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Abstract

Marine protected area 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, governance, and social 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 have various co-occurring, potentially conflicting objectives. MPANs with biodiversity and societal objectives considered attributes (e.g., human well-being and economic distribution, institutional partnerships, and network-specific ecological attributes) among all dimensions, with greater frequency than MPANs with only biodiversity objectives. Nonetheless, ecological attributes were always perceived as 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 the important attributes considered in MPANs offers insight into the practice of MPAN design, implementation, monitoring, and evaluation and can help improve MPAN success.

KEYWORDS

evaluation, expert elicitation, marine conservation, marine protected area networks, MPA networks, multiple dimensions, multiple objectives, social-ecological, survey

1 | INTRODUCTION

Networks of marine protected areas (MPAs) are increasingly promoted as a cornerstone tool for protecting biodiversity and contributing to sustainable development (Gaines et al., 2010). 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 (Leslie, 2005). The protection of species and habitats can contribute to the achievement/realization of sustainable fisheries, cultural values and subsistence, and wellbeing, and may be primary objectives for MPAN implementation (Ban et al., 2020; Leslie et al., 2005). This variety of possible 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—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 (Figure 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, evolutionary, and ecological processes (CBD, 2008; Dudley & Parish, 2006). 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—and hence evolutionary potential to continue evolving—are maximized between sites within an MPAN (IUCN-WCPA, 2008; Rodríguez-Rodríguez, 2019). Resilience—the ability of an ecosystem to recover from a stress—is another important MPAN characteristic (McLeod et al., 2009). 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 (Burt et al., 2014; Grorud-Colvert et al., 2011; Holling, 1994; Nyström et al., 2000; Rees et al., 2018; Thomas & Shears, 2013).

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 (Alexander & Armitage, 2015; Bodin & Crona, 2009; Horigue et al., 2015). Shared information through collaborative alliances such as "sister sites"

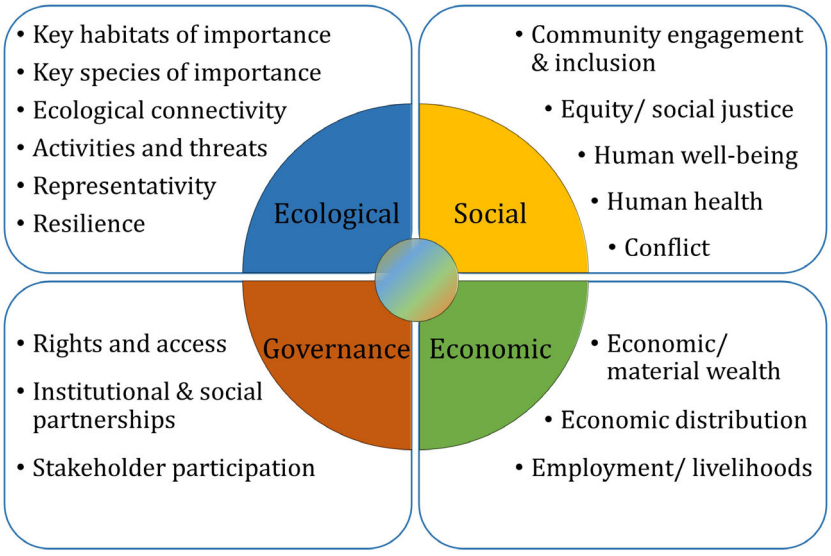

FIGURE 1 Dimensions of marine protected area networks and their associated attributes.

can help improve the ecological outcomes of an MPAN by overcoming barriers to effective management (IUCN-WCPA, 2008; Pittman & Armitage, 2017; Wenzel et al., 2019). Additional social attributes include access to resources, expanded social cohesion, and improved human wellbeing (Cárcamo et al., 2014; Mbaru et al., 2021; Miller et al., 2012). 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, 2009; Nelson et al., 2018). Governance attributes include participation and partnerships with rights-holders and stakeholders, which may 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 among 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 (Fox et al., 2014; Gurney et al., 2019; Pollnac et al., 2010; Pomeroy et al., 2005) where social conditions and relationships influence MPAN success (Dehens & Fanning, 2018; Kelly et al., 2020). All of these dimensions are known to improve the effectiveness of MPANs in conserving biodiversity (Blicharska et al., 2019; Pomeroy et al., 2005). Indeed, research has shown that neglecting these dimensions can be counterproductive for both social and ecological outcomes, leading to heightened community tensions, including poaching and reduced legitimacy (Ban et al., 2019; Christie, 2004; 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 the following research questions: (1) What are the objectives associated with MPANs, and how do the attributes of the four core dimensions of MPANs align with them? (2) 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.

2 | METHODS

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 (Krueger et al., 2012; Martin et al., 2011) and help improve the process of conservation programs and policies (Álvarez-Fernández et al., 2017; Whitney & Ban, 2019). Experts, including MPAN managers, researchers, and field technicians, shared information on the MPAN objectives, attributes of the four dimensions considered in any stage of the MPA planning, implementation, and evaluation process, 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 320 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 & 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 S1) 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 focused on practitioners because of

their familiarity with MPANs; we did not seek to obtain the views of rights-holders and stakeholders in this research. We first publicized the survey and launched it on February 28, 2020 and closed it on May 1, 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 (Figure 1). Our survey specifically set out to explore the attributes of each dimension considered by practitioners 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 complete the survey (see Appendix S1 for details). For the first part of the survey, we provided a list of attributes associated with each dimension 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 questions with an open-ended response category for respondents to include attributes they thought were missing from the multiple-choice survey answer options. We downloaded survey data into Excel (Microsoft Corporation, 2021) and carried out data preparation, cleaning and analysis in the R software v. 4.0.2 (R Core Team, 2020). Because respondents from a same MPANs are more likely to have similar responses, trends emerging from the data could be biased by a larger influence of few MPANs over others. To account for potential variation among respondents we treated the data differently among the overarching questions about attributes considered and respondent's perceptions of importance. We carried out our analyses about MPAN objectives and MPAN attributes with MPANs as the unit of analysis so that MPANs with multiple respondents did not skew responses. For our goal of understanding practitioner perceptions regarding the importance of attributes, we used individual responses.

2.2 | Marine protected area network (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 created a network graph using igraph in the FSA package (Csardi & Nepusz, 2006) in R (R Core Team, 2020) to visualize the relationship among objectives (Janssen et al., 2006). We were interested in assessing differences between MPANs that only included 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 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.

2.3 | Attributes considered in MPAN planning, implementation, and evaluation

We compiled the attributes selected and added by respondents for each dimension. We categorized attributes that were added manually (those respondents thought to be missing from our indicator 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 common 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 S2 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).

To understand the factors that influenced what attributes were considered in each dimension, we first assessed the similarity of responses from practitioners representing the same MPANs using Cronbach's alpha

(α). Cronbach's α measures whether several items measuring the same general construct produce similar scores (Cronbach, 1951). We then collated these responses so that each response represented one MPAN. We then transformed the data from the number of times each attribute was selected (count) to binary (presence/absence) format to ensure MPANs with more respondents did not have an outsized influence on the end results. This transformation also allowed for comparison between variables, such as the different objective types, that were not evenly distributed among responses. We created descriptive statistics, figures, and performed a permutational multivariate analysis of variance (PERMANOVA; Anderson, 2001) to test whether the attributes considered in MPA planning, implementation, and evaluation differed between MPAN objective types. We further calculated a multilevel pattern analysis using the Indicspecies package (De Cáceres et al., 2020) to identify which attributes are found statistically more abundantly in one group versus another. To get a sense of the balance of attributes considered among participants associated with MPANs that have different 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.

2.4 | Perceived importance of attributes for MPAN management effectiveness

To assess whether the suite of attributes associated with each dimension was considered in the MPAN process as being important for the overall performance, 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. To preserve individual perception-based responses about the importance of attributes considered in the MPAN process, we assessed individual responses of the Likert-type questions. We summarized the Likert-type data using R 'Psych' package (Revelle, 2021). To evaluate if the MPAN objective type was associated with differences in the perceived importance of attributes across the four dimensions, we performed an ordinal Chi-square analysis using the Cochran–Mantel–Haenszel (CMH) test (Agresti, 2007). Here we used one independent variable with two levels (B and B&S), an ordered dependent variable (importance), and we stratified the analysis using the four dimensions. Stratification allowed identifying differences in perception among the attributes according to MPAN objective type within each dimension. We used count data (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 CMH tests to determine which dimensions differed in importance levels between objective types. Finally, we performed a Chi-square analysis within each dimension with a Bonferroni adjustment for multiple testing of attributes, to determine the attributes that contribute to the results (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). We generated correlograms using R 'Corrplot' package (Wei, 2021) with the Chi-square residuals for each attribute to illustrate where the differences came from.

3 | RESULTS

3.1 | Eliciting expert knowledge

A total of 75 complete survey responses were collected, describing 46 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 S3). Respondents' roles consisted primarily of researcher/academic (39%), followed by habitat or species specialist, project manager, and "other" (12%, 11%, and 10%, respectively). Given the large number of researcher/academic respondents, we tested whether their responses differed from others. Sample sizes for respondents' affiliations were small, therefore 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). PERMANOVA results 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 ($R^2 = 0.03$, $F = 0.97$, $p < .55$). In subsequent analyses we therefore did not differentiate between affiliations of respondents.

3.2 | MPAN objectives

We confirmed that most MPANs have multiple objectives and identified 41 unique combinations of up to

8 co-occurring primary objectives. Every objective had a strong connection to biodiversity (Figure 2). 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 given less consideration (24% and 22% of B&S and B MPANs, respectively) and the social and economic dimensions were given the least consideration (13% and 11% B and 23% and 18% of B&S MPANs, respectively).

3.3 | Attributes considered in MPAN planning, implementation, and evaluation

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. Due to the overall consistency of responses among responses from the same MPANs (Table S4), we collated responses to avoid overrepresentation of specific MPANs. After combing these responses, we identified 13 responses for MPANs with solely biodiversity (B) objectives, and 34 responses for MPANs with biodiversity and socially-oriented (B&S) objectives (Table S5); none had only socially-oriented objectives. The consideration of attributes appears to be influenced slightly by the primary objectives of an MPAN. We found that respondents in B&S MPANs took into consideration several attributes associated with the social and governance dimensions to a greater degree than respondents in B MPANs, while ecological attributes garner a similar level of consideration across MPANs with these two objective types (Figure 3). 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 (Figure 3). Representation was the most frequently considered network-specific ecological attribute. 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. Among the 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

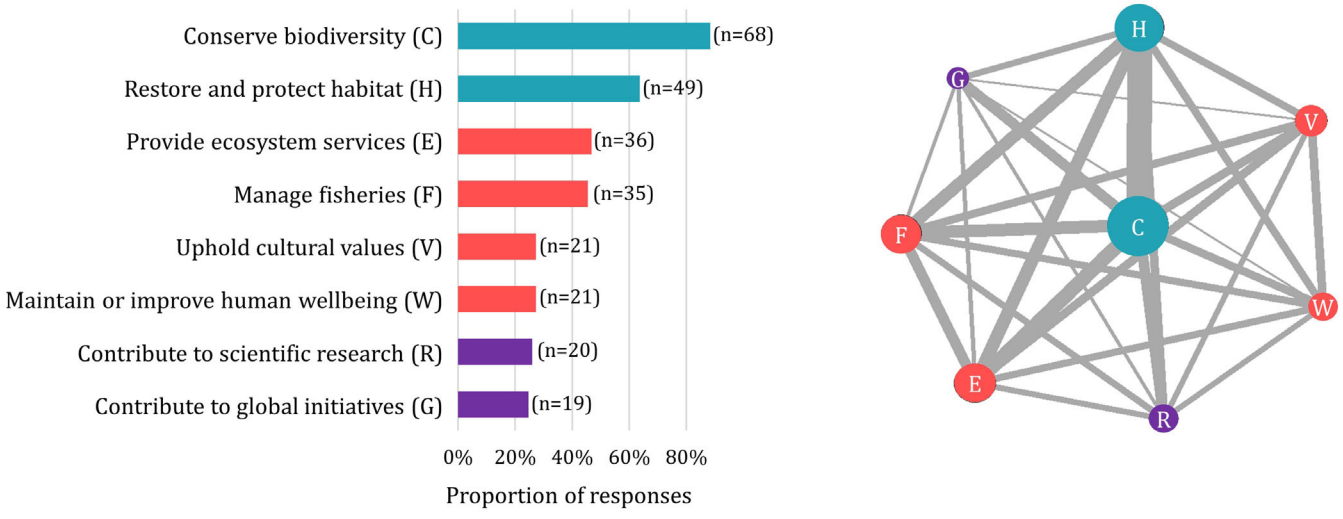

FIGURE 2 (a) The proportion of stated objectives for marine protected area networks (MPANs) from 77 survey respondents. Total count in parentheses. (b) Network diagram showing the connections among primary objectives of MPANs. The size of the nodes indicates the number of times participants selected the objective as primary. Colors indicate groups of objectives: biodiversity only (teal), biodiversity and socially-oriented objectives (coral), and general objectives (purple). The width of linkages indicates the number of times nodes (objectives) co-occurred (ranging from most [C-H, $n = 47$] to least [V-G, $n = 4$]).

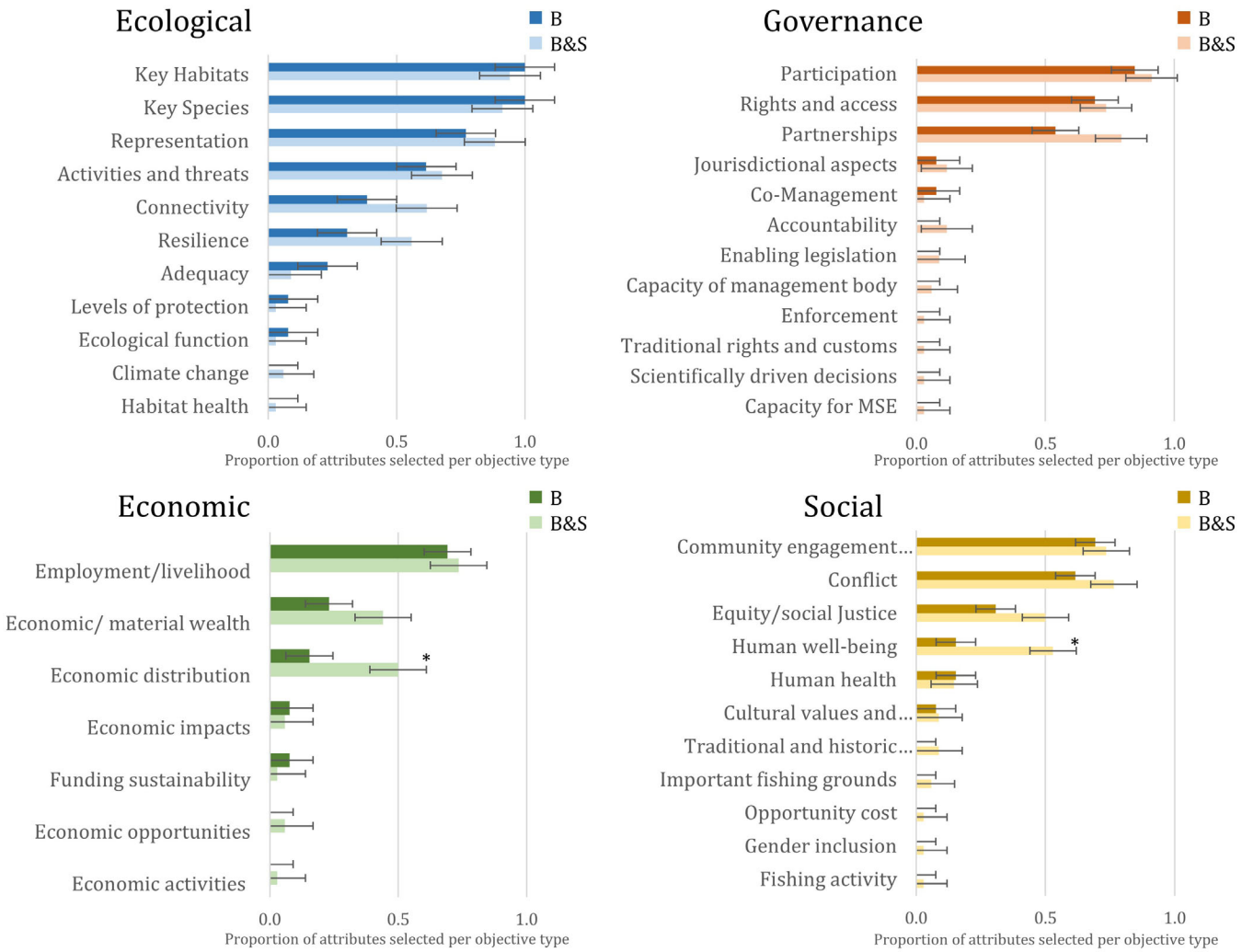

FIGURE 3 Attributes of each dimension considered among the two objective types in the marine protected area network (MPAN) process according to survey participants. Bold attributes indicate attributes originally included in the survey; regular text indicates attributes added by participants (i.e., "Other" attributes) ($n = 24$ [B], 53 [B&S]). Dark colors represent the proportion (±SE) of attributes selected in MPANs with only biodiversity (B) objectives. Light colors represent the proportion (± SE) of attributes selected in MPANs with biodiversity and socially-oriented objectives (B&S). Asterisks indicate where significant differences occur between MPAN objective types ($p < 0.05$, Indespecies).

MPANs (Figure 3). Among attributes added by participants, coordinated management and co-management were selected most often in B MAPNs, 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 participant added attributes, respondents selected cultural values and significance the most. Evenness scores (Table S6) indicate that MPANs with socially-oriented objectives have a slightly more balanced set of attributes considered among all dimensions. Results of the PERMANOVA suggest limited differentiation in attributes considered between MPANs with the two objective types (df = 1, $p < .1$). Multilevel pattern analysis indicated that the small differences were related to MPANs with socially-oriented objectives showing greater consideration for human wellbeing, and economic distribution (Table S7).

3.4 | Attributes added by participants

Survey participants identified 131 unique attributes that were not suggested in our survey (39 ecological, 41 social, 15 economic, and 38 governance attributes, Table S2).

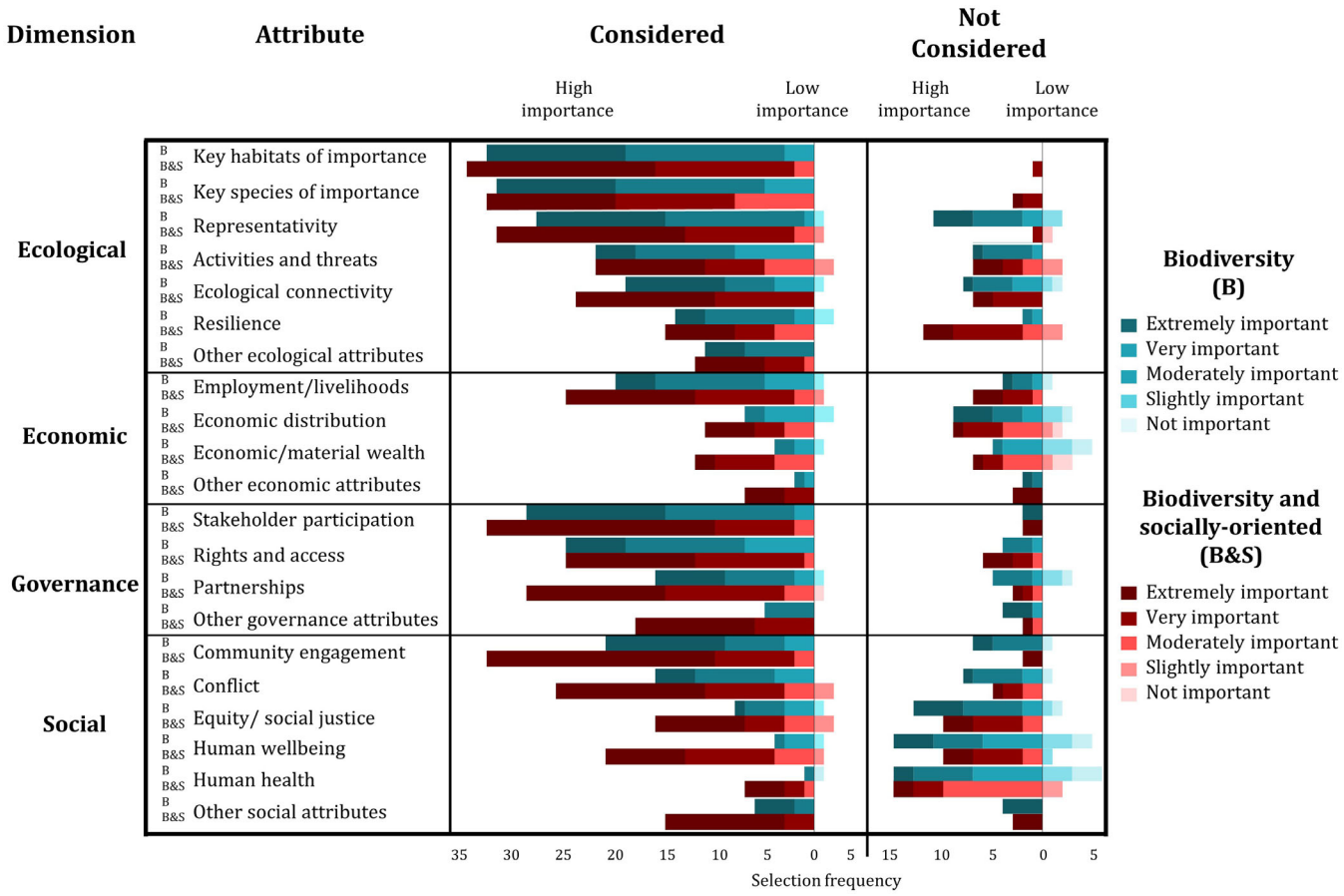

FIGURE 4 Selection frequency (number of times an attribute was selected as considered by survey participants) and levels of importance for the attributes of each dimension considered (left panel) and not considered (right panel) in the design, implementation, and monitoring of marine protected area networks (MPANs). Biodiversity-only (B) MPANs are indicated in blue-green, and MPANs with biodiversity and socially-oriented objective types (B&S) are indicated in red. 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, and Low importance (slight to not important) is shown in lighter shades on the right side of each panel.

After coding and organizing responses, we had 31 additional attributes considered by respondents (Table S2, Figure 3). Governance attributes saw the greatest addition (10 added) while economic saw the least (5 added). Among the added 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, Figure 3). 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. Notably, participants added attributes in every dimension that were not considered in the MPAN process yet were perceived as very important (Figure 4). Economic attributes of funding sustainability, nonmarket values, and opportunity costs, social attributes include indigenous values and culture, and access rights. Governance attributes not 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.

3.5 | Perceived importance of attributes for MPAN management effectiveness

The same attributes used in the MPAN process were identified by experts as being moderately to extremely important for MPAN effectiveness (Figure 4). We collected 24 individual responses for MPANs with solely biodiversity (B) objectives, and 53 responses for MPANs with biodiversity and socially-oriented (B&S) objectives. 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 S8, Figure 4). Ordinal Chi-square test of association identified differences in levels of importance selected for dimensions between the two objective types ($\chi^2 = 29$, $p < .001$, Table S8). The significant differences identified in 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 S8). 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 (Figures 4 and S1). 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 (Figure S1). 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 (Figures 4 and S1). 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 (Figures 4 and S1). Even in cases where a dimension was not considered, it was often perceived as being at least moderately important.

4 | DISCUSSION

Our results 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). This is a timely finding as many countries and environmental organizations are showing an increasing interest in MPANs that have objectives beyond only biodiversity conservation (Aiken & Bissonnett, 2020; FAO, 2017; Molenaar et al., 2020). In fact, our research identified greater consideration for a 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. Ecological attributes were considered at a similar frequency among all MPANs, however network-specific ecological attributes were considered at a greater frequency in MPAN with socially-oriented objectives. Results suggest that conservation interventions intended to improve biodiversity would benefit from including societally relevant attributes, improving understanding of social relationships that ultimately influence success.

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 in MPANs with B&S objectives compared to MPANs with solely B objectives. This could be a result of increasing the scope of MPANs to include socially-oriented objectives. For example, MPANs play an important role in providing ecosystem services and managing fisheries (FAO, 2011; Halpern et al., 2010; Leenhardt et al., 2015; Weigel et al., 2014). 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., 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 (Ban et al., 2019; CBD, 2010, Chaigneau & Brown, 2016; Charles & Wilson, 2009; Daw et al., 2015; Gurney et al., 2014; IPBES, 2019; Mace et al., 2012; 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 (Bodin & Crona, 2009; Friedlander et al., 2016; IUCN-WCPA, 2008). However, the literature is short on information about social network features, such as collaborative alliances (see Alexander et al., 2017, Pittman & Armitage, 2017; Wenzel et al., 2019). We hoped our survey would provide more insight on this attribute but found limited consideration in the MPANs we explored. Our study aligns with others that have identified existing assessment tools as inadequate to evaluate economic, governance, social and network-specific ecological dimensions (Moureaux et al., 2018).

Governance attributes such as coordinated management and overlapping jurisdictions are important to the overall success of 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 added attributes include "co-management" which refers to partnership arrangements between several communities and governments. These attributes are complemented by another added attribute, "enabling legislation and strategies", which refer 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). Enabling legislation also 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 considered infrequently and generally were not perceived as important to overall effectiveness. Anticipated economic benefits associated specifically with MPANs are attributed to collaborative partnerships that share administrative responsibility or economic and human resources that aim to reduce the economic burden on individual sites (Lowry, 2009; Nelson et al., 2018). Additionally, recent discourse on MPANs has focused on the equitable distribution of benefits and costs in the process of MPAN implementation (Davis et al., 2019; Kockel et al., 2019). The low frequency of consideration for economic distribution corroborates insights from the literature suggesting that issues around economic inequality in conservation are insufficiently evaluated even though its influence on environmental values is well known (Drupp et al., 2018). Funding sustainability, an attribute added by several participants, is the subject of much research and discussion as MPAs generally struggle with budgetary and capacity constraints (Adams et al., 2019; Gill et al., 2017).

We recognize that context plays an important part in the evaluation and understanding of MPAN performance and impacts on ecosystems. As such, one of the aims of this research was to gather a better appreciation about how individuals working in MPANs understand attributes associated with each dimension. We anticipated that participants would add attributes not initially identified in the survey. Therefore, we allowed respondents at ascribe attributes as they deemed appropriate, and not alter these responses based on our own positionality. Many more attributes were identified by participants than are readily available in the literature (e.g., Fox et al., 2014; Meehan et al., 2020), particularly in the governance and social dimensions. While the dimension whereby participants categorized each attribute may not seem intuitive to us, we intentionally left these where they were added, hoping to encourage discussion about context-dependent assumptions and showcase the reciprocal nature of attributes among different dimensions (Sterling et al., 2017). It is important to show the complex nature of certain cross-dimensional attributes, as we saw here.

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 (Gill et al., 2019; Woodhouse et al., 2018) 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 well-known driver of success, and insufficient capacity increases the risk of a conservation intervention failing to meet its objectives (Gill et al., 2017). A major impediment to implementing nuanced approaches to examine and accomplish broad wholistic goals is the need for greater economic, institutional, and individual capacity under constrained circumstances (Fulton et al., 2015; Law et al., 2018; Woodhouse et al., 2015). Our research suggests that MPAN outcomes would benefit from adding measures of network-specific ecological (including but not limited to, comprehensiveness, adequacy, resilience), economic (funding sustainability, income generating activities, and nonmarket values), social (cultural values, opportunity cost), and governance (management capacity, collaborative decision-making, integration) attributes to evaluations due to their perceived levels of importance among survey participants and contribution from the literature. Many of these features can be challenging to measure, taking time and capacity that is already limited, but are necessary to ensure MPANs are performing to their potential (Babcock et al., 2010).

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 UK, USA, Canada, and Australia. This study did not have sufficient data across country incomes to test for an effect on attributes. While a survey is a useful tool to elicit responses from various individuals, it is not capable of reaching practitioners that speak other languages not included in the survey. Additionally, respondents were biased toward academics, our survey had fewer responses from project managers, facilitators, and monitoring specialists. Although we found no differences between responses based on participants roles, this could be an interesting are of additional research to examine whether participants' roles bias how an MPAN is measured. 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 (Grorud-Colvert et al., 2021; Hockings et al., 2006). 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.

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 (Cumming & Allen, 2017; McGinnis & Ostrom, 2014). This study has brought to light the multiple objectives associated with a MPANs, and the potential added benefit of incorporating socially-oriented objectives into MPANs—an increased focus on the social, economic and governance attributes that underpin MPANs ecological success. Strategic focus on key network attributes from each of the four core dimensions, such as connectivity, sustainable funding, 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 (Chaigneau & Brown, 2016; Di Franco et al., 2016; Failing & Gregory, 2003; 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 understanding of MPAN evaluations on the ground and offers insight into the focus of evaluations to improve an intervention's success.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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