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REVIEW SUMMARY

MARINE CONSERVATION

The MPA Guide: A framework to achieve global goals for the ocean

Kirsten Grorud-Colvert*, Jenna Sullivan-Stack, Callum Roberts, Vanessa Constant, Barbara Horta e Costa, Elizabeth P. Pike, Naomi Kingston, Dan Laffoley, Enric Sala, Joachim Claudet, Alan M. Friedlander, David A. Gill, Sarah E. Lester, Jon C. Day, Emanuel J. Gonçalves, Gabby N. Ahmadia, Matt Rand, Angelo Villagomez, Natalie C. Ban, Georgina G. Gurney, Ana K. Spalding, Nathan J. Bennett, Johnny Briggs, Lance E. Morgan, Russell Moffitt, Marine Deguignet, Ellen K. Pikitch, Emily S. Darling, Sabine Jessen, Sarah O. Hameed, Giuseppe Di Carlo, Paolo Guidetti, Jean M. Harris, Jorge Torre, Zafer Kizilkaya, Tundi Agardy, Philippe Cury, Nirmal J. Shah, Karen Sack, Ling Cao, Miriam Fernandez, Jane Lubchenco

BACKGROUND: Marine Protected Areas (MPAs) are places in the ocean that receive protection to safeguard biodiversity from abatable threats. Confusion exists about the definition of "protection" and likely MPA outcomes. This is because not all MPAs are the same. They range from full to minimal protection; some exist only on paper, not in practice. The resulting, understandably divergent outcomes can lead to controversies about effectiveness, undermine confidence in MPAs, and jeopardize conservation goals, including those of the Convention on Biological Diversity and the United Nations (UN) Sustainable Development Agenda. We integrated decades of research to clarify these issues.

ADVANCES: We propose a science-based, policy-relevant framework—The MPA Guide—to categorize, evaluate, and plan MPAs. It complements the well-known International Union for Conservation of Nature (IUCN) Protected Area Categories for management objectives and governance types. Together, these tools enable a comprehensive picture of any MPA.

The guide consists of four elements that define types of MPAs and activities, conditions for success, and likely outcomes. First, the four STAGES of establishment of an MPA are (i) Proposed/Committed, by a governing or other organizing body; (ii) Designated, by law or other authoritative rulemaking; (iii) Implemented, with activated regulations; and (iv) Actively Managed, with ongoing monitoring and adaptive management.

Second, the four LEVELS of protection from abatable activities within an MPA (or MPA zone), based on allowed activities, are (i) Fully Protected—no impact from extractive or destructive activities; (ii) Highly Protected—minimal impact; (iii) Lightly Protected—moderate impact; and (iv) Minimally Protected—high total impact, although still an MPA by IUCN criteria.

Third, to succeed, an MPA should be established and sustained through the enabling CONDITIONS for effective and equitable MPA planning, design, governance, and management.

Fourth, the likely OUTCOMES of an MPA depend directly on STAGE, LEVEL, and CONDITIONS to succeed.

OUTLOOK: The MPA Guide enables smart planning, design, and evaluation of new or existing MPAs by informing decisions about scientific, societal, and policy priorities and facilitates evaluating progress on international conservation targets. The guide draws attention to quality, not just quantity, of MPAs. It points to fully or highly protected areas as having the greatest likelihood of achieving biodiverse and healthy ecosystems, once the MPA is implemented or actively managed, if enabling CONDITIONS are in place. Last, our synthesis also identifies research priorities, including examining MPAs' effectiveness across LEVEL of protection for climate mitigation and adaptation, social change, and comprehensive marine spatial planning. ■

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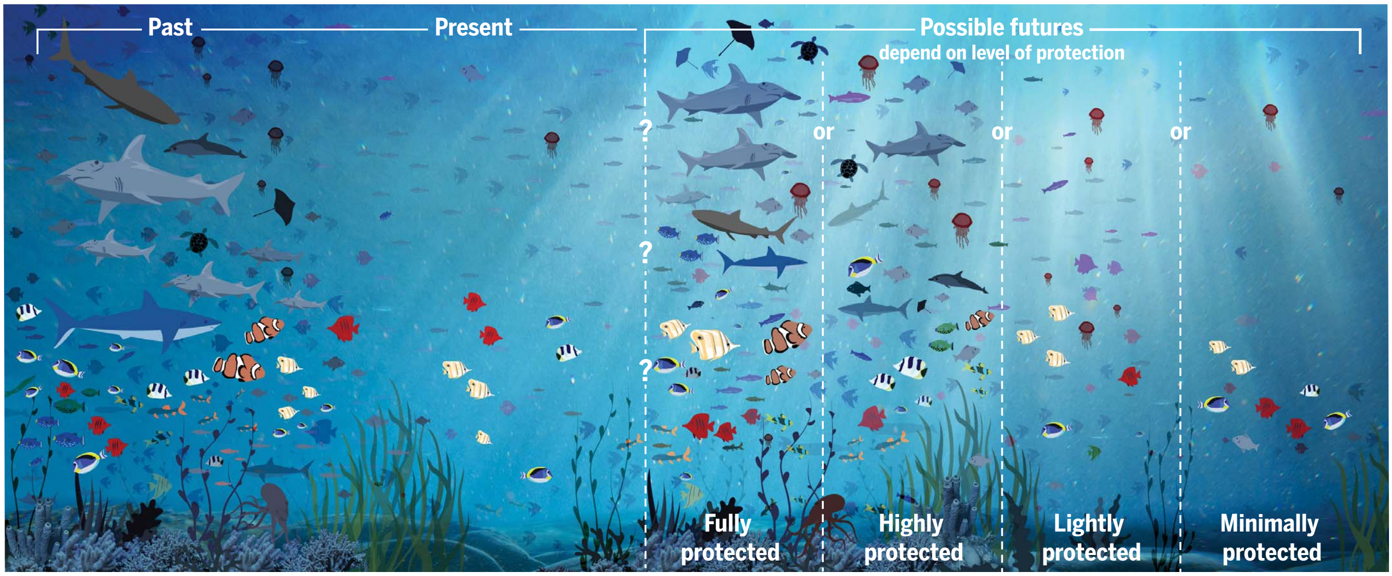

The level of protection, and therefore the effectiveness of MPAs, will greatly influence the future state of the ocean. Past ocean ecosystems were abundant and diverse in species and habitats. Over time, expanded and intensified human activities depleted and disrupted ocean ecosystems and reduced their services. MPAs, in conjunction with climate mitigation strategies and more sustainable uses of the ocean, can conserve and restore biodiversity and the resilient ecosystems needed for human well-being. Different levels of protection will result in different outcomes, if enabling conditions are satisfied.

REVIEW

MARINE CONSERVATION

The MPA Guide: A framework to achieve global goals for the ocean

Kirsten Grorud-Colvert[1]*, Jenna Sullivan-Stack[1], Callum Roberts[2], Vanessa Constant[3]†, Barbara Horta e Costa[4], Elizabeth P. Pike[5], Naomi Kingston[6], Dan Laffoley[7], Enric Sala[8], Joachim Claudet[9], Alan M. Friedlander[10,11], David A. Gill[12], Sarah E. Lester[13], Jon C. Day[14], Emanuel J. Gonçalves[15,16], Gabby N. Ahmadia[17], Matt Rand[18], Angelo Villagomez[18], Natalie C. Ban[19], Georgina G. Gurney[20], Ana K. Spalding[21,22], Nathan J. Bennett[23], Johnny Briggs[18], Lance E. Morgan[24], Russell Moffitt[5], Marine Deguignet[6], Ellen K. Pikitch[25], Emily S. Darling[26], Sabine Jessen[27], Sarah O. Hameed[28], Giuseppe Di Carlo[29], Paolo Guidetti[30,31], Jean M. Harris[32], Jorge Torre[33], Zafer Kizilkaya[34], Tundi Agardy[35], Philippe Cury[36], Nirmal J. Shah[37], Karen Sack[38], Ling Cao[39], Miriam Fernandez[40], Jane Lubchenco[1]

Marine Protected Areas (MPAs) are conservation tools intended to protect biodiversity, promote healthy and resilient marine ecosystems, and provide societal benefits. Despite codification of MPAs in international agreements, MPA effectiveness is currently undermined by confusion about the many MPA types and consequent wildly differing outcomes. We present a clarifying science-driven framework—The MPA Guide—to aid design and evaluation. The guide categorizes MPAs by stage of establishment and level of protection, specifies the resulting direct and indirect outcomes for biodiversity and human well-being, and describes the key conditions necessary for positive outcomes. Use of this MPA Guide by scientists, managers, policy-makers, and communities can improve effective design, implementation, assessment, and tracking of existing and future MPAs to achieve conservation goals by using scientifically grounded practices.

Marine Protected Areas (MPAs) are one of many tools that policy-makers, managers, and communities use to stem the loss of biodiversity, disruption of ocean ecosystems, and the decline of the many benefits provided to people by healthy ocean ecosystems (*1*, *2*). Although most of the ocean used to be a de facto MPA because of limited access, technology has enabled exploitation of almost all of the ocean (*3*). In addition, although there are numerous examples of successful traditional resource management, customary marine governance including the use of closed areas has been eroded in many countries as a result of processes such as colonization and market expansion (*4*). Because degradation, pollution, and exploitation have substantially affected the open ocean, the coast, and adjoining lands (*1*), integrated efforts are urgently needed to make extractive uses sustainable, minimize impact of destructive activities, and expand effective protection of species, habitats, and ecosystem functioning (*5*, *6*).

MPAs by definition prioritize the conservation of nature [International Union for Conservation of Nature (IUCN); (*7*)] and are the primary area-based tool for marine biodiversity conservation. In this Review, we focus only on MPAs because of their prevalence and extensive scientific underpinnings based on decades of tracking and evaluation (*8*, *9*). Other area-based management tools for which biodiversity conservation is not the primary goal are not MPAs, although they may confer some conservation benefit. For example, Locally Managed Marine Areas (*10*) or Fisheries Management Areas (*11*) have different management priorities. If the protection they provide effectively conserves biodiversity, they may qualify as Other Effective area-based Conservation Measures (OECMs) (*12*, *13*). International governing bodies have set global targets for MPAs and OECMs—for example, to protect 10% of the ocean by 2020 [Convention on Biological Diversity's (CBD's) Aichi Target 11 (*14*) and United Nations Sustainable Development Goal 14.5 (*15*)]. Calls are increasing for the more ambitious target of effectively protecting at least 30% of the ocean by 2030 (*16*, *17*).

However, confusion and disagreements pervade many discussions of MPAs and detract from conservation efforts. Quantifying how much of the ocean's biodiversity is effectively protected is challenging. Substantial discrepancies exist over what "protected" means, when to "count" an area as protected, and which types of MPAs achieve the intended conservation goals (*8*, *9*, *18*, *19*). At present, global databases document that a relatively small proportion of the ocean is protected in MPAs. Specifically, at the time of this writing 7.7% of the ocean is self-reported by countries as existing in some type of designated MPA (*20*), but only 5.9% is in MPAs that have been implemented, with likely much less actively managed (*21*). Additionally, not all of the tallied areas in those percentages meet the IUCN definition of an MPA (*7*). The race to simply protect a certain percentage of the ocean could detract from the importance of MPA quality, leading to perverse outcomes from establishing MPAs that are insufficiently protected or not adequately designed to achieve conservation goals (*22*).

Removing confusion around MPAs

We posit that much of this confusion can be resolved by addressing three critical questions.

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(i) What does "protected" mean for biodiversity conservation? Even under the IUCN definition, the "protected" in "marine protected area" encompasses numerous levels of protection with an almost endless variety and combination of activities that are allowed or not allowed and, consequently, lead to a wide range of impacts on biodiversity (*8*, *23*). As a result, the ecological and social outcomes expected from MPAs, or a zone within an MPA, vary widely [for example, (*18*)]. Clarifying why MPAs differ from one another and which types will deliver specific desired outcomes is essential to help evaluate whether any given MPA is set up with the appropriate protection to achieve its aims.

(ii) When should an MPA count as effectively protected? There are many steps in the process to create an MPA. Global tallies differ from one another in part because they use different criteria to count MPAs [for example, (*20*, *21*)]—for example, when it is proclaimed in law versus when it is implemented in the water. This disparity becomes problematic when some MPAs are counted as achievements toward global targets but no real protection is in place in the water (*24*). There is a need to track all stages of MPAs and clarify that biodiversity protection is not expected to begin until the MPA rules and regulations are in place and active.

(iii) What is needed to achieve effective ocean protection? To prevent overestimation of how much ocean is actually protected (*9*, *19*, *25*, *26*), knowledge of the total MPA coverage across different levels of protection is needed at the global scale. This requires assessment of the number, area, and impact of MPAs to ensure these are sufficient to achieve local, national, or international goals for healthy, productive, and resilient ocean ecosystems that support biodiversity and sustainable use (*27*).

A new framework to understand protected areas in the ocean

With input from diverse global collaborators, we reviewed MPA science and its implications for global biodiversity conservation targets to develop a multidisciplinary, collaborative scientific synthesis that addresses the above three questions. We present our findings as a new framework called The MPA Guide. This guide organizes MPAs according to stage of establishment (STAGE) and level of protection (LEVEL), defined below. We then link these MPA types to measured outcomes (OUTCOMES), on the basis of the enabling social and ecological conditions (CONDITIONS) that research shows are key to an MPA successfully achieving its goals.

This guide strategically complements the IUCN Protected Area Categories, an existing framework that categorizes areas by their management objectives and governance types [IUCN (*28*)], but not by STAGE or LEVEL of protection. Together, the MPA Guide and the IUCN Categories provide a comprehensive picture of an MPA. This guide helps to consolidate and advance the reporting framework of United Nations Environment Programme (UNEP)–World Conservation Monitoring Centre (WCMC) World Database on Protected Areas (WDPA) and the IUCN MPA Standards (*7*), which summarize and distill approved motions by the global conservation community in past World Conservation Congresses. As long as an MPA (or zone within a multizone MPA) meets the IUCN definition of an MPA (*7*), it will fit into one STAGE of establishment and one LEVEL of protection at any point in time.

Stage of establishment (STAGE) and when to count an MPA

MPA establishment generally occurs as a series of steps by governing or other authorities on the basis of their local and national context. This guide specifies minimum criteria for an MPA to achieve each STAGE and provides guidelines for best practices (STAGES Expanded Guidance) (fig. S1). In some cases, it may take several years between an announcement of intent to create an MPA to the time when in situ protection and management occurs. In other situations, an MPA may be designated and implemented simultaneously if the announcement has legal authority and a management plan. Below, we describe each STAGE and provide examples.

At STAGE Proposed/Committed, the intent to create an MPA is made public. An MPA must be announced in some formal (although nonbinding) manner by means of a statement by a government, community, conservation organization, or other organizing group—for example, through an international meeting, a press release, or online. The MPA site must be identified, ideally with clear goals and informed by stakeholder and rights-holder participation, and that of Indigenous or other local peoples, and scientific knowledge of the social-ecological context. At the time of this writing, two examples of proposed/committed MPAs are in the East Antarctic (*29*) and in the Weddell Sea (*30*), where potential MPAs are currently under consideration by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).

At STAGE Designated, the MPA is established or recognized through legal means or other authoritative rulemaking. A designated MPA must satisfy three minimum criteria: (i) defined boundaries, (ii) legal gazetting or equivalent Indigenous or traditional authorization or customary recognition, and (iii) clearly stated goals and process to define allowed uses and associated regulations or rules to control impact. MPA boundaries (including zones within the MPA) are ideally published, unambiguous, and known to local users. A designated MPA should have a database ID number in the WDPA that signifies official recognition of the MPA. The MPA should be long term; for example, it should not have a sunset clause or review process that allows for rescinding protection in less than 25 years (*7*). As an example, Seychelles recently legally designated 30% of its ocean territory as an MPA network, which is currently in the process of being implemented (*31*).

MPAs that are proposed/committed or designated are not yet implemented with changes in activities and thus will not accrue biodiversity conservation benefits. Protection does not begin until implementation. MPAs that are designated for an extended period of time without being implemented are often referred to as "paper parks." These situations may reflect a lack of capacity and support (*24*).

At STAGE Implemented, the MPA has transitioned from existence "on paper" to being operational "in the water," with management plans activated. Biodiversity conservation benefits begin to accrue at this stage, not before. Resource users are aware of the rules, and mechanisms to promote compliance and enforcement exist. Plans for regulating MPA activities are in place. Stakeholders are engaged, users are aware of regulations, financial and human resource management systems are established, and performance measures are part of a plan to evaluate and monitor the MPA. Ideally, governance and administrative structures for management, implementation, and sustainable financing are specified (such as in management plans). Zones and their goals should be described, if applicable [for example, (*32*)]. A management body should exist to implement and review plans. For example, Niue's Moana Mahu MPA is implemented (*33*) and includes 40% of the exclusive economic zone (EEZ) as fully protected, with enforcement activities underway, partnerships in place, and ongoing stakeholder engagement.

At STAGE Actively Managed, MPA management is ongoing, including monitoring, periodic review, and adjustments made as needed to achieve biodiversity conservation and other ecological and social goals. All necessary MPA management activities for sustained functioning and achievement of goals continue. The MPA management authority documents, monitors, and evaluates MPA outcomes. Adaptive management will lead to adjustments in plans and activities as needed to ensure good compliance, stakeholder and rights-holder collaboration, and achievement of MPA goals. Comprehensive systems exist to evaluate actively managed MPAs, such as the IUCN Green List (*34*) and the Marine Conservation Institute's Blue Parks Program (*35*). Periodic reviews of actively managed areas are based on evaluations of MPA management function such as sustainable financing, staffing, and outreach as well as data collected frequently inside and outside the MPA. These should involve a social-ecological systems approach (36) and ideally the participation of local communities and stakeholders (37). For example, the California network of MPAs established by the Marine Life Protection Act is actively managed and undergoes a systematic and comprehensive periodic 5-year review by using monitoring data to evaluate current management and inform future decisions (38).

Level of protection (LEVEL) for biodiversity conservation

By IUCN's definition, an MPA's primary goal is the conservation of nature (7). Thus, this guide focuses on evaluating protection on the basis of the biodiversity outcomes that different activities at different scales are expected to produce.

Extensive peer-reviewed research shows that MPAs, or specific MPA zones, effectively protect biodiversity if they adequately prohibit extractive and destructive uses [for example, (39–42); a list of others is provided in the supplementary materials, LEVELS Expanded Guidance, and fig. S1] and if key factors for positive desired outcomes are in place (CONDITIONS). It is possible to conserve biodiversity while also balancing sustainable uses (43); assuming full compliance with rules, some extractive and destructive activities may be allowed in an MPA, albeit with conservation outcomes that are likely more limited [for example, (18, 42, 44)].

This MPA Guide describes four LEVELS of protection based on the impact of allowed activities. It incorporates guidance from the Regulations-Based Classification System for MPAs (23) and IUCN's guidelines (7). Impact is determined by activity type, intensity, scale, duration, and frequency relative to biodiversity conservation goals and is described as "none," "low," "moderate," "high/large," or "incompatible with biodiversity conservation" (Fig. 1 and fig. S2). Using this impact scale, a LEVEL of protection can be assigned for any given MPA or zone regardless of location, species, or circumstances. Impacts of certain activities may scale differently considering specific features of an MPA or zone, such as size; for example, distribution of an activity across areas of different sizes may render it high impact in a smaller MPA but moderate impact in a larger MPA. Incompatible activities include industrial extraction such as industrial fishing (for example, vessels > 12 m using towed or dragged gears), oil and gas exploration, mining, or other extremely impactful activities such as fishing with dynamite or poison (supplementary materials, LEVELS Expanded Guidance,

Fig. 1. Level of protection based on maximum allowed impact of seven potential activities in MPAs. An MPA or MPA zone can be categorized into one of four LEVELS of protection: Fully, Highly, Lightly, or Minimally, on the basis of seven types of activities and their impacts (a decision tree approach is available in fig. S2). Dials indicate the scale of impact that may be occurring at a given protection level: none, minimal, low, moderate, or high/large. If impacts are high/large, the site must still provide some conservation benefit to meet the definition of an MPA. If the impact of any of these activities is greater than high, the MPA is incompatible with the conservation of nature (fig. S2). For example, some activities such as mining and mineral and oil prospecting have such a high impact that they are incompatible with biodiversity conservation and should not occur in any MPA; here, the allowed impact of mining is scored as "none" across all four LEVELS.

and fig. S1). Any activity that may be conducted for scientific research purposes in an MPA or zone is subject to the review and approval of the MPA management authority based on its impact.

At LEVEL Fully Protected, no extractive or destructive activities are allowed; all abatable impacts are minimized. Minimizing impacts requires attention to the scale of the protected area and the scale of the activity. MPAs cannot abate or prevent some impacts (such as climate change, coastal urbanization, or pollution), although in certain circumstances, they can enhance ecosystem resistance and resilience (both the ability of the ecosystem to resist impacts of disturbance and to return to a healthy state after disturbance) to some of these threats (*45*). The meaning of other, similar terms such as "strong" or "strict" protection, "marine reserves," or "no-take" areas varies considerably from user to user (*46*). We use and clearly define the term "fully protected" because it encompasses more than just extractive activities and emphasizes the positive intent of the action (compared with "no-take," which emphasizes what is prohibited). Nonextractive low-impact tourism or low-impact cultural activities may be compatible with fully protected areas, provided collective impact is low (Fig. 1 and fig. S2). Potentially impactful activities such as aquaculture are only allowed for restoration purposes and not extraction. Examples include small-scale, decades-old community comanaged MPAs in the Philippines (*47*), large-scale MPAs such as the Palau National Marine Sanctuary [which covers 80% of the country's EEZ (*48*)], or zones within multizone MPAs (*19*).

At LEVEL Highly Protected, only light extractive activities with low total impact are allowed, with all other abatable impacts minimized. Some allow a small amount of subsistence or small-scale fishing with minimal impact, depending on the number of fishers and gear types [up to five or fewer low-impact gears; for example, use by few fishers of highly selective gear such as hand lines or collection by freedivers may be compatible with highly protected status (*23*)]. Allowed activities include low-impact tourism and low-density, unfed aquaculture. Highly protected areas may allow low-impact cultural and traditional activities such as sustainable fishing by Indigenous communities [for example, (*49*)], which are supported by clear property rights affording local stakeholders and rights-holders the authority to govern areas, including restricting exploitation by nonlocal actors (*50*). The 2016 expansion zone of the United states's Papahānaumokuākea Marine National Monument, which allows only low-frequency and low-impact activities, is highly protected (*51*).

At LEVEL Lightly Protected, some protection of biodiversity exists, but moderate to substantial extraction and other impacts are allowed. These MPAs can achieve some protection of biodiversity for certain species or habitats, but the number and impacts of activities allowed are greater than for highly protected areas. A larger number of fishing gear types might be used [10 or fewer (*23*)], or fishing occurs with less selective gear types (such as gill, trammel, or small-scale drift nets). Tourism could have moderate impacts on habitats and species, such as damage caused by high-intensity recreational diving. Aquaculture may occur by means of semi-intensive, unfed methods or small-scale and low-density fed methods. The vast majority of MPAs worldwide are lightly protected or minimally protected (*9*, *19*, *21*) and often attempt to balance biodiversity conservation goals with resource use and development goals. For example, Habitat Protection Zones in Australia's Great Barrier Reef Marine Park are lightly protected because they allow multiple types of fishing (*52*).

At LEVEL Minimally Protected, extensive extraction and other impacts are allowed, but the site still provides some conservation benefit in the area. Extensive extraction and other impacts occur in a minimally protected area, but the area still achieves sufficient biodiversity conservation to satisfy the IUCN definition of an MPA. For example, the area must not allow industrial fishing (*53*). Nonetheless, minimally protected areas are unlikely to deliver substantial biodiversity conservation benefits for nature and people. A recent analysis showed that more than 10 fishing gear types used in an MPA either recreationally or commercially likely leads to large-scale impacts (*18*, *23*). Minimally protected MPAs often allow many or high-impact gear types for extraction and may include medium- to high-density aquaculture and/or large-impact anchoring or infrastructure. For example, the US Hawaiian Islands Humpback Whale National Marine Sanctuary is minimally protected because it allows extensive fishing and anchoring (*54*).

LEVELs of protection are designed to harmonize with and build on, but not replicate, the information provided by the IUCN Protected Area Categories. For this reason, LEVEL in The MPA Guide does not map directly to an IUCN Category. The zones in the Great Barrier Reef (GBR) Marine Park provide useful examples. Some fully protected zones correspond with IUCN Category Ia; for example, the GBR Preservation Zones are "no-go" areas with all extractive and destructive activities prohibited. Other Category Ia areas, such as the GBR Scientific Research Zones, are highly protected with low-impact extractive research and traditional resource use allowed. The GBR Conservation Park and Buffer zones are both IUCN Category IV MPAs, but Buffer Zones are highly protected, whereas Conservation Park zones are lightly protected because of the range of fishing gears allowed.

Within The MPA Guide, LEVEL of protection for any particular MPA, or zone within a multizone MPA, depends on activity types that are explicitly permitted or prohibited by the MPA rules or are based on overlapping regulations for the surrounding area (Fig. 1). Some activity types or impact levels are not explicitly stated in MPA rules and regulations, often because they are not within the management jurisdiction of the MPA authority. In these circumstances, knowledge of whether or not that activity occurs may be used. Because it is the current activities that influence the degree to which an MPA is protecting biodiversity at a given point in time, the assessment of MPA LEVEL should reflect activities actually occurring in the site at the time of reporting, whether or not they are explicitly stated in the management plans.

Seven main types of activities determine LEVEL: (i) mining/oil and gas extraction; (ii) dredging and dumping; (iii) anchoring; (iv) infrastructure; (v) aquaculture; (vi) fishing, whether it is subsistence, professional, or recreational fishing—this activity encompasses extraction of wild fish and other marine species and includes gleaning; and (vii) nonextractive activities, including recreational, traditional, and cultural (supplementary materials, LEVELS Expanded Guidance, and fig. S1). The compatibility of each activity with conservation goals was evaluated through multiple, iterative workshops that used peer-reviewed literature, scientific judgment, expert opinion, and IUCN resolutions and protected area guidance [for example, (*23*)].

This guide does not include every possible activity but provides best practices wherever possible. For example, shipping is not explicitly addressed because the right of innocent passage is mandated under international law and regulated by International Maritime Organization treaties. As a result, it is challenging for an MPA managing authority to restrict shipping movement. Nonetheless, it is recommended that ships with dangerous goods or toxic antifouling chemicals not transit MPAs, and that shipping activity be restricted to shipping lanes to minimize noise pollution and other negative impacts, such as collisions with marine life (supplementary materials, LEVELS Expanded Guidance, and fig. S1) (*55*). Guidance is intended to evolve with new knowledge, activities, and technology. Emerging threats due to electromagnetic fields, excessive or persistent noise, high-energy active sonar, or other technologies not explicitly addressed here are subject to the burden of proof [for example, (*55*, *56*)], meaning that management bodies should receive evidence of their expected impacts before allowing their use and should monitor to assess and actively manage their actual impacts. Impacts should not exceed those associated with a given LEVEL.

Enabling conditions (CONDITIONS) for effective MPAs

MPAs cannot achieve their goals unless key CONDITIONS are in place. These are the conditions by which an MPA is effectively planned, designed, implemented, governed, and managed to achieve desired ecological outcomes and the direct and indirect human well-being outcomes that result. These CONDITIONS may vary in their importance during the process of achieving each of the four STAGES [for example, (*57*–*59*)] (Table 1), but aspects of each apply when moving from proposed/committed to designated [for example, (*60*–*62*)], to implemented [for example, (*34*, *63*)], and to actively managed [for example, (*34*, *63*, *64*)]. They will also vary according to local challenges, opportunities, and resources, requiring engagement in a prioritization process that is specific to each context.

The beneficial governance practices that these CONDITIONS span—such as inclusivity, transparency, and accountability—increase legitimacy, ownership, support, and overall effectiveness of conservation (*65*, *66*). These practices give voice to those who often disproportionately bear the costs of degradation or conservation and identify livelihood support or other strategies to help mitigate impacts and increase benefits. For example, MPAs in the Mediterranean received greater support from community members with transparent decision-making that recognized and strengthened the rights of local resource users (*66*). MPAs that exclude resource users from decision-making and ignore their rights and livelihood dependencies can erode their well-being and undermine compliance. In Mnazi-Bay, Tanzania, exclusion of resource users from

Table 1. Enabling conditions for effective MPAs. These CONDITIONS may vary in their importance during the process of achieving each of the four STAGES.

Enabling conditions across all stages of establishment	• Clearly defined vision and objectives • Long-term political will and commitment • Sustainable financing • Public participation with contextual and procedural fairness • Evidence-based decision-making • Knowledge integration, e.g., across academic disciplines, local, Indigenous, practitioner domains • Coordination with related governance institutions • Collaboration across jurisdictions	• Transparency and communication • Upward and downward accountability to legal mandate and to stakeholders • Recognition and support of existing governance by Indigenous peoples and local rights-holders, including sovereignty, self-determination, and rights of access, use, and management • Conflict resolution mechanisms
Enabling conditions from Proposed/ Committed to Designated	*All the Enabling Conditions above, plus:* Ecological design principles: • Viability based on MPA location, size, spacing, shape, and permanence • Representativeness and replication of habitats • Incorporation of habitats and species of unique conservation value • Design for connectivity and resilience • Precautionary approach considering current and emerging threats • Consideration of existing threats and mitigation	Social design principles: • Inclusion of social objectives for multi-dimensional human well-being • Recognition of pre-existing rights, tenure, uses: extractive and non-extractive • Consideration of pre-existing resource use and socio-economic status • Accounting for unequal costs and benefits to different social groups • Impact- and benefit-sharing with distributional fairness
Enabling conditions from Designated to Implemented	*All the Enabling Conditions above, plus:* • Sufficient and properly organized staffing and funding • Appropriate and adequate administrative structures and processes • Stakeholder engagement plan	• Compliance and enforcement (including graduated sanctioning) • Education and outreach initiatives • Clarity of rules, rights, and boundaries
Enabling conditions from Implemented to Actively Managed	*All the Enabling Conditions above, plus:* • Ongoing monitoring, evaluation, and knowledge sharing • Adaptive management • Support for livelihoods, e.g. development programs, capacity building, hiring • Effective management of broader seascape and external pressures	• Ongoing efforts to build trust, strong local leadership, partnerships with local users • Local collaboration in monitoring, enforcement, and management • Ongoing consideration of cultural values, traditions, and activities in site management

the MPA process led to negative social outcomes, including increased food insecurity, violent conflict, and lower educational outcomes (67).

Linking MPA goals to measurable outcomes: Achieving ocean protection

We integrate peer-reviewed scientific literature and expert working group products to link STAGE and LEVEL with the ecological and social OUTCOMES expected from different types of MPAs. If biodiversity is conserved, an MPA would be considered successful at meeting its primary goal. However, this does not preclude other outcomes from also occurring and producing benefits, including those for human well-being. Once an MPA is implemented with CONDITIONS in place, it can lead to interrelated ecological and social outcomes based on LEVEL of protection.

Ecological outcomes of MPAs

Thousands of MPA studies document the ecological effects of MPAs across almost all ocean regions and seas, demonstrating that MPAs are an effective tool to conserve biodiversity and improve ecosystem functioning (Table 2; expanded references are provided in table S1). Outside their borders, MPAs can also enhance fish stocks through egg and larval export and spillover of juveniles and adults to areas outside the MPA boundaries (68). Interconnected networks of MPAs are expected to deliver scaled benefits (69). Highly mobile species and those with very large home ranges may receive lower benefit levels from MPA protection than that of more sedentary species, unless MPAs are larger or dynamic with mobile boundaries (70, 71) or they protect critical life stages [such as spawning aggregations, nursery or feeding grounds, or migration bottlenecks (72, 73)]. Long-ranging species require well-designed MPA networks and effective management outside MPAs (74).

Research is often biased toward ecological and fisheries responses to MPA protection [for example, (75)] because these are related to the biodiversity conservation goals of MPAs (7) and the main impact that MPAs abate (fishing). However, other benefits are possible (Table 2 and table S1). Water quality can

Table 2. Ecological OUTCOMES of MPAs as a result of LEVEL of protection. The outcomes discussed here assume that best practices in CONDITIONS have been met and that the system has had time to progress from a degraded state to one with relatively few fluctuations. Not all OUTCOMES can be expected from all MPAs because they vary by habitat type, oceanographic conditions, and previous state of degradation. Levels of confidence are indicated with shaded circles; the darker the circle, the higher the confidence, either high, moderate, or low confidence. Confidence level represents expert judgments based on the quantity and quality of research available. Citations are available in table S1.

	Outcome	Level of Protection: Fully	Highly	Lightly	Minimally
Biodiversity conservation	Abundance	High	High	High	High
	Population age structure	High	High	High	High
	Biomass	High	High	High	High
	Species richness (no. of species)	High	High	High	High
	Reproductive output and replenishment	High	High	High	High
	Connectivity of populations	High	High	High	High
	Rare and endangered species protected	High	High	High	High
	Genetic diversity	High	High	High	High
	Habitats	High	High	High	High
	Ecosystem functioning	Moderate	Moderate	Moderate	Moderate
	Ecosystem resilience (ability to recover after disturbance)	Low	Low	Low	Low
Effects on exploited species	Spillover	High	High	High	High
	Larval export	High	High	High	High
	Insurance against management failure or stock collapse	Moderate	Moderate	Moderate	Moderate
	Protection of vulnerable life stages	High	High	High	High
Water quality	Eutrophication .	Low	Low	Low	Low
	Pathogens and pollutants	Moderate	Moderate	Moderate	Moderate
	Suspended sediment	Low	Low	Low	Low
Climate resilience	Carbon	Moderate	Moderate	Moderate	Moderate
	Acidification	Low	Low	Low	Low
	Productivity	Low	Low	Low	Low
	Coastal protection	High	High	High	High

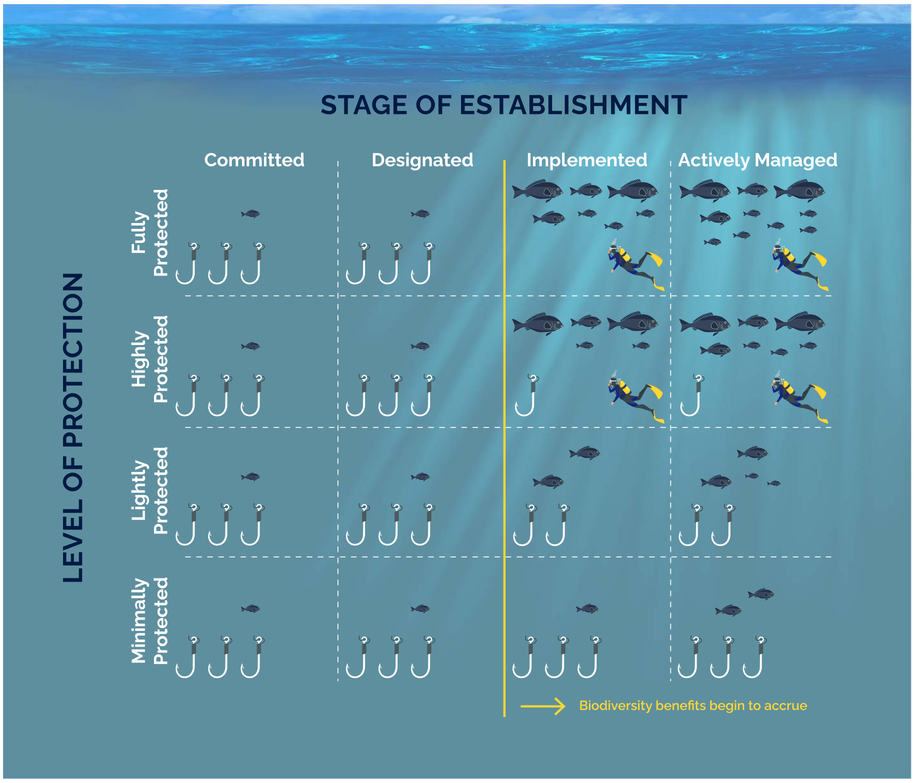

Fig. 2. Matrix based on LEVEL of protection and STAGE of establishment of MPAs. Any MPA or MPA zone sits in one of the 16 cells in this matrix according to its LEVEL and STAGE, and global area of ocean protected in MPAs can also be tallied by each matrix cell. Hooks indicate extractive use; divers indicate recreational, traditional, and cultural use; and fish indicate biodiversity outcomes. As long as CONDITIONS are in place, the OUTCOMES of an MPA will depend primarily on its protection LEVEL and STAGE, as depicted (other factors such as state of ecosystem degradation before establishment of the MPA may also enhance or reduce outcomes). Protection does not begin until an MPA is implemented or actively managed. The most effective biodiversity conservation OUTCOMES from an MPA are likely in the top right quadrant of this matrix, where MPAs are fully or highly protected and implemented or actively managed. In considering the global area protected, a larger percentage in the top right quadrant would indicate more effective protection than that of a larger percentage in the bottom left quadrant.

improve if MPAs restore and recover vegetated habitats and filter-feeding bottom communities (*76*). Evidence is accumulating that MPAs can enhance mitigation, adaptation, and resilience to climate change (*45*, *77*, *78*). Protecting "blue carbon" habitats can preserve their ability to provide carbon sequestration and coastal protection, particularly if supplemented by restoration (*79*).

In well-managed MPAs, ecological benefits relative to surrounding unprotected areas are more prominent where species have previously been depleted, particularly by factors that can be managed or excluded. Substantial prior habitat damage or human impacts outside MPAs can slow recovery (*65*). In more intact areas, protection can guard against future losses (*80*). Threats that cannot be abated by protection may reduce benefits, especially in the short term. However, protection may partially mitigate some of these impacts by protecting functioning ecosystems, boosting resilience, and hastening recovery (*45*, *81*, *82*). Extractive activities displaced by protection may lead to impacts outside MPAs, underscoring the need to integrate MPAs into comprehensive marine spatial planning to ensure that damaging activities are not displaced onto more sensitive habitats or the ranges of more vulnerable species.

Whereas some benefits occur quickly after protection, others can take decades. Species respond to protection at different rates depending on factors such as life history characteristics, behavior, depletion at the time of protection (such as for fished species), and other human impacts (*40*). Early results often include increases in species already common within the MPA, but as time passes, such benefits also include increases in rare and vulnerable species, reestablishment of natural population age structure (especially for long-lived species), and recovery of degraded structural ecosystem elements and habitats (*83*). The Outcomes in Table 2 assume that adequate protection has been in place long enough for effects to develop.

Recovery is more likely, faster, and more complete at the higher LEVELS of protection: Positive ecological outcomes are more substantial and less variable in fully and highly protected areas than in lightly and minimally protected areas (Table 2) [for example, (*18*, *23*, *84*)], with greater potential for ecosystem restoration when areas are fully protected (*85*). In protection levels with more activities occurring, management often addresses competing or conflicting uses of an area and may advantage certain groups of users (such as small-scale or recreational over larger commercial fishers). Decisions about the appropriate protection LEVEL will depend on conservation and management goals, social context, and CONDITIONS, which enable OUTCOMES (Table 1). For example, poorly designed, managed, and resourced MPAs, with low compliance and staff, will deliver fewer benefits (*57*, *86*), and a highly protected area could produce better outcomes than those of a fully protected area if it has stronger enabling conditions.

Social outcomes of MPAs

MPAs can directly and indirectly affect all aspects of human well-being [social, health, culture, economic, and governance (*87*)] for different rights-holders and stakeholders (such as Indigenous peoples, fishers, tourism operators, and coastal residents). When key CONDITIONS are in place, positive benefits of MPAs can be enhanced, and negative impacts can be minimized. A recent comprehensive review found that about half of all documented human well-being outcomes of MPAs were positive and about one-third were negative, with the remaining showing no change or change that was not attributable as positive or negative (*88*). Common positive outcomes were community involvement, increased catch per unit of fishing effort (CPUE), and higher income, whereas negative outcomes commonly manifested through increasing costs of activities (fishing) and conflict (*89*). Both positive and negative impacts can occur at the same time [for example, (*90*, *91*)]. Four MPAs in Indonesia had positive effects on material wealth and scientific environmental knowledge but negative effects on perceived well-being, fish catch, and marine resource control (*92*).

Direct effects of MPAs on human well-being can be immediate owing to changes in access or decision-making (*93*). For example, discussions about whether to have MPAs, where to place them, and what management measures to include can directly affect levels of conflict, perceptions of procedural fairness, access to resources and incomes, and sense of agency in resource management, either negatively or positively (*94*, *95*). Indirect effects also occur through subsequent management actions and ecosystem changes, including altered catches, CPUE, and income from resource extraction or nonextractive activities (65, 96, 97). Such effects are the most common positive MPA outcomes for human well-being; the timing of these outcomes varies according to ecological recovery rates. Both direct and indirect effects may shift over time [for example, (92)]; negative impacts on the fish catch for certain commercial fishers increased over 4 years in two MPAs in the Gulf of Mexico (98).

The effects of MPAs can vary substantially across and within stakeholder groups depending on previous rights, dependence, and uses (99, 100) and across the broader social-ecological context (100, 101). Differential MPA effects have been examined most commonly for fishers, particularly by fishing method (such as commercial or artisanal and use of different gear types) (88, 90). This variability can depend on level of resource dependency [such as dietary dependency or livelihood diversity (102, 103)], ability to adapt to changes [such as fishing areas or jobs (94, 103, 104)], involvement in MPA establishment processes [for example, (65)], and other sociocultural characteristics that structure society [such as age, gender, and ethnicity (92)].

The direction and strength of MPA impacts on different societal groups can also change temporally [for example, (100)] and can affect power dynamics within coastal communities as some members of the community benefit and others are excluded [for example, (99)]. Individuals from marginalized groups with high resource dependency and low adaptive capacity often bear disproportionate costs (67, 105), particularly when excluded from decision-making processes (104). Alternatively, if protection strengthens local community property rights and excludes outside users, and/or provides economic benefits (such as from tourism), an MPA may benefit local communities. Achieving more positive outcomes requires attention to the MPA goals and the CONDITIONS during all STAGES to support stakeholders and rights-holders; the contribution of marine ecosystems to their wellbeing, including livelihoods; and long-term MPA functioning (Table 1).

Protection LEVEL influences all indirect social impacts but only some direct impacts. A higher LEVEL of protection can generate greater recovery of socially, culturally, and economically important species or habitats, especially over the longer term (an indirect impact). Such protection could also increase the likelihood of conflict resulting from fishers being displaced but may not change other direct effects (such as empowerment in decision-making). In some cases, lightly or minimally protected areas may meet the needs of the local community, at least in the short term. Overall, when key CONDITIONS are met (such as long-term protection or high levels of compliance) (Table 1), fully and highly protected areas are associated with more positive outcomes (88), aligning with the positive outcomes found in ecological studies [for example, (106)].

Moving forward with clarity and transparency

Existing international targets highlight the key role of MPAs in conserving biodiversity and supporting a sustainable ocean economy—the blue economy. Achieving these goals has become even more important because of escalating threats to ocean biodiversity and ecosystem functioning (1, 5) and the disproportionately large impacts of the COVID-19 pandemic on near-shore communities (107). We argue that three key actions using this framework would strengthen MPA understanding and use at local, national, and global scales.

(i) Incorporate STAGE of establishment and LEVEL of protection into global reporting on progress toward international targets. The WDPA (20) reports on progress toward the 10% Aichi Target 11 and will report on the subsequent Post-2020 Target yet to be adopted by the CBD at the time of this writing. The WDPA is mandated to report designated MPAs (combined with implemented and actively managed areas) in their tally of total protected area worldwide and does not track LEVEL of protection. Tracking STAGE and LEVEL—for example, by using them as indicators of progress toward the future CBD Target—provides a full matrix evaluation (Fig. 2) of MPA quality and thereby moves global assessment of protection beyond a single percentage metric. This matrix approach may be similarly useful for OECMs and terrestrial protected areas.

(ii) Use this framework to identify immediate opportunities to strengthen existing or to create new MPAs. An urgent need to recover ocean health and concomitant benefits to people means that high-priority and ample pay-off opportunities exist to create new MPAs and to strengthen the level of protection and compliance for existing MPAs. Doing so was one of the Ocean Panel's five immediate action opportunities for COVID-19 recovery (107). The MPA Guide can help local, regional, and national bodies develop, implement, and manage new and existing MPAs.

Recognizing the distinct STAGE of an MPA can help MPA agencies and those working in civil society to progress an MPA to the next step—for example, by thinking through and addressing capacity constraints such as lack of financial, social, and scientific capital. When developing a new MPA, decision-makers and managers can also assess different protection LEVELS and their expected outcomes when deciding which activities to allow. A review of the rules and regulations in existing MPAs and how they map to protection LEVELS can help to determine whether these activities are consistent with desired ecological and social outcomes. Indonesia recently underwent an evaluation of their MPAs by STAGE and LEVEL, highlighting the impressive resource and capacity the country has invested toward active management while also identifying MPAs that may require increased protection to achieve their goals (108). At a regional level, we can track how much of an ecosystem or habitat type is in each LEVEL of protection and identify sites in need of increased protection for biodiversity (19). Identifying how much ocean is still in proposed/committed or designated MPAs shows what has been promised for protection but is still in need of further action to implement [for example, (109)].

(iii) Develop research agendas to link MPA protection LEVEL, CONDITIONS, and OUTCOMES. Although some types of MPAs have been studied for decades, two paths forward are required in a new era of MPA research. First, datasets should be organized around the protection provided by different MPAs in different LEVELS. Most existing ecological research lumps MPAs into fully protected areas and "partially protected" areas, the latter of which combines highly, lightly, and minimally protected [for example, (42, 44, 84)]. Combining these levels limits our ability to understand and predict OUTCOMES (Table 2) and to assess trade-offs to biodiversity conservation and trade-offs among different stakeholder groups. Explicit research across these three levels of protection is now possible by using this framework.

More research is also needed to better understand MPA effects on specific social outcomes, across different societal groups (such as gender, age, and ethnic groups), and over time (88, 90). Research should expand geographically to assess how MPAs affect the multiple dimensions of human well-being in diverse contexts (36, 88, 90) and should use an impact-evaluation lens, including rigorous counterfactual study designs (37, 92) in qualitative as well as quantitative studies (88). Further research is also needed to better understand the CONDITIONS as they relate to an MPA's STAGE and LEVEL of protection, and the specific aspects of MPA planning, governance, and management that produce positive or negative outcomes for equity (110) and other dimensions of human well-being.

Conclusion

The stakes have never been higher for connecting MPA science to policy and action. Development of the new CBD and other MPA goals and targets requires improved clarity and harmonization to be effective from local to global scales. Use of The MPA Guide would shift the conversation from arguments about what MPAs can deliver to answering questions such as, "What level of protection is needed for an MPA to produce the desired outcomes for biodiversity and human well-being?" and "What is the global tally of MPAs by stage of establishment and level of protection, and what does this tell us about progress toward ocean conservation goals?" This scientific synthesis and guide offers a framework, language, and detailed guidance toward doing so.

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SUPPLEMENTARY MATERIALS

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Figs. S1 and S2
Table S1
References (*101–213*)

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