métricas específicos del sitio que usted utiliza. Sí no ve una categoría de indicador apropiada, utilice la categoría "Otro" para nombrar los indicadores.
Q12
Por favor, haga coincidir los indicadores ecológicos con cada dimensión ecológica considerada en el diseño, implementación o monitoreo de esta red de AMPs.
Las dimensiones ecológicas que seleccionó se enumeran en la parte superior de la siguiente tabla. Los indicadores ecológicos relacionados se enumeran en el lado izquierdo, con una opción para agregar más en la parte inferior.

	Dimensión Ecológica	Dimensión Ecológica	Dimensión Ecológica	Dimensión Ecológica	Dimensión Ecológica	Dimensión Ecológica
	Conectividad	Representación	Hábitats claves	Especies claves	Resiliencia	Actividades adyacentes y amenazas
Área bajo impacto humano reducido o nulo	☐	☐	☐	☐	☐	☐
Área que muestra signos de recuperación	☐	☐	☐	☐	☐	☐
Distribución y complejidad del hábitat	☐	☐	☐	☐	☐	☐

Distancia entre parches de hábitat	☐	☐	☐	☐	☐	☐
Centros de endemismo o áreas silvestres intactas	☐	☐	☐	☐	☐	☐
Número de especies / hábitats replicados	☐	☐	☐	☐	☐	☐
Abundancia de especies focales	☐	☐	☐	☐	☐	☐
Distribución de especies	☐	☐	☐	☐	☐	☐
Dispersión de especies	☐	☐	☐	☐	☐	☐
Proporción de distribución de especies cubiertas por AMPs	☐	☐	☐	☐	☐	☐
Tamaño y disposición espacial de las áreas protegidas	☐	☐	☐	☐	☐	☐
Cobertura de ecorregiones	☐	☐	☐	☐	☐	☐

Cobertura de áreas claves para la biodiversidad	☐	☐	☐	☐	☐	☐
Cobertura de puntos críticos de riqueza de especies	☐	☐	☐	☐	☐	☐
Composición y estructura de la comunidad.	☐	☐	☐	☐	☐	☐
Estructura poblacional de especies focales	☐	☐	☐	☐	☐	☐
Integridad de la red alimentaria	☐	☐	☐	☐	☐	☐
Reclutamiento exitoso dentro de la comunidad	☐	☐	☐	☐	☐	☐
Tipo, nivel y rendimiento del esfuerzo pesquero	☐	☐	☐	☐	☐	☐
Alcance y gravedad de las amenazas.	☐	☐	☐	☐	☐	☐
Ninguna	☐	☐	☐	☐	☐	☐

Otro indicador no mencionado anteriormente (por ejemplo, corrientes oceanográficas, contaminación, resistencia del hábitat)	☐	☐	☐	☐	☐	☐
Otro indicador ecológico no mencionado anteriormente	☐	☐	☐	☐	☐	☐
Otro indicador ecológico no mencionado anteriormente	☐	☐	☐	☐	☐	☐

Q13
Por favor, haga coincidir los indicadores sociales con cada dimensión social considerada en el diseño, implementación o monitoreo de esta red de AMPs.
Las dimensiones sociales que seleccionó se enumeran en la parte superior de la siguiente tabla. Los indicadores relacionados con las redes sociales se enumeran en el costado a la izquierda, con una opción para agregar más en la parte inferior.

	Participación de la comunidad	Equidad / Justicia social	Conflicto	Salud humana	Bienestar humano
Calidad de la salud humana	☐	☐	☐	☐	☐
Valores y creencias sobre los recursos marinos	☐	☐	☐	☐	☐
Percepciones de los efectos del AMP con los medios de subsistencia	☐	☐	☐	☐	☐
Nivel de conflicto de los recursos	☐	☐	☐	☐	☐
Nivel de gobierno y liderazgo	☐	☐	☐	☐	☐
Nivel de cumplimiento	☐	☐	☐	☐	☐
Nivel de comunicación y difusión de la información	☐	☐	☐	☐	☐
Ninguna	☐	☐	☐	☐	☐

Otros (por ejemplo, liderazgo, redes sociales, acceso a recursos, equidad)	☐	☐	☐	☐	☐
Otro indicador social	☐	☐	☐	☐	☐
Otro indicador social	☐	☐	☐	☐	☐

Q14
Por favor, haga coincidir los indicadores de gobernanza con cada dimensión de gobernanza considerada en el diseño, implementación o monitoreo de esta red de AMPs.
Las dimensiones de gobierno que seleccionó se enumeran en la parte superior del siguiente gráfico. Los indicadores relacionados con la gobernanza se enumeran en el costado a la izquierda, con una opción para agregar más en la parte inferior.

	Asociaciones	Participación	Derechos y acceso
Disponibilidad y asignación de recursos administrativos de AMP (financiación asegurada)	☐	☐	☐
Nivel de cumplimiento de las reglas	☐	☐	☐
La aplicación de procedimientos claramente definidos	☐	☐	☐
Comprensión local de las reglas y regulaciones de AMP	☐	☐	☐

Existencia y adecuación de la legislación	☐	☐	☐
Existencia y adopción de un plan de gestión	☐	☐	☐
Existencia y aplicación de investigaciones y aportes científicos	☐	☐	☐
Existencia de un órgano de toma de decisiones y gestión	☐	☐	☐
Grado de interacción entre gerentes y partes interesadas	☐	☐	☐
Nivel de cooperación y coordinación regional	☐	☐	☐
Existencia de medidas de gestión integradas en los planes de gestión	☐	☐	☐
Nivel de participación de la comunidad y las partes interesadas	☐	☐	☐
Nivel de gobierno y liderazgo	☐	☐	☐
Nivel de obstaculización o apoyo del entorno político y civil externo.	☐	☐	☐
Nivel de beneficio comunitario	☐	☐	☐
Nivel de conflicto de recursos	☐	☐	☐

Nivel de participación y satisfacción de los interesados en la gestión	☐	☐	☐
Nivel de capacitación brindada al personal y la administración	☐	☐	☐
Nivel de capacitación brindada a las partes interesadas en participación	☐	☐	☐
Ninguna	☐	☐	☐
Otros (por ejemplo, cooperación regional, participación / apoyo del gobierno, grupos de trabajo colaborativos)	☐	☐	☐
Otro indicador de gobernanza	☐	☐	☐
Otro indicador de gobernanza	☐	☐	☐

Q15
Por favor, haga coincidir los siguientes indicadores económicos con cada dimensión económica considerada en el diseño, implementación y monitoreo de esta red de AMPs.
Las dimensiones económicas que seleccionó se enumeran en la parte superior de la siguiente tabla. Los indicadores relacionados con la economía se enumeran en el costado a la izquierda, con una opción para agregar más en la parte inferior.

	Empleo / medios de subsistencia	Distribución económica	Riqueza económica / material
Fiabilidad y adecuación de la financiación	☐	☐	☐
Riqueza material	☐	☐	☐
Gestión de turistas	☐	☐	☐
Ninguna	☐	☐	☐
Otros (por ejemplo, financiación, desarrollo de capacidades, oportunidades de empleo)	☐	☐	☐
Otro indicador económico	☐	☐	☐
Otro indicador económico	☐	☐	☐

Q16
¿Hay algún otro indicador que le resulte útil para evaluar la efectividad de la red de AMPs? Por favor explique (Opcional)
Q17
¿Hasta qué punto está de acuerdo o en desacuerdo con que el monitoreo y la evaluación actual permiten evaluar si la red está cumpliendo sus objetivos?

	Muy en desacuerdo	Parcialmente en desacuerdo	Ni de acuerdo ni en desacuerdo	Parcialmente de acuerdo	Muy de acuerdo	No hay un plan de monitoreo.
El monitoreo que se está realizando actualmente nos permite evaluar si la red está logrando sus objetivos.	☐	☐	☐	☐	☐	☐

Q18
En esta sección le haremos algunas preguntas más sobre la red en la que usted trabaja.
Q19
¿Qué nivel (s) de protección existen en la red? (Seleccione todas las que correspondan)

☐ Totalmente protegido: no se permiten actividades extractivas o destructivas, y se minimizan todos los impactos

☐ Altamente protegido: solo se permiten actividades extractivas ligeras, y otros impactos se minimizan en la medida de lo posible

☐ Ligeramente protegido: existe cierta protección, pero se permite la extracción y los impactos de moderados a significativos

☐ Mínimamente protegido: se permite la extracción extensiva y otros impactos mientras se proporciona algún beneficio de conservación al área

☐ Otro (Ingrese el texto)

Q20
¿Cuál es la estructura de gestión de esta red de AMPs? (si está gestionado conjuntamente, seleccione todos los grupos involucrados)

- ☐ Indígena o comunitario
- ☐ Gobierno central o federal
- ☐ Municipal
- ☐ Provincial o regional
- ☐ Organización no gubernamental (ONG)
- ☐ Privado
- ☐ Otro

Q21
¿Cuál es tu afiliación? (Seleccione todas las que correspondan)

- ☐ Gobierno federal / nacional
- ☐ Gobierno provincial / estatal
- ☐ Gobierno indígena
- ☐ Gobierno local / comunitario
- ☐ No gubernamental (ONG)
- ☐ Institución académica / Universidad
- ☐ Agencia internacional (por ejemplo, Naciones Unidas)
- ☐ Grupos recreativos / industria del turismo
- ☐ Privado
- ☐ Otro

Q22
¿En qué rol o función trabajas en la red MPAs? (Seleccione todas las que correspondan

- ☐ Investigador / Académico
- ☐ Gerente de proyecto

- ☐ Facilitador del proyecto
- ☐ Hábitat o especialista en especies
- ☐ Analista de políticas
- ☐ Técnico de monitoreo
- ☐ Comunicaciones
- ☐ Coordinador comunitario
- ☐ Líder comunitario
- ☐ Otro (ingrese el texto)

Q23
¿Cuántas AMP individuales hay / estarán en la red?

- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6-8
- ☐ 9-10
- ☐ Más de 10

Q24
¿En qué año se estableció la red MPAs?

- ☐ No lo sé
- ☐ Posterior a 2020
- ☐ 2020
- ☐ 2019
- ☐ 2018
- ☐ 2017

- [ ] 2016
- [ ] 2015
- [ ] 2014
- [ ] 2013
- [ ] 2012
- [ ] 2011
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- [ ] 1995
- [ ] 1994
- [ ] 1993

☐ 1992

☐ 1991

☐ 1990

☐ Antes de 1990

Q25
¿En qué país o países se encuentra la red de AMPs?
Q26
Gracias por completar esta encuesta, le haremos dos preguntas finales sobre un posible contacto futuro con este proyecto.

Q27
¿Estaría dispuesto a participar en una entrevista de seguimiento de 10 minutos, si es necesario, en dos semanas a través de Skype?

☐ SI

☐ NO

Q28
Ingrese su dirección de correo electrónico para la entrevista de seguimiento
Q29
¿Le gustaría recibir un resumen de los resultados de esta encuesta?

☐ Si

☐ No

Q30
Por favor, ingrese su dirección de correo electrónico para recibir un resumen de los resultados de la encuesta.