Establishing marine protected areas in a changing climate

Lauren Wenzel, Zachary J. Cannizzo, Fabrice Stephenson, Shane Orchard, Stephanie Clarkson, Emma Wheater, Steffan Howe, Amanda Kirkland, and Danielle Becker

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Establishing marine protected areas in a changing climate

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Cover photo(s): Front: Chumash complete their traditional tomol (canoe) journey to the Channel Islands (a national marine sanctuary). © NOAA/Robert Schwemmer.

Back: Hawaiian monk seal and green sea turtle spending time together in Papahānaumokuākea Marine National Monument, newly designated as a national marine sanctuary in 2025. © NOAA/Mark Sullivan

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A traditional boat in the Batu Islands located off the west coast of Sumatra, Indonesia. Photo © Shane Orchard

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Lauren Wenzel highlighting proactive governance in the Central Arctic Ocean.

Zachary J. Cannizzo on Indigenous-led governance in the Chumash Heritage National Marine Sanctuary.

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Executive summary

Addressing the linked crises of climate change and biodiversity loss is critical to fully realise the contributions of nature in mitigating and adapting to climate impacts and sustaining human well-being. Recognising the vital role of marine protected areas (MPAs), other effective area-based conservation measures (OECMs), and areas conserved by Indigenous peoples in conserving marine biodiversity and its benefits to humans, the Convention on Biological Diversity's Kunming-Montreal Global Biodiversity Framework (GBF) calls for the conservation of at least 30% of the earth's lands, waters and seas, especially areas of particular importance for biodiversity and ecosystem functions and services, by 2030.

This guidance aims to inform the planning, design, and implementation of new and expanded MPAs, OECMs, areas conserved by Indigenous peoples, and networks of protected and conserved areas at the community, national, and international levels. It focuses on why it is important to consider climate change in MPA[1] planning, and how new areas can be established in ways that build climate resilience, adaptation, and mitigation. The audience for this guidance includes relevant government agencies and non-governmental organizations at the national, sub-national, and regional scales, as well as Indigenous peoples and communities. While the focus is on new and expanded MPAs and networks, much of this guidance is also relevant to the climate-adaptive management of existing MPAs. This guidance recognises the broader context of marine spatial planning and ecosystem approaches to management within which MPA networks often operate. It also recognises the wealth of resources already available on implementing climate-adaptive MPAs and provides a brief introduction to these tools and approaches.

The four principles (*understand change, strengthen adaptation and resilience, ensure equity and inclusivity*, and *generate holistic co-benefits)* described in this guidance provide a solid foundation for creating climate-informed MPAs. *Understanding change* requires that managers understand current environmental and ecological conditions and the range of plausible future conditions, as well as climate and non-climate stressors and the interactions between them. This can be achieved through assessments of current conditions and potential vulnerabilities, bioclimatic modelling of potential future scenarios, and by conducting monitoring and evaluation to establish baseline conditions and inform climate-adaptive management as conditions change. *Strengthening adaptation and resilience* includes actions such as establishing climate-smart goals and objectives for MPA networks; designing boundaries that allow for the lasting protection for target ecosystems and features; including ecological connectivity, representativeness, replication and refugia in MPA and network design; and targeting adaptation actions, such as habitat restoration and reducing non-climate stressors in a manner that is forward-looking and responsive to future conditions. *Ensuring equity and inclusivity* is fundamental to all protected area planning and management, but is particularly important as climate change magnifies existing inequities, disproportionately affects marginalized communities, and requires active community engagement for successful adaptation. Finally, *generating*

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[1] While the scope of this report is inclusive of MPAs, OECMs and areas conserved by Indigenous peoples, for brevity, the authors refer to "MPAs" throughout.

holistic co-benefits informs and enables the other principles by focusing on the full suite of climate and non-climate benefits that MPAs can provide and ensuring that these co-benefits, and any potential trade-offs among them, are recognised in decision-making processes.

This guidance also includes case studies that illustrate how these principles are being used to inform real-world examples of MPA establishment and expansion. The Central Arctic Ocean Fisheries Agreement, while not an MPA, demonstrates how countries can take a proactive approach to prohibit commercial fishing in a rapidly changing high seas area to ensure that sufficient science and knowledge are available to guide future management actions (*understanding change*). In Australia, the Central Eastern Marine Park established boundaries that provide ecological connectivity between the nearshore to offshore environments, and from north to south along the East Australian Current to allow for range shifts of habitat and associated populations and species (*strengthening adaptation and resilience*). The Chumash Heritage National Marine Sanctuary in the United States highlights how Indigenous peoples proposed the MPA to protect a highly culturally significant area, and how they will be involved in MPA management through new governance structures (*ensuring equity and inclusivity*). In the Ay and Rhun MPA in Indonesia, planners included "no take" areas and designed for ecological connectivity while also including traditional knowledge and management practices, and on the Kenya/Tanzania border, planners are using tools including Modern Portfolio Analysis and scenario planning to protect diverse and replicated habitats under a range of potential future conditions, and including local and Indigenous peoples in decision making (*strengthening adaptation and resilience; ensuring equity and inclusivity*). Finally, in the United Kingdom, new highly protected MPAs are being established to allow for the protection and restoration of the entire ecosystem, and to provide essential climate-related ecosystem services, such as the ability to provide resilience to climate change, shoreline protection, and food security (*strengthening adaptation and resilience, generating holistic co-benefits*).

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CHAPTER 1.

Purpose

1. Purpose

Recognising the vital role of MPAs in conserving marine biodiversity and its benefits to humans, the Kunming-Montreal Global Biodiversity Framework (GBF) calls for the conservation of at least 30% of the earth's lands, waters and seas, especially areas of particular importance for biodiversity and ecosystem functions and services, by 2030. With current marine protected area (MPA) coverage at 8% of the global ocean (Protected Planet, 2025), and recognition of and reporting on Other Effective Area-based Conservation Measures (OECMs) in very early stages, there is an urgent need and wealth of opportunities for accelerated progress to establish effective and equitable MPA networks by 2030.

The GBF represents a promising commitment of political will, as biodiversity is increasingly threatened by human impacts, including climate change. Climate impacts such as warming waters, sea level rise, changes in ocean currents, changing wind patterns, and changes in frequency and intensity of storms and precipitation, as well as ocean acidification, threaten marine ecosystems in many ways. Over the past 75 years, many marine species across the globe have experienced shifts in geographic range in response to ocean warming and biogeochemical changes (such as oxygen loss), resulting in shifts in species composition and abundance, and impacting ecosystem structure and function (IPCC, 2019). A recent study found that under a high-emissions scenario (SSP5-8.5), 87% of European MPAs and 80% of threatened and commercially important species in those MPAs will be at risk (Predragovic, 2024).

This guidance aims to inform the planning, design, and implementation of new and expanded networks of protected and conserved areas at the community, national, and international levels with emphasis on why it is important to consider climate in MPA planning, and how new areas can be established in ways that build climate resilience, adaptation, and mitigation. The audience for this guidance includes relevant government agencies and non-governmental organizations at the national, sub-national, and regional scales, as well as Indigenous peoples and local communities. While the focus is on new and expanded MPAs and networks, much of this guidance is also relevant to the climate-adaptive management of existing MPAs. Moreover, it recognises the broader context of marine spatial planning and ecosystem approaches to management within which networks of protected and conserved areas often operate. This guidance provides resources and case studies to support the incorporation of climate change management into MPA establishment, including approaches that consider multiple knowledge systems (including Indigenous and traditional knowledge). It also recognises the wealth of resources already available on implementing climate-adaptive MPAs, and provides a brief introduction to these tools and approaches.

CHAPTER 2.

Background

2. Background

Climate change poses significant threats to ocean ecosystems, impacting their ecological, economic, and social dimensions. Rising sea temperatures, ocean acidification, increased frequency of extreme weather events, and other climate change-driven impacts disrupt marine habitats, leading to declines in biodiversity and altering the livelihoods of local communities reliant on these resources. Warming waters, including extreme marine heat waves, cause widespread coral bleaching, contribute to large-scale kelp die-offs, increase vulnerability to disease, facilitate spread of invasive species, deplete ocean oxygen needed by marine species, and create conditions for more extreme storms that threaten coastal communities and ecosystems (Cooley et al., 2022). Sea level rise threatens coastal habitats that may not be able to keep pace with rising waters, as well as impacting species like sea turtles, seals, and seabirds that use coastal areas for breeding and haul-outs. Ocean acidification (like climate change, driven by carbon dioxide emissions) makes it more difficult for some animals at the base of the food web, as well as many larger organisms like shellfish and corals, to build and maintain the protective skeletons or shells they need to survive. While some plants may benefit from the increased carbon dioxide associated with ocean acidification, shell-forming phytoplankton and calcareous algae may experience negative impacts. Ocean acidification can also affect the growth, reproduction, and larval success of species (Talmage & Gobler, 2010), having cascading effects through entire ocean food webs.

MPAs and OECMs play a critical role in mitigating these impacts by protecting vital habitat for marine life, promoting resilience, and enabling ecosystems to adapt to changing conditions. As nature-based solutions, MPAs contribute to climate change adaptation by safeguarding biodiversity and enhancing ecosystem services, which are vital for both environmental health and human well-being. They can also play a role in the mitigation of climate change through the protection of blue carbon and other carbon sinks and reservoirs.

Achieving long-term conservation goals within MPAs is crucial, particularly in the context of a changing climate. The International Union for Conservation of Nature (IUCN) defines “long-term” as the management of protected areas in perpetuity, underscoring the importance of sustained commitment to conservation efforts (Dudley, 2008; Fitzsimmons et al., 2024). This long-term intent must be reflected in concrete actions, such as employing management practices to preserve the integrity of ecosystems and implementing robust monitoring programmes to assess conservation outcomes within these areas. This commitment also extends to privately protected areas (PPAs) and other conservation initiatives, reinforcing the need for comprehensive responses to evolving environmental challenges.

The increasing intensity of ocean use underscores the need for comprehensive spatial planning and ecosystem-based management (EBM). In a broader context, as human activities expand, competing demands for marine resources require thoughtful integration of conservation priorities into marine spatial planning frameworks. The policy landscape surrounding biodiversity conservation is also dynamic, shaped by commitments such as the GBF’s Target 3 (2022), the United Nations Framework Convention for Climate Change Paris Agreement (2015), and the approval of the Biodiversity Beyond National Jurisdiction (BBNJ) Agreement (2023) (Table 2). Other GBF targets, including Targets 1, 2, and 10, are also relevant. In response, there is a need to develop national policies that align climate actions with biodiversity strategies, reflecting the interconnectedness of these issues. It is essential to recognise the distinct roles of policy and management in this context; effective policy frameworks provide the foundation for implementing adaptive management strategies within MPAs and OECMs.

Addressing climate change effectively requires consideration at multiple spatial scales, from large-scale network planning across Exclusive Economic Zones (EEZs) and the high seas to localized, site-specific strategies. Interconnected social-ecological systems at multiple spatial scales, described as panarchy, move through stages of adaptation, change and reorganization (Angeler et al., 2023). This multi-scale approach requires a comprehensive understanding of how different marine areas can be interconnected and managed collaboratively to ensure that both conservation and climate resilience goals are met. By integrating diverse knowledge systems – including Indigenous and traditional knowledge – into the planning and management processes, managing entities can enhance the effectiveness and inclusivity of new and expanding MPAs and networks, ultimately fostering a more resilient marine environment and allowing for adaptation in the face of climate change.

Box 1: Key Terms

Adaptation: the process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities (IPCC). Adaptation can include reorganization and/or transformation in such a manner that allows a system to better meet challenges presented by changing conditions. Adaptation allows a system to “bounce forward,” in the anticipation or aftermath of climate change impacts.

Adaptive management: an approach to decision-making that involves regularly revisiting and adjusting objectives, plans, and actions during implementation to improve management over time and in an uncertain or changing context.

Climate hotspot: an area where climate changes drive the ecosystem towards a new state and/or an area where conditions have or are expected to change more rapidly than surrounding areas.

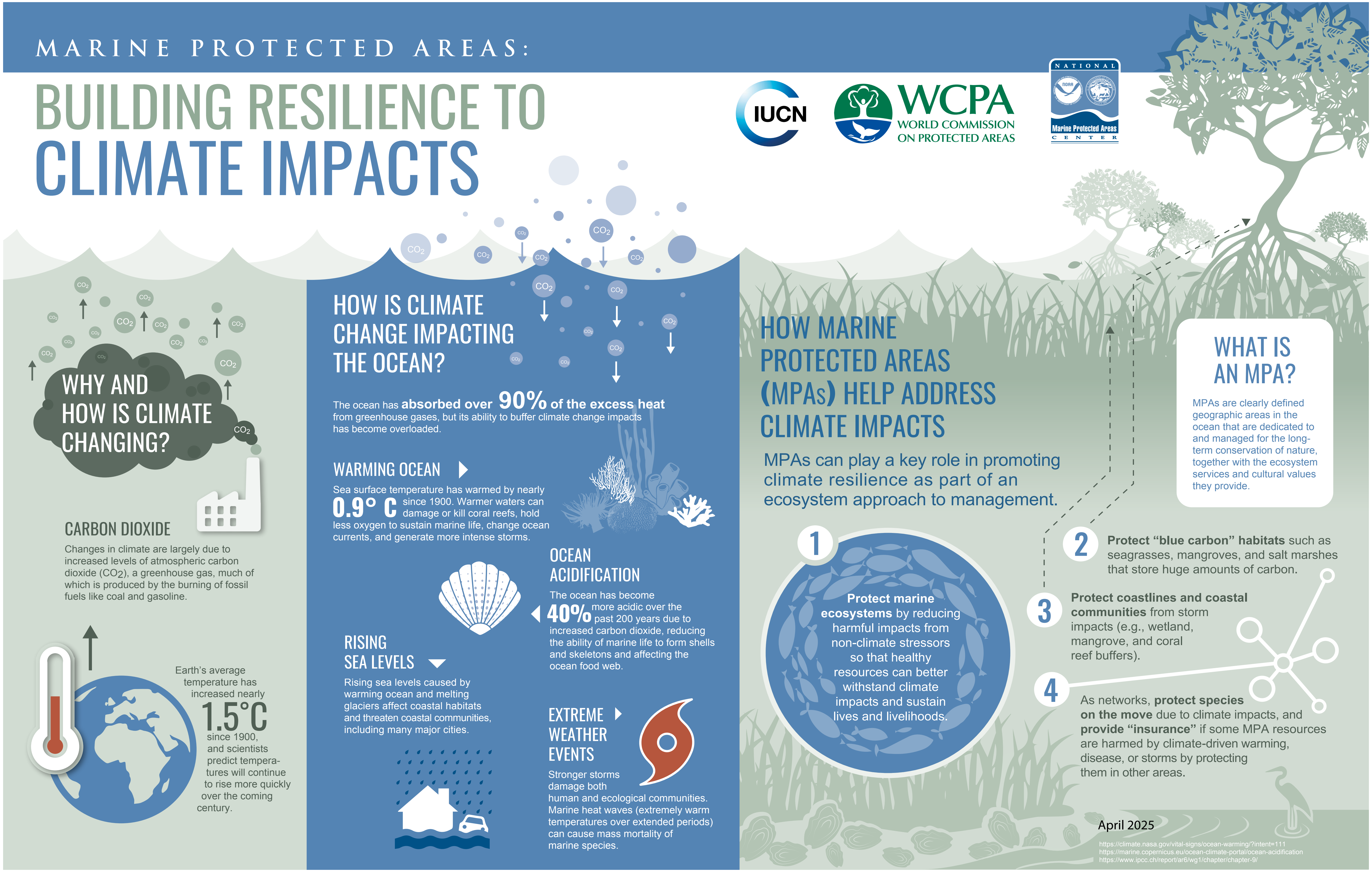
Ecological connectivity: the movement of populations, individuals, genes, gametes, and propagules between populations, communities, and ecosystems, as well as that of non-living material from one location to another

Ecological restoration: the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed. This process often has the goal of producing an ecosystem that is resilient and self-sustaining with respect to structure, species composition and function, as well as being integrated into the larger landscape and supporting sustainable livelihoods (IUCN).

Refugia: (1) Current climate refugia: an area that has and is expected to remain relatively shielded from the impacts of climate change over time and/or where conditions are or are expected to change more slowly than surrounding areas. (2) Future climate refugia: an area where oceanographic processes drive range expansion opportunities that may sustain populations. These areas should be considered for protection as part of a climate-informed MPA network.

Resilience: the capacity of social, economic, and environmental systems to cope with a hazardous event, or trend, or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation (IPCC).

Restoring mangroves adjacent to an offshore wind farm. Photo © Ocean Image Bank/Kim Cuong Nguyen Trang



MARINE PROTECTED AREAS:

BUILDING RESILIENCE TO CLIMATE IMPACTS

WHY AND HOW IS CLIMATE CHANGING?

CARBON DIOXIDE

Changes in climate are largely due to increased levels of atmospheric carbon dioxide (CO_2), a greenhouse gas, much of which is produced by the burning of fossil fuels like coal and gasoline.

Earth's average temperature has increased nearly **1.5°C** since 1900, and scientists predict temperatures will continue to rise more quickly over the coming century.

HOW IS CLIMATE CHANGE IMPACTING THE OCEAN?

The ocean has **absorbed over 90% of the excess heat** from greenhouse gases, but its ability to buffer climate change impacts has become overloaded.

WARMING OCEAN

Sea surface temperature has warmed by nearly **0.9° C** since 1900. Warmer waters can damage or kill coral reefs, hold less oxygen to sustain marine life, change ocean currents, and generate more intense storms.

OCEAN ACIDIFICATION

The ocean has become **40%** more acidic over the past 200 years due to increased carbon dioxide, reducing the ability of marine life to form shells and skeletons and affecting the ocean food web.

RISING SEA LEVELS

Rising sea levels caused by warming ocean and melting glaciers affect coastal habitats and threaten coastal communities, including many major cities.

EXTREME WEATHER EVENTS

Stronger storms damage both human and ecological communities. Marine heat waves (extremely warm temperatures over extended periods) can cause mass mortality of marine species.

HOW MARINE PROTECTED AREAS (MPAs) HELP ADDRESS CLIMATE IMPACTS

MPAs can play a key role in promoting climate resilience as part of an ecosystem approach to management.

WHAT IS AN MPA?

MPAs are clearly defined geographic areas in the ocean that are dedicated to and managed for the long-term conservation of nature, together with the ecosystem services and cultural values they provide.

1 **Protect marine ecosystems** by reducing harmful impacts from non-climate stressors so that healthy resources can better withstand climate impacts and sustain lives and livelihoods.

2 **Protect "blue carbon" habitats** such as seagrasses, mangroves, and salt marshes that store huge amounts of carbon.

3 **Protect coastlines and coastal communities** from storm impacts (e.g., wetland, mangrove, and coral reef buffers).

4 As networks, **protect species on the move** due to climate impacts, and **provide "insurance"** if some MPA resources are harmed by climate-driven warming, disease, or storms by protecting them in other areas.

April 2025

https://climate.nasa.gov/vital-signs/ocean-warming/?intent=111
https://marine.copernicus.eu/ocean-climate-portal/ocean-acidification
https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-9/

Figure 1. Marine Protected Areas: Building resilience to climate impacts. [NOAA/Matt McIntosh, based on NASA, Copernicus and IPCC sources cited in graphic].

CHAPTER 3.

Principles for considering climate change in MPA establishment

3. Principles for considering climate change in MPA establishment

This guidance describes four principles for establishing MPAs in a changing climate. These principles are essential to the long-term success of MPAs through the conservation of biodiversity, and the promotion of adaptation, resilience and mitigation of climate impacts. They build on existing guidance for establishing protected areas (IUCN-WCPA, 2017) and establishing MPA networks by incorporating key principles such as protecting ecologically and biologically important areas, ensuring representativeness, enhancing connectivity, incorporating replication, and including adequate and viable sites (CBD, 2008). These principles also align with the IUCN Green List standard (IUCN-WCPA, 2017), which provides recognition for well-designed and managed protected or conserved areas that achieve ongoing results for people and nature.

The four principles (*understand change, strengthen adaptation and resilience, ensure equity and inclusivity*, and *generate holistic co-benefits)* described in this guidance provide a solid foundation for creating climate-informed MPAs (see Table 1). *Understanding change* requires that managers understand current environmental, ecological, and social conditions and the range of plausible future conditions, as well as climate and non-climate stressors and the interactions between them. This can be achieved through assessments of current conditions and potential vulnerabilities, bioclimatic modelling, and by conducting monitoring and evaluation to establish baseline conditions and inform adaptive management. *Strengthening adaptation and resilience* includes actions such as establishing climate-smart goals and objectives for an MPA (i.e. consider and incorporate climate factors); designing boundaries that allow for the lasting protection for target ecosystems and features (which may include establishment and review of zoning); including ecological connectivity, representativeness, replication and refugia in MPA and network design; and targeting adaptation actions, such as habitat restoration and reducing non-climate stressors in a manner that is forward-looking and responsive to future conditions. *Ensuring equity and inclusivity* is fundamental to all protected area planning and management, but is particularly important as climate change magnifies existing inequities and disproportionately affects marginalized communities. Finally, *generating holistic co-benefits* informs and enables the other principles by focusing on the full suite of climate and non-climate benefits that MPAs can provide and ensuring that these co-benefits, and any potential trade-offs among them, are recognised in decision-making processes. The pillars listed under each principle are strategies that can be used to implement the principles and are noted in italics in this report.

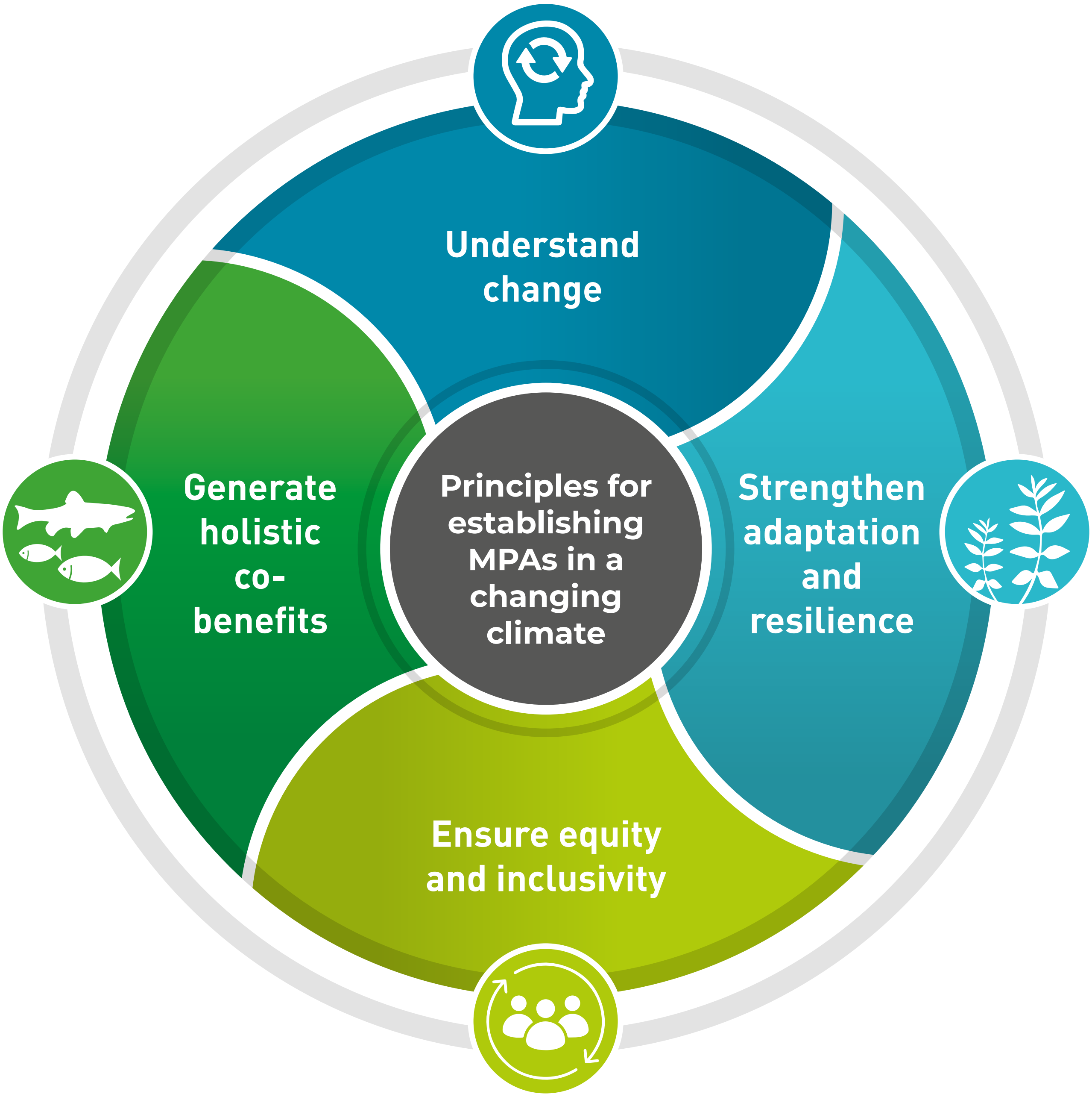


Figure 2. Principles for establishing MPAs in a changing climate (report authors)

Table 1. Principles for establishing MPAs in a changing climate

1. Understand change	2. Strengthen adaptation and resilience	3. Ensure equity and inclusivity	4. Generate holistic co-benefits
Understand and monitor past, current, and future environmental, ecological, and social change to inform marine protected area planning and adaptive management.	Proactively provide effective area-based conservation in a changing climate to support adaptive and resilient ecosystems.	Ensure equitable and inclusive design and management in support of the adaptation, resilience, and wellbeing of human communities, cultural practices, and values.	Safeguard and strengthen climate mitigation, adaptation, and resilience co-benefits, whilst acknowledging the full spectrum of ecosystem services for people.
Supporting pillars			
Establish practices to monitor environmental, ecological, social, and economic conditions to understand change.	Establish conservation objectives and goals that explicitly consider climate change and its impacts on biodiversity over relevant timeframes.	Ensure the early inclusion of diverse communities, peoples, and interests, particularly Indigenous peoples and underserved communities, in design, management, and decision-making processes. Focus on co-development of goals, priorities and methods, by including Indigenous and traditional knowledge and other knowledge systems.	Use community-based participatory methods to establish goals and objectives that explicitly consider climate mitigation, adaptation, and resilience co-benefits, together with biodiversity, social, and economic goals.
Ensure an understanding of environmental, ecological, and social conditions, as well as climate and non-climate stressors, through assessments of current conditions, the range of plausible future conditions, and potential vulnerabilities.	Design boundaries that will provide lasting protection for target ecosystems and features considering and incorporating ecological connectivity, climate refugia, representativeness, and other principles necessary to be responsive to environmental change.	Embed MPA networks within marine spatial planning frameworks to equitably balance multiple cultural, social, and economic uses, and changes to those uses as a result of climate change.	Identify areas, ecosystems, and features that provide nature conservation and climate change mitigation and/or adaptation and resilience benefits across a range of ecosystem services, and designing boundaries and regulations to protect these co-benefits.
Incorporate adaptive measures and strategies into planning, policy, regulatory, and management processes that allow for adaptive and nimble responses to changing conditions.	Establish and implement regulations and non-regulatory programmes that provide lasting protection for target ecosystems and features that are responsive and adaptive to environmental change.	Implement human dimensions research and processes in design, establishment and management to ensure the understanding and consideration of social, economic and cultural impacts of climate change.	Establish policies and regulations to proactively consider established, new, and emerging technologies that do not detract from conservation objectives to enhance climate mitigation, adaptation, and resilience within MPAs and broader seascapes.

Source: Report authors

CHAPTER 4.

Understand change

4. Understand change

Principle 1: Understand and monitor past, current, and future environmental, ecological and social change to inform marine protected area planning and adaptive management.

Environmental monitoring

Understanding past, recent, and current conditions is a key, but often overlooked, aspect of adaptive MPA design. Only by understanding current conditions, while considering what has been typical in the past, can managers truly understand changing conditions and respond appropriately. Managers should *establish practices to monitor environmental, ecological, social and economic conditions to understand change* early in the design and implementation of an MPA or MPA network.

The design and designation process is an ideal time to establish a baseline by gaining an understanding of past and current conditions. This should include the establishment of sustained monitoring, as well as a comparison of past and current conditions to determine if and how they are already changing, and to distinguish the impacts of climate change from other factors. Information on past and current conditions will almost always need to be obtained in collaboration with partners. Common sources of data include hindcasting models, existing social and economic surveys, re-analyses, time series, census data, long-term ecological monitoring, palaeoecological approaches, and historical datasets obtained from existing and sustained monitoring programmes or through Indigenous and traditional knowledge. Such long-term, sustained environmental, social, and economic datasets can be invaluable to discovering changing conditions and informing management decisions.

While invaluable, the sustained, long-term (> 30 years) monitoring datasets ideal for establishing robust baselines are rare, particularly in marine environments. In instances where such data are not available, other sources of information can be leveraged through methods such as hindcasting models and re-analyses to determine baseline conditions, understand if they are shifting, and make MPA design decisions accordingly (Box 2). Methodologies and bodies of knowledge outside of western science can also provide valuable information that can not only fill data gaps but may more accurately reflect past and current conditions and changes than regionally scoped models and methods (particularly when such knowledge is place-based). Key examples include Indigenous and traditional knowledge (e.g. Reid et al., 2021; Gazing Wolf et al., 2024), historical ecology (e.g. Thurstan et al., 2015), and local and user knowledge. Indigenous and traditional knowledge, when shared through collaboration and with informed consent, can be particularly valuable for understanding long-term changes and baselines, as well as underpinning traditional management approaches that may be relevant to climate action (Alexander et al., 2011). Establishing baselines can be critical to understanding change and determining boundaries, policies, and objectives.

Once an understanding of past and current conditions is established, sustained monitoring of environmental, ecological, social, and economic factors within and of relevance to the MPA or MPA network, and use of data to update and improve models, is critical to maintaining adaptability and resilience in a changing environment. Ideally, a diversity of monitoring technologies, from *in situ* buoys to census data and satellite and aerial imagery to regular surveys, would be deployed and leveraged to understand a suite of climate-relevant environmental, social, and economic factors. Establishing such a focused, standardized monitoring programme can help managers understand conditions, and how they may change, over time. In practice, most MPAs do not have the resources and staff to establish and maintain a full environmental, social, and economic monitoring programme. For this reason, leveraging partnerships with other organizations capable of or already undertaking monitoring in and of relevance to the proposed MPA can enable the sustained monitoring necessary to understand change and respond appropriately.

While environmental, social, and economic monitoring should continue to occur after an MPA is established or expanded, considering monitoring objectives, methods, and locations is important to MPA design. Establishing a monitoring programme in founding policies can ensure it is maintained and sustained throughout the life of the MPA while considering monitoring needs and existing infrastructure can influence its design.

Understanding future impacts

In addition to understanding past and current conditions, managers must have an understanding of projected future conditions and the impacts they may have on marine ecosystems when establishing or expanding an MPA. Proactive adaptive management of MPAs in a changing climate requires that managers *ensure an understanding of environmental, ecological, and social conditions, as well as climate and non-climate stressors, through assessments of current conditions, the range of plausible future conditions, and potential vulnerabilities*. It is critical to build the management, planning, and where possible, scientific infrastructure to achieve this understanding from the beginning of the design and implementation of an MPA and its management processes. There are many ways to understand possible futures, from formal, model-derived climate scenarios such as those produced by the Intergovernmental Panel on Climate Change (IPCC) to narrative scenarios developed for a specific location through scenario planning exercises. More important than the form a manager uses to understand possible futures is defining those futures, understanding how they were developed, and ensuring they provide information at spatial and temporal scales of relevance to management decisions and conservation objectives

This requires that managers have access to and are able to understand projections of future change (see Box 2 for an overview of approaches). Ideally, such projections should be tailored to the MPA and provide information at spatial and temporal scales that are relevant to management and decision-making. In practice, managers will likely need to make use of available models and projections. While many environmental models and projections are accessible through the scientific literature and public data dashboards, working with trusted climate science partners can help managers identify the most relevant information, understand what it means for the design and management of the MPA.

Understanding how marine ecosystems, target features, and social and economic systems are likely to be impacted by climate change is a crucial step in successful climate-adaptive management and can help aid in decision making both during and after the design and designation of an MPA. Many strategies and tools can help managers assess the impacts of climate change on key resources. One of the most common is a climate vulnerability assessment (CVA). A CVA is an analytical tool used to identify which resources or target features may be most vulnerable based on their exposure, sensitivity, and adaptive capacity to climate change and other stressors (Cannizzo et al., 2025; Füssel et al., 2006). While there are many methods for conducting a CVA, they all provide information to support management that is proactive and climate-informed (Cannizzo et al., 2023; CEC, 2017; Dudley et al., 2021; Foden et al., 2019). In addition to CVAs, frameworks, and exercises such as foresighting (Kelly et al., 2022) and scenario planning (Haward et al., 2013; Miller et al., 2022; NPS Scenario-Based Adaptation Showcase, 2025) can provide information on potential futures to inform management decisions.

For example, a CVA may determine that a marine ecosystem being considered for protection is particularly vulnerable to a certain climate stressor, warranting enhanced protection and regulation (e.g. through zoning) or boundary designs that ensure sufficient protection of connected populations. For anthropogenic stressors, this information could be used to establish regulations limiting the activity within the MPA while also establishing monitoring for the driving environmental factor and a threshold of change that triggers additional restrictions on the activity if needed. A modelling or scenario planning exercise may determine that an ecosystem may shift geographically, potentially encouraging selection of boundaries that protect areas where the ecosystem does not currently exist, but is likely to in the future. Together, these assessments can help managers better understand the factors leading to potential futures - both environmental and anthropogenic, prioritize management actions that may be the most impactful, and identify thresholds and tipping points leading to potential futures, which can inform management responses.

Adaptive management

Understanding past, current, and future conditions during the design of an MPA allows a strong foundation for managers to *incorporate adaptive measures and strategies into planning, policy, regulatory, and management processes that allow for adaptive and nimble responses to changing conditions.*

Adaptive management is not explicit to climate change, but is rather a practice that recognises choices always need to be made with incomplete information and allows for the ability to adapt as new information arises. This practice is particularly applicable to managing resources under a changing climate. As such, climate-adaptive management recognises that conditions are changing and will continue to do so, and that the management of resources within MPAs will need to change in response to continue to meet conservation objectives. Adaptively managing MPAs under future climate change is not only beneficial, but necessary. Establishing practices for climate-adaptive management into the design and processes of an MPA from the beginning makes this process both easier and more effective (Gross et al., 2016).

There are many climate-adaptive management frameworks, but a shared trait is the need to consistently assess environmental conditions and the efficacy of management actions to be ready to adjust management if and when conditions change or previous actions are no longer effective. The climate-smart planning cycle (Stein et al., 2014; Figure 2) is a general climate adaptation planning and implementation framework that was developed for natural resource management and concisely demonstrates the principles behind climate-adaptive management. As demonstrated by this cycle, management approaches that consider climate adaptation should be built into planning and processes from the beginning. This allows policies, monitoring, and management actions to explicitly consider climate change and the need to be adaptive. For example, regular reassessments of resource condition and management actions should be built into the processes of an MPA from the beginning to allow for regular updates to management in a manner that is nimble and adaptive. Monitoring of adaptation is most effective when framed by explicit goals and evidence-based assessments, which are not always embedded in MPA management (O'Regan, 2021). Building these regular assessments and monitoring procedures into policy and process increases the likelihood that they are conducted in a timely manner, inherently increasing the adaptability of MPA management (IUCN-WCPA, 2023).

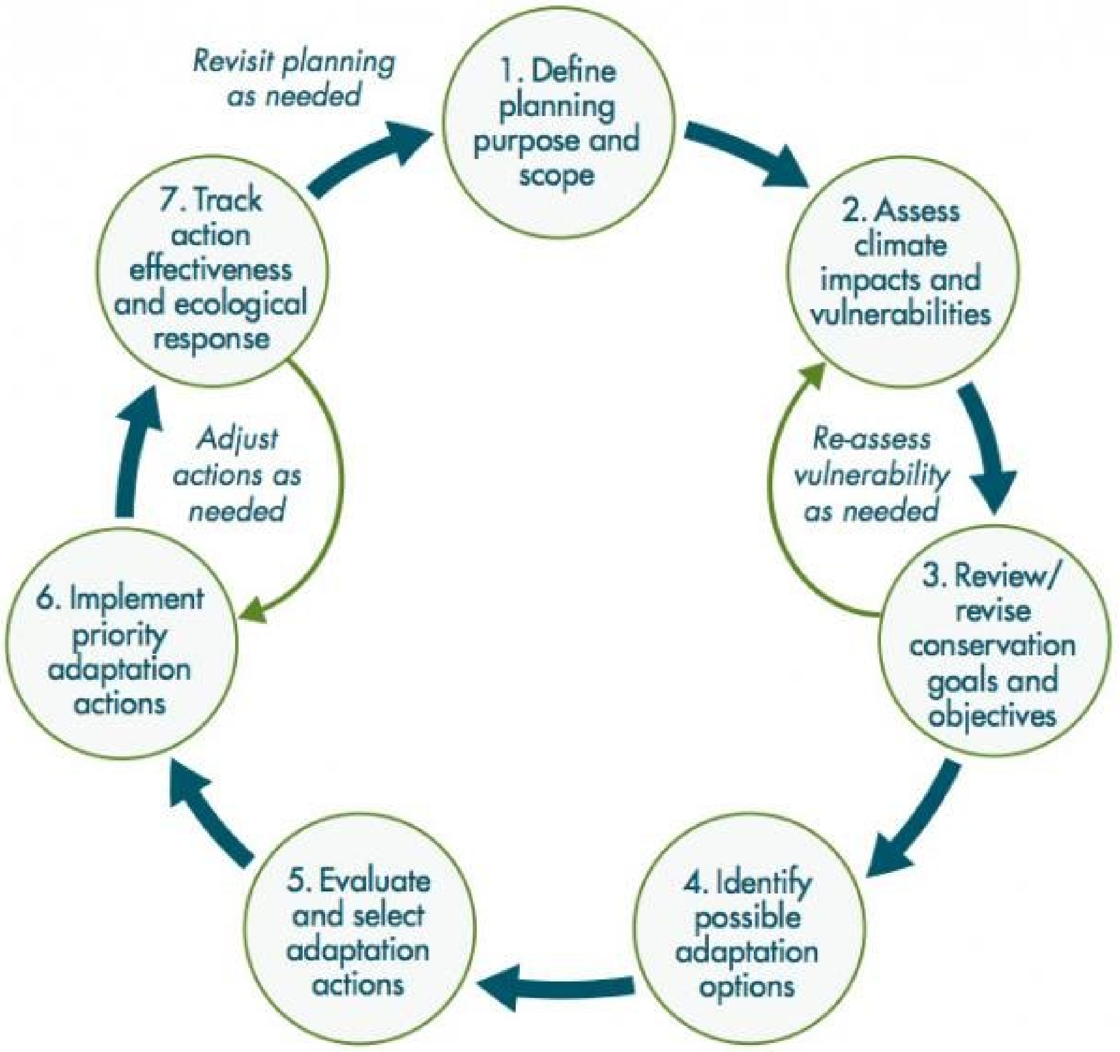


Figure 3. Climate Adaptation Planning Cycle (Stein et al., 2014)

Box 2: Tools for planning MPAs in a changing climate

Biodiversity monitoring and mapping

Monitoring and mapping biodiversity provide both the baseline understanding and ability to track changes that are necessary for effective adaptive management. Establishing biodiversity monitoring early in the MPA design process can ensure that management decisions are informed by a robust understanding of recent and current conditions and trends in species, habitats, and ecosystems of conservation concern. Biodiversity monitoring involves collecting data on species presence, abundance, demographics, and distribution across a geographic area and forms the foundation for creating biodiversity maps as well as helping managers better understand ecosystem health. Biodiversity monitoring can determine the status of biological diversity and assess changes over time and space to inform adaptive management and conservation decisions (Niemelä, 2000; Schmeller et al., 2017; Lindenmayer et al., 2012; Kerry et al., 2022).

Once relevant data is collected (i.e. field surveys, remote sensing, high-resolution acoustic mapping, historical mapping and monitoring, etc.) maps can be created by layering this information into geographic information systems (GIS). Data layers, including species occurrence records, habitat types, environmental variables like temperature and elevation, and human impact indicators, can then be combined and analysed to generate visual representations of biodiversity patterns (see Box 3 for more details) (McCarthy et al., 2021; Brown et al., 2023; Geller et al., 2017). Various techniques have been utilized for mapping and monitoring of biodiversity in real time, including satellite and aerial imagery, active and passive radio detection and ranging (RADAR) systems, light detection and ranging (LiDAR) systems, and molecular techniques (Kerry et al., 2022; Bouvier et al., 2017; Bae et al., 2019; Bakx et al., 2019). These techniques have been used to map mangrove forest biodiversity to infer the presence of specific tree species (Wang et al., 2022), create distribution maps to understand mammal species presence and abundance (Leyequien et al., 2007), and generate maps of marine biodiversity hotspots that combine data on ocean currents, temperature, salinity, and depth with species observation records (Kavanaugh et al., 2021; Robert et al., 2015). These techniques can help researchers and managers identify areas with high species richness, critical habitats, and potential conservation priorities, ultimately informing conservation and adaptation strategies and decision-making. National and regional expert-led processes have been conducted and are ongoing to identify important marine biodiversity areas, including Ecologically and Biologically Significant Areas, Important Marine Mammal Areas, Important Shark and Ray Areas, Important Marine Turtle Areas, and Key Biodiversity Areas (Jones, 2024).

Distribution models

Species distribution models (SDMs) are a commonly used tool for describing spatial patterns of biodiversity based on predictions. They are correlative models that predict the occurrence or abundance of species in relation to spatially continuous environmental variables (Guisan & Zimmermann, 2000). The advent of readily available biological and environmental open-source data, such as the Ocean Biodiversity Information System and Bio-ORALE v3, (Assis et al., 2024), in combination with the development of machine learning approaches, has resulted in increasing availability of predicted species' distributions. These include 12,000 species in European waters (Principe et al., 2024), 980 marine structuring species globally (Gouvea et al., 2024), 600 seafloor species in New Zealand (Stephenson et al., 2023a). SDMs can also support global biogeographical classifications (e.g. Costello et al., 2017). In the UK, the Investigating Climate Change resilience of Vulnerable Marine Species project used sophisticated modelling tools to produce fine scale maps showing the future distribution of vulnerable marine species under different future climate scenarios. The project combined projected future environmental conditions from existing regional climate models with SDMs to identify areas of suitable habitat where the species could live in the future.

Biodiversity projections under future climatic conditions

Marine environmental conditions can be projected using Earth System Models (e.g. Assis et al., 2024) under different climate change scenarios reflecting different levels of social-ecological risk. For example, coastal fringe (e.g. dunes) and blue carbon ecosystems (e.g. mangroves, saltmarsh) are expected to undergo shifts in distribution in response to many climate drivers (Cavanaugh et al., 2019; Lovelock et al., 2017; Wåhlström et al., 2022). These shifts will vary in severity due to complex interactions. For example, changes in sea-level, land motion (i.e. uplift or subsidence), sedimentation or erosion regimes (Lovelock et al., 2011; Orchard et al., 2020; Woodroffe et al., 2016), and the frequency of extreme warming or cold events will all interact to determine the speed and magnitude of the distributional shift (Cavanaugh et al., 2019; Wåhlström et al., 2022). Such shifts have obvious consequences for protected area networks due to their potential to displace ecosystems away from their current locations and existing area-based protections (Thirukanthan et al., 2025).

Linked biological and geophysical models can be used to project species' distributions under these possible future environmental conditions. For example, the distribution of habitat forming deepwater corals in the South Pacific has been predicted to substantially shift in location (Anderson et al., 2022) and decrease in abundance (Zelli et al., 2024) by the end of the 21st century under both moderate and strong increases of greenhouse gas concentration trajectories (i.e. following IPCC's Shared Socioeconomic Pathways SSP2 and SSP3 (Anderson et al., 2022; Zelli et al., 2024)).

However, the ecological impacts of climate change vary based on the breadth of the species' environmental niche, environmental plasticity, and magnitude of environmental change in any given location. This variation is reflected in the projected changes in species' distributions and abundance across climate change scenarios, with different taxa predicted to have more restricted distributions, others predicted to have increased distributions, and some predicted to have mixed responses (i.e. increasing under one possible emissions scenario, but decreasing under another, e.g. Gouvea et al., 2024; Principe et al., 2024; Gordo-Villaseca et al., 2024).

For taxa at the trailing limit of their ranges, changes are often projected to be negative and in many cases severe. For example, Gordo-Villaseca et al., (2024) predicted significant shifts in marine fish communities in the North Atlantic and Arctic Oceans as a result of ocean warming. In particular, projected changes in key fish biomass suggests that Arctic demersal fish may be at risk of local extinction by the end of the century if no climate refugia are available at eastern latitudes. These examples also illustrate the utility of scenario analyses to explore the outcomes of plausible future scenarios that are identified from statistical and/or process-based modelling approaches (IPBES, 2016). Ultimately, such future-looking models, when complemented by other tools, can provide useful information for MPA design and management.

Spatial decision support tools for conservation planning

The practical challenges of selecting areas to conserve biodiversity over extensive geographic areas have led to the development of several computer-based decision-support tools such as Marxan and Zonation (Ball et al., 2009). This software enables the incorporation of thousands of spatial layers and use of algorithms to identify area-based management options that have the highest value for conservation. In addition to accounting for conservation value, other resource uses or values can be included in these models for multi-objective analyses (Moilanen et al., 2022), for example conservation solutions that minimise economic impacts to fisheries (Stephenson et al., 2024). Predicted future species distributions can be used as inputs to these tools to explore the possible effectiveness of MPAs for conserving future distributions, but can also be used in spatial prioritization analyses to identify spatial configurations where existing and future climate refugia can provide the maximum conservation benefit across projected greenhouse gas emission pathway scenarios (e.g. Floridó & Mair, 2024; Queirós et al., 2021).

Given the uncertainty of future climate impacts, the robustness of decision-making can be improved by evaluating the risks and trade-offs associated with different climate scenarios (Kujula et al., 2013). Spatial prioritization tools that account simultaneously for the present and potential future distributions of species can help identify conservation areas that are predicted to be beneficial for protecting species' future distributions without jeopardizing present-day conservation values (Kujala et al., 2013). For example, a study of cold water corals found that when designing protection using current day predictions of suitable habitat alone (the "usual approach"), spatial marine protection was unlikely to provide adequate conservation for deep water-corals in the future due to distribution shifts associated with the multiple impacts of climate change and fishing (Stephenson et al., 2023b). However, analyses that accounted for future distributions of suitable coral habitat, identified areas that may provide climate refugia for corals while still providing efficient protection for current distributions (regardless of the climate change scenario). These results demonstrate that there are considerable risks associated with developing MPAs that do not account for current and future stressors and social considerations of current and future ecological, social and economic values in a combined framework.

Visitors explore Turtle Beach in West Java, a nesting site for green sea turtles protected through a government run turtle conservation programme.
Photo © Shane Orchard

Case Study: Taking a proactive approach to conserving fisheries in the Central Arctic Ocean

About the area

The Central Arctic Ocean is a large marine ecosystem characterised by multi-year pack ice and the species that depend on this important habitat, including whales, seals, polar bears, fishes, invertebrates and algae. While all of the Arctic Ocean is ice-covered in winter, sea ice typically melts away from continental shelves, while remaining in most of the Central Arctic Ocean. September Arctic sea ice -- the time of year with the least ice coverage -- is now shrinking at a rate of 12.2% per decade, compared to its average extent during the period from 1981 to 2010 (Figure 4). Arctic sea ice is now the youngest and thinnest since scientific records began about 70 years ago, prompting concerns about the potential for increased unregulated access to this fragile ecosystem as a result of climate change.

Arctic sea ice is rapidly melting, changing access to this remote area. Photo © NOAA.

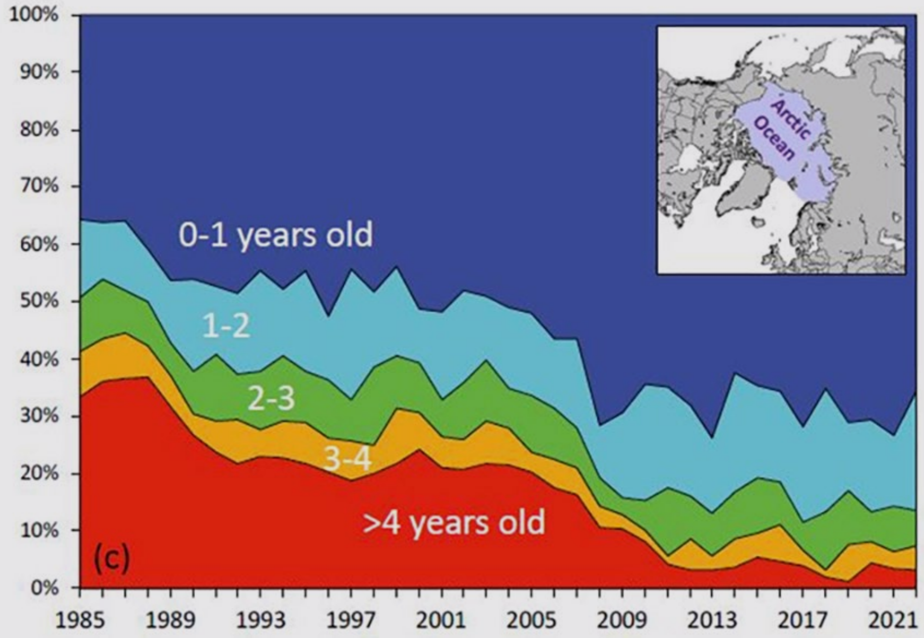


Figure 4. Sea ice age percentage within the Arctic Ocean for the week of 11-18 March 1985-2022 (NOAA)

Climate change considerations

Since most of the Central Arctic Ocean lies beyond the exclusive economic zones of national governments, management decisions for this area must take place through international cooperation. In 2018, ten countries came together to sign the Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean (also referred to as the Central Arctic Ocean Fisheries Agreement, or CAOFA) (Figure 4). Signatories to the agreement include Canada, the People's Republic of China, Denmark (for the Faroe Islands and Greenland), the European Union, Iceland, Japan, Norway, the Republic of Korea, the Russian Federation, and the United States of America. The Agreement, which entered into force in 2021, aims to prevent unregulated fishing in the high seas portion of the central Arctic Ocean as part of a long-term strategy to ensure the conservation and sustainable use of fish stocks. While there is currently no commercial fishing in the Central Arctic Ocean, interest in commercial fishing could grow as sea ice continues to shrink and marine species move northward. The Agreement prohibits all commercial fishing until at least 2037, and will be extended automatically thereafter in five-year increments, unless any of the parties object. It also creates a research and monitoring program to better understand the area, and states that Indigenous Knowledge must be part of the implementation of the Agreement.

Figure 5. Map showing the area covered by the agreement to prevent unregulated high sea fisheres in the Central Arctic Ocean (PAME/Arctic Council Secretariat).

CAOFA builds on actions taken by the United States (2010) and Canada (2014) to effectively prohibit commercial fishing in the Beaufort and Chukchi Seas until more scientific information is available to inform fisheries management. In 2015, Canada, the United States, the Kingdom of Denmark, Norway and the Russian Federation signed the non-binding Oslo Declaration, agreeing not to fish in the Central Arctic Ocean, and to reach out to other fishing nations, ultimately leading to CAOFA.

The precautionary, legally binding, multi-lateral approach taken by the CAOFA is a useful model for other high seas areas undergoing rapid change from climate and other stressors. With the signing of the new Biodiversity Beyond National Jurisdiction (BBNJ) Agreement in 2023, and its expected entry into force in the next few years, many countries and civil society organizations are beginning to consider areas of the ocean that should be designated as high seas MPAs. While not formally designated as an MPA, CAOFA demonstrates how a precautionary approach that includes Indigenous peoples can help protect this fragile ecosystem, including providing connectivity with management areas in adjacent EEZs.

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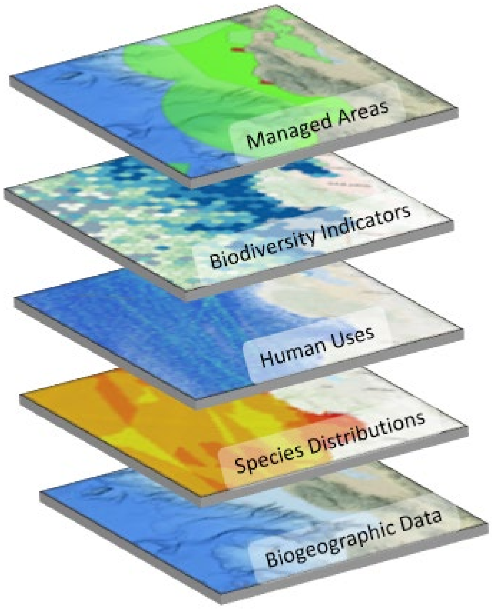
Box 3: Geospatial information for climate-informed MPA planning

Below is a list of thematic areas (with examples provided under each) for geospatial information to guide climate-informed MPA planning. These are general data themes, and specific data layers needed will be determined by the particular geography, governance and other attributes of the planning area. While planners should use the best available information and not be deterred by information gaps, filling these gaps and using common data layers for MPA network planning provides a more systematic approach to planning. When possible, data layers should be created to illustrate past and predicted changes in these thematic areas, as well as current status.



Graphic: NOAA/Mimi D'Iorio

Biological and ecological data

- Species distribution and abundance (e.g., fish, corals, marine mammals)
- Habitat types and extent (e.g., coral reefs, seagrass beds, kelp forests)
- Biodiversity indicators
- Trophic relationships and ecosystem connectivity

Oceanographic and physical data

- Sea surface temperature (SST)
- Salinity
- Currents and circulation patterns
- Wave height and energy
- Sea level and tidal data
- Bathymetry and seafloor topography

Human use and impact data

- Fishing effort and catch data
- Shipping routes and vessel traffic
- Tourism and recreational use
- Pollution sources and levels
- Marine debris and plastics

Governance and regulatory data

- MPA boundaries and zoning maps
- Jurisdictional boundaries
- Permits and access regulations
- Compliance and enforcement data

Cultural and socioeconomic data

- Traditional knowledge and cultural sites
- Community reliance on marine resources
- Economic value of ecosystem services
- Stakeholder engagement and perceptions

Climate and environmental change data

- Ocean acidification
- Coral bleaching events
- Storm frequency and intensity
- Long-term environmental trends

CHAPTER 5.

Strengthen adaptation and resilience

5. Strengthen adaptation and resilience

Principle 2: Proactively provide effective area-based conservation in a changing climate to support adaptive and resilient ecosystems

Including climate goals and objectives

MPAs and MPA networks are designed and established to meet specific conservation objectives and goals. Such objectives and goals have historically focused on the protection or conservation of specific attributes such as species and habitats, and their ecosystem services, as well as heritage resources. However, as environmental conditions continue to change, effective conservation increasingly requires those pursuing establishment or expansion of an MPA, or adaptation of existing MPAs, to *establish conservation objectives and goals that explicitly consider climate change and its impacts on biodiversity*. As such, effectively establishing and managing MPAs and MPA networks that are adaptive and resilient requires that climate change be considered from the beginning of, and be woven throughout, design, establishment, and implementation. The objectives and goals of an MPA drive important aspects of design and management including boundaries, authorities, regulations, and management actions. Goals that are climate-smart (i.e. consider and incorporate climate factors) and objectives that are SMARTIE (i.e. specific, measurable, achievable, relevant, time-bound, inclusive, and equitable) (UNESCO MSP Global International Guide, 2021) can ensure a clear direction for both the design and management of an adaptive and resilient MPA or network.

Most conservation policies and legislation are flexible enough to allow for (or in a few cases, explicitly encourage) the establishment of objectives and goals that consider climate change and encourage adaptive management (Lopazanski, 2023; O'Regan, 2021). Climate change-focused MPA objectives should be explicitly considered together with biodiversity conservation and social and economic objectives. For example, an objective to conserve a particular species should also ensure that the species is adaptive and resilient to climate change. Explicitly braiding climate change considerations throughout MPA goals and objectives, and noting these interrelationships in designating documents, ensures that design, implementation, and management will consider climate change and leads to enhanced conservation outcomes (e.g. Rubidge et al., 2024).

MPA goals and objectives are often influenced by international and national policies and legislation (Table 2). This can provide both an opportunity and an obstacle to establishing objectives and goals that explicitly consider climate change and lead to effective adaptive management. Policies and legislation that assume resources should be maintained as they are now, or were in the past, rely on a defunct assumption of static environmental conditions (stationarity) and may need to be changed to allow for the establishment of adaptive, effective objectives and goals. Such changes are often difficult and take time. Resolving potential conflicting values in MPA goals and objectives are discussed further in Chapter 8, Holistic Co-Benefits.

Table 2. Major international treaties or policies with relevance to MPAs in a changing climate

Major international treaties or policies	Relevance
United Nations Framework Convention on Climate Change (UNFCCC)	Aims to stabilise greenhouse gas concentrations in the atmosphere to protect ecosystems and enable sustainable development. MPAs protect habitats that help mitigate climate impacts and ecosystems adapt to climate change and maintain resilience. Parties commit to establish National Determined Contributions that can include ocean-based solutions for climate change such as MPAs.
United Nations Convention on the Law of the Sea (UNCLOS)	Provides a comprehensive legal framework for all activities related to the world's oceans, including sovereign rights, navigation, fishing, and the exploitation of marine resources.
Agreement under UNCLOS on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction (BBNJ Agreement)	Addresses four issues to ensure the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction: marine genetic resources, including the fair and equitable sharing of benefits; area-based management tools, including MPAs; environmental impact assessments; and capacity building and the transfer of marine technology.
United Nations Sustainable Development Goal 14 (UNSDGs)	The 17 Sustainable Development Goals were approved by the UN as part of the 2030 Agenda for Sustainable Development. SDG14 emphasises the need to conserve and sustainably manage ocean ecosystems, including MPAs, a key tool to protect vulnerable marine life and habitats threatened by a changing climate and other impacts.
Kunming-Montreal Global Biodiversity Framework (GBF)	The Framework sets out an ambitious pathway to reach the global vision of a world living in harmony with nature by 2050. Target 1 emphasises the need for comprehensive spatial planning and effective management strategies across all marine environments, including MPAs and conservation areas to protect critical biodiversity hotspots. Target 2 requires the restoration of degraded ecosystems by 2030. Target 3 aims to ensure and enable that by 2030, at least 30% of terrestrial and inland water areas, and 30% of marine and coastal areas are conserved and equitably managed to ensure preservation of biodiversity, ecosystem functions and services, while recognising and respecting the rights of Indigenous peoples over their traditional territories.
Convention on Migratory Species of Wild Animals (CMS)	Provides the legal foundation for internationally coordinated conservation measures throughout a migratory range, including for species facing extinction (listed on Appendix 1) and those in need of conservation (listed on Appendix 2). As some species ranges and migratory pathways are shifting due to climate change, the CMS is an important tool for their protection.

Source: Report authors

Managers should seek opportunities to include climate-informed goals, despite policy barriers. For example, if a policy requires the preservation of an ecosystem that is at risk under future climate scenarios, a climate-smart objective could be to maintain the resilience of the current ecosystem distribution (as required by existing policies) while working to make it adaptive to future changing conditions. Actions under such an objective could work to mitigate climate impacts to the ecosystem, identify and protect refugia, and encourage the establishment of adaptive or resilient genotypes (the genetic makeup of an organism). Such an approach could buy time for the ecosystem and set the stage for adaptation. For example, the Australian Coral Reef Resilience Initiative (ACRRI) combines coral re-seeding with broadcasting healthy reef sounds to attract fish and improve the resilience of coral reefs affected by climate change (Azofeifa-Solano et al., 2025; ACRRI 2025; Gordon et al., 2019). By taking a "whole-of-system" approach to reef restoration, spanning two World Heritage sites (i.e. Great Barrier Reef and Ningaloo Reef) the ACRRI is laying the foundation for a novel ecosystems-based approach to support coral reef resilience through restoration while also facilitating adaptation to changing conditions through approaches such as reseeding into new areas (ACRRI 2025).

Boundaries and level of protection

As the objectives and goals of an MPA drive all other decisions, ensuring that they consider climate change allows for more climate-smart decision-making throughout the design and establishment process, from boundaries to regulations. Thus, it is critical that those establishing an MPA *design boundaries that will provide lasting protection for target ecosystems and features considering and incorporating ecological connectivity, climate refugia, representativeness, and other principles necessary to be responsive to environmental change*. Such design principles differ from those traditionally employed for MPAs, which focus on protecting habitat and species from the impacts of current anthropogenic pressures, such as overfishing, often under assumptions of a relatively static natural environment.

Designing MPA boundaries that provide lasting protection for natural resources under a changing climate requires information including:

- the extent, distribution, and current condition of ecosystems, habitats, and/or species requiring protection as well as how they may change under future conditions;
- the identification and extent of existing and emerging anthropogenic activities that are capable of impacting resources under future climate scenarios;
- the identification of current climate refugia, future refugia, and climate change hotspots (Box 1);
- the identification of areas important for climate mitigation (e.g. coastal and oceanic blue carbon ecosystems that store and sequester carbon); and
- the development of climate change scenarios to identify opportunities to 'direct' environmental change away from less desirable states to more desirable states (where change is unavoidable).

In addition to this information, MPA management should have the capacity to:

- establish regulations that are adaptive and responsive to change in a timely manner, such as boundaries, zoning, management, or regulations that can be changed based on environmental conditions;
- consider social implications of climate adaptation and building social acceptance and capacity for climate-adaptive management; and

- Include information from diverse knowledge sources, such as Indigenous and traditional knowledge, and consider cultural values of Indigenous peoples and local communities.

All of these considerations, individually or with others, provide information leading to the design of effective boundaries and regulations that are more likely to result in environmental resources being adaptive and resilient to climate change.

To ensure that key resources are adaptive and resilient to climate change, an MPA must also be designed to protect these resources as they respond to changes. This may necessitate the design of boundaries that include areas where habitats and species are not currently found but are predicted to be in the future (i.e. range shifts) as well as areas that are key to different life stages of organisms such as breeding or feeding grounds (Box 2).

These changes in ecosystems, habitats and species ranges, and the legal structures that make it difficult to change MPA boundaries in many countries have led some MPA programmes to focus on expanding the size of MPAs to encompass current and future refugia and range shifts. For example, Papahānaumokuākea Marine National Monument in the Northwest Hawaiian Islands was established in 2006 to protect coral islands, seamounts, banks and shoals supporting a wealth of marine life. In 2016, the monument was expanded from 362,062 square kilometres to 1,508,870 square kilometres, becoming the largest MPAs in the world at the time, and with climate resilience cited as a major rationale for the expansion. However, large scale MPAs can be difficult to establish due to competing economic activities, particularly in heavily used areas. To address this, the state of California used a different strategy, implementing an ecologically connected statewide network of smaller MPAs between 2004 and 2012. While climate change was not explicitly considered in the establishment of California's network, a recent report on climate resilience in the network noted that many of its design principles are also central to climate resilience (OPC SAT 2021). In considering MPA and network boundaries, planners should consider the opportunities for and trade-offs between large scale and multiple smaller scale protected areas.

Multiple studies over decades have demonstrated that MPAs with higher levels of protection (that prohibit or highly restrict extractive and damaging uses) deliver stronger conservation benefits, including total biomass; total biomass of larger, more fecund organisms; and species richness (Graham, 2014) and can help maintain long-term fisheries yields (McClanahan, 2021). As such, highly protected MPAs should be an important part of a climate resilient MPA network. Recently, the MPA Guide provides an assessment tool to managers to assess likely ecological and social outcomes based on level of protection and stage of establishment, assuming enabling conditions are in place (OSU, 2023).

Dynamic measures

It is unlikely that any single MPA, no matter how large, will be able to include every aspect described above to ensure lasting protection under changing conditions. Increasingly, MPAs will need to be integrated into well-designed, interconnected networks and broader marine spatial planning in order to accomplish conservation objectives in a changing environment. But even when the boundaries of MPAs and MPA networks are appropriately designed, ensuring lasting adaptability and resilience will require managers to *establish and implement regulations and non-regulatory programmes that provide lasting protection for target ecosystems and features that are responsive and adaptive to environmental change*, including dynamic measures.

Dynamic measures are those that can move in space and time with expected range shifts, movements of species, or environmental conditions, and can be applied across MPAs or within specific zones. They can also be used to rotate protection across MPAs or MPA zones, protect endangered or sensitive species during certain life stages, and track changing environmental conditions. Fisheries management has long used a similar strategy through seasonal measures (e.g. to protect spawning aggregations), and dynamic measures within MPAs build on this concept.

For example, in response to an unprecedented marine heatwave in 2023, Florida Keys National Marine Sanctuary has established special use areas, which can be activated through emergency action, where coral fragments being grown for restoration can be moved to deeper, cooler waters when temperatures rise. In another example, both Canada and the United States have implemented dynamic management areas where fishing and shipping regulations are altered when North Atlantic Right whales are detected in response to unprecedented northward shifts of this critically endangered species. Moreover, dynamic MPAs can potentially address climate change in conservation planning by providing a management tool that benefits more widely ranging species – including species experiencing range shifts due to climate change – in addition to the benefits provided to more low-movement species by traditional MPAs (Caughman, 2024). Such dynamic and nimble management strategies are likely to be increasingly necessary as climate change progresses. By building authorities to conduct these and other novel management strategies into the designation of an MPA, managers can be more nimble, adaptive, and flexible if such measures need to be employed.

Ecological connectivity

Ecological connectivity – how species, propagules, and materials move through space and time – is a key component of any MPA design and can help to enhance the adaptation and resilience of resources. Ensuring that ecological connectivity is conserved requires either that an MPA be large enough (which is often infeasible for all but organisms with the lowest level of connectivity and movement) or that it be part of a network of MPAs that is designed and managed to conserve essential connectivity for ecosystems and their components (Assis et al., 2021).

Well-designed MPA networks explicitly consider and work to conserve ecological connectivity through the protection of key interconnected areas (e.g. feeding and breeding grounds, habitats connected by propagule dispersal) and the corridors that connect them. In the context of climate change, networks that consider the potential for range shifts can provide protected routes and safe "landing spaces," acting as stepping stones for shifting species that allow them to maintain a level of protection as they move across geographic space (Lausche et al., 2021). Networks will likely be of particular importance to highly migratory species and those that move, or may shift across, international jurisdictions to foster their continued protection across their range.

Taking a broader seascape approach allows managers to consider how to implement climate resilient network principles such as ecological connectivity and replication. For example, California's statewide network of MPAs was intentionally designed to reflect such principles and recently underwent a decadal review to assess the network's performance.

Case Study: Establishing a climate-resilient conservation area in the biodiverse transboundary region of Kenya and Tanzania

About the area

The transboundary region of Kenya and Tanzania (TBCA) is a shared marine ecosystem rich in biodiversity and critical ecological resources. The TBCA encompasses diverse ecosystems such as coral reefs, mangroves, seagrass beds, and coastal forests that support local livelihoods, cultural practices, and economic activities, including fishing, seaweed farming, and tourism. Efforts are underway to establish a marine transboundary conservation area to protect these shared ecosystems and resources. The TBCA aims to balance conservation goals with the socioeconomic and cultural needs of local communities while addressing challenges such as climate change, overfishing, habitat degradation, and land-based pollution. The design process is complex and data-intensive, requiring the balance of considerations for multiple threats and uses, a process further complicated by the differing ability of institutions across the Kenya-Tanzania border to adapt to climate change.

Parrotfish in a healthy seagrass bed in Zanzibar, Tanzania. Photo © Ocean Image Bank/Ben Jones

Climate change considerations

Climate change poses significant risks to the TBCA, including coral bleaching, sea level rise, species redistribution, mangrove diebacks, and changes in species fecundity and connectivity. Emerging threats, such as tropical cyclones, further exacerbate these risks. The TBCA design will be informed by an understanding of past, current, and future socio-environmental factors and dynamics. Baseline assessments of ecological and socioeconomic conditions, including climate and non-climate related stressors, will guide the planning process. The design will explicitly incorporate climate change into its conservation objectives, ensuring protection for target ecosystems. Boundaries will be designed to include ecological connectivity, climate refugia, and representativeness, while regulations will be adaptive to environmental change.

The TBCA design will incorporate climate change considerations that aim to enhance ecosystem resilience and adaptive capacity. Key strategies include, using Modern Portfolio Theory to protect a portfolio of ecosystems with varying exposure levels to climate risks, and ensuring resilience through diversification and spatial replication. Planners will use scenario analyses to evaluate the impact of protection at different spatial configurations, maximizing biodiversity conservation and climate resilience. Land-sea planning will also be prioritised to address land-based threats, such as runoff and pollution, through integrated water resource management and a source-to-sea approach. To prioritise areas in the TBCA that can enhance resilience, the area's governance will consider the adaptive capacity of the diverse institutions that shape decision-making processes, and their structures, processes and traditions.

The design of the TBCA will also address equity and inclusivity by engaging with local communities, Indigenous peoples, and under-served groups in decision-making processes. The community across the border are migratory fishers sharing family ties and operate on both sides

of the border.Indigenous and local knowledge will be integrated into the design through our collaboration with local governments, grass-root NGOs and community groups, to ensure the preservation of cultural practices such as kaya forests and community-driven activities like octopus closures and ecosystem restoration. Socioeconomic and cultural impacts of climate change are also being considered in the design where tradeoffs between food production and livelihoods will carefully be managed. The TBCA will also support climate mitigation, adaptation, and resilience co-benefits. Mangroves and seagrass beds, which provide blue carbon sequestration and storage, are prioritised for protection, aligning with Kenya and Tanzania's NDC commitments under the UNFCCC. The design will support ecosystem-based adaptation (EbA) activities, such as mangrove restoration and coral reef protection, which enhance coastal resilience and provide socioeconomic benefits to local communities.

The TBCA design represents a pioneering effort to establish a marine transboundary conservation area in a changing climate. By integrating principles of understanding change, adaptive resilience, equitable design, and holistic climate co-benefits, the TBCA aims to protect shared ecosystems, support local livelihoods, and enhance climate resilience.

Figure 6. Proposed location for the marine transboundary conservation area.

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Representativeness, replication, and refugia

Ensuring that representativeness of key resources is built into the design of an MPA or network can greatly enhance the adaptability and resilience of resources. By establishing boundaries that include both a diversity of ecosystem types as well as multiple different, but interconnected, habitat or ecosystem patches of the same type (i.e. replication), an MPA or network can ensure that if one patch is lost or damaged, another continues to persist. Areas that persist may even be able to re-seed degraded areas, if protected and connected. It is important to ensure that boundaries, either in a single MPA or a network, include the full range of key habitats and areas for species being targeted for protection, and ideally multiples of each. For example, if a species has different feeding, breeding, and nursery grounds, all should be considered for protection as well as areas that may serve as new feeding, breeding, or nursery grounds as conditions change. This helps to ensure that a species is protected both throughout its life cycle and into a changing future.

Beyond ensuring ecological representativeness, a climate-adaptive MPA or network should seek to identify and protect existing and future climate refugia and manage climate hot spots (Box 1). Protecting climate refugia should be prioritized in MPA planning as they can provide safe havens for ecosystems and species threatened by climate impacts and can give species time to adapt or evolve to changing conditions. They can also provide sources of larvae to other areas that are changing more rapidly, enhancing the resilience of those areas. Future refugia can act as safe landing spots for expanding species where conditions allow them to maintain and sustain a population into the future, potentially “pre-seeding” a geographic area and enhancing the likelihood of successful adaptation. For example, during the 2014-2016 Pacific Marine Heatwave dozens of species were recorded up to hundreds of kilometres northward of their previous range edge (Falgor & Bourdeau, 2018; Sanford et al., 2019). While most of these species retreated as waters cooled, some established populations that continue to persist years after the heat-wave has ended (Sanford et al., 2019). For these species, such areas represent future climate refugia. As important as the identification and protection of refugia is the identification and management of emerging novel ecosystems. As species and ecosystems respond to the impacts of climate change in different ways, ecosystems are being altered in manners that are resulting in combinations of species and functions that have not previously been witnessed. These novel ecosystems present both management challenges and opportunities and should be recognised, considered, and managed thoughtfully to maximize conservation outcomes, rather than resisting the change out of hand.

Adaptation actions

Once adaptive management is integrated into MPA design and planning, adaptation actions can be undertaken to enhance the adaptive capacity and resilience of marine ecosystems. For MPAs, these actions generally fall into eight broad categories:

- *Alleviate climate impacts*: strategies that directly reduce the impact of climate stressors

- *Manage dynamic conditions*: strategies that are responsive and adaptive to changing conditions, including ‘directing’ ecosystems away from less desirable changes in state to more desirable ones where change is unavoidable or irreversible.

- *Habitat protection*: strategies that focus on protecting habitat or key ecosystem processes.

- *Active habitat and species recovery/restoration*: strategies including restoring habitat or key ecosystem processes, species translocation, marine debris removal, etc.

- *Reduce human disturbance*: strategies that restrict or reduce access to sensitive habitats to limit disturbance and enhance resilience.

- *Manage for invasive species*: strategies that address the impact of invasive species on habitat resilience.

- *Water quality management*: strategies that improve, or prevent the decline of, water quality.

- *Promote education*: strategies that increase awareness, directly target harmful human behaviors, and build social acceptance for adaptation strategies (including loss of some ecosystems as we currently know them while focussing on opportunities for other ecosystem services).

Many of these strategies include actions that MPAs already routinely implement. The key to ensuring these actions serve as effective climate adaptation measures is to intentionally and explicitly consider climate change during their design and implementation. Considering which actions may be necessary during the designation or review of an MPA or MPA network can also inform regulations, processes, and authorities, and demonstrate where legislative authorities may need to be altered or expanded to allow for effective climate adaptation. In many countries, changing the boundaries or regulations of an MPA is a major undertaking, in some cases requiring new legislation. Therefore, considering climate-informed regulations during designation can help ensure that managers have the ability to be responsive to the inevitable environmental changes and surprises that will challenge resource management in the future.

Within the eight categories described above are many potential actions that an MPA could take to enhance adaptation. Determining which actions to take is a more difficult task. Exercises such as CVAs and scenario planning (described above) can provide the information needed to make an informed decision. Additional tools and frameworks, such as structured decision making (Martin et al., 2009) and scenario-based decision analysis (Miller et al., 2023) can further leverage the information obtained through a CVA or other process to help managers think through potential actions, particularly when faced with difficult or unprecedented decisions.

One example of such a tool is Resist-Accept-Direct (RAD), a framework that helps managers make decisions in the context of climate-driven ecosystem transformations (Lynch et al., 2021; Schurmann et al., 2021). RAD posits that when faced with an ecosystem state change (for example, in a climate hotspot or a shift towards a novel ecosystem), managers can “resist” the change through actions such as restoration or preservation, “accept” the change by effectively allowing it to take place, or “direct” the change through actions that push it to a preferable alternative state that maximizes conservation outcomes. Other frameworks can guide management decisions by helping managers understand how cultural values and ecosystem services may change as a result of climate change (Adapt-React-Cope), how to take actions to directly reduce resource vulnerability, and other topics (Cannizzo et al., 2023; Green et al., 2021). Ultimately, decision frameworks encourage managers to consider a breadth of management strategies to ensure that when action is taken, it is done so intentionally and considering climate change. Frameworks like RAD and Adapt-React-Cope can be of particular use in situations where managers are facing changes that are increasingly difficult to resist, unlikely to be reversible, and/or may challenge the utility of traditional or established MPA management practices (Cannizzo et al., 2025; Lynch et al., 2021; Schurmann et al., 2021). In such situations these frameworks can help managers better understand potential management options and levers while they navigate inevitable changes to the resources they are responsible for (e.g. Keller at al. 2025). Adaptive management actions and decision frameworks can be particularly impactful during the design of an MPA or MPA network, potentially informing the placement of boundaries and/or policies, regulations, and processes. For example, these exercises may lead to the development of novel management tools and strategies that could require changes to policies or procedures. Undertaking such exercises during activities such as management plan reviews can also help to determine if and when such policy updates may be necessary, and even if boundaries may need to expand (or change).

Napoleon Wrasse at Rhun Island 2021. Photo © CTC Kasman LR

Case Study: Central Eastern Marine Park, Australia – designing for climate change

About the area

Central Eastern Marine Park lies about 30 kilometres off the east coast of Australia at the edge of the continental shelf and was established in 2018 as part of the Temperate East Marine Parks network (Figure 1). The park itself covers 70,054 km^2 and has a depth range of 120-6,000 metres. It includes three zone types: 1) National Park Zone (IUCN category II), 2) Habitat Protect Zone (IUCN category IV), and 3) Multiple Use Zone (IUCN category VI) - see Table 1. The park includes habitats, species and ecological communities associated with the Central Eastern Province, the Central Eastern Shelf Transition and the Tasman Basin Province. It also includes three key ecological features: canyons on the eastern continental slope (valued as a unique seafloor feature with ecological properties of regional significance); the Tasmantid Seamount Chain; and the Tasman Front and eddy field (both valued for high productivity, aggregations of marine life, biodiversity and endemism). Central Eastern Marine Park is adjacent to the Sea Country of the Yaegl and Gumbaynggirr and part of the world's oldest on-going culture. Sea Country is valued by Traditional Owners for cultural identity, health and wellbeing.

Australasian gannets in the Central Eastern Marine Park in Australia. Photo © Alan Danks

Climate change considerations

The park was designed with a long north to south section to allow for southward migration of species expected with changes in the East Australian Current (EAC) environmental characteristic due to climate change (Figure 2). The zoning within the park can be reviewed as part of management plan reviews which allows for species range shifts down the east coast of Australia to be considered. The park is also designed with a west to east section encompassing the Solitary Canyon, which connects the continental slope and deep-open ocean with the continental shelf Central Eastern Marine Park.

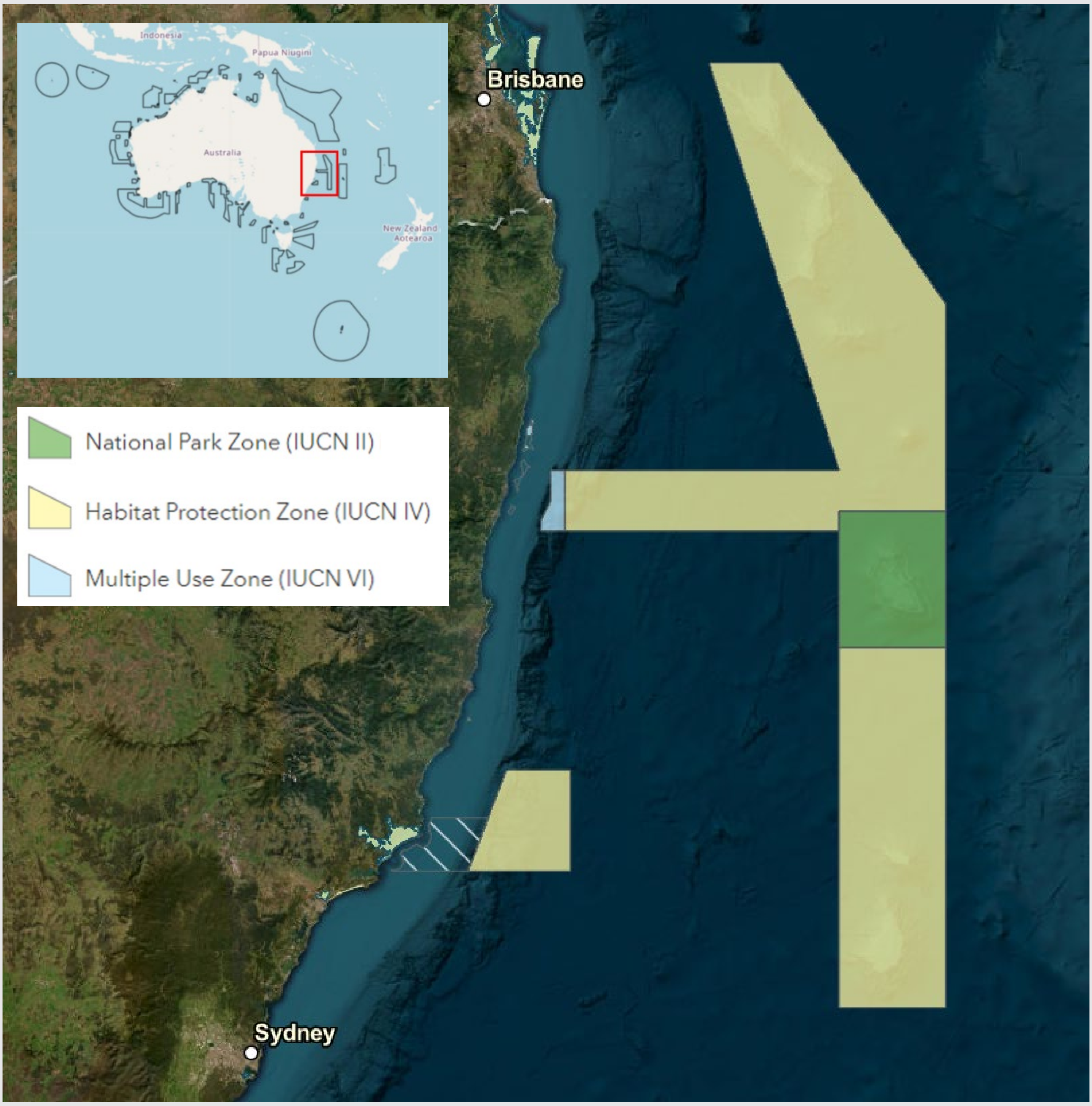

Figure 7. Central Eastern Marine Park different zones. *Inset - outer boundaries of Australian Marine Parks showing location of Central Eastern Marine Park.*

Ongoing science and management

The EAC, along this predominantly wind-driven downwelling coast, is thought to play an important role in driving sporadic upwelling of cooler, nutrient rich waters onto the shelf-region via deep canyon systems that incise the shelf and thus setting the physical environment of the coastal marine park. Upwelling of nutrients is especially important on the narrow east Australian continental shelf, as the region depends on open ocean nutrient fluxes to sustain marine productivity. The Yaegl and Gumbaynggirr Traditional Owners who have Sea Country adjacent to the park also continue to share oral history traditions that have retained information about previous climate events (see references and further reading). The western and Indigenous science in the park and surrounding areas continues to provide valuable information to help inform management, including:

- Highlighting the role of the Solitary Canyon in 'channelling' cooler nutrient rich waters from abyssal depths up onto the continental shelf (Figure 3).
- Providing baseline information that allows assessment of condition and future trend in condition assessments, such as the high level of biodiversity in Solitary Canyon.
- Development of an integrated monitoring and modelling approach based on research that can help predict potential climate futures impacts.
- Recognising and valuing Indigenous science and the importance of co-designed research and cooperative projects to inform climate adaptation.

Park Australia will continue to use an adaptive approach and use the best available science and knowledge to support management of the park in a changing climate.

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Mooring buoys in Florida Keys National Marine Sanctuary provide access to boaters without anchor damage to fragile coral reefs and seagrass beds. Photo © NOAA/Matt McIntosh

CHAPTER 6.

Ensure equity and inclusivity

6. Ensure equity and inclusivity

Principle 3: Ensure equitable and inclusive design and management in support of the adaptation, resilience, and wellbeing of human communities, cultural practices, and values

Equity

Processes to establish MPAs have often been top-down, limiting the inclusion of local perspectives and values. Yet, social acceptance of MPAs is fundamental to their ecological success (Christie, 2004; Pajaro et al., 2010; Bennett and Dearden 2014). recognising this, the Convention on Biological Diversity's (CBD) Aichi Targets (2010) and subsequent GBF (2022) (WWF, IUCN-WCPA, 2023) emphasise the importance of "equitably managed" or "equitably governed" protected area networks. Moreover, MPAs are an important tool for sustainable development – contributing to fisheries for commercial use and local food security, tourism, and other components of coastal economies.

In the climate change and biodiversity context, equity is the principle of fairness in sharing the burdens of climate change, ensuring that the impacts, costs, and benefits are distributed more equally across society (IPCC, 2018). Impacts are experienced differently based on intersecting identity factors such as an individuals' gender, age, ability, ethnicity, race, sexuality, indigeneity, nationality, and socio-economic status, among others (Adaptation Fund Board, 2022; IPCC 2022). Equity also includes recognition (the acknowledgement of and respect for the rights and the diversity of identities, values, knowledge systems and institutions of rights holders and stakeholders) and fair procedure (inclusiveness of rule- and decision-making) (CBD, 2018).

Target 3 of the Framework specifically commits parties to "recognising and respecting the rights of Indigenous peoples and local communities, including over their traditional territories." Meaningful involvement of Indigenous peoples and underserved communities entails recognition of past inequities and legacies of colonialism in order to create new trusted spaces for collaboration and creativity, and a recognition of diverse ways of knowing (Reid et al., 2021). For example, Parks Canada is working with First Nation, Métis, and Inuit communities across the country to develop an Indigenous stewardship framework focused on honouring relationships; empowering Indigenous voices; supporting Indigenous leadership and self-determination; respecting Indigenous rights and knowledge systems; and building a more equitable and sustainable future for generations to come (Parks Canada, 2024). Meaningful involvement of Indigenous peoples is not only vital to equitable design and management, it can also lead to improved conservation outcomes. In contrast to western protectionist paradigms that seek to exclude humans and human uses (Primack, 2006), Indigenous models of conservation often emphasise humans and nature as a part of the same system (Cinner et al., 2006). Such Indigenous approaches bring a more holistic approach to conservation based on community stewardship and close observation of the environment, and can lead to more adaptive and resilient outcomes in a changing climate (Cinner et al., 2006).

While the growing focus on the social, economic and cultural aspects of MPAs has fostered the development and sharing of more equitable and transparent approaches to MPA establishment, climate researchers have noted the many ways in which climate change magnifies existing inequities (Chisada, 2023). Because climate change creates greater inequities, managers need to make sure they are addressing equity in MPA establishment (including social and economic impacts, equitable establishment processes, etc.). Although MPAs play a role in protecting ecosystems and biodiversity, which aid in climate change adaptation and mitigation, they are ultimately tools for managing human activities. Therefore, MPA design often entails trade-offs between achieving conservation objectives and addressing other social and economic considerations for local communities and other users of those areas (Voyer et al., 2012; Gill et al., 2019; Rasheed, 2020).

Inclusivity

MPA establishment processes should *ensure the early inclusion of diverse communities and peoples, particularly Indigenous peoples and underserved communities, in design, management, and decision-making processes*. This requires an understanding of community-engaged and participatory approaches and bringing Indigenous and local community members into the project at the beginning so that they are involved in project design and priority setting (Arnstein 1969; Bennett and Dearden 2014; Dawson et al., 2021). These collaborative approaches require sufficient budgets to fund community engagement and timelines that allow for deliberative processes within Indigenous governments and local communities. For example, the IUCN Green List recommends creating a stakeholder consultation plan outlining who will be consulted, when, how, and the expected outcomes. This plan should be periodically reviewed and adapted based on stakeholder needs and cultural norms. Methods such as stakeholder mapping, running stakeholder workshops and social and cultural impact assessments can help in this process and results should guide MPA design and management (Voyer et al., 2012; Franco et al., 2020; MMO, 2024).

During the scoping process, MPA planners should use collaborative approaches to identify areas with important cultural, social, or economic values, as well as those with high ecological value. Recognising that different community members may have different values, MPA management entities should establish processes for conflict resolution during the establishment process and as part of ongoing management.

One important approach to considering these diverse values is to *embed MPA networks within marine spatial planning frameworks to equitably balance multiple cultural, social, and economic uses, and changes to those uses as a result of climate change*. MPAs exist within broader seascapes, and are subject to diverse pressures from multiple human uses of the ocean that can be managed holistically through a marine spatial planning framework. The CBD GBF's Target 1 calls on signatories to ensure that all areas within a country are under participatory, integrated, and biodiversity-inclusive spatial planning to bring the loss of areas of high biodiversity importance and ecosystems of high integrity close to zero by 2030, while respecting the rights of Indigenous peoples and local communities. IUCN developed guidance for these spatial planning processes, which complement this guidance, and include: clear goals and objectives that address biodiversity loss; holistic and addressing ecological connectivity; spatially focused across multiple realms; participatory; and focused on biodiversity and human well-being outcomes (Grantham, 2024).

New MPAs require baseline and ongoing ecological, social, cultural and economic monitoring to assess their performance and inform adaptive management. Managers should *implement human dimensions research and* *processes in design, establishment and management to ensure the understanding and consideration of social, economic and cultural impacts of climate change* (Ban et al., 2009). Such research, which is most effective when it uses community-engaged approaches, will help build an understanding of the positive and negative impacts of the proposed MPA on human communities and practices. By using inclusive and equitable processes to establish MPAs, managing entities have an opportunity to identify and address community concerns, including ways in which MPAs can help build community resilience and allow adaptation through enhanced food security and coastal protection. The Site-level Assessment of Governance and Equity (SAGE) tool developed by the International Institute for Environment and Development (IIED) is one example of a tool to help MPA planners and communities consider and improve equity and other governance components in MPA design. Another example is the MSPACE project which integrates climate change considerations into marine spatial planning by developing tools and strategies to support climate-smart marine plans across the UK.

Nature-based solutions are defined by IUCN as are actions addressing key societal challenges through the protection, sustainable management and restoration of both natural and modified ecosystems, benefiting both biodiversity and human well-being. While not limited to climate mitigation and adaptation, nature-based solutions are important tools to achieve these goals. In 2020, IUCN created a framework for nature-based solutions to increase the scale and impact of these approaches, and prevent harmful outcomes (IUCN, 2020). Nature based solutions can be applied within protected and conserved areas (such as habitat restoration) or at a broader scale that can help integrate climate considerations for protected areas within the wider landscape or seascape.

Healthy mangroves and corals support climate resilience and small scale tourism in Palau. Photo © NOAA/Lauren Wenzel

Case study: Promoting resilience at Ay and Rhun Island MPA through climate change principles and traditional management practices

Background

The Banda Islands in Indonesia are a group of ten small volcanic islands in the Banda Sea, about 2,000 km east of Java. The islands and the Bandanese people played a significant role in world history with the advent of the spice trade that attracted merchants from across the seas, leading to historical reminders in architecture and traditions.

Of all the Banda Islands, Ay and Rhun Islands, with a population of 3,118 people, are surrounded by the most biodiverse, distinct, and globally significant marine ecosystems. The islands are home to diverse coral reef ecosystems and fish species, and are a critical area for sea turtles, the endangered napoleon wrasse, mandarin fish, and tuna. These areas also support important migratory routes, feeding grounds, and nursery areas for blue whales and other marine mammals.

The Coral Triangle Center (CTC), a foundation strengthening marine resource management in the Coral Triangle to protect coral reef ecosystems, ensure sustainable livelihoods, and food security, has been working in the Banda Islands since 2012. Initial collaboration started with rapid ecological and socio-economic assessments to identify the potential of the marine resources and identify challenges faced by local communities. CTC worked with the local government (the Marine and Fisheries Agency of Maluku Province), local communities and other partners to conduct surveillance and monitoring of resource use, coral health monitoring, socialization and public consultations leading to the establishment of Ay and Rhun Islands as a Marine Protected Area (MPA).

In 2021, the Ministry of Marine Affairs and Fisheries designated Ay and Rhun as an MPA to protect the area's rich marine biodiversity from the threats of destructive and overfishing, coastal development, and the global threat of climate change.

Village leaders and visitors on Ay Island in the Banda Sea ceremonially mark the closure of the *Sasi*, a traditional resource management system practiced in parts of eastern Indonesia. Photo © Coral Triangle Center/Dwi Surkan Darmawan.

Climate change considerations

Climate change was one of the threats identified during the development and establishment process of the Ay and Rhun Islands MPA. The conservation targets are coral reefs, seagrasses, sea turtles, napoleon wrasse, and marine mammals. The MPA management plan highlights climate change as one of the major stressors on these conservation targets especially for coral reefs, seagrasses, and marine mammals. It was also one of the main considerations leading to the establishment of the MPA and in developing the management and zoning plan. Climate adaptation design principles were applied during the process that included:

- Selecting locations with healthy coral reefs that have proven to be resilient during El Nino events

- Considering upwelling as one of the key features in the design of the MPA zoning. Upwelling mixes cold water mass from the depths with warmer surface waters, minimizing the impact of increasing sea surface temperature that can disrupt coral reefs and other ecosystems or marine biota.

- Determining core (no-take and no-go area; only very limited research and education are allowed based on a permit) and no take zones (non-extractive activities can be allowed such as sustainable marine tourism activities including snorkeling and diving) in several locations, thus reducing the impacts of fishing and other extractive uses.

- Considering the habitat distribution and distance between zones to foster connectivity between biota and habitats in the Banda Islands as well as replication of habitats as 'insurance' in case of bleaching, and other impacts.

- Integrating traditional wisdom and management practices such as Sasi system practices and sacred areas into the MPA zoning system.

The public consultation process with the community in the establishment of the MPAs intensified during 2017-2019 with more than 20 meetings involving around 700 people including customary leaders, village government, youth groups, fishermen, women and the community surveillance group. This process was supported by trainings for the community regarding MPA 101, MPA design, EAFM and other training to increase their understanding on MPAs and sustainable fisheries and the community's participation in the planning and design process. The Ay-Rhun Islands MPA was established two years later by the Minister of Marine Affairs and Fisheries Regulation No. 48 of 2021. Strong community support remains for the MPA to date that is pivotal to ensure effective management and achieve the outlined objectives of the MPA.

Revitalizing and integrating the *Sasi* system in the MPA design allows for an inclusive and equitable design that combines ecological aspects, cultural practices and values, with participatory methods to sustain co-benefits including biodiversity protection, food security and climate resilience (Fajariyanto et.al., 2024). Furthermore, the design of Ay and Rhun Islands MPA is connected and aligned with the wider Banda Islands MPA Network and Maluku Coastal and Marine Spatial Planning (Pemerintah Provinsi Maluku, 2018)

CTC remains committed to supporting and improving the effectiveness of MPA management in the Banda Islands by increasing the competence of MPA management units and encouraging MPA management learning networks for managers, practitioners and local NGOs.

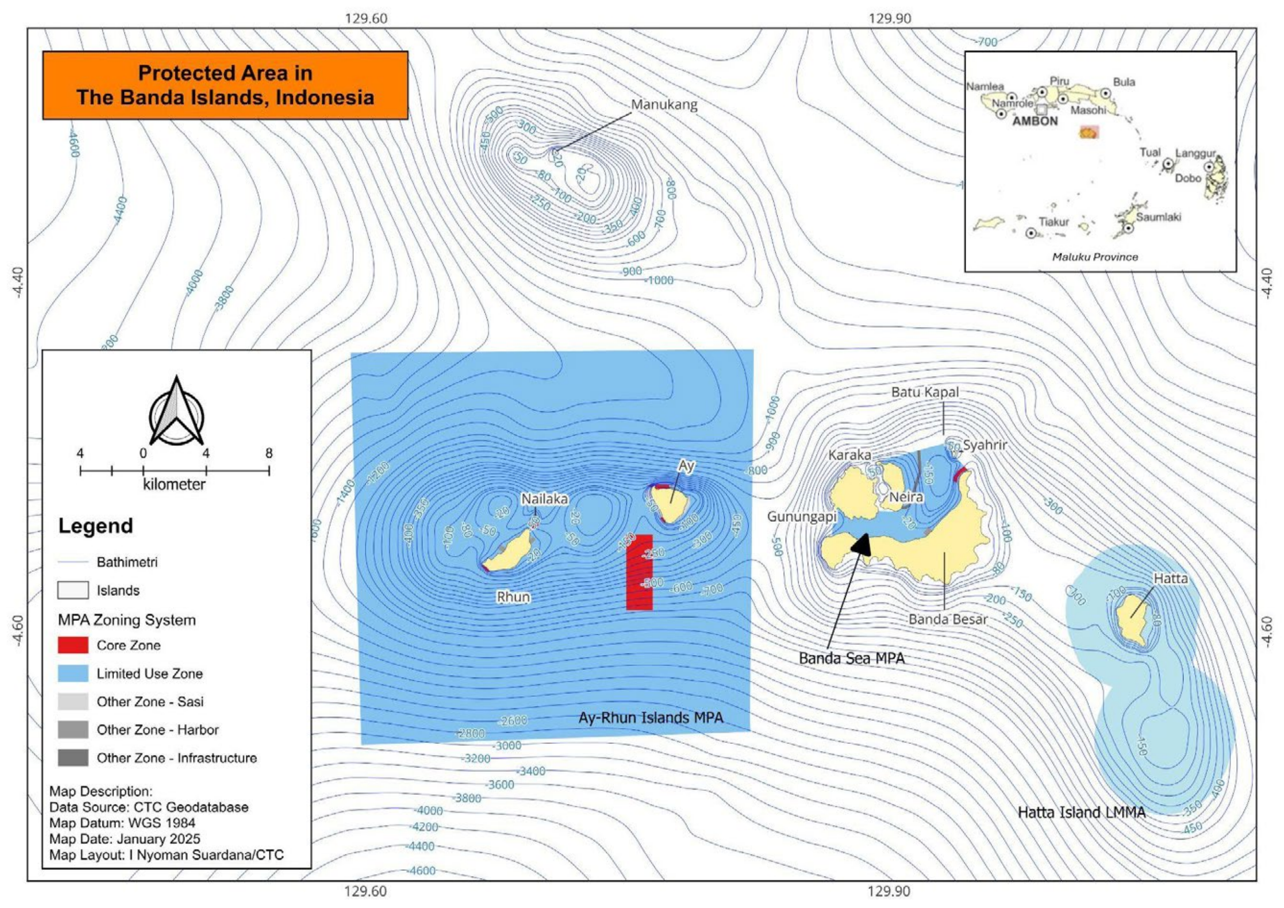

Figure 8. Ay and Rhun Islands MPA Zoning System

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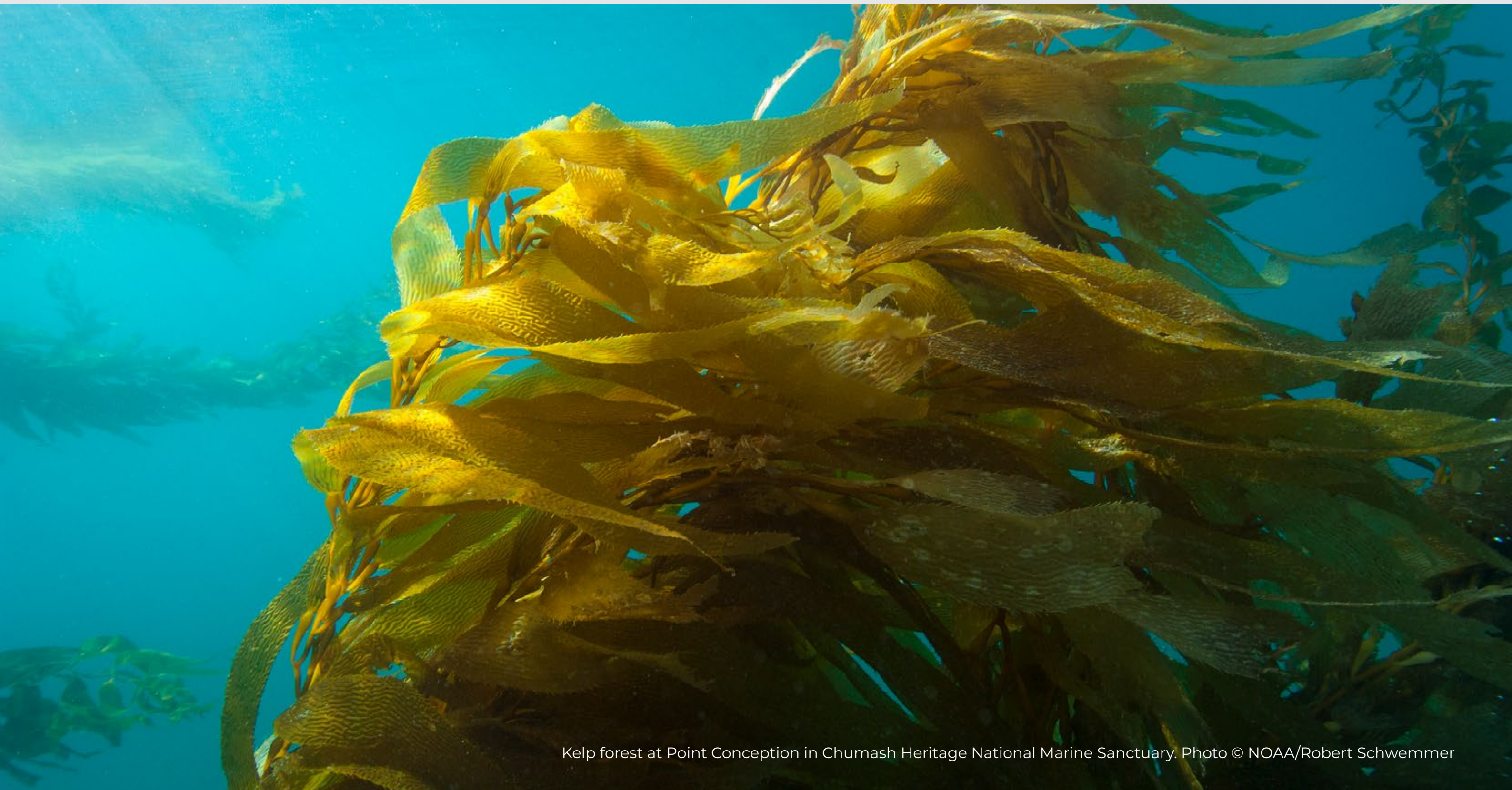
Case Study: Building an Indigenous-focused and climate-adaptive Chumash Heritage National Marine Sanctuary

About the area

Chumash Heritage National Marine Sanctuary (NMS) lies within the traditional homelands of the Chumash Peoples, governed by the yak titʸu titʸu yak tiłhini (ytt), Santa Ynez Chumash Band of Indians, and the Barbareño Band of Chumash Indians. Indigenous governments and communities have cared for these waters and adjacent lands from time immemorial and continue to care for them through a deep sense of responsibility, reciprocity, and respect.

The Chumash Heritage NMS was nominated as a national marine sanctuary by the Northern Chumash Tribal Council, a non-profit organization, in recognition of its cultural and ecological values. Its *equitable design* seeks to honor the historical significance of the Chumash Peoples and protect the *holistic co-benefits* the region provides. Further, the founding documents of the sanctuary establish a flexible strategy to *understand changes* and take actions to ensure sanctuary resources and the communities that depend on them are *adaptive and resilient*.

Chumash Heritage NMS protects 4,543 square miles of Central California's coastal and ocean waters. As the first Indigenous-led nomination of a U.S. National Marine Sanctuary, its designation on November 30, 2024 represents a watershed moment. The Chumash governments, Northern Chumash Tribal Council, and several other Indigenous organizations worked closely with the U.S. National Oceanic and Atmospheric Administration (NOAA) during the design and designation process. Following the sanctuary's designation in November 2024, NOAA continued working closely with Chumash governments and organizations to further explore and co-develop a collective approach that ensures that the area's deep cultural and historic significance, along with its social, economic and ecological importance, is supported through implementation of the sanctuary management plan.



Kelp forest at Point Conception in Chumash Heritage National Marine Sanctuary. Photo © NOAA/Robert Schwemmer

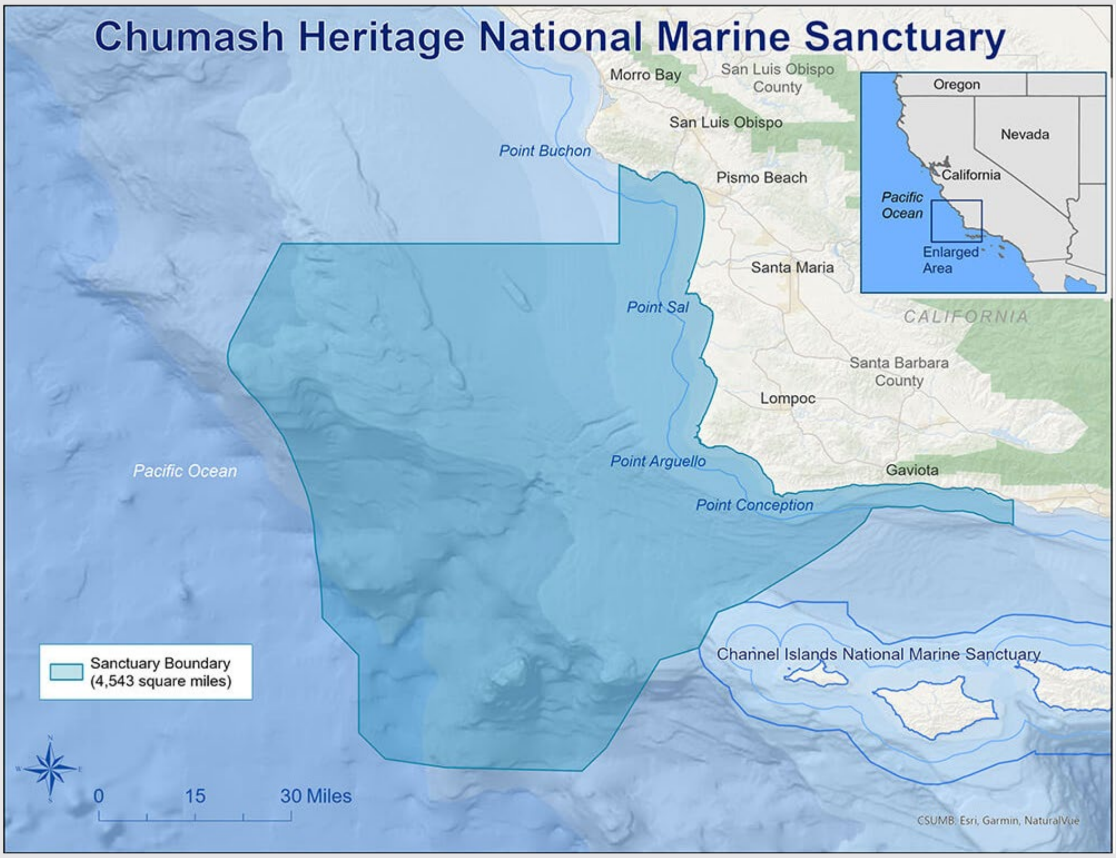


Figure 9: Chumash Heritage National Marine Sanctuary

Climate change considerations

The sanctuary's management plan includes an extensive climate change action plan; a first for a newly-designated sanctuary. This plan lays the foundation for understanding change through monitoring and other scientific endeavors, directs the development of a climate adaptation plan, public outreach and education, and the exploration of climate co-benefits such as blue carbon. Critically, the management plan centers the importance of honoring and engaging with Chumash governments and organizations, and supports the inclusion of Indigenous Knowledge and science, with free, prior and informed consent. The management plan further outlines a flexible co-stewardship approach, including within the climate change action plan. Under the National Marine Sanctuaries Act, new oil and gas development is prohibited. In addition, non-climate stressors are reduced by limiting discharges and disturbance of the seabed.

The sanctuary is located within a larger region with many ocean uses, including wind energy leases, itself a climate solution. This multi-use context will be considered as the sanctuary management plan is implemented, including the potential future expansion of sanctuary boundaries.

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A Native Hawaiian community group is working with the He’eia Bay National Estuarine Research Reserve to restore a traditional fish pond as part of a broader effort to restore Hawaiian culture and improve food security. Photo © NOAA/Lauren Wenzel

CHAPTER 7.

Generate holistic co-benefits

7. Generate holistic co-benefits

Principle 4: Safeguard and strengthen climate mitigation, adaptation, and resilience co-benefits, whilst acknowledging the full spectrum of ecosystem services for people

Planning for multiple objectives in protected area networks

Based on IUCN's definition of a protected area, their primary purpose is the "long term conservation of nature and associated ecosystem services and cultural values." To achieve this long-term goal, MPA planners need to maintain effective protection for nature in a changing climate and embrace opportunities for carbon capture or storage to reduce the rate of global warming. Planners should *use community-based participatory methods to establish goals and objectives that explicitly consider climate mitigation, adaptation, and resilience co-benefits, together with biodiversity, social, and economic goals*.

Examples of potential benefits that may be supported by MPAs for climate mitigation, adaptation and resilience include:

- Carbon sequestration and storage through "blue carbon" ecosystems
- Coastal protection against natural hazards by coastal habitats such as coral reefs, oyster reefs, mangroves and saltmarsh
- Community resilience benefits such as food security and natural resources that underpin wellbeing and livelihoods

Blue carbon refers to the carbon stored in coastal and marine ecosystems (Tokoro et al., 2014; IUCN, 2017). It is often related to the role that tidal marshes, mangroves and seagrass meadows play in mitigating climate change through high rates of carbon sequestration, thus helping to reduce greenhouse gas concentrations (Hilmi et al., 2021; Macreadie et al., 2021). However, when blue carbon ecosystems are destroyed or degraded, they release carbon back to the atmosphere, thereby adding to greenhouse gas emissions (Lovelock et al., 2017; Shah et al., 2024). Maintaining these carbon stores is, therefore, an important focus for protected area management (Smith et al., 2025). Recently, other coastal and marine ecosystems such as kelp and seaweed beds, intertidal flats, and seabed sediments are being increasingly considered in climate mitigation assessments and studies on climate regulating services (e.g. Howard et al., 2023; Kuwae et al., 2016; Smale et al., 2018).

In addition to biodiversity benefits, many coastal and near-coastal habitats like coral reefs, oyster reefs, mangroves, and seagrasses serve as natural barriers that protect shorelines from erosion and storm surges. MPAs play a crucial role in conserving these habitats, ensuring their health and resilience against climate-related impacts (Murti & Buyck, 2014). By reducing the intensity of wave action and storm damage, these ecosystems help to safeguard coastal communities and infrastructure, mitigating the risks associated with extreme events that are becoming more common with climate change (IPCC, 2023). The effective management of MPAs can ensure that these critical habitats continue to provide essential coastal protection, ultimately enhancing the safety and resilience of vulnerable communities.

Beyond their climate mitigation and coastal protection functions, marine and coastal ecosystems provide many other vital services, including critical habitats for numerous marine and migratory species (Barbier et al., 2011; zu Ermgassen et al., 2016). They contribute to community wellbeing and resilience by providing natural resources and supporting food security (Rasheed, 2020), including protecting nursery areas for commercially important species, supporting nature-based recreation and tourism (Orchard, 2025; Spalding et al., 2017) and through the filtration and cycling of contaminants (zu Ermgassen et al., 2016). Importantly, these many services vary in both their distribution and cultural value to stakeholders and communities, creating the need to recognise diversity and embrace inclusiveness when evaluating the potential co-benefits (or conversely, impacts) of a new MPA or OECM.

As the continued availability and resilience of all ecosystem services are affected by climate change, planners should consider the potential availability and future value of co-benefits that can be provided by MPAs and other area-based management tools. These area-based approaches have a central role in safeguarding natural ecosystems and their services through limiting harmful activities, promoting sustainable practices, and facilitating habitat restoration and adaptation efforts. *Identifying areas, ecosystems, and features that provide nature conservation and climate change mitigation and/or adaptation and resilience benefits across a range of ecosystem services, and designing boundaries and regulations to protect these co-benefits* is not only essential for biodiversity conservation but can also contribute to global climate actions that support many other aspects of sustainable development.

Approaches for selecting and balancing objectives

Selecting conservation, social, cultural, economic and climate objectives for an MPA or MPA network can be a complex process, and various tools can be used to inform these processes (Box 2). Viskamp et al., (2023) call for a flexible but transparent approach to priority setting in protected areas, where different conservation objectives can be explicitly considered and weighed against each other, to facilitate deliberative societal and political decision making. Marine spatial planning can also offer examples and models for balancing multiple objectives (Lombard, et al., 2019). Literature reviews and participatory mapping are generally applicable and cost effective methods for gathering and sharing local information on a wide range of attributes and community values.

Many countries use a form of regulatory impact analysis (RIA) to assess the potential impact of proposed regulations within an area before they are implemented. Climate change can be incorporated into RIAs to support decision makers in developing policies and regulations that enhance climate change mitigation and adaptation and help to identify those that may negatively impact achieving the site's conservation objectives (Leskinen, et al., 2024).

Regardless of which tools are used, certain approaches apply, including:

- Using community and stakeholder-based participatory methods to establish objectives and goals that explicitly consider the ability to provide climate mitigation, adaptation, and resilience co-benefits.
- Using best available information, including Indigenous and traditional knowledge.

- Being transparent about the process and evidence used.
- Explicitly acknowledging trade-offs between different objectives, including different values.
- Using mapping to inform decision making among community members and others with different knowledge bases.

Managing MPAs and climate mitigation technologies

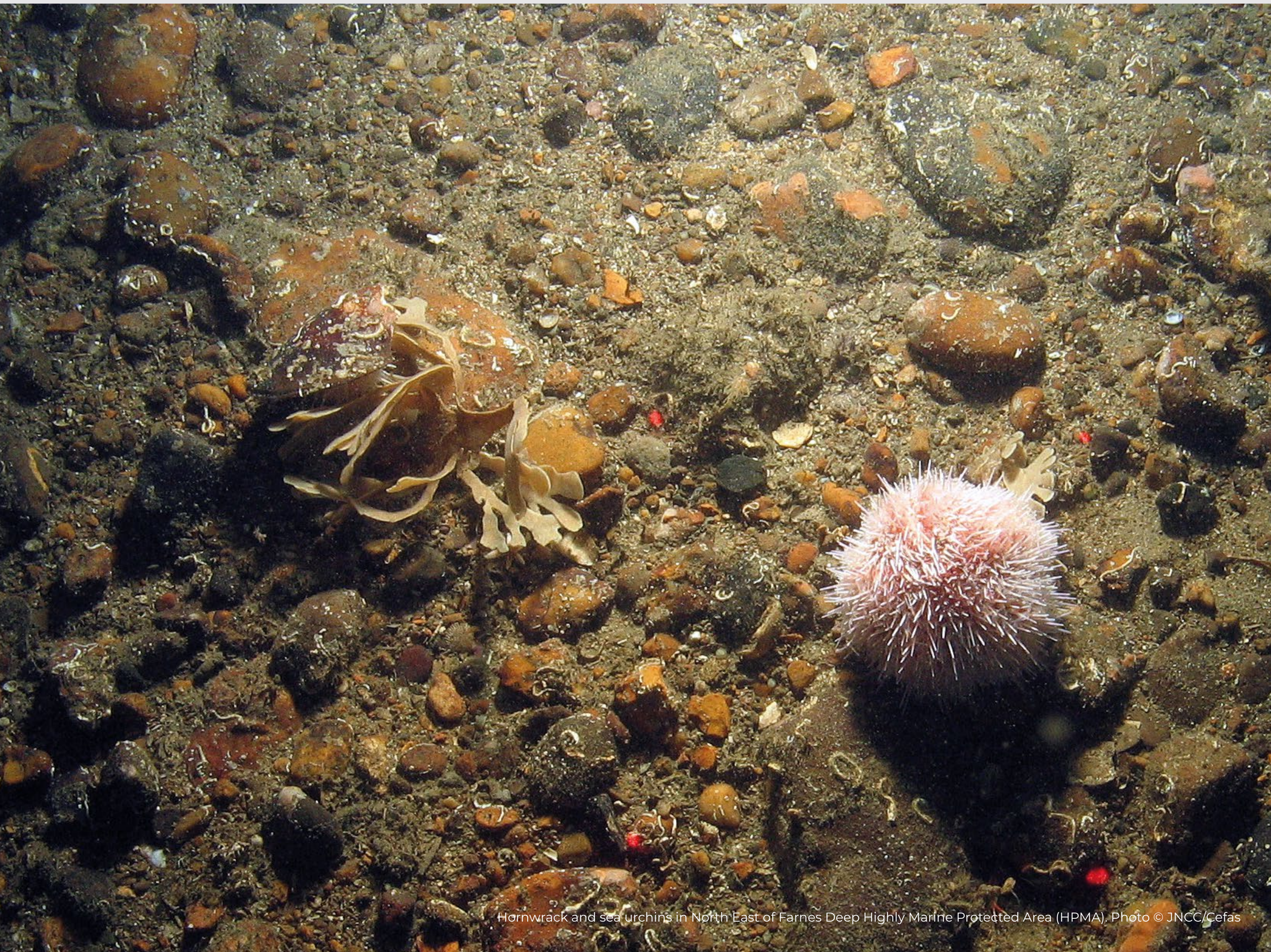
Establishing policies and regulations to proactively consider established, new, and emerging technologies that do not detract from conservation objectives can enhance climate mitigation, adaptation, and resilience within MPAs and broader seascapes. This includes considering zero- or low-emission energy sources and marine transportation (including alternative fuels) in or adjacent to MPAs, while minimizing their impacts to conservation. Additionally, innovative strategies like managed marine carbon dioxide removal (mCDR), while still largely theoretical, and grey-green infrastructure can play a significant role in enhancing ecosystem resilience. For example, alkalinity enhancement both draws down carbon dioxide and locally mitigates ocean acidification while "living shorelines" of marsh grasses can stabilise eroding shorelines while creating or restoring coastal habitat. These engineering solutions often include hardened components, such as offshore sills, to address areas of high wave energy. By thoughtfully incorporating these technologies and strategies, policymakers can ensure that they complement conservation efforts, fostering a holistic approach to managing marine ecosystems.

Effectively using these technologies requires proactive spatial planning that accommodates multiple uses within designated areas, allowing for coexistence of conservation and sustainable development where compatible. In cases where new MPAs are being considered in areas also sought for activities such as renewable energy or mCDR, marine spatial planning can create designated areas for these industrial activities, helping to strategically place them to minimise impacts on critical habitats, species, and conservation objectives. By fostering collaboration among stakeholders, including government agencies, scientists, and local communities, MPAs can seek "win/win" solutions for larger seascapes that meet the challenges posed by climate change – including reducing carbon emissions – while maintaining their core mission of conserving marine biodiversity and ecosystem services. This integrated approach can help increase ecosystem resilience while also potentially increasing the resilience of the communities that depend on the resources MPAs manage.

Case Study: Establishing the first highly protected marine areas (HPMA) in English waters to enhance protections in the face of a changing climate

About the area

In England, Highly Protected Marine Areas (HPMAs) are areas of the sea that are legally designated to allow for the protection and restoration of the whole marine ecosystem within the site's boundaries. HPMAs in English waters prohibit extractive, destructive, and depositional uses. In summer 2023, three HPMAs were designated in English waters: one inshore site, Allonby Bay, and two sites more than 12 nautical miles offshore, Dolphin Head and North East of Farnes Deep (Figure 1). These HPMAs protect a variety of important habitats and species, which can contribute to a range of climate regulatory and supporting ecosystem services.



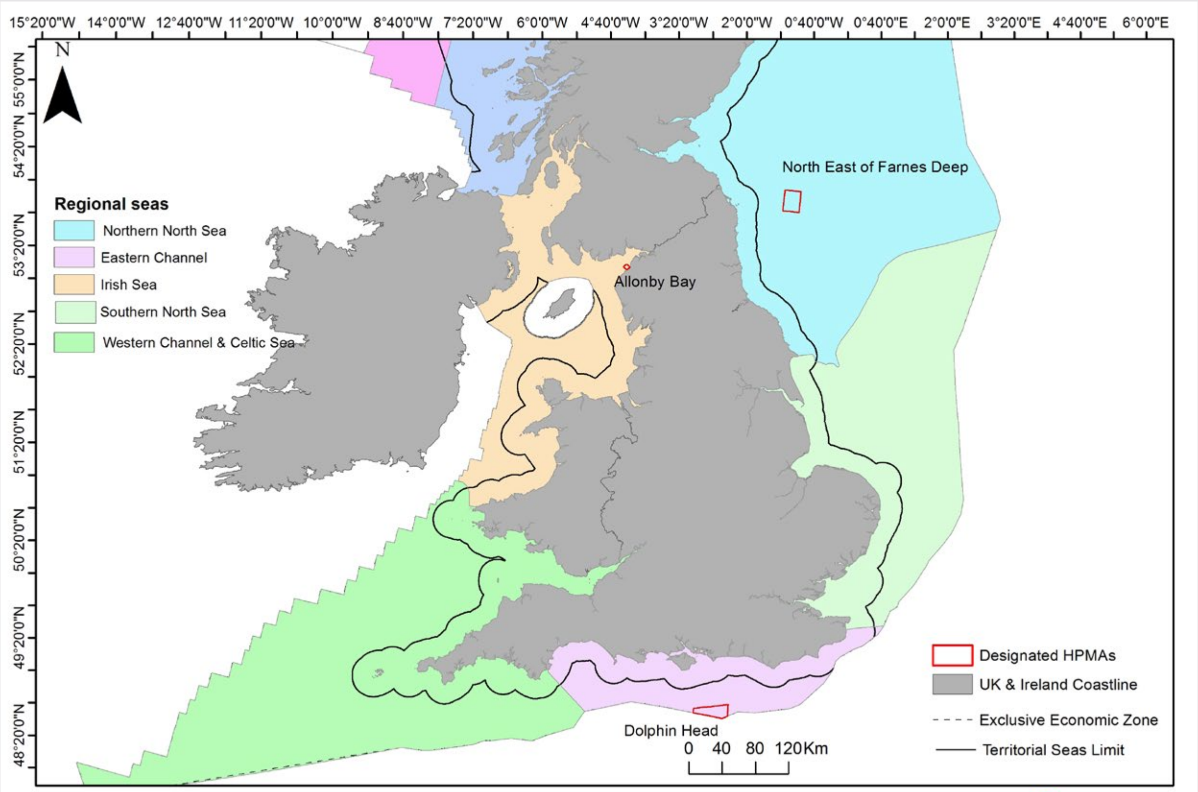
Hornwrack and sea urchins in North East of Farnes Deep Highly Marine Protected Area (HPMA). Photo © JNCC/Cefas

Climate change considerations

HPMAs align with the core principles of Adaptive and Resilient, and Holistic Climate Co-Benefits. By providing protection for the entire site, HPMAs have the potential to safeguard whole ecosystems and their functions, which provide essential climate-related ecosystem services, such as the ability to provide resilience to climate change, shoreline protection, and food security.

The first HPMAs in English waters were designated following the recommendations of the Benyon Review Into Highly Protected Marine Areas (2020), which recognised the valuable ecosystem services provided by the marine environment. The HPMA designation process was the first MPA process in the UK to include climate-specific criteria core principles for site selection. These criteria consisted of habitats considered important to the long-term storage of carbon, and in the provision of flood/erosion protection. The high level of protection afforded by HPMAs will help ensure that climate change mitigation and adaptation benefits provided by these critical habitats are safeguarded. For example, by prohibiting extractive, destructive and depositional activities such as bottom disturbance from fishing and aggregate extraction, HPMAs enhance the ability of habitats, such as subtidal muds, to capture and store carbon more effectively, strengthening the UKs MPA network’s contribution to mitigating climate change.

As HPMAs provide whole marine ecosystem protection, considerations of socioeconomic factors were crucial in their designation, including trade-offs due to prohibited activities. Engaging stakeholders through consultations was an important step, to gather feedback, address concerns and clearly highlight the ecological and economic benefits of HPMAs, especially in light of climate change.



© JNCC 2022. Contains public sector information, licensed under the Open Government Licence v3.0, from the United Kingdom Hydrographic Office. Bathymetry © British Crown Copyright 2016.
Regional Seas: Contains JNCC data © copyright and database right 2004 derived in part from bathymetry © GEBCO Digital Atlas, British Oceanographic Data Centre on behalf of IOC and IHO 1994 & 1997.
Projection: WGS 1984 UTM Zone 31N, Inset map projection: BNG.

Figure 10. The three designated HPMAs in English waters: Allonby Bay, Dolphin Head and North East of Farnes Deep

Management plans are in development for the recently designated sites, with protection provided through the planning and marine licensing processes. A formal public consultation was held on a proposed byelaw to prohibit fishing activity in all three sites, and appropriate management measures for other activities are being considered.

HPMA monitoring will aim to collect evidence to assess changes in the condition of marine ecosystems to build understanding of ecosystem recovery, assess whether HPMA conservation objectives are being met, and determine whether marine management measures are effective. The analysis and subsequent monitoring report from the first dedicated surveys of all three HPMAs, which commenced in 2023, are in development.

Increased understanding of marine habitats, particularly regarding their ability to sequester carbon and protect coastlines from rising sea levels and erosion, would enable more informed designation projects to safeguard these critical habitats. In addition, incorporating knowledge from predictive tools that highlight the future impacts of climate change on UK waters in a spatial context, will strengthen the capability of the UK MPA network to provide essential climate mitigation and adaptation services.

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Phosphorescent sea pens and a hermit crab found on sublittoral mud within the North East of Farnes Deep HPMA. Photo © JNCC/Cefas.

Mangroves provide valuable fish habitat and shoreline protection, as well as sequestering carbon. Photo © USGS/Caroline Rogers

CHAPTER 8.

Conclusion

8. Conclusion

With 2030 only five years away, and countries ramping up their MPA planning activities to meet the GBF's Target 3, it is essential that the other aspects of this target are not lost in the push to meet quantifiable targets. Both MPAs and OECMs are defined as contributing "long-term outcomes for biodiversity", a factor that is particularly important to consider in the face of a changing climate. Conserving and protecting 30% of the ocean is only meaningful if that protection is effective now, and into a future where conditions are increasingly different from those of the past. Addressing climate change during the design and establishment phase of MPAs and OECMs, and their ongoing implementation, is essential to this long-term effectiveness.

In addition to increased planning for networks of protected and conserved areas in national waters, additional opportunities to establish MPAs in the high seas (which makes up nearly two thirds of the global ocean) are on the horizon with the expected entry into force of the High Seas Treaty (the Agreement on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction) in the next few years. This treaty provides a mechanism for area-based management, including MPAs, in areas beyond national jurisdiction, and includes among its criteria for identifying areas for protection under the treaty, "vulnerability, including to climate change and ocean acidification."

Given this momentum for new conservation actions, it is critical that managers apply the principles outlined in this report and existing tools for integrating climate into protected area management in order to achieve long-term outcomes for biodiversity and the benefits it provides to communities. Weaving expertise across disciplines and knowledge systems can help address the complexity of addressing climate impacts within marine conservation networks. For example, climate scientists should continue to deliver and refine data and tools, such as downscaled climate projections, that managers can readily use to address existing and expected climate impacts.

MPA programmes also need to create an enabling environment for climate-adaptive management, such as learning from experience and successful approaches. Networks of MPA managers are important institutions for sharing knowledge and building capacity, as well as for communicating management perspectives to policy makers. Managers play a key role in communicating and engaging with local communities, helping to build local support and broader political will for climate actions in MPAs and OECMs. They can also help build public understanding of the role of protected and conserved areas as part of nature-based solutions, while recognising the broader societal actions needed to address climate change.

Protected and conserved area networks – including MPAs, OECMs, Indigenous managed territories and areas, and areas under dynamic management – bring together different area-based management tools to provide a more comprehensive, ecologically connected, and representative approach to conservation. When combined with a broad marine spatial planning framework, these diverse tools also allow for multiple conservation and sustainable use goals, including industrial uses that contribute to climate solutions, such as marine carbon dioxide removal and renewable energy.

Effectively integrating climate considerations into MPA planning and management is still fairly new, and donors, policy-makers, MPA planners and managers are encouraged to enlist peer learning networks and opportunities to share capacity, tools, and lessons learnt. The next five to ten years present a critical opportunity to establish policies and practices that will ensure an adaptive and resilient future that can achieve the global targets for 2030 and beyond. The four principles explored in this guidance represent a strategy for MPAs to meet this challenge. They are built on well-established practice and theory, and are likely to stand the test of time. In addition, the global MPA community will continue to try new things, succeed, fail, and learn as we all face the consequences of climate change. As such, our understanding of best practices will also continue to evolve with new and updated guidance likely to be needed in the future. The authors hope to publish a future edition of this guidance with additional case studies and reflections as this work evolves.

Humpback whale breach. Photo @NOAA/Robert Schwemmer

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Zachary Cannizzo (Ph.D.) holds a Ph.D. in Marine Science from the University of South Carolina. His work focuses on the integration of climate change adaptation and mitigation strategies into protected area planning, design, and management. This work has included six years as the Climate Coordinator for NOAA's Office of National Marine Sanctuaries as well as scientific research on the impacts of climate change on ecological communities. Zachary has recently transitioned to a role leading the ecology conservation planning and management portfolio for a local protected areas system in Illinois.

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Fabrice Stephenson (Ph.D.) is a Quantitative Marine Ecologist at Newcastle University and Vice Chair (Marine Theme) of the IUCN World Commission on Protected Areas (WCPA). Fabrice uses modelling approaches to study spatial biodiversity patterns and anthropogenic impacts (e.g., fisheries, climate change) to inform strategic policy approaches to managing the marine environment.

Lauren Wenzel is the former Director of NOAA's National Marine Protected Areas Center and currently Co-Chair of IUCN's Protected Areas and Climate Change Specialist Group. She focuses on connecting and strengthening the world's diverse marine and coastal protected area programs through capacity building, information and tools; communication and learning; and collaborative governance. Her focus is on building partnerships among U.S. and international marine and coastal programs, Tribal and Indigenous communities, community and nongovernmental partners, and stakeholders to protect the ocean's most important places. She holds a Master's degree from the University of Michigan in natural resource policy and planning.

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PROTECTED AREA AND OECM DEFINITIONS, MANAGEMENT CATEGORIES AND GOVERNANCE TYPES

IUCN defines a protected area as:
A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.

The definition is expanded by six management categories (one with a sub-division), summarised below.

Ia Strict nature reserve: Strictly protected for biodiversity and also possibly geological / geomorphological features, where human visitation, use and impacts are controlled and limited to ensure protection of the conservation values.

Ib Wilderness area: Usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, protected and managed to preserve their natural condition.

II National park: Large natural or near-natural areas protecting large-scale ecological processes with characteristic species and ecosystems, which also have environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities.

III Natural monument or feature: Areas set aside to protect a specific natural monument, which can be a landform, sea mount, marine cavern, geological feature such as a cave, or a living feature such as an ancient grove.

IV Habitat/species management area: Areas to protect particular species or habitats, where management reflects this priority. Many will need regular, active interventions to meet the needs of particular species or habitats, but this is not a requirement of the category.

V Protected landscape or seascape: Where the interaction of people and nature over time has produced a distinct character with significant ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.

VI Protected areas with sustainable use of natural resources: Areas which conserve ecosystems, together with associated cultural values and traditional natural resource management systems. Generally large, mainly in a natural condition, with a proportion under sustainable natural resource management and where low-level non-industrial natural resource use compatible with nature conservation is seen as one of the main aims.

The category should be based around the primary management objective(s), which should apply to at least three-quarters of the protected area – the 75 per cent rule.
The management categories are applied with a typology of governance types – a description of who holds authority and responsibility for the protected area. IUCN defines four governance types:

Type A. Governance by government: Federal or national ministry/agency in charge; sub-national ministry or agency in charge (e.g. at regional, provincial, municipal level); government-delegated management (e.g. to NGO).

Type B. Shared governance: Transboundary governance (formal and informal arrangements between two or more countries); collaborative governance (through various ways in which diverse actors and institutions work together); joint governance (pluralist board or other multi-party governing body).

Type C. Private governance: Conserved areas established and run by individual landowners; non-profit organisations (e.g. NGOs, universities) and for-profit organisations (e.g. corporate landowners).

Type D. Governance by Indigenous peoples and local communities: Indigenous peoples' conserved areas and territories – established and run by Indigenous peoples; community conserved areas – established and run by local communities.

The Convention on Biological Diversity defines an "other effective area-based conservation measure" (OECM) as: A geographically defined area other than a Protected Area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the in situ conservation of biodiversity, with associated ecosystem functions and services and, where applicable, cultural, spiritual, socioeconomic, and other locally relevant values. This covers three main cases:

1. Ancillary conservation – areas delivering in-situ conservation as a by-product of management, even though biodiversity conservation is not an objective (e.g. some war grave sites).

2. Secondary conservation – active conservation of an area where biodiversity outcomes are only a secondary management objective (e.g. some conservation corridors).

3. Primary conservation – areas meeting the IUCN definition of a protected area, but where the governance authority (i.e. community, Indigenous peoples' group, religious group, private landowner or company) does not wish the area to be reported as a protected area.

For more information on the IUCN definition, categories and governance types, see Dudley (2008). *Guidelines for applying protected area management categories*, which can be downloaded at: https://doi.org/10.2305/IUCN.CH.2008.PAPS.2.en

For more on governance types, see Borrini-Feyerabend et al. (2013). *Governance of Protected Areas: From understanding to action*, which can be downloaded at https://portals.iucn.org/library/node/29138.

For more information on OECMs, see Jonas et al. (2023) Site-level tool for identifying other effective area-based conservation measures (OECMs): first edition, which can be downloaded at: https://doi.org/10.2305/WZJH1425

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