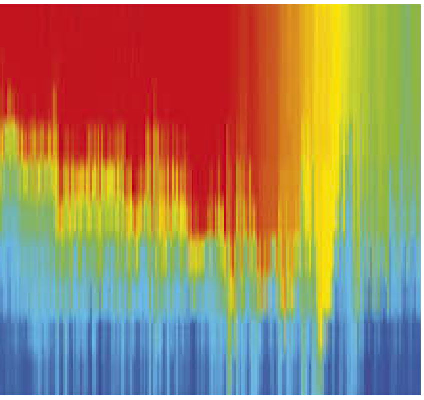
Marine Protected Areas and climate change:

Adaptation and mitigation synergies, opportunities and challenges

Simard, F., Laffoley, D. and J.M. Baxter (editors)



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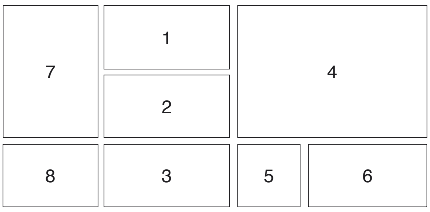

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4- Figure 3.3, p. 33: Traditional fishing in Gökova Bay, Turkey.
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5- PAME (2015). *Framework for a Pan-Arctic Network of Marine Protected Areas, A Network of Places and Natural Features Specially-managed for the Conservation and Protection of the Arctic Marine Environment*.

6- Figure 4.7, p. 47: Vezo children fishing in mangrove lagoon, southwest Madagascar.
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About IUCN

IUCN is a membership Union uniquely composed of both government and civil society organisations. It provides public, private and non-governmental organisations with the knowledge and tools that enable human progress, economic development and nature conservation to take place together.

Created in 1948, IUCN is now the world's largest and most diverse environmental network, harnessing the knowledge, resources and reach of more than 1,300 Member organisations and some 16,000 experts. It is a leading provider of conservation data, assessments and analysis. Its broad membership enables IUCN to fill the role of incubator and trusted repository of best practices, tools and international standards.

IUCN provides a neutral space in which diverse stakeholders including governments, NGOs, scientists, businesses, local communities, indigenous peoples organisations and others can work together to forge and implement solutions to environmental challenges and achieve sustainable development.

Working with many partners and supporters, IUCN implements a large and diverse portfolio of conservation projects worldwide. Combining the latest science with the traditional knowledge of local communities, these projects work to reverse habitat loss, restore ecosystems and improve people's well-being.

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Foreword

Inger Andersen
IUCN Director General

Marine protected areas (MPAs) remain one of our most effective tools in the fight against climate change. When properly managed, those areas can help conserve rich marine biodiversity and the life-supporting services that the ocean provides us with. They absorb large amounts of global carbon emissions, strengthen the ocean's resilience and are critical in supporting our ability to mitigate and adapt to climate change.

However, the ocean – and its capacity to support life on earth – is increasingly threatened by the scale of human-induced greenhouse gas emissions. These emissions continue to alter – at an unprecedented rate – some of the ocean's underlying characteristics and chemistry. Rising sea levels and temperatures, as well as increasing acidification are just some of the consequences of these changes, which are already impacting food supplies, affecting human health and increasing the frequency and severity of extreme weather events.

In recent years we have witnessed remarkable progress in the global recognition of the importance of protecting the ocean. 2015 saw world leaders usher in a new era for climate action – one that clearly defines the health of our ocean as a priority in the global response to climate change. Signatories to the Paris Agreement have pledged to strongly address rational management and cooperative conservation action for the ocean. Expanding MPA coverage and enhancing their management is clearly a pivotal component in this endeavour. And yet, only about 4% of the ocean is currently protected, with around 1.5% covered by strictly, permanently protected MPAs.

The IUCN World Conservation Congress, convened in Honolulu in September 2016, built on the momentum generated in Paris, with a resolution adopted by a large majority of IUCN State, Government and NGO members, calling for the full protection of at least 30% of the world's ocean. This resolution will support the declaration and creation of more MPAs and therefore make significant contributions to the pledges made by countries under the Paris Agreement to conserve ocean biodiversity and bolster ocean resilience.

The Marine Protected Areas and Climate Change report comes off the back of these milestone commitments. It provides the science and guidance that governments need in order to make informed decisions, and puts a spotlight on the policy responses required to increase climate resilience through effective MPA management. Its findings underline the urgent need for a better management of coastal areas and the creation of a comprehensive network of effective, resilient MPAs to help preserve the ocean's ability to support life on earth.

ACRONYMS AND ABBREVIATIONS

AR6	Sixth assessment report cycle of the IPCC
CBD	United Nations Convention on Biological Diversity
CDM	Clean Development Mechanism
COP	Conference of the Parties
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
EbA	Ecosystem-based Adaptation
EbM	Ecosystem-based Mitigation
EC	European Commission
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization of the United Nations
GFNMS	Greater Farallones National Marine Sanctuary
GI	Green Infrastructure
IMO	International Maritime Organization
IPCC	International Panel on Climate Change
IUCN	International Union for Conservation of Nature
LMA	Large Marine Areas
LMMA	Locally Managed Marine Area
NAMA	Nationally Appropriate Mitigation Action
MPA	Marine Protected Area
NOAA	National Oceanic and Atmospheric Administration
PAME	Protection of the Arctic Marine Environment
PIFACC	Pacific Islands Framework for Action on Climate Change
PIPAP	Pacific Islands Protected Areas
PSSA	Particularly Sensitive Sea Area
REDD	Reducing Emissions from Deforestation and Forest Degradation
REDD+	REDD including the role of conservation, sustainable management of forests and enhancement of forest carbon stocks
SBSTTA	Subsidiary Body on Scientific, Technical and Technological Advice
SDG	Sustainable Development Goals
SIDS	Small Island Developing States
SPREP	Secretariat of the Pacific Regional Environment Programme
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VMA	Vulnerable Marine Areas
WDPA	World Database on Protected Areas

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Executive Summary

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RAPID CHANGE IN THE CLIMATE SYSTEM

The Earth's climate has always changed, alternating ice ages and interglacial periods that have shaped the living world. The contemporary human activities, through the emission of greenhouse gases are the new engine of the evolution of the climate system. The speed of contemporary climate change seems unprecedented and exceeds the natural adaptive capacity of many living organisms.

The ocean is a major player in the regulation of the world's climate system. Future oceanic climatological changes are inevitable as a result of the increased content of greenhouse gases in the atmosphere, and even if emissions were drastically reduced in the medium term this trend will continue to be expressed and will amplify over the very long term. Such physico-chemical changes in the ocean are associated with significant effects on marine ecosystems.

On a global scale, there are three major changes that affect all the physico-chemical processes of the ocean, at any latitude and depth: increase in CO_2 dissolved in sea water, which leads to a lowering of the pH; increase in temperature of the surface and deep ocean waters; and sea-level rise. These changes are accompanied by other phenomena such as the deoxygenation of ocean waters. Within this global picture there is also a large regional variability that is still poorly known.

Offshore, the expression of climate-oceanic changes present large spatial and temporal variability related to the influence of the ocean circulation, latitude, depth and interactions with the atmosphere. At the coast and on continental shelves, the expression of climate-oceanic changes present large spatial and temporal variabilities due to the influence of the shallow depths, and proximity to land and river flows.

MAJOR CHANGES IN MARINE ECOSYSTEMS

Oceanic climatological changes lead to profound changes in marine ecosystems. They particularly involve range shifts towards the poles, causing an overall decrease in biodiversity at the equator and the tropics, and an increase in biodiversity at higher latitudes. Some species, populations, communities or habitats will move, disappear, or decrease drastically; they will be replaced by others, indigenous, migrant or non-native species that will eventually prosper. These bio-geographical changes will lead to a global reorganization of the distribution and abundance of the species, and will be highly variable in time and space.

They are accompanied by many other changes, e.g. biological, behavioural, ecological, leading to decoupling of predator – prey relationships and various symbiotic associations, in desynchronization between periods of reproduction, recruitment, dispersal and migration. Many marine organisms, plants and animals, with a skeleton or a calcareous shell (corals, shellfish, etc.) will have greater difficulty achieving calcification. Ecological functions, including food webs will be modified, biomass will change, and ecosystem services will be redistributed and potentially different. The inter-annual and decadal natural variability will be exceeded, but it is unclear precisely how the physical, chemical, biological and ecological processes will react and interact.

MARINE PROTECTED AREAS: TOOLS TO CONTRIBUTE TO THE ADAPTATION AND MITIGATION OF THE IMPACTS OF CLIMATE CHANGE

On most of these phenomena, MPAs will have relatively little, if any, concrete and significant influence. A rational approach, should lead us to better identify and accept the natural processes that MPAs could suffer without being able to necessarily act. It is necessary to accept and assume that forecasting, modelling of processes, their intensity, and their magnitude in time and in space includes significant uncertainties. These uncertainties are related to the estimation of future levels of greenhouse gas emissions, the response of the physico-chemical mechanisms, the consequences for biological and ecological processes, the inertia and the retro actions of these systems, and the interactions with other pressures of anthropogenic origin.

However, MPAs do have a key role to play in accompanying these developments. This situation is an opportunity to step back and imagine the role of the MPAs in the medium and long term, to adapt to climate change and mitigate its effects. The living world is not static and immobile; it is by definition constantly evolving/changing. The speed and intensity of oceanic climatological changes bring additional difficulties and challenges, and MPAs, management tools and protection of marine biodiversity, must by necessity accompany the evolution of ecosystems. The reasons for the creation of MPAs, and the management measures that are implemented to achieve these objectives must therefore evolve to meet these challenges.

MARINE PROTECTED AREAS AND MITIGATION

Mitigation involves taking measures to limit greenhouse gas emissions and / or increase the storage of these gases. To contribute effectively to the increased storage of carbon by marine ecosystems, MPA management must incorporate realistic actions to increase the capabilities of the physico-chemical and/or biological carbon pumps. Those habitats and species that are known to be important carbon stores but are vulnerable to particular anthropogenic activities need to be protected through appropriate management measures being implemented.

The open ocean is an important carbon sink and plays an essential role in regulating the climate. The physico-chemical and biological carbon pumps are at the core of the ocean carbon. The development of the mitigation role of MPAs in the offshore area would require a significant increase the number of large MPAs offshore, covering both the continental shelves and on the high seas. The methods, objectives and management of geo-engineering solutions within MPAs will be important issues to consider in the future.

In temperate zones and high latitudes, the coastal seas are overall carbon sinks; but in lower latitudes, they are overall sources of carbon. However, the coastal waters in estuaries and bays emit more carbon that they capture. These areas are a predominantly heterotrophic operation compared to more offshore areas, due to large river inputs of organic matter that is consumed and degraded, involving significant respiration and therefore significant CO_2 emissions.

Coastal ecosystems such as seagrass beds, saltmarshes and mangroves act as carbon sinks. These habitats, very important also because of the many ecological functions and associated ecosystem services they perform, but face considerable local anthropogenic pressure and are therefore particularly vulnerable.

The active transport of organic carbon to the sea bed is mainly carried out by the zooplankton populations, fish, cephalopods and jellyfish making vertical migrations to feed in surface water areas at night. In addition to the important biomass that they represent, these species produce significant amounts of dead organic matter and faeces which drops rapidly into the depths assuring a long-term carbon storage. Marine Protected Areas within these productive ecosystems that ensure a significant reduction in fishing effort, especially on fish species making vertical migrations, may contribute to increased carbon sequestration in the long term.

MARINE PROTECTED AREAS AND ADAPTATION

Marine Protected Areas can play a key role in bringing together the various interested parties within an area to implement the most appropriate management measures to increase or maintain ecosystem resilience. The involvement of stakeholders around a common project is an important asset to ensure that the best solutions and answers for adaptation to climate change are taken. Marine Protected Areas are suitable tools to devise essential joint solutions for adapting to climate change, but also for outreach, education and communication to the general public, in particular to increase the involvement of society in management and to contribute to the reduction of carbon emissions.

Marine Protected Areas are one mechanism to manage human activities and ultimately reduce the associated pressures on the environment. Such management will contribute to the maintenance or increased resilience of ecosystems and the sustainable use of ecosystem services.

Marine Protected Areas may form a network of observatories and ecological and climate monitoring stations, fostering partnerships with the scientific community and promoting exchanges MPAs can help provide the necessary connectivity between suitable habitats for species to meet the challenges of climate change forced movements.

1. Introduction

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With the welcome and increasing attention on ocean issues by the international climate change community there is an opportunity to draw together knowledge, science and experiences to explain the role that MPAs have in addressing biodiversity conservation as well as climate change adaptation and mitigation actions.

This report, developed through a workshop that was held in Paris in March 2015. It gathered inputs from scientists, and MPA and marine climate change experts. This work was then built on over the following months, specifically following the outcomes of Conference of the Parties to the UN Framework Convention on Climate Change (UNFCCC-CoP21) that took place in Paris in December 2015.

The purpose of the report is to provide information to underpin the outcomes of COP21 and in particular to demonstrate the importance of the role of MPAs in climate change adaptation and mitigation. Such a recognition of the role of MPAs is also an important step towards increasing the effectiveness of MPAs under the CBD 2020 agenda.

To do this the report brings together scientific information on how MPAs can help to solve climate change issues in coastal and ocean ecosystems. The focus is on ocean warming, sea-level rise, change in currents, and other associated phenomena. Carbon dioxide (CO_2) emissions and ocean acidification are not specifically included. In this report, an MPA is defined as “A protected area is a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values” according to IUCN’s official definition[1].

1 Day J., Dudley N., Hockings M., Holmes G., Laffoley D., Stolton S. and S. Wells, 2012. *Guidelines for applying the IUCN Protected Area Management Categories to Marine Protected Areas.* Gland, Switzerland: IUCN. 36 pp.

The scope of the report is intended to cover all marine ecosystems from coastal to open and deep sea. In developing this report it became clear that there is much more information about the relationship between climate change and coastal ecosystems than the open sea ones, and that most of the MPAs are coastal. However, this inconsistency is currently being addressed by the trend to take into consideration open sea ecosystems in climate change interactions, in particular in mitigation (carbon sinks), alongside the increasing number of new designations of MPAs in the open ocean far from land.

This report intends to provide the best available knowledge about the role of MPAs in adaptation to, and mitigation of, climate change in marine ecosystems, from both global and regional perspectives. To do this the report is divided into two main sections:

- A section on adaptation which explores the ways by which implementation of MPAs can provide increased resilience to climate change impacts. The scope of adaptation used in this report includes both the adaptation of marine ecosystems to changes induced by climate, as well as the adaptation of local communities to changes. It tackles the issues of resilience, both ecological and social.
- A section on mitigation which includes the improved management of coastal carbon sinks – so called ‘blue carbon’ and how this relates to MPAs, as well as options for establishing appropriate sustainable financing mechanisms.

In taking this twin-track approach the report also provides some thoughts about the focus of adaptation and mitigation on science to support action, and about the expansion of economic and political science consideration of coastal and ocean blue carbon. Finally, the report tackles issues such as using MPAs as potential sentinel sites for early warning and ground-truthing trends in marine climate change, as well as the role of MPAs as nature based solutions for climate change.

2. Strengthening the relationship between Marine Protected Areas and ocean protection and measures to deliver climate change adaptation and mitigation

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2.1 INTRODUCTION

The deepening knowledge about the functioning of marine ecosystems and their role in the major cycles of the planet has increasingly highlighted the fundamental role of the ocean in controlling global climate. Reducing CO_2 emissions is fundamental to supporting solutions to mitigate global warming, acidification and de-oxygenation of the ocean, coupled with increased efforts and better sustainable management of ecological resources and services for the protection of coastal and marine ecosystems.

The global network of marine protected areas (MPAs) in the world in 2014 covered just over 10% of the coastal and marine areas within national jurisdiction, and approximately 4% of the global ocean (UNEP-WDPA and IUCN, 2016) including 0.25% of marine areas beyond areas under national jurisdiction. This is despite the commitments made by member states at Nagoya in 2010 at the 10th Conference of the Convention on Biological Diversity to protect 10% of the ocean by 2010. In 2013 at the 3rd International Marine Protected Area Congress it was stressed that special efforts must be made at the regional and sub-regional levels. Scientists and NGOs, who gathered in Sydney in 2014 at the 6th World Parks Congress, again called for the stricter protection of the ocean with at least 30% of marine habitats afforded such protection by 2030. It is also a worrying fact that there is significant spatial disparity in marine conservation efforts between countries around the world: e.g. only 20 maritime countries (out of 150) account for the creation of 80% by area of all marine protected areas in the ocean.

At a time when a new international instrument under the UN Law of the Sea is being debated in New York to better protect and manage biodiversity beyond national jurisdiction, the question remains as to how international law can deliver sustainable development at the same time as global biodiversity is facing the challenges of climate change? What place is there for marine ecosystem-based solutions and, in this context, what is the role of the marine protected areas? The key lies both in strengthening multilateral action and in developing stronger regional links between the creation and management of MPA and actions to deliver measures for climate change adaptation and mitigation.

2.2 STRENGTHENING MULTILATERAL ACTION ON MPAS AND CLIMATE CHANGE ADAPTATION AND MITIGATION EFFORTS

Scientific knowledge shows that the ocean is undeniably and inevitably part of the solution to combating climate change and achieving sustainable development; the various multilateral agreements on biodiversity and climate change, developed separately nevertheless show a growing integration of their respective issues and an openness to the multifunctional opportunities presented by MPAs. So how much progress has there been on this growing integration in recent years?

In recent decades the concept of biodiversity conservation has gradually developed leading to various multilateral frameworks on sustainable development and climate change to reflect the importance of biodiversity, ecosystems and the essential ecosystem services they provide. However, the actual translation of such concepts into policy and legislation has been rather more recent.

The state of multilateral law is only now showing a growing “cross-fertilization” of ideas and concepts. Adopted under the auspices of the United Nations, the Sustainable Development Goals (SDGs), the United Nations Framework Convention on Climate Change (UNFCCC), and the United Nations Convention on Biological Diversity (CBD) each have their own framework of negotiations, their own agenda and the joint liaison group strives to instil a problematic unit[2]. Whilst synergies are being increasingly recognized further integration is needed – for example it would have been useful if the recent report by UNEP-WCMC on the mapping of multilateral tools for achieving the Aichi targets could also have incorporated tools available under the UNFCCC (UNEP-WCMC, 2015). Nevertheless, cross-fertilization is happening little by little. The standard mantra of coupling conservation with delivering sustainable management is slowly being replaced by the three interrelated concepts of conservation, sustainable development and resilience. This in itself seems to be a good indicator of the progress of this cross-fertilization in the field of international multilateral law.

Protection of coastal and marine ecosystems has a key role not only in the delivery of sustainable development programmes, but also in adaptation and mitigation climate change strategies as well as in resilience actions. The final document adopted at the third International Conference on Small Island Developing States entitled "SIDS Accelerated Modalities of Action (SAMOA) Pathway" (UNGA, 2014) (1-4 September 2014, Samoa, A CONF.223.10– UNGA, A/RES/69/15) calls for:

> "*ambitious and urgent action on climate change, by protecting biodiversity, by calling for the conservation and sustainable use of oceans and seas and their resources and by and adopting strategies for the promotion of renewable energy.*" (Resolution adopted by the General Assembly on November 14, 2014, 69/15. Modalities of action accelerated of Small Island Developing States (Samoa Pathway), A/RES/69/15, 18). It highlights SIDs strong support to "*the urgent action to protect coral reefs and other vulnerable marine ecosystems through the development and implementation of comprehensive and integrated approaches for the management and the enhancement of their resilience to withstand pressures, including from ocean acidification and invasive species (*Resolution adopted by the General Assembly on November 14, 2014, 69/15. Modalities of action accelerated of Small Island Developing States (SAMOA Pathway), A/RES/69/15, 58e*)*" and promotes the *"integrated ecosystem approach to ocean-related activities is needed to optimize opportunities… based on the best available science"* and to *"give due regard to conservation efforts and precautionary approaches and ensure coherence and balance among the three dimensions of sustainable development (*Resolution adopted by the General Assembly on November 14, 2014, 69/15. Modalities of action accelerated of Small Island Developing States (SAMOA Pathway), A/RES/69/15, 57*)".*

The recognition of the need for a combination of conservation, sustainable development and resilience is not yet formalized, even though the relationship between resilience and sustainable development is mentioned:

> "***Healthy, productive and resilient oceans and coasts*** *are critical for, inter alia,* ***poverty eradication, access to sufficient, safe and nutritious food, livelihoods, economic development*** *and essential ecosystem services, including carbon sequestration, and represent an important element of identity and culture for the people of small island developing States. Sustainable fisheries and aquaculture, coastal tourism, the possible use of seabed resources and potential sources of renewable energy are among the main building blocks of a sustainable ocean-based economy in small island developing States* (Resolution adopted by the General Assembly on November 14, 2014, 69/15. Modalities of action accelerated of Small Island Developing States (SAMOA Pathway), A/RES/69/15, .53)".

Similarly, objective 13 of the Sustainable Development Goals mentions resilience (UNGA, 2015) but in a round-about way: *«Strengthen resilience and adaptive capacity* ***to climate-related hazards and natural disasters*** *in all countries.»* (*Sustainable Development Goal 13, 13.1*) but it does not highlight the role of ecosystems, nor the issue of their protection and sustainable management. Objective 14 of the Sustainable Development Goals dedicated to oceans initiates, on the other hand, a better integration *"From now to 2020,* ***manage and protect sustainable marine and coastal ecosystems namely by strengthening their resilience*** *to avoid the serious consequences of their degradation and take measures for their restoration to restore the* ***health and productivity of the oceans****."* (*Sustainable Development Goal 14, 14.2.*). However, the protection mentioned, is not directly related to and recalling the target of 10%. (Sustainable Development Goal 14, 14.5 : «*from here to 2020, save at least 10% of marine and coastal areas, in accordance with national and international law and taking into account the best available scientific information*»).

The strategic plan for biodiversity 2011-2020 and the Aichi targets adopted by the 10th Conference of the Parties of the Convention on Biological Diversity in 2010 (COP10; Decision

2 In August 2001, a Joint Liaison Group (JLG) between the three Rio Conventions was established as an informal forum for exchanging information, exploring opportunities for synergistic activities and increasing coordination. The JLG comprises the officers of the Conventions' scientific subsidiary bodies, the Executive Secretaries, and members of the secretariats.

Each of the Conference of the Parties of the three conventions has encouraged the JLG to facilitate cooperation at the national and international levels, to identify possible areas of joint activities, and to enhance coordination (CBD decision VI/20, CCD decision 12/COP.6, FCCC decision 13/CP.8). At its fifth meeting in Bonn, Germany (January 2004), the JLG identified three issues as priorities for joint collaboration: adaptation, capacity building and technology transfer.

Aichi Biodiversity Targets (extracts)

Target 5
By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.

Target 6
By 2020, all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.

Target 10
By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.

Target 11
By 2020, at least 17% of terrestrial and inland water, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

X/2) aimed[3] at "*ensuring that by 2020 the **ecosystems are resilient** and continue to provide essential services, thus preserving the diversity of life on Earth, and contributing to human well-being and the eradication of poverty*". Several objectives of Aichi directly mention the marine ecosystems (see box).

Since 2004, the Conference of the Parties of the Convention on Biological Diversity (CBD COP) has adopted decisions on biodiversity and climate change, stressing that synergies exist (Decision UNEP/CBD/COP/DEC/VII/15. 7) and that adaptation and mitigation actions can mutually serve the international conventions of the United Nations through the adoption of the ecosystem approach. Regional cooperation to support resilience and connectivity was encouraged back in 2006 with reference to protected areas (Decision UNEP/CBD/COP/DEC/VIII/30). In 2008, at the World Conservation Congress, IUCN launched with partners PACT 2020 aiming to *"Ensure that protected areas and protected area systems are recognised as an important contribution to climate change adaptation/mitigation strategies for biodiversity and human livelihoods"* (Dudley *et al.*, 2010).

In 2010, two decisions of the CBD COP stressed the importance of regional efforts for the protection of the coastal and marine environments, namely the issue of resilience and the role of the conventions of the regional seas (Decision UNEP/CBD/COP/DEC/X/29), the need to strengthen the networks of protected areas with the development of ecological networks and ecological corridors (Decision UNEP/CBD/COP/DEC/X/33). In 2012 *"the significant role that protected areas, restored ecosystems and other conservation measures can play in climate change related activities"* (Decision UNEP/CBD/COP/DEC/XI/21 6.d) was emphasized again but without further details.

Convention on Biological Diversity

To be tangible and for fostering synergy, MPAs should be oriented towards the effective protection of areas important for biodiversity and ecosystem services. For too long efforts have been confined to coastal areas and despite the declaration of large marine protected areas, marine protection still needs to be extended to the pelagic areas and deep waters, canyons and seamounts of the high seas. In the context of climate change, the role of networks of MPAs is to ensure biological

3 In decision X/2, the tenth meeting of the Conference of the Parties, held from 18 to 29 October 2010, in Nagoya, Aichi Prefecture, Japan, adopted a revised and updated Strategic Plan for Biodiversity, including the Aichi Biodiversity Targets, for the 2011-2020 period.

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and ecological connectivity that strengthens the resilience of coastal and marine ecosystems. To achieve this, they must be representative and demonstrate in a coherent manner their contribution to providing resistance and resilience to climate change.

Protection efforts must themselves be connected and create synergy within a resilient global network of MPAs. A full spectrum of approaches is required to deliver this, ranging from the smallest marine area for the needs of the local fishing community (LMMA - Locally - Managed Marine Area) to large marine protected areas (LMA - Large Marine Areas). This may be by direct protection and management measures or by combining with other sectorial tools for the protection of the oceans: e.g. the particularly sensitive marine areas recognized and designated by the International Maritime Organization (IMO, PSSAs – Particularly Sensitive Sea Areas) or vulnerable marine areas of FAO (VMA – Vulnerable Marine Areas). This integration would naturally strengthen the effectiveness of the outcomes, as well as the governance of the sea.

The ocean could be at the heart of a range of climate change solutions at the multilateral level but greater opportunities as seen in terrestrial situations need to be taken to achieve this. For example, whilst a technical report was published on the resilience of forests, biodiversity and climate change (Thompson *et al.,* 2009), the equivalent one on the ocean focused only on the impact of acidification (Secretariat of the Convention on Biological Diversity, 2009). Similarly, in 2015 when a preliminary report was prepared for the UNFCCC COP 21 on the contribution of the Aichi targets on land mitigation (Leadley *et al*., 2015), no similar report was developed on the ocean in order to contribute to the discussions at the UNFCCC COP 21. A SBSTTA report on the particular role of MPA adaptation, mitigation and resilience would be thus very useful.

The Paris Agreement and its adoption by the UNFCCC COP 21 marked a notable step forward regarding the acknowledgement of the ocean's role and it has now opened the door for more concrete actions regarding the interrelationship of ocean/climate change under the UNFCCC. While "ocean, coastal and marine ecosystems" have always been included in Art 4.1(d) of the original 1992 Convention, the word "ocean" *per se* has not thus far been referenced in existing COP decisions or related frameworks or agreements.

The recent decision of the International Panel on Climate Change (IPCC) to prepare a Special Report on climate change and oceans and the cryosphere during its Sixth Assessment Report cycle (AR6) is a welcome step. The IPCC will consider the draft Special Report on climate change and oceans and cryosphere as early as possible during the Sixth Assessment Report cycle. This is important recognition of the importance of the ocean and once completed will help guide the ocean/climate actions particularly with prioritization of policy-relevant questions in the Summary for Policymakers in the IPCC report.

The text of Paris Agreement includes recognition of the conservation of sinks and reservoirs and the ocean under the banner of "ecosystems". Its preamble includes the recognition of the "*fundamental priority of safeguarding food security and ending hunger*", as well as: *"Recognizing the **importance of the conservation** and enhancement, as appropriate, **of sinks and reservoirs** of the greenhouse gases referred to in the Convention, noting the **importance of ensuring the integrity of all ecosystems, including oceans, and the protection of biodiversity**, recognized by some cultures as Mother Earth, and noting the importance for some of the concept of "climate justice", when taking action to address climate change,"*(Paris Agreement).

The Paris Agreement is already aligning resilience and sustainable development in the adaptation planning processes (Art.7.9.e) "*Building the resilience of socioeconomic and ecological systems, including through economic diversification and sustainable management of natural resources*" and coupling resilience of communities, livelihoods and ecosystems with the loss and damage (Art. 8.4.h). Article 5 of the Agreement text doesn't expressly mention the ocean but by "*including forest*" it is implicitly opening the door to other ecosystems. Article 5.2's rationale as well would be very relevant for coastal and marine ecosystems with " *policy approaches and positive incentives for activities relating to reducing emissions from deforestation* (/destruction of coastal and marine ecosystems) *and forest degradation* (/coastal and marine ecosystems degradation)*, and the role of conservation, sustainable management of forests* (/coastal and marine ecosystems) *enhancement of forest* (/coastal and marine) *carbon stocks in developing countries; and alternative policy approaches, such as joint mitigation and adaptation approaches for the integral and sustainable management of forests* (/coastal and marine ecosystems)*, while reaffirming the importance of incentivizing, as appropriate, non-carbon benefits associated with such approaches*".

With the Paris Agreement a greater opportunity can definitively be found for better integrating coastal and marine ecosystems into Ecosystem-based Adaptation (EbA) and mitigation (EbM) (with three references to sinks in the Agreement text itself) through various mitigation related efforts – REDD+, NAMAs, CDM – which already, and should further, include protected areas. It will be interesting also to see how the upcoming UNFCCC COP will address the development of alternative policy approaches, such as joint mitigation and adaptation approaches not only for forest sustainable management (UNFCCC, 2015) but for coastal and marine ecosystems too.

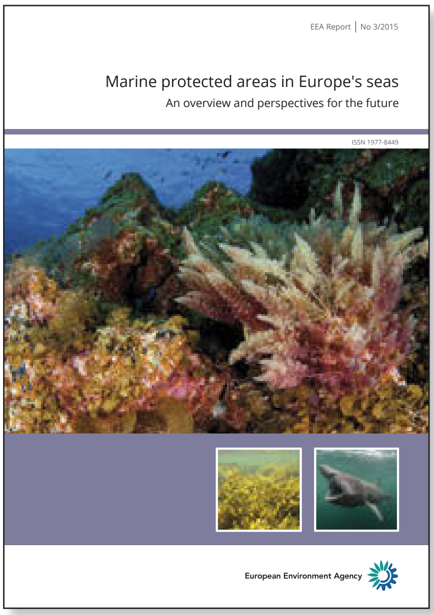
As stressed by the COP21 decision, it is now important to uphold and promote regional and international cooperation in order "*to mobilize stronger and more ambitious climate action by all Parties and non-Party stakeholders, including civil society, the private sector, financial institutions, cities and other subnational authorities, local communities and indigenous peoples*" (UNFCCC, 2015). The implementation at the national and regional levels is now critical for ensuring the inclusion of marine and coastal measures, such as MPAs and marine spatial planning, and to tangibly transcribe the ocean/climate interrelationship.

Integration of issues is underway at the multilateral level but it has yet to be further clarified in order to better connect issues of marine conservation – climate change – sustainable development and resilience. This cross-sectoral approach of the oceans for better addressing climate change is a critical challenge for the regional frameworks and agreements and more particularly for the Regional Seas conventions.

2.3 ACHIEVING BETTER REGIONAL RECOGNITION OF MPAs AS THE FRAMEWORK FOR DELIVERING ADAPTATION, MITIGATION AND RESILIENCE

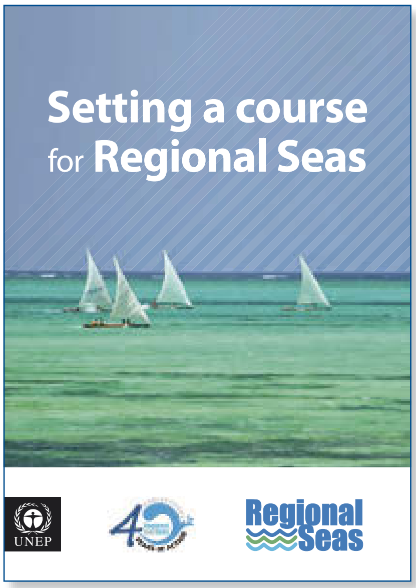
It is still the case that very few networks of MPAs explicitly incorporate the effects of climate change in their definition and design (e.g. Martinez *et al.*, in press). If efforts are increasingly made to support adaptive management, so the design of MPA networks and their development will require significantly more effort to help address climate change impacts.

The European Union has a particular responsibility in this regard with its policies and the geographical extent of EEZs that place the European Union, its Member States and the European Overseas Entities at the top of the world ranking in terms of marine area. With the European Outermost Regions and the Overseas Countries and Territories, the European Union is 'present' in all the oceans of the world. However, neither the State of the Environment Report (EEA, 2015a) nor the specific report regarding European MPAs (EEA, 2015b), both which mention the impacts of climate change as a source of pressure or risk, offer any analysis of the role of MPA networks in relation to issues of resilience. In 2017 the European Commission will report on the implementation of the EU Strategy on Adaptation and may propose its revision, and this may present a good opportunity to review and take into account the role of coastal and marine ecosystems in its midst, as well as in the importance of securing dedicated funding for more ecosystem based adaptation actions. The EU has indeed integrated climate change into all EU spending areas, representing a commitment of 20% of the budget of the European Union 2014-2020.



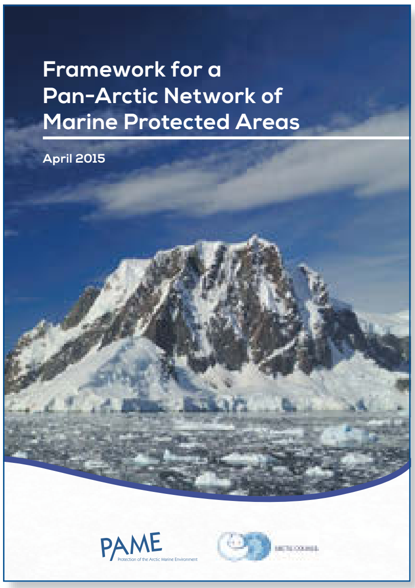
The European Union's strategy on adaptation to climate change (European Commission, 2013a) indicates in this regard that the Commission should "*explore the need for **additional guidance** for authorities and decision makers, civil society, private business and conservation practitioners to ensure the full mobilisation of ecosystem-based approaches to adaptation.*" (European Commission, 2013a). Additional guidance on blue infrastructures would be very valuable but so far are not yet elaborated. The EC Communication on the green infrastructure (European Commission, 2013b) defines green infrastructure as "*a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas*". However, it does not mention adaptation nor resilience in the section devoted to green infrastructure that applies to marine and only a brief reference to coastal defence and blue carbon *"With regard to the marine environment, green infrastructure can help put the current strategies on marine spatial planning and integrated coastal zone management into practice, in particular the strategies for sustainably managing coastal zones and making coastal defences more efficient. Further developing blue carbon approaches, beneficial for fish stocks, can also profit from the application of GI principles to promote multiple ecosystem services in the marine environment."* (European Commission, 2013b). A few case studies listed on the European platform Clim-Adapt consider conservation activities with a view to adaptation but very few of these focus on coastal and marine ecosystems such as Ria Formosa in the Portugal or the saltmarshes of the United Kingdom.

For other regions, the global strategic guidelines for the Regional Seas Programmes that cover the period 2008-2012 include the protection of marine biodiversity, its sustainable use, and climate change. Its 60th strategic directive refers to *"**Assess and address the impact of climate change***



on the marine and coastal environment, in particular, the potential social, economic and environmental impacts and consequences on fisheries, tourism, human health, marine biodiversity, coastal erosion, and small islands ecosystems. ***Promote cooperation for formulating regional climate change adaptation strategies****"* (UNEP, 2007). The UNEP Regional Seas@40 report makes reference to climate change and highlights the acidification of the oceans as a *'major future challenge'* (UNEP, 2014a). Only a passing mention of the role of MPAs in resilience is made, and neither climate change, nor adaptation, nor resilience are included among the four actions needed in future years, but are only mentioned in the strategic partnerships with the idea of dedicated groups for climate change, risks and disasters narrowing down to a risk management sciences approach.

It is actually at the level of southern and northern regional seas that the clearest reference to the role of MPAs in adaptation to climate change and their support to ecosystem resilience can be found. Article II of the CCAMLR already provides as a principle of conservation "*the prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades, taking into account the state of available knowledge of the direct and indirect impact of harvesting, the effect of the introduction of alien species, the effects of associated activities on the marine ecosystem and of the effects of environmental changes, with the aim of making possible the sustained conservation of Antarctic marine living resources."* (CCAMLR, Article IIc). The Antarctic and Southern Ocean Coalition (ASOC) requested in 2007 that the CCAMLR adopt the use of *"climate change implication statements"* in all future working documents and reports on fisheries (CCAMLR, 2007). In 2009, a resolution of the CCAMLR (CCAMLR, 2009a) noted that *"management action can help build resilience and protect the unique Southern Ocean environment against potentially irreversible impacts of climate change, and ensure the continued conservation and rational use of the Antarctic marine living resources"*. In 2011, a conservation measure of the CCAMLR setting the general framework for the establishment of MPAs (CCAMLR, 2011) recognizes that *"CCAMLR MPAs aim to contribute to sustaining ecosystem structure and function, including in areas outside the MPAs, maintain the ability to adapt in the face of climate change, and reduce the potential for invasion by alien species, as a result of human activity"* and includes among the MPA creation objectives *"iv) the protection of areas vulnerable to impact by human activities, including unique, rare or highly biodiverse habitats and features;… vi) the protection of areas to* ***maintain resilience*** *or the ability to adapt to the effects of climate change."*. The expected benefits of MPAs have been highlighted under climate change and especially their potential to increase the resilience of species and ecosystems, but only on the condition that they are sufficiently large and connected and in place for an indefinite period (CCAMLR, 2013). Since the protection of South Orkney Islands southern shelf in 2009 (CCAMLR, 2009b), and despite the existence of three tangible proposals for the Ross Sea, the Weddell Sea and East Antarctica, no new MPA has been established in the framework of the CCAMLR. The CCAMLR members have hitherto not reached a consensus on proposals for the creation of MPAs in the Antarctic, some members calling for the integration of a *"Sunset clause"* in establishing these MPAs for a fixed period/duration referring to the commonly accepted definition of MPA, a temporary measure is not an MPA (Dudley, 2008).



In the Arctic, the latest work in the field of MPAs and more specifically the development of a framework for a pan-Arctic network of MPAs (PAME, 2015) anchors such a network in the context of the resilience issue. Developed by the PAME working group of the Arctic Council in 2015, the vision of this network is defined as *"An ecologically connected, representative and effectively-managed network of protected and specially managed areas that* ***protects and promotes the resilience*** *of the biological diversity, ecological processes and cultural heritage of the Arctic marine environment, and the social and economic benefits they provide to present and future generations."* (PAME, 2015). Although legally non-binding, this document includes very useful and important guidelines. It stresses that the protection and conservation of the Arctic marine environment and biodiversity are a key priority for the Arctic Council because of the role of the Arctic waters in the global climate system, the protection of marine biodiversity, food security, income and cultural identity of the peoples and communities of the Arctic. Both in its principles and objectives, the pan-Arctic network of marine protected areas specifically includes the issue of ecological resilience. The first of its interrelated objectives indeed aims to strengthen ecological resilience to direct human pressures and climate change impacts. The fifth of its nine common principles focuses on resilience and adaptation to change (PAME, 2015).

The framework also specifies in greater detail how a pan-Arctic network can strengthen ecological resilience (see beside).

The framework also underlines how this network must integrate into its design the need for adaptive management areas in the light of current and future changes as well as the connectivity which is *"particularly important as a network principle in a dynamic environment"* (PAME, 2015). It also proposes setting up dynamic MPAs, protecting important ecological areas able to move over time.

PAME, 2015 (extracts)

A pan-Arctic MPA network can strengthen the ecological resilience of the Arctic, for example by:

Protecting natural ecological values (e.g. species habitats, especially habitats of species at risk or IUCN red-listed species; key species for Arctic food webs and human harvest; places of importance for ecological processes, such as primary productivity).

Connecting and protecting spatially separate habitats essential to the life cycles of trans-boundary marine species, such as feeding, breeding, and nursery grounds and migration corridors for marine mammals, fish and seabirds.

Providing refuge for marine species (often referred to as redundancy or replication). For example, by protecting multiple examples of important habitat features, a network can provide insurance that at least one sample of the habitat type and its associated biodiversity will remain intact, should a catastrophic event occur in the area.

Protecting and connecting features and habitats that support the ability of species to be resilient to, or adapt to, climate change (e.g. sea ice areas with forecasted persistence) by providing biodiversity reservoirs that can help species repopulate after extreme events and areas that are protected from other stressors that deplete resilience.

Supporting or restoring marine community structure, productivity, and food web complexity.

Protecting natural bio-physical values (e.g. sequestration of carbon; filtration of pollutants; features such as recurring leads and polynyas and corals that are important for ecosystem structure and function).

Since 2008, the Barcelona Convention has focused on climate change through the production of statements (Declaration of Almeria 2008) and reports (Perez, 2006). The Mediterranean Sea has been identified as a global climate change hotspot and one of the most responsive regions to climate change globally (Giorgi, 2006). Work was initiated in 2010 for the development of a regional framework for adaptation to climate change in the Mediterranean whose vision includes *"By 2025 the Marine and Coastal Areas of the Mediterranean countries and their communities have* ***increased their resilience*** *to the adverse impacts of climate variability and change, in the context of Sustainable Development"* (UNEP, 2016) (see below). The main objective of the Framework is to set a "*regional strategic approach to increase the resilience of the Mediterranean marine and coastal natural and socioeconomic systems to the impacts of climate change*" (UNEP, 2016) in assisting policy makers and stakeholders at all levels across the Mediterranean in the development and implementation of coherent and effective policies and measures by identifying strategic objectives, strategic directions and priorities that:

— promote the right enabling environment for mainstreaming adaptation in national and local planning;

— promote and exchange best practices and low-regret measures;

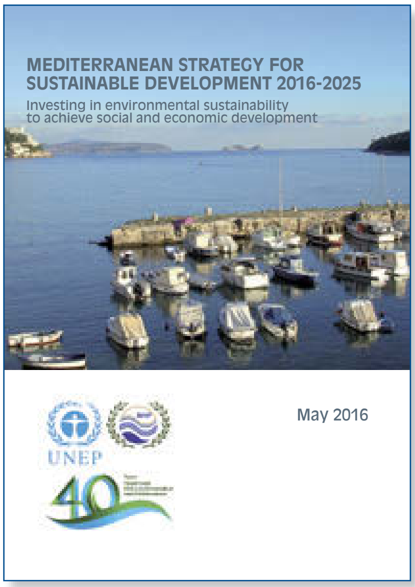
— promote leveraging of necessary funding; and

— exchange and access best available data, knowledge, assessments and tools on adaptation.

A regional plan of action for adaptation has been proposed and under discussion. Analyses and specific training (MedPAN, 2014) on MPAs have also been developed by CAR SPA and partners (Otero *et al.*, 2013).

In the Indian Ocean, a climate change strategy has been drafted in the context of the Nairobi Convention (UNEP, 2015). Not yet adopted the strategy's vision is "*To make coastal communities, economies and marine ecosystems in the Western Indian Ocean* ***resilient*** *to the effects of a changing climate and climate variability.",* combining climatic, economic and environmental issues. This document foresees better support for the creation of new MPAs through a mapping index of coral reef resilience and underlines the challenge to integrate the implementation of adaptation measures in the planning of MPAs (UNEP, 2015).

In the Caribbean region, no climate change strategy has been developed. The work plan 2015-2016 (UNEP, 2014b) mentions climate change through strengthening MPAs management capacity for adaptation to climate change, and the development of a partnership for coral reefs under the Regional Seas Programme of UNEP to safeguard coral reef ecosystem services, protect biodiversity, and create resilience to climate change. In addition, it seeks to improve conservation of mangroves in the region through incentives and financial mechanisms, in coordination with international programmes such as the Framework Convention of the United Nations on climate change. The last two-year plan mentions the development of systemic management plans



Mediterranean Framework Strategic Objectives (extracts)

The Framework is structured around four Strategic Objectives, each of them identifying several Strategic Directions with Priorities for consideration.

1. Appropriate institutional and policy frameworks, increased awareness and stakeholder engagement, and enhanced capacity building and cooperation:

1.1. Enhancing awareness and engagement of key stakeholders on climate adaptation

1.2. Promoting adequate institutional and policy frameworks

1.3. Promoting a regional approach on Disaster Risk Management

1.4. Improving implementation and effectiveness of adaptation policies through monitoring and reviewing progress for a selection of pilot protected areas for sustainable development of the communities living within the ecosystems concerned, however, such an approach and support are not yet deployed for resilience. On this point, a workshop was organized on the resilience of MPAs and climate change in 2013 (IUCN *et al.*, 2013).

In the Pacific, protection is mentioned among the measures of adaptation within the Pacific Islands Framework for Action on Climate Change (PIFACC) (SPREP, 2011) in support of the resilience of coastal systems. The portal dedicated to the Pacific Islands Protected Areas (PIPAP) has useful documents for setting up and defining MPAs in relation to issues of climate change and resilience (Fernandes *et al.,* 2012). In 2013, at the 9th Pacific Islands Conference on nature conservation and protected areas it was underlined that "*a resilience lens was needed to plan for the future and a strategic approach was needed*" (SPREP, 2013) inviting further developments.

More and more acute climate issues are arising at the regional sea level and require further developments. Climate change highlights the critical need for inter-regional cooperation between regional seas, like the important high-seas to which the regional seas conventions are not all attached (Druel *et al.,* 2012). However, the development of MPA systems as adaptation, mitigation and resilience infrastructures seem to be gradually emerging and underlining the usefulness of inter-regional exchanges to support the efforts and synergies in the various oceanic basins.

2.4 CONCLUSION

The interrelation between MPAs and climate change is now being examined and shines a new light on the need for the ecosystem and integrated approaches, adaptive management and effective governance. It now requires greater integration to be achieved between the main components of the biosphere to thus break down barriers and further develop integrated actions and legal frameworks.

Initially focused on the conservation of species, the MPA approach must adapt in light of climate change impacts. Further to the cultural and economic dimensions of environmental issues, climate change highlights the dialectic between spatial measures and dynamics of the biosphere, and the necessary evolution of the systems, starting with the legal one, with a deeper integration of issues. More specifically the regional seas frameworks now need to embrace the integration of MPAs with climate change actions.

1.5. Integrating climate adaptation into local plans for the protection and management of areas of special interest

2. Development of best practices (including low regret measures) for effective and sustainable adaptation to climate change impacts:

2.1. Identifying adaptation needs and best practices

2.2. Mainstreaming, exchanging and adopting best practices

3. Access to existing and emerging finance mechanisms relevant to climate change adaptation, including international and domestic instruments:

3.1. Prioritizing public spending relative to climate adaptation and mobilizing national sources of climate finance

3.2. Accessing international financing

3.3. Building alliances with the banking and insurance sectors

4. Better informed decision-making through research and scientific cooperation and availability and use of reliable data, information and tools:

4.1. Understanding of the vulnerability of natural and socioeconomic systems and sectors and of possible impacts

4.2. Building capacities for and promoting the use of vulnerability and risk assessment at regional to local levels

4.3. Strengthening science-policy interface and accessibility of related knowledge

4.4. Developing regional climate information at a resolution suitable for adaptation planning

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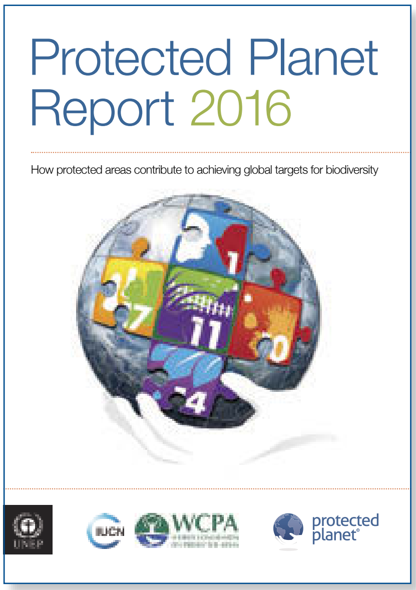

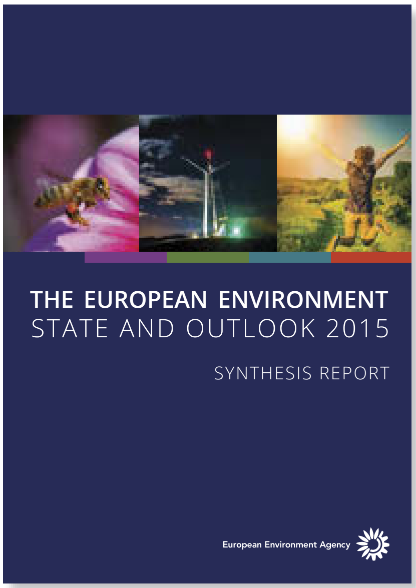

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3. Marine Protected Areas and adaptation to climate change: How can MPAs increase climate resilience?

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3.1 INTRODUCTION

Climate change is reshaping the biophysical and chemical characteristics of coasts and oceans, from increased water temperature, sea-level rise, and extreme events, to ocean acidification, with serious consequences for natural systems. Multiple and combined pressures are increasingly recognized as eroding the functioning and health of marine and coastal ecosystems, and impacting the multiplicity of ecosystem services that society relies on such as food production, flood and erosion control, carbon storage, sequestration and water quality.

Marine protected areas, as place-based and long term designations, can play an important role in addressing impacts of climate change and building ecological resilience by lessening the impact of non-climate change stressors such as water pollution, overfishing, and habitat destruction. Marine protected areas also provide the infrastructure to focus research and monitoring efforts to observe climate trends. As an education tool, they can help raise awareness of local communities and the public at large of the impacts of climate change on biodiversity and human wellbeing and for the need to reduce carbon emissions to avoid irreversible changes. Marine protected areas and MPA networks can also be designed to protect (or restore) key ecosystem services underpinning human wellbeing as their primary objective, distinct from their conservation function.

This chapter examines the evidence supporting the idea that MPAs may promote resilience across socio-ecological systems from two perspectives:

— First, by focusing on biological communities and highlighting the observed mechanisms by which ecosystem protection facilitates the resistance or recovery from exposure to climate change pressures and climate variability.

— Second, by focusing on ecosystem services and how the protection of key habitats as natural infrastructure will contribute to social resilience.

3.2 MECHANISMS BY WHICH PROTECTION FACILITATES ECOSYSTEM RESILIENCE

Reducing pressure generated by human activities is identified as being one of the major areas of work to increase the capacity of habitats and biological communities to adapt to climate change (IPCC, 2014). Reduction of anthropogenic pressures in MPAs may maintain a favourable ecological status and a greater resilience (the capacity to resist change or recover following a perturbation, thus maintaining ecological function).

For instance, local stressors reduce the capacity for corals to regrow and recover following bleaching (Carilli *et al.*, 2009). Climate change will ultimately change the spatial distribution of species and habitats and there will be taxa and regions that will be either "climate change winners" or "losers". In some cases, management actions may only delay inevitable changes in the distribution or disappearance of species (particularly with increased seawater temperature). Management interventions may lead to longer lasting ecosystem services provided by nature.

The establishment of MPAs or more adaptive management of existing MPAs may lessen the impacts of climate change and offer new opportunities that will arise under a changing climate. While MPAs have legal authority to minimize some local disturbances (e.g. living marine resource extraction, bottom disturbance, vessel discharge, and infrastructure development), they are also susceptible to disturbances originating outside their boundaries, at local to global scales, such as those associated with climate change (e.g. sea-level rise, warming sea surface layers, ocean acidification, magnitude and frequency of storms, storm surge, spread of invasive species, species range shifts). Placing MPAs and their management in a broader context, such as integrated coastal zone management or marine spatial planning, may be critically important to realizing their socio-ecological resilience potential.

A wide range of management objectives, approaches and types of governance are used within protected areas in different countries. Management objectives may range from cultural subsistence use, strict protection and exclusion of humans to broad-scale multi-use approaches, such as protecting seascapes and traditional use of marine resources with ecotourism (Dudley *et al.,* 2008; Day *et al.*, 2012). Independent of governance and category, it is important that MPA managers be aware of climate change risks and vulnerabilities and explicitly incorporate climate change adaptation in MPA management plans and objectives. Managers, and where possible, stakeholders should work towards minimizing impacts on biodiversity and the livelihoods of local communities that depend on the ecosystem services these places provide.

Large, well-managed MPAs host high abundances and biomass of species, and overall diversity (e.g. Fenberg *et al.*, 2012; Edgar *et al.*, 2014). Diverse rocky and coral reef fish communities appear more resistant to warming and variability in temperature (Duffy *et al.*, 2016) and are more temporally stable (Mellin *et al.*, 2014). This may be due to the portfolio effect –greater diversity relates to a greater variety of species which, on average, may lead to greater range of ecological functions – and increase the capacity to recover (Figge, 2004). Indeed, long-term data from Australia's Great Barrier Reef provide strong support that ecological community composition is more stable within MPAs in comparison to adjacent unprotected habitats, with greater recovery following disturbance (Mellin *et al.*, 2016). Thus, while responses of biological communities are certainly variable, scientific evidence is emerging that show that shifts in the structure of biological communities following protection ultimately lead to a greater capacity to withstand, adapt and recover from the types of pressures that can be expected under climate change through a variety of known mechanisms.

By limiting potentially destructive human activities and promoting management best practices within their boundaries, MPAs also protect habitat-forming species (Figure 3.1). Increases in species diversity following protection can lead to greater habitat complexity with strong implications for population recovery and overall diversity, including enriching habitat for juvenile populations. For instance, coral and kelp cover are greater in some protected areas (Sala *et al.*, 2012), and given the importance of corals and macroalgae in providing habitat, increasing productivity, and supporting ecosystem services, the capacity for protection to indirectly increase the complexity of habitat and entire taxonomic groups (such as corals and kelp) that are predicted to decline with ongoing climate forcing indicates a possible management tool for building community resilience.

Intact trophic webs following protection can also lead to resilience through changes in trophic structure (Figure 3.1). First, the retention or recovery of top predators can resist colonization by invasive species because protecting higher trophic levels leads to greater complexity in the food web and stronger top-down control on community structure (Bates *et al.*, 2014). Invasive species are expected to expand under climate change, in particular as a response to warming (Sorte *et al.,* 2013), and protection may deter the spread of invasive species across seascapes. Second, herbivory also controls community structure. For instance, the impacts of coral bleaching can be less severe in MPAs due to herbivory effects (Mellin *et al.*, 2016), in combination with minimizing other stressors related to human activities, including damage and transmission of disease.

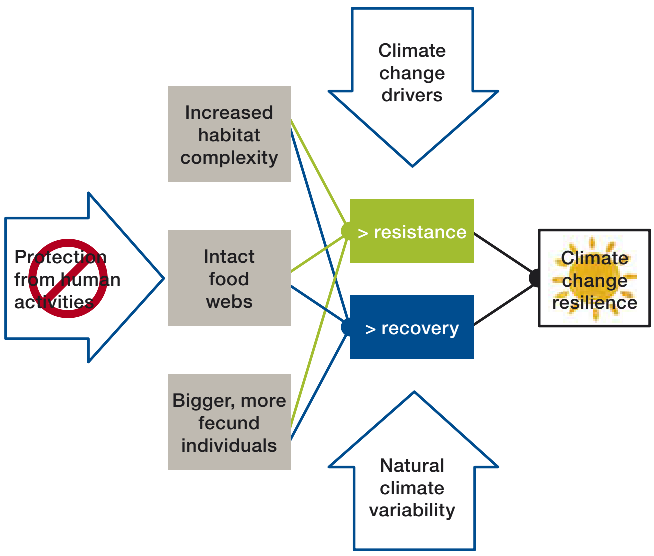


Figure 3.1:
Mechanisms by which MPAs may increase ecological resilience.

CASE STUDY:

RESISTING COLONIZATION OF INVASIVE URCHINS IN SOUTH-EAST AUSTRALIA'S MARINE PROTECTED AREAS

Figure 3.2:
The urchin, *Centrostephanus rodgersii,* has moved into the waters of Tasmania, forming extensive rock barrens, leading to large-scale community change. MPAs resist colonization by the urchin.
Photo credit: © Scott Ling, Institute for Marine and Antarctic Studies (IMAS), University of Tasmania.

Coastal systems in South-east Australia are rapidly warming and are increasingly supporting species more typical of subtropical latitudes. One ecologically important species that has moved poleward and proliferated in this region is the sea urchin *(Centrostephanus rodgersii).* The urchin grazes kelp beds, creating rocky barrens, ultimately driving a loss of biodiversity and the services that kelp forests provide. Marine protected areas across the region are seen to resist colonization by the urchin (Ling *et al*., 2009). A series of experiments and monitoring has revealed that this resistance can be attributed to the presence of large spiny lobster *(Jasus edwardsii)* that feed on urchins. Protection from fishing within the MPAs means more and bigger lobsters, keeping the numbers of urchins in check and preventing the formation of barren rock habitats.

MPAs further play a critical role in facilitating population recovery following mortality events (such as those associated with climate extremes) because populations within MPAs tend to be larger and more fecund (Figure 3.1). Larger and more fecund fish, tend to have longer spawning seasons. This means that individuals can persist during unfavourable periods and spawn upon the return of more favourable conditions, thereby promoting successful recruitment (reviewed in Hixon *et al.,* 2014). Indeed, following a hypoxic event in Baja California that caused widespread mortality in many benthic invertebrate species, pink abalone (*Haliotis corrugata*) were less affected in MPAs (Micheli *et al.,* 2012). The relatively larger body size of the adults found within MPAs, and the related gain in egg production in these individuals facilitated successful juvenile recruitment, stability of the population and its recovery following exposure to low oxygen.

3.3 BENEFITS OF MPAs IN ADAPTING TO CLIMATE CHANGE AND BUILDING RESILIENCE

Climate resilience is about the capacity for socio-ecological systems to sustain shocks, maintain the integrity of functional relationships, and utilize changes as opportunities for innovation and evolution of new pathways that improve the system's ability to adapt. MPAs and place-based management are tools for protecting ecosystem functions and building socio-ecological resilience is several ways:

3.3.1. STRATEGIC PROTECTION OF NATURAL INFRASTRUCTURE

There is increasing recognition of the key role and multiple benefits of marine and coastal ecosystems such as coral and oyster reefs, seagrasses, wetlands and mangroves which act as natural buffers to damage from severe storms, flood and erosion. For example, coral reefs reduce wave action, storm surge and maintain shoreline elevation. A study on the effectiveness of coral reefs for reducing coastal hazards and adaptation showed that coral reefs can reduce wave energy by an average of 97%, reef crests alone dissipating most of this energy (86%) (Ferrario *et al.,* 2014). Coral reefs can provide comparable wave attenuation benefits to artificial defences such as breakwaters, and can be cost effective. Reefs face growing threats yet there is an opportunity to guide adaptation and hazard mitigation investments towards reef restoration to strengthen this first line of coastal defence.

Other studies have also found that saltmarshes can effectively reduce the height of damaging waves in storm surge conditions by close to 20% and may dissipate over 90% of the wave energy that arrives at the coast (Kirwan and Megonigal, 2013; Möller *et al.*, 2014). In sheltered up-stream estuarine areas, saltmarshes also offer water storage capacity which may reduce the potential impacts of sea- level rise.

Ecosystem-based solutions for climate change adaptation are now being recognized as cost-effective solutions that can replace or complement engineered solutions to increase the resilience of coastal populations and contribute to sustainable development and food security, which are also an important aspect of climate resilience. In strategically protecting coastal and marine habitats, MPAs and MPA networks can play a critical role in climate change adaptation, mitigation and development strategies.

Designating new MPAs and or managing existing MPAs for climate change adaptation (and/or mitigation) require both an assessment of climate risks and vulnerabilities and an assessment of key marine and coastal habitats for their risk reduction/adaptation potential (which may or may not coincide with their biodiversity value) to ensure the services they provide are effectively captured. The design of MPAs and MPA networks should also consider the restoration of strategically located marine and coastal habitats that are degraded where ecosystem services of value for climate resilience have been lost, and vulnerability is greatest, as a legitimate focus for marine protection and an integral part of climate change adaptation strategies.

Climate change impacts marine and coastal systems in two ways, by adding new threats to existing pressures and by limiting their ability to deliver ecosystem functions to reduce those risks. The question is whether existing MPAs and MPA networks do and will in fact protect priority areas for ecosystem service delivery where they are needed to reduce the harmful impacts of climate change. The answer may be in some cases yes and some cases no, depending on the location of those MPAs. Spalding *et al.* (2014) analysed the spatial distribution of six ecosystem services provided by three coastal habitats and MPA distribution at the global level. They found that 32% of coral reefs were included in MPAs, but only 17% of their protection value was included in MPA designation, suggesting that MPA designation may favour offshore MPAs rather than coastal MPAs where coastal protection value of coral reefs would be most important. Taking a flexible approach to MPA designation and management, within a broader ocean governance context, would ensure that MPA networks deliver a suite of benefits, from conservation to climate change adaptation and mitigation to sustainable development. It must be noted that not all ecosystem services will be permanently provided by the same MPA over time, but rather, across the MPA network. Marine protected area designation and management must be responsive to these changes and adapt accordingly.

3.4 CONNECTIVITY ACROSS SEASCAPES

Functional connectivity between MPAs provides a route for key species to relocate in the face of climate change. This is not only important in improving the resilience of rare and threatened species, but also for those species that are important in carbon sequestration and storage, coastal protection, or food production. The design of any network needs to take into account the potential need for such species to move and ensure that appropriate habitat space

CASE STUDY:
PROMOTING THE CONSUMPTION OF WARM-WATER SPECIES IN TURKISH GÖKOVA MPA

Figure 3.3:
Traditional fishing in Gökova Bay, Turkey.
© Zafer Kızılkaya, Mediterranean Conservation Society (http://www.akdenizkoruma.org.tr/).

The fishery in Gökova Bay is very dynamic and today four exotic invasive species, the Randall's threadfin bream, *Nemipterus randalli,* the brushtooth lizardfish, *Saurida undosquamis*, the marbled spinefoot, (or rivulated rabbitfish) *Siganus rivulatus,* and the goldband goatfish, *Upeneus moluccensis,* comprise an important percentage of the catches of artisanal fishermen. Local communities with the assistance of NGOs (Mediterranean Conservation Society) and managers, are developing innovative fishing techniques to exploit these new resources, thus increasing catches at the same time as reducing their negative impact on the native ecosystem. Public awareness campaigns including short films and fish tasting festivals together with a marketing campaign have also increased the public appreciation for these species and the revenue of the local fishery cooperative.

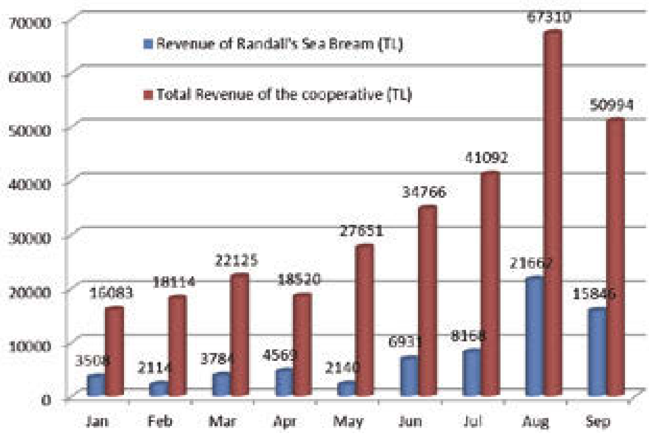


Figure 3.4:
Revenue of Randall's sea bream
versus Total Revenue of the Akyaka Fishery Cooperative
from January 2015 to September 2015.

is available in adjacent areas so that they can re-establish there. The protection afforded through MPA networks, or some alternative spatially-based management measure, is needed to enable the re-establishment of species threatened by climate change. Ensuring connectivity between habitats will assist in the maintenance of different life stages of key species, and provide stepping-stones for species dispersal.

Understanding the predicted impacts of climate change on the spatial distribution, life cycles and food webs of species of socio-economic importance (and in particular, migratory species of fish such as tuna) is essential to develop effective climate smart and sustainable development strategies which ensure their long term survival, and at the same time builds resilience of marine resource-dependent communities and economies, as is the case for small island states. Marine protected areas and MPA networks in both inshore and open oceans can be established to protect key habitats/processes, critical for species' life cycles and food webs, taking into account predicted distributional shifts as a result of climate change and/or ocean acidification, and complementing non-spatial species management measures to ensure sustainable use.

Marine protected areas and MPA networks may need to be located and managed in a broader ocean governance framework in order to ensure connectivity across seascapes. As a mechanism for allocation of ocean and coastal space for a range of uses and management objectives, marine spatial planning and integrated coastal management are good tools to assess climate risks and vulnerabilities, which will be patchy, and the identification of priority areas for ecosystem and social resilience to be included in a network of MPAs as well as informing other complementary ecosystem-based adaptation (and mitigation) interventions.

The impacts of climate change on oceans will be long lasting, and will likely include changes to the species composition of biological communities. Species and habitats with greater tolerance to increased temperature or acidification may flourish, whilst others may not in any given location. Similarly, some human communities may fare better than others, based on their socio-economic characteristics and resource dependency. Building resilience is not just about the ability to withstand impacts, it is also about adapting to new circumstances, and encouraging innovation and opportunity whilst ensuring the integrity of functional relationships is maintained. Some of those early adaptors may become new resources and offer opportunities for local communities.

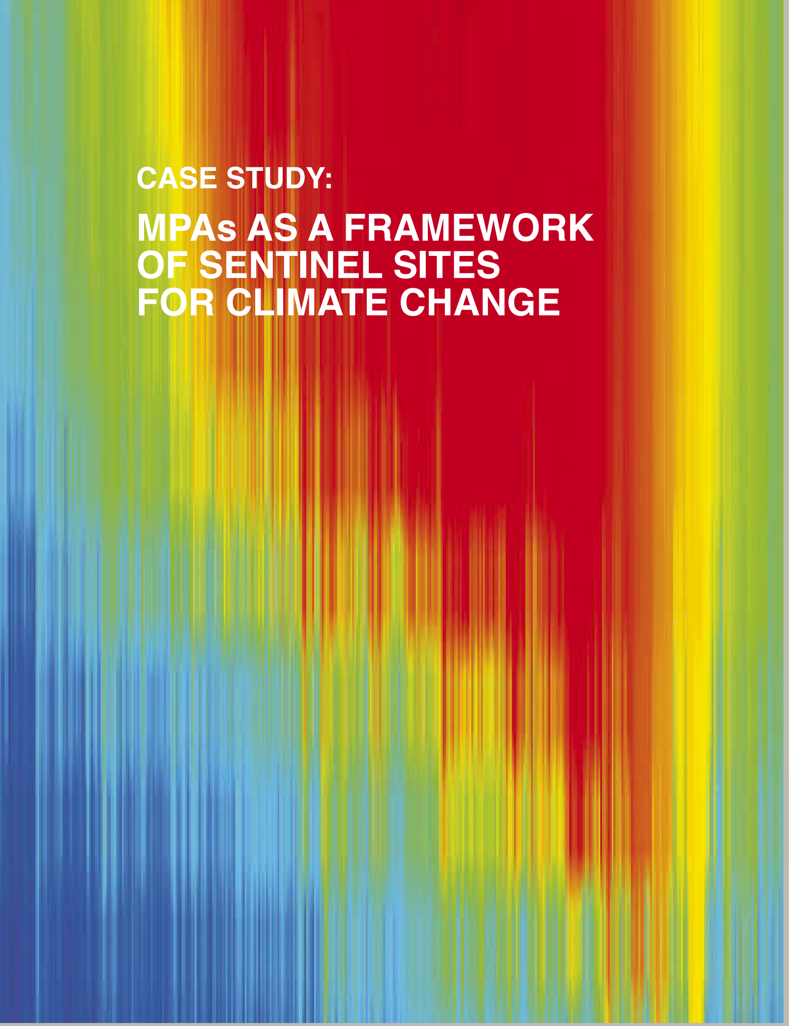
3.5 PROVIDING EARLY WARNING AND KNOWLEDGE ON CLIMATE CHANGE EFFECTS

Global trends in ocean climate changes are quite clear. However, at the regional level, the physico-chemical changes and their biological and ecological effects vary widely and are often still very uncertain.

The physico-chemical effects of climate change (on temperature, pH, current, oxygen and sea level) lead to biological and ecological effects including, but not limited to, redistribution of marine and coastal biodiversity. For example, the rapid increase in surface temperature causes more migration of communities, with a general movement from low latitudes to high latitudes. These climate migrations may affect, in theory, all components of biodiversity, pelagic species like fish, marine mammals, and birds, and benthic species.

It is therefore very likely that in the years and decades to come, important changes that reshape marine communities will be observed across seascapes and in MPAs. These changes could lead to rarefactions, smooth or sudden disappearances of species and communities, as well as the appearance of new species, food web changes, changes in ecological functions and ultimately changes in the ecosystem services that people rely on at the sites.

Depending on the type of habitat within MPAs (high sea, coastal, inner bays, etc.) their latitudinal position and the species and populations concerned, managers may not be able to counteract the impact of climate change on the resources, especially when these impacts are compounded by local anthropogenic pressures. However, they may be able to increase the resilience of the resources by focusing on reducing non-climate stressors. In addition, larger scale impacts such as marine biodiversity loss would need to be addressed at a broader/regional scale by focusing on MPA networks (rather than individual sites).



CASE STUDY:

MPAs AS A FRAMEWORK OF SENTINEL SITES FOR CLIMATE CHANGE

Figure 3.5:
Placing temperature loggers in Columbretes Island Marine Reserve, Spain. © Diego K. Kersting

Monitoring surface sea water temperature is key to understanding if the impacts observed in the communities are related to climate change or other threats from the surrounding environment. In the Mediterranean, several MPAs are participating in a common programme (T-med Net) collecting high resolution temperature records within the top 40-50m of the water column. This enables positive temperature anomalies to be recorded and related to impacts such as mass-mortality events of invertebrates. Moreover, it helps to increase the ability to detect, understand and forecast the impact of climate change on coastal ecosystems and MPAs in particular.

3.6 MANAGING FOR CLIMATE CHANGE / CLIMATE-SMART CONSERVATION

Despite climate change being widely accepted as a major threat to biodiversity and to local coastal communities and indigenous cultures, MPA managers may still be grappling with how to integrate the topic into their day-to-day management. High level principles of climate-smart conservation can provide managers with an approach that can be adapted to the individual circumstances of their MPA (Stein, 2014). Specifically, these include 1) linking management actions to specific climate impacts, 2) managing for change, not just persistence, especially as climate change may cause irreversible changes within and outside marine protected areas, 3) reconsidering goals, not just strategies, in some cases focusing on sustaining ecological functions, rather than historical assemblages of plants and animals, and 4) integrating adaptation into existing work and mainstreaming climate change adaptation into the MPA's operations. Adaptive management therefore requires a flexible approach that values learning and does not penalize the error, it must be able to respond to new information and be coherent with the regional issues and with the MPA plans.

The involvement of the local stakeholders is a significant asset to locally and collectively look for the best solutions and adaptation responses to climate change. Changes in the marine and coastal system, including loss and/or modification of ecosystem services, may lead to increased tensions and misunderstandings between users of the marine space, which could, if not explicitly managed for, be detrimental to appropriate responses to climate change adaptation. The education value of MPAs is therefore significant in demonstrating how climate change affects nature and people in practical and concrete ways and is a driver towards responsible behaviour.

CASE STUDY:

INTEGRATING CLIMATE CHANGE IN THE MANAGEMENT OF GREATER FARALLONES NATIONAL MARINE SANCTUARY

Figure 3.6:
Cliffs overlooking the waters of Greater Farallones National Marine Sanctuary in the North central coast of California.

http://sanctuaries.noaa.gov/california-expansion/
Photo credit: Matt McIntosh/NOAA.

Greater Farallones National Marine Sanctuary (GFNMS) protects the wildlife and habitats within 3,295 square miles off the northern and central California coast, just a few miles from San Francisco, California. Encompassing a diversity of highly productive marine habitats, the sanctuary supports an abundance of life, including many threatened and endangered species. The sanctuary established its ocean climate programme (http://farallones.noaa.gov/manage/climate/), as an effort to integrate climate change science, monitoring, adaptation, mitigation, and communication into sanctuary management to achieve a healthy, resilient ocean for future generations. To that end, the sanctuary coordinated a collaborative, multi-year effort to enable marine resource managers to respond to, plan, and manage for the impacts of climate change to habitats, species, and ecosystem services within the region.

GFNMS engaged representatives of nearly 30 different agencies and organizations in a series of decision-support workshops to assess the vulnerability, due to climate and non-climate stressors, of sanctuary resources, including 31 species, eight habitats and five ecosystems services. The resulting Vulnerability Assessment Report (Hutto *et al*., 2015) is now a foundational, collaborative, and science-based work that identifies how and why focal resources across the North-central California coast and ocean region are likely to be affected by future climate conditions. The report is a useful resource for local actors such as county managers, some of whom have used the resulting information to inform their own local sea-level rise planning efforts. Such information facilitates efficient allocation of limited resources by identifying priority areas for management action and responses. It also helps managers understand why a given resource may or may not be vulnerable to a changing climate, enabling a more appropriate and effective management response.

The vulnerability assessment formed the basis for developing management strategies that would effectively reduce vulnerability and enhance resilience of the region's most vulnerable habitats (beaches/dunes, estuaries, and rocky intertidal). A working group of 21 representatives of local, state and federal agencies, as well as a few NGOs and academic organizations, developed 90 management strategies that address climate and non-climate stressors and call on a multitude of agencies to take action to protect and restore habitats, species, and ecosystem services. These strategies are diverse, innovative, proactive and adaptive, and are the result of a highly collaborative effort. Many strategies address climate impacts directly, while others focus on reducing non-climate stressors to enhance resiliency. While not all of the strategies can be implemented directly by GFNMS, the diversity of this working group has not only increased regional awareness, but also ensures that other implementing agencies are invested in the process and have some degree of "buy-in" for strategy implementation.

The exemplary work completed by GFNMS and project partners has provided a model for other marine sanctuaries in the United States to integrate climate-smart conservation principles into their own management, broadening its significance not only across the region, but nationally and internationally. It has been highlighted at the 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in Paris in December 2015 and was featured in a synthesis report of good practices and lessons learned in adaptation planning, prepared for the UNFCCC Nairobi Work Programme. At the local level, the resulting innovative, collaborative and exhaustive set of management recommendations for the region can now be implemented in order to reduce impacts, improve management response and capacity, and ultimately increase the resilience of the region's most vulnerable coastal habitats, and associated species and ecosystem services.

3.7 CONCLUSIONS

Climate resilience is about the capacity of socio-ecological systems to sustain shocks, maintain integrity of functional relationships and utilize changes as opportunities for innovation and evolution of new pathways that improve the system's ability to adapt.

To develop effective responses to climate change requires the understanding of the biophysical impacts of climate on marine and coastal ecosystems over time and space as well as the interaction between oceans, climate and people.

Oceans are an essential component of the climate system. They absorb and transfer heat across oceans and regulate CO_2 exchange with the atmosphere. This regulatory capacity is at risk of being exceeded with increasing CO_2 in the atmosphere. These changes in the biophysical characteristics of coasts and oceans add to existing pressures from human activities on marine and coastal ecosystems.

Marine and coastal ecosystems can play a unique role in building the resilience of socio-ecological systems. Unlike man-made solutions, ecosystems are complex, multi-functional, dynamic, resilient and adaptive to change. Mangroves and coral reefs have migrated over geological times under natural climate variability. The challenges posed by climate change mean that there is the real possibility that those capacities may be overwhelmed, with irreversible changes and loss of functionality.

Managing for climate change is not a choice, it is a necessity. The contribution of ecosystems to climate change adaptation is about ecological resilience as much as it is about social resilience with ecosystem services being the link between natural and social systems. With climate change comes the need to expand the scope of traditional ocean and coastal management to include managing for climate resilience (adaptation, mitigation and development).

Establishing MPAs has been, to date, one of the tools of choice for the protection of marine and coastal biodiversity from human pressures. There has been in recent years, however, a change in mindset whereby ecosystems are also viewed as providers of goods and services to people. The Convention on Biological Diversity (CBD) for example now considers the role of ecosystems for development and climate change and the inclusion of ecosystem services in the definition of target 11 on protected areas, with two targets on restoration of important ecosystem services. The UNFCCC and the recent Paris Agreement also recognizes the role of ecosystems (and oceans) as nature-based solutions for climate change adaptation and mitigation (See chapter 2).

In this chapter, we have presented the role of MPAs in reducing human pressures and hence building ecosystem resilience and functionality, the need to place MPAs and MPA networks in the context of a broader ocean governance framework to better account for climate risk and vulnerabilities, maintaining ecological connectivity and developing flexible and effective responses to climate change impacts. We have also argued for the role of MPAs and MPA networks as laboratories to monitor the impacts of climate change and tipping points, recognizing that impacts are not uniform in time and across the marine domain and that global and local adaptation responses will be needed.

We have also argued the critical role of ecosystem services in reducing climate related risks to human populations in vulnerable areas and the need to protect (and restore) natural infrastructure through MPAs and other measures, noting that existing MPAs may not capture some of those critical ecosystems.

MPA managers have an important role to play in engaging and educating the public about climate change its impacts on ecosystems, the benefits of healthy ecosystems to people and what might be lost to climate change, thus encouraging greater support for marine and coastal conservation, adaptation and mitigation actions.

Climate change is challenging the traditional MPA model of a fixed institution in time and space with a primary conservation objective and put into perspective their role and adaptation needs in a changing climate. The model that is emerging emphasizes multiple functionality, connectivity and change. This may require greater flexibility in the design and management of MPAs and MPA networks.

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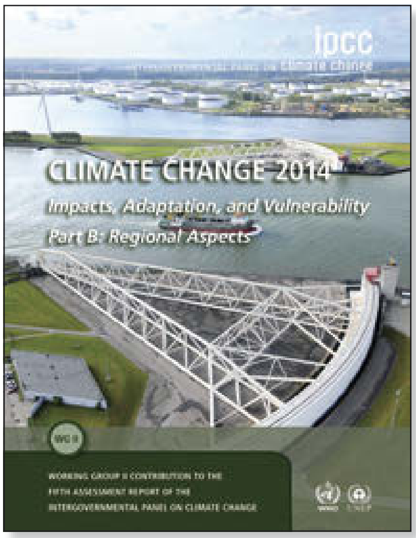

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4. Marine Protected Areas and climate change mitigation: how MPAs can contribute to the reduction of greenhouse gas emissions?

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4.1 INTRODUCTION

Marine species and habitats face a range of pressures as a result of climate change that threaten their continued survival and hence their capacity to continue to provide a range of ecosystem services including the mitigation of climate change through the reduction in greenhouse gas emissions and the enhancement of biological carbon sinks.

The protection of habitats and species for the long-term through the designation of MPAs provides the opportunity to address the impacts of climate change by providing a focus for the implementation of management measures and undertaking scientific research. Furthermore, they act as focal points to engage and educate the public of the challenges faced by habitats and species and the benefits they can provide in tackling climate change. It is not only the opportunities presented by individual MPAs that need to be considered but also the additional benefits derived from MPA networks which can maximize the ecological connectivity of any measures put in place, even extending beyond the boundaries of the MPAs themselves.

Until now MPA networks have largely comprised a set of individual MPAs that have, at best, limited connectivity actually designed into their selection, and for the most part have been selected in order to protect specific endangered, vulnerable or rare habitats or species. The selection of MPAs (let alone MPA networks) for features with the specific purpose of promoting climate change mitigation is yet to happen so any contribution that they can make to climate change mitigation is purely coincidental. As our understanding of the potential benefits of MPAs to helping address climate change improves this may be a fruitful area for reappraisal of existing networks and their expansion to target key habitats and species based on their carbon sequestration and storage potential and their long term vulnerability of other pressures.

Marine protected areas can contribute to addressing climate change and its mitigation through a number of different routes:

— **Reduction of other ocean stressors**. Marine habitats and species are potentially vulnerable to a range of anthropogenic pressures that are not only damaging in their own right but also can reduce their resilience to climate change. Marine protected area designation provides the infrastructure for legally binding management measures to be put in place to protect features. These provide the additional opportunity to help mitigate climate change impacts or at least reduce the impacts of these other stressors. With the greater protection and reduced stress on the features within the MPA this can have wider beneficial effects beyond the boundaries of the MPA through spill-over of larvae, juveniles and adults into the surrounding areas making them more resilient to the pressures that they face. The key to this working as best as possible is by ensuring that there is a truly ecologically coherent network of sites designed to protect a range of features, and especially those that represent important carbon sinks. Until recently the focus has been on a few key habitats such as saltmarsh, mangroves and seagrass beds, but it is becoming increasingly apparent that in temperate regions other features such as maerl beds and even muddy seabed sediments represent important carbon stores that are vulnerable to disturbance from activities such as trawling and dredging. Thus any management measures that help protect such habitats and species will make a significant contribution to helping mitigate climate change impacts.

— **Provision of 'stepping stones' or corridors for shifting species.** Where there is functional connectivity between MPAs this can provide a route for key species to relocate in the face of climate change. This is not only important in improving the resilience of rare, and threatened species but also for those species that are important in carbon sequestration and storage. The design of any network needs to take into account the potential need for such species to move and ensure that appropriate habitat space is available in adjacent MPAs so that they can re-establish there and continue to capture and store carbon, thus continuing to contribute to the mitigation of climate change. Without the protection that can be afforded by the adjacent MPAs the likelihood is that any re-establishment of the species, should it be vulnerable to specific activities, would be compromised where such activities cannot be adequately managed.

— **Reducing risk and promoting resilience.** There is still a lot of doubt about which species and habitats are most vulnerable to climate change although it is clear that some, such as many coral species, are particularly sensitive to ocean warming. Other impacts such as ocean acidification are much more complicated than first thought and it is increasingly apparent that it is a combination of impacts that are of the greatest concern and that different species and different life stages of individual species differ in their sensitivity. With careful management, ecosystem functionality can be protected within the MPA by providing protection for as much diversity as possible thus reducing the risk of losing key habitats and species that provide a range of ecosystem services and in particular carbon sequestration and storage.

— **Sentinel sites.** In all MPAs it is important to have the necessary monitoring programme to measure the impact of the management measures that are in place and to adapt these, as necessary, based on the outcomes of monitoring results. Marine protected areas are an ideal place for long term monitoring programmes as they are based on specific locations which are subject to control of certain damaging activities. Thus when changes are observed it is possible to reduce the number of possible factors affecting the results, although this is always dependent on the MPAs being large enough that they do not suffer from the spillover effects of activities occurring outside the site. Where all potentially damaging activities are banned, such MPAs can essentially serve as sentinel sites for climate change effects and provide early indication of any problems arising as a result of climate change impacts. This enables key decisions to be taken to improve where possible the resilience of the key features but at the same time ensure that whatever measures are appropriate are taken to enhance the network and address any threats to carbon rich habitats and species.

— **Raising awareness and education.** The importance of carbon stores on land are relatively widely recognized and the benefits of protected areas in managing these are accepted. There is less appreciation of the scale and importance of the carbon stocks in the marine environment – blue carbon – and MPAs are ideal focal points for educational programmes targeted at a range of different audiences. Whilst, in themselves, such programmes do not result in any mitigation per se they can be powerful vehicles for people to be informed and inspired to take action in a range of ways to cut their greenhouse gas emissions.

— **Ecosystem services.** Marine protected areas have typically in the past been identified, designated and managed on the basis of protection of rare, vulnerable and threatened habitats and species some of which are also important in efforts to mitigate climate change through their carbon capture capacity. Other means of reducing greenhouse gas emissions might involve the more efficient exploitation of marine resources through providing the space for the intensive management of activities such as aquaculture and fisheries. Through targeted management measures stocks of commercial species (particularly those that are rather place specific) may be enhanced and as such be easier and more cost effective to exploit. This could result in much smaller steaming times thus reducing the greenhouse gas emissions.

4.2 MPA NETWORKS AND CLIMATE CHANGE MITIGATION

Perhaps the biggest opportunity under the ecosystem services role comes from using MPAs to manage coastal and marine carbon sinks and thereby mitigate emissions from the trapped carbon they store. A recent review, perhaps the first of its kind, looking at the blue carbon resources in the Scottish inshore MPA network has highlighted the potential importance of some of these MPAs for their capacity to sequester carbon and as such better inform the management measures that should be put in place to ensure these processes continue.

Blue carbon is the carbon stored in coastal and marine ecosystems. These ecosystems sequester and store more carbon per unit area than terrestrial forests and are now being recognized for their role in mitigating climate change. Coastal ecosystems of mangroves, tidal marshes and seagrass meadows also provide essential benefits for climate change adaptation, including coastal protection and food security for many coastal communities. However, if the ecosystems are degraded or damaged, their carbon sink capacity is lost or adversely affected, and the carbon stored is released, resulting in emissions of CO_2 that contribute to climate change. Dedicated conservation efforts using MPAs can ensure that coastal ecosystems continue to play their role as long-term carbon sinks.

Conserving and restoring terrestrial forests, and more recently peatlands, has been recognized as an important component of climate change mitigation. Several countries are developing policies and programmes in support of sustainable development through initiatives that reduce the carbon footprint associated with the growth of their economies, including actions to conserve and sustainably manage natural systems relevant to the United Nations Framework Convention on Climate Change (UNFCCC) and the Reducing Emissions from Deforestation and Forest Degradation (REDD+) mechanism.

These approaches are now being broadened to manage other natural systems that contain rich carbon reservoirs and to reduce the potentially significant emissions from the conversion and degradation of these systems. Coastal ecosystems such as mangroves, saltmarshes and seagrasses need to be conserved and restored as globally vital carbon sinks. Although the combined global area of mangroves, tidal marshes, and seagrass meadows equates to only 2-6% of the total area of tropical forests (Figure 4.1), their ongoing losses account for up to 19% of emissions from global deforestation given their high carbon content – a total of 0.5 billion tons of CO_2 emissions annually. Ongoing destruction and degradation of these systems contributes to additional human induced GHG emissions (Figure 4.2).

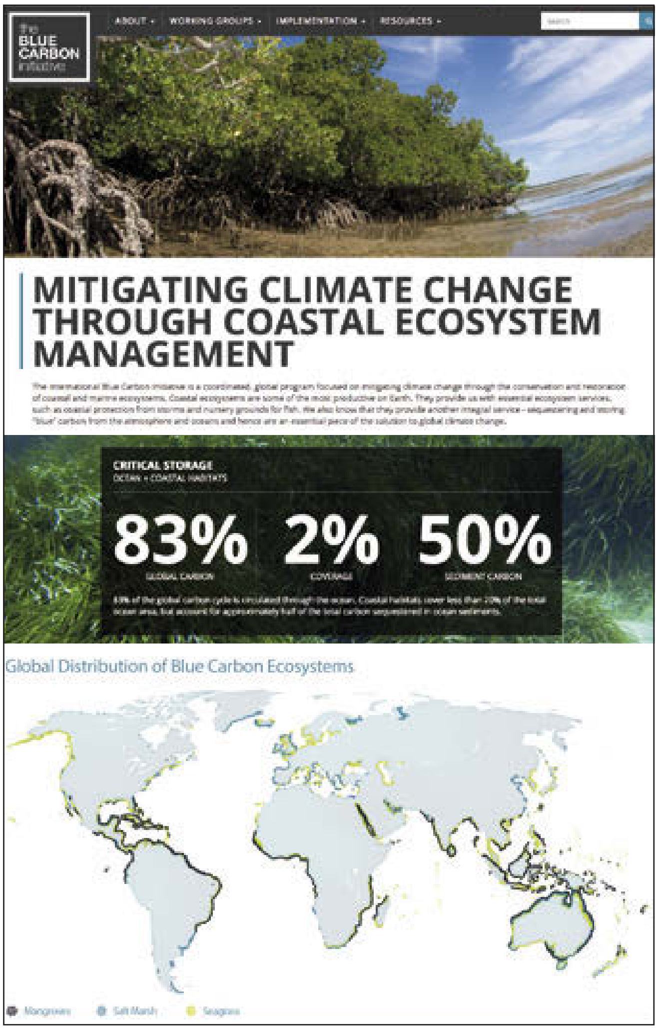

Figure 4.1:
Global distribution of Blue Carbon Ecosystems (http://thebluecarboninitiative.org).

4.3 THE MANAGEMENT OF BLUE CARBON IN MPA NETWORKS

Marine protected areas provide an ideal framework within which to achieve the conservation and recovery of such carbon-rich coastal ecosystems. There are 685 marine protected areas containing mangroves globally, distributed between 73 countries and territories (Spalding, 1997). Countries with very large areas of mangroves have a significant number of protected areas notably Australia (180), Indonesia (64) and Brazil (63). Due to the lack of complete maps for the global distribution of seagrass meadows and saltmarshes, the number of MPAs covering seagrass and saltmarshes is not available.

Alongside MPAs another tool for broader action that can help safeguard and recover coastal carbon sink ecosystems is Marine Spatial Planning (MSP). While a network of marine protected areas might be one outcome of MSP, it seeks to balance economic development and environmental conservation, and not focus solely on the goals of conservation or protection. Marine spatial planning is a process of analysing and allocating parts of three-dimensional marine spaces (or ecosystems) to specific uses or objectives, to achieve ecological, economic, and social purposes that are usually specified through a political process.

Countries are already using mechanisms to do just this and the three case studies demonstrate action across Africa as regional examples for implementation with climate mitigation benefits. These solutions are following a “solutions for learning and action” approach developed and applied in two global initiatives: Blue Solutions and Panorama.

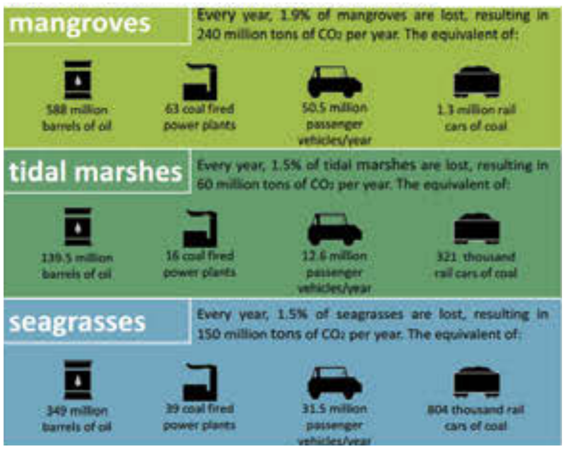

Figure 4.2:
Comparative analysis of wetland carbon stocks and emissions (from Herr *et al.,* 2015).

CASE STUDY:

AN INVENTORY OF BLUE CARBON RESOURCES IN THE SCOTTISH MPA NETWORK

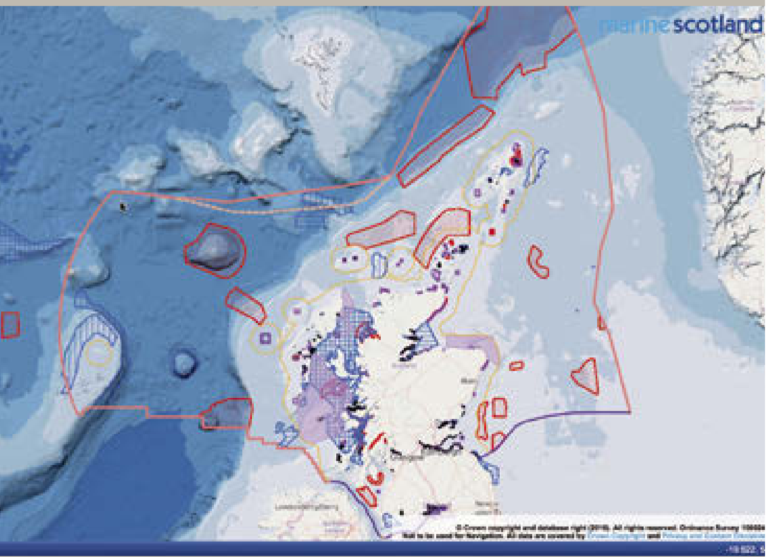

Figure 4.3:
The evolving marine protected area network in Scotland.

http://www.gov.scot

The inshore network of 48 MPAs in Scotland has been designated for a range of habitats and species, including both biological and geological features. These include some features such as kelp forests that capture and cycle large amounts of carbon whilst others such as maerl beds and seagrass beds not only capture but also act as carbon stores. Furthermore, the inventory has looked at the capture and storage potential of various biogenic reefs such as cold water coral reefs, horse mussel beds and brittlestar beds. In addition to these the carbon storage potential of the seabed muds has also been estimated.

The purpose of the inventory was to provide some quantification of the scale of carbon stored within the MPAs and also estimate their carbon capture potential. With this information, decisions can be taken to ensure that any management that is implemented is with the dual purpose of protecting and enhancing both the biological diversity of the MPAs and the carbon capture and storage potential. This knowledge will ensure that the best possible informed decisions are taken. This is the first inventory of its kind carried out for any MPA network and it is hoped that the lessons learned from this exercise can be shared with other places to ensure that MPAs provide protection for a range of ecosystem services and not just the protection of biodiversity per se.

CASE STUDY:

GUINEA BISSAU - MANGROVE CONSERVATION, CLIMATE CHANGE AND FOOD SECURITY

Alfredo Simão da SILVA, Biodiversity and Protected Areas Institute Guinea Bissau (IBAP),
Pierre CAMPREDON, IUCN, Guinea-Bissau

Sea-level rise makes it necessary to raise the dykes of rice fields in mangrove areas. Rural exodus is leaving the indigenous people community of Guinea-Bissau with a lack of labour force to sustainably cultivate these areas. The initiative focuses on restoring mangroves in abandoned rice fields as part of a climate change mitigation strategy and on helping to maintain rice fields considered of strategic importance by the population. A set of alternative activities (fishing, tourism, etc.) and conservation measures complement this shared governance model.

A participatory spatial planning approach involving the local population has helped to identify the rice field areas to maintain, as well as the formerly cultivated areas that are now dedicated to the restoration of mangroves. Some rice growing areas threatened by sea-level rise were recovered through the raising of the dykes. In return, part of the mangroves was recovered with the help of the population, which had impacts on fisheries resources and biodiversity.

The shared governance approach was extended to other aspects of the protected area management and community development (fisheries, tourism, conservation, education, monitoring). This pioneer approach has been replicated in other protected areas of the country.

Figure 4.4:
Mangrove in Guinea Bissau.

Courtesy of and © Sander Carpay – Wetlands International Africa. http://africa.wetlands.org/Africanwetlands/Mangroves/tabid/2938/galleryType/SlideShow/ItemID/1755/AlbumID/131/language/en-US/Default.aspx

CASE STUDY:

MIKOKO PAMOJA: COMMUNITY BASED MANGROVE CARBON OFFSET PROJECT IN KENYA

Figure 4.5:
@mikoko_pamoja project coordinator @SMwarima teaches Mikoko Pamoja committee members to monitor planted mangroves #conservation

Courtesy of and © Molly Czachur and Mikoko Pamoja.
https://twitter.com/mikoko_pamoja/with_replies
www.mikokopamoja.com

At Gazi Bay, mangroves have been exploited for many years for building poles and fuel wood. Losses of mangroves have led to shortages of resources, reduction in fisheries, and increased shoreline erosion. The degradation of mangroves leads to increased emissions of GHGs. Mikoko Pamoja seeks to reverse these conditions through providing incentives to communities involved in mangrove restoration and management.

The potential of mangroves to capture and store carbon is being maintained through avoiding deforestation and the annual replanting of degraded mangrove areas. The total emissions reduction expected over the next 20 years is 50.000 tCO_2. Mikoko Pamoja is supporting the provision of nursery grounds for fish, shoreline protection and sediment stabilization. Income generated through the sale of carbon credits is used to cover dedicated staff time for the project; with the remaining income being allocated to community projects and mangrove conservation activities overseen by village committees. Direct impacts to the community include, improved education standards, reduction in water borne diseases, and improved mangrove productivity.

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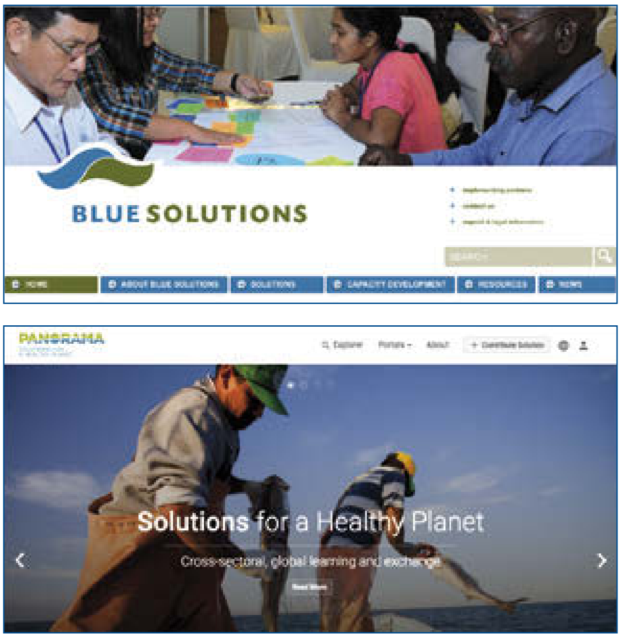


Figure 4.6:
Blue Solutions and Panorama portals.

https://bluesolutions.info/
http://panorama.solutions/en

Blue Solutions, a global initiative implemented jointly by GIZ, GRID-Arendal, IUCN and UNEP, provides a platform to collate, share and generate knowledge and capacity for the sustainable management and equitable governance of marine and coastal resources.

The Panorama is an initiative to collate protected area (coastal, marine and terrestrial) success stories, to complement IUCN's engagement in Blue Solutions. "Inspiring Protected Area Solutions" continuously being gathered through the Panorama is an integral part of the Promise of Sydney, the outcome document of the IUCN World Parks Congress 2014. They provide the evidence of protected areas offering solutions to numerous global challenges, including climate change adaptation and mitigation.

Dedicated efforts to reduce degradation, to increase conservation, and restoration of coastal habitats help to ensure that no new emissions arise from such loss of habitat and stimulate new carbon sequestration. At an implementation level, mangroves, saltmarshes and seagrasses can be included in national accounting, now that the new Intergovernmental Panel on Climate Change (IPCC) 2013 Supplement to the 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement) has been issued. Mangroves can also be included in REDD+, and all three ecosystems can be incorporated into NAMAs. Some technical elements need to be improved, e.g. accounting for soil carbon, and an expansion of programmes and projects all around the world is still needed to stop the ongoing loss of these systems. These need to be further strengthened (e.g. the accounting for soil carbon as part of REDD+) and be replicated in other countries. More and more efforts now also try to link between the mitigation and adaptation benefits of these systems, and to direct the appropriate management and policy responses through national development goals as well as coastal planning efforts.

Other marine ecosystems and species in the open ocean play a significant role in absorbing, moving and storing carbon, but don't demonstrate globally relevant climate mitigation potential. Corals, kelp, plankton, and other marine fauna act as significant carbon conduits, but at present are not considered to represent long-term carbon sinks appropriate to be included under existing climate mitigation policies and incentive mechanisms. Moreover, ecosystems and species in the open ocean present jurisdictional challenges in terms of who 'owns' and 'manages' these systems or species, thus the attribution to any national carbon balance would be difficult.

4.4 CLIMATE POLICY CONSIDERATIONS

Currently marine ecosystems are not recognized as climate mitigation options under the UNFCCC, in contrast with other ecosystems and their uses under the Land Use Land Use Change and Forestry (LULUCF) sector, including coastal wetlands (mangroves, seagrasses and saltmarshes). Further debate and dialogue is now needed to analyse the opportunities to develop an incentive mechanism for the open ocean carbon stores under the Climate Convention.

Since an ecologically degraded ocean loses its capacity to support the carbon cycle and act broadly as a carbon sink, all necessary international and national policies (UNCLOS, CBD, RFMOs, and other marine management regimes) need to be mobilized to sustainably manage for the maintenance of marine resources and their services. Alongside the Aichi Target 11 of the CBD the new Sustainable Development Goals have particular reference for action to safeguard inter-alia these coastal carbon-rich ecosystems:

Goal 14.2 - By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.

As well as reinforcing the CBD requirements on countries:

Goal 14.5 - By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information.

The scientific understanding of the role of marine flora and fauna for climate change mitigation is increasing steadily. This needs to be further supported while a debate is started about how these elements are appropriately addressed in future climate change efforts.

Thus by reducing the range of non-climate stressors on the environment and providing protection to coastal and marine resources most at risk, MPAs can help improve the resilience and health of marine ecosystems. Healthy robust ecosystems are much better placed to resist and recover from the impacts of climate change and thus help to buffer impacts on important carbon stores.

Figure 4.7:
Vezo children fishing in mangrove lagoon, southwest Madagascar.
Courtesy of and © Garth Cripps 2016, http://www.garthcripps.com

CASE STUDY:

AN INCENTIVIZED, PARTICIPATORY APPROACH TO MANGROVE CONSERVATION

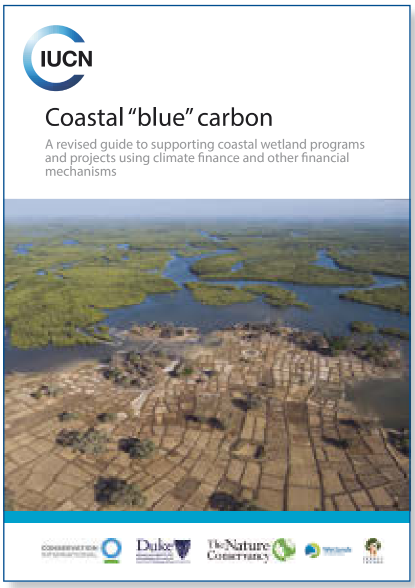
Lalao Aigrette RAVAOARINOROTSIHOARANA,
Tahiry HONKO, Blue Ventures

Blue Ventures is employing a participatory monitoring and management approach as a solution to address degradation and deforestation of mangroves in the Bay of Assassins, in the Velondriake Locally Managed Marine Area (LMMA). This approach uses the generation of carbon credits, which can in turn generate sustainable financing for both the residents of the Bay of Assassins and the Velondriake Management committee.

The participatory mangrove zoning scheme has placed 830 ha of mangroves under strict protection against logging, with 1877 ha of mangroves harvested by the community under a controlled harvesting regime and an additional 1095 ha of mangroves designated for replanting by community groups in the project area. Community groups (seaweed farmers, youth clubs, school children, and women's associations) have re-planted 12 ha of degraded mangrove to date.

Figure 4.8:
Just elected General Assembly of the Velondriake Association.
Courtesy of and © Johanna Medvey.

https://blog.blueventures.org/elections-bring-new-leaders-energy-into-velondriake-association-madagascars-flagship-lmma/



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5. Conclusions

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The ocean faces a genuine paradox: despite the central role it plays in shaping the Earth's climate and its variability, it has taken considerable time for the ocean to be recognized in the UNFCCC framework. This recognition is critical as scientists agree on their high capacity for heat regulation and carbon dioxide storage, but also that marine ecosystems are under unprecedented pressure and that climate change is now exacerbating local stressors to breaking point.

Being both victims and solutions, MPAs experience the same types of ambivalent relationship with climate change impacts as do broader marine and coastal environments. Impacts from climate change are already affecting management objectives for MPAs and even their existence itself, if it is confirmed that 60% of species for which they have been created could move or disappear by 2100. On the other hand, by reducing other ocean stressors, MPAs can also help to reduce risks and build resiliency, thus offering an effective way to cope with climate change impacts.

The problems presented by climate change provide a strong basis to expand the scope of conservation, from a reactive approach focused on biodiversity conservation to a predictive vision based on ecological services. There was a strong message from the workshop to incentivise this transformation paradigm, to design and to implement « climate aware » MPAs. To make this happen a number of key messages and actions became evident from this work

To better define and embed the role of MPA in climate change adaptation and mitigation actions the following conclusions can be drawn:

— **Act on the basis of current information.** Long term observations are necessary to fill knowledge gaps, in particular to distinguish natural variability and climate change impacts on biodiversity. These data will shape future adaptation scenarios but given the threats from climate change and the need to act now, the precautionary principle must apply: actions can and should be undertaken on the basis of available information, while also advancing, strengthening and deepening the associated knowledge base.

— **Expand the coverage of MPAs and in so doing embrace their role in delivering ecological resilience.** To have significant impact in moving forward MPAs will need to cover large areas and be much more interconnected through marine spatial planning. This means that State Parties of the Convention on Biological Diversity have to speed up implementation of Aichi Target n°11 and go beyond the 10 % objective. The expansion of coastal and marine protected areas should now embrace and recognize their role to support the resilience of the overall landscape within which they sit. As progress is made special attention will need to be paid to their ecological representativity by focusing on areas of critical importance for mitigation and adaptation, most vulnerable species and habitats as well as under-represented key ecosystems.

— **Ensure that MPAs are effectively managed to maximize their contributions.** Networks of MPAs respond better to climate change and other stressors when effectively managed. This includes the assessment of ecosystem vulnerability to climate change, the reduction of anthropogenic pressures affecting mitigation and adaptation capacity, and the implementation of new management options.

— **Create sustainable financing mechanisms to support MPAs.** Marine protected areas can provide multiple benefits but to be cost effective they need a sustainable economic model. Any investment in conservation and ecosystem restoration for climate change should be considered as a no-regret strategy. The green climate fund should be used to enable the necessary provision of support to developing countries in their mitigation and adaptation efforts, with a focus on biodiversity conservation and coastal area protection.

— **Spread the word on successes and innovations delivered by MPAs.** Some MPAs demonstrate innovative and inspiring solutions for adaptation and mitigation to climate change. It is essential to provide and encourage tools and mechanisms for capacity building and enable cross-sectoral sharing of successful experiences. The use of existing databases like Blue Solutions or Solutions Panorama could be encouraged to this end.

— **Create better incentives for participation in delivering MPA benefits.** To implement adaptive strategies to climate change, MPAs not only have to conserve biodiversity but more globally to manage socio-ecological systems. This framework incentivizes participatory management, involving more people and institutions.

In terms of mainstreaming MPAs into climate change adaptation and mitigation strategies it is evident that MPAs provide key opportunities to increase public awareness and to draw attention of decisions makers to natural solutions to climate change in marine and coastal ecosystems. This requires a shift from seeing MPAs in a purely ecological context to one that includes a sociological perspective. To reach their targets, messages need to highlight the importance of the blue carbon environment for human activities, sustainable growth, and to link to communities who want to experience healthy ecosystems.

To promote the conservation of marine and coastal ecosystems as an effective way to adapt and mitigate climate change, strategic alliances must be established with Governments, NGOs, Universities, and MPA managers. This also includes a need for greater synergies among the three Rio conventions. “Think globally, act locally” should be delivered by a significant increase in regional action to bridge the gap between local interest and global approaches. In the open ocean the creation of MPA networks, in and beyond jurisdictions on the high seas, would be much more effective with increased support from regional seas conventions and other regional instruments.

Being in the frontline, MPAs are needed more than ever, but they are not sufficient on their own. Above all, stabilization of the climate is urgently needed to dramatically reduce the heat-trapping emissions that cause global warming. This is so that adaptation and mitigation actions can stand a chance of working effectively. Alongside this and to fully recognize MPAs as relevant solutions for climate change adaptation and mitigation, a broader vision is necessary, considering all the types and scenarios, developing actions outside the limits and integrating them more into their wider landscape and seascape. In other words, climate change provides a “last chance” opportunity to rethink conservation strategies for wider and essential benefits.

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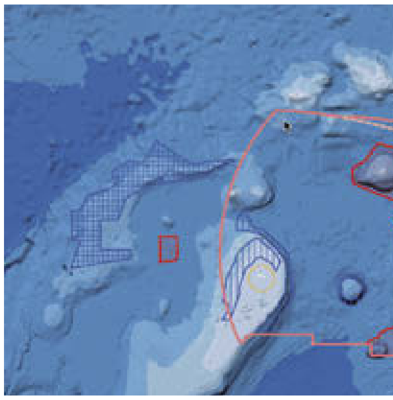

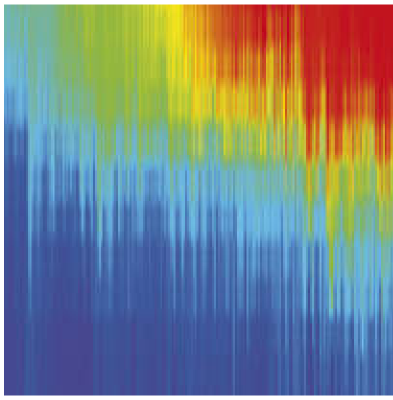

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