Marine Protected Areas

ECONOMICS, MANAGEMENT AND EFFECTIVE POLICY MIXES

OECD

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BETTER POLICIES FOR BETTER LIVES

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Preface

Sustainably managing our oceans, seas and marine resources is one of the defining challenges of our time. This is now also recognised and firmly embedded in the Sustainable Development Goals (SDG 14), in addition to the Aichi Targets under the Convention on Biological Diversity. From coral reefs and seagrass beds to mangrove forests and the deep sea, marine ecosystems provide us with incalculable benefits, including food, coastal protection, marine biodiversity and carbon sequestration. Yet these ecosystems and the services they provide are under severe pressure from a wide range of human activities. Furthermore, competing demands for marine space and resources are projected to rise.

Marine protected areas (MPAs) are one of the policy instruments available to help ensure the conservation and sustainable use of our vast, yet vulnerable and interconnected ecosystems. While MPA coverage is increasing, further efforts will be needed to achieve the SDG target of 10% of marine and coastal ecosystem protection by 2020. And new MPAs need to be located in the right places – those areas where biodiversity is most under threat and can therefore yield the greatest environmental benefits. This won't be easy because these are often the areas where extractive uses are the most commercially attractive. Drawing from examples around the world, this book highlights the costs and benefits of MPAs, the main issues in their design and implementation, how to scale up finance for them, and the need to flank them with supportive policies.

I am delighted that the OECD is contributing to the issue of sustainable marine ecosystem management. I hope policy makers will be able to draw on this report both for inspiration and pragmatic insights into how better policies can underwrite healthier, more resilient marine ecosystems.

Simon Upton
OECD Environment Director

Foreword

The costs of poor ocean management practices include environmental and social costs that are often not factored into decision-making processes. This undermines the resilience of the ecosystems upon which we depend, for food, for income, but also other less visible life-support functions such as coastal protection, habitat provisioning and carbon sequestration.

While previous OECD work has focused on sustainable fisheries and more broadly on the ocean economy, this report focuses on one policy instrument, namely marine protected areas (MPAs), to help ensure the conservation and sustainable use of our oceans. The report *Marine Protected Areas: Economics, Management and Effective Policy Mixes* considers MPAs from both an environmental and economic perspective. It examines recent developments and experiences with MPAs around the world and provides good practice insights for more effective management. Issues covered include:

- What is the role and current state-of-play of MPAs in the conservation and sustainable use of marine biodiversity and ecosystems?
- What are the benefits and costs associated with MPAs?
- What are the key design and implementation features that need to be considered to ensure the effective management of MPAs?
- How are MPAs financed and what options are there to scale this up?
- How have MPAs been implemented alongside other policy instruments, to more comprehensively and effectively address the multiple pressures on marine ecosystems?

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Acronyms and abbreviations

ABNJ	Areas beyond national jurisdiction
CBD	Convention on Biological Diversity
CHICOP	Chumbe Island Coral Park Ltd. (Zanzibar)
CITES	Convention on International Trade in Endangered Species
CPUE	Catch per unit effort
CSMR	Coral Sea Marine Reserve
EEZ	Exclusive economic zone
EIA	Environmental impact assessment
FAO	Food and Agriculture Organization
GCF	Global Conservation Fund
GDP	Gross domestic product
GEF	Global Environment Facility
GNP	Gross national product
GVP	Gross value of production
IMPASEA	Integrated marine protected area socio-economic assessment
IPCC	Intergovernmental Panel on Climate Change
ITQ	Individually transferable quota
IUCN	International Union for Conservation of Nature
IUU	Illegal, unreported and unregulated
MCZ	Marine conservation zone
MESP	Marine Ecosystem Services Partnership
MPA	Marine protected area

MSC	Marine Stewardship Council
MSP	Marine spatial planning
NGO	Non-governmental organisation
NPV	Net present value
OECD	Organisation for Economic Co-operation and Development
PES	Payment for ecosystem service
PIPA	Phoenix Islands Protected Area (Kiribati)
SDG	Sustainable Development Goal
SEA	Strategic environmental assessment
SMART	Specific, measurable, achievable, realistic and time-bound
TEV	Total economic value
TMR	Taputeranga Marine Reserve (New Zealand)
TNC	The Nature Conservancy
TURF	Territorial use rights in fisheries
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
WDPA	World Database on Protected Areas
WTP	Willingness to pay
WWF	World Wildlife Fund

Executive summary

The state of marine biodiversity and ecosystems is degrading at an alarming rate. It is estimated that 60% of the world's major marine ecosystems have been degraded or are being used unsustainably. Many fisheries are over-exploited, with some stocks on the verge of collapse, and coral reefs are bleaching due to exposure to high temperatures and other pressures. Concurrently, pollution from land-based sources, including marine litter, is threatening species and marine habitats, and climate change compounds these effects and alters both the thermal and chemical characteristics of the ocean as well as its dynamics and nutrient availability. Since the 1980s, for example, an estimated 20% of global mangroves have been lost and 19% of coral reefs have disappeared. The welfare costs that this imposes on society are high and pressures from human activities are projected to grow.

Marine protected areas (MPAs) have been receiving increasing attention from policy makers as an instrument for marine biodiversity conservation and sustainable use. Though no single definition exists, MPAs are generally described as any defined area within or adjacent to the marine environment which has been reserved by legislation or other effective means so that its marine and/or coastal biodiversity enjoys a higher level of protection than its surroundings. MPAs cover about 4.1% of the total marine environment and, under both the Convention on Biological Diversity (CBD) and the Sustainable Development Goals (SDGs), members have agreed to conserve 10% of marine and coastal areas by 2020. In addition to protecting habitats, and buffering against storms and erosion, MPAs can help ensure the provision of multiple other ecosystem services that are fundamental for human well-being, including for fisheries, tourism, recreation and carbon storage. Total ecosystem service benefits of achieving 10% coverage of MPAs have been estimated at USD 622-923 billion over the period 2015-50.

While some progress has been made in expanding MPA coverage over the past few years, further efforts are required. This includes substantial efforts in enhancing the design and implementation of MPAs, as evidence suggests that in many cases they are not meeting their intended objectives. Key challenges include strategically siting MPAs so as to maximise environmental and socio-economic benefits in a cost-effective way, agreeing on and implementing adequate management plans, putting in place robust monitoring and reporting frameworks, ensuring solid compliance and enforcement mechanisms, and mobilising sufficient finance to enable sustainable management. This report therefore considers the benefits and costs of MPAs, key issues in effective design and implementation, scaling up finance for MPAs, and the need for effective policy mixes.

Key findings and recommendations

Develop a clear understanding of the state of and pressures on particular marine and coastal ecosystems, the likelihood that MPAs can address these, and the range of stakeholders involved. Clearly define the goals and objectives of the MPA, and the required level of protection to achieve these. These should be stated at an operational level, so as to be specific, measurable, achievable, realistic and time-bound (SMART); accompanying indicators should be identified that will enable the eventual assessment of whether the objectives are being met.

Estimate the expected costs and benefits of MPAs. While studies evaluating the costs and benefits of MPAs do exist, in general economic valuation is not yet widespread and is not being used to help inform the design and implementation of MPAs. Siting of MPAs needs to be undertaken in a more strategic manner, to enhance the environmental as well as cost effectiveness of MPAs. Software tools such as Marxan and MarZone which aid systematic reserve design have been used in several cases but could be adopted more widely.

Develop an MPA management plan, with robust monitoring and reporting and compliance and enforcement approaches. Monitoring both ecological and socio-economic data is important, initially to define the baseline, as well as regularly thereafter to assess trends in performance over time. This has often not been undertaken as rigorously as needed, and challenges encountered include lack of sufficient human and financial resources, equipment and infrastructure. Monitoring protocols can help to provide guidance to MPA managers, as well as to streamline monitoring methods across MPAs so as to facilitate comparison. Reporting via the creation of national or regional online databases with publicly available information increases transparency and enables the sharing of information and lessons learnt across different MPAs, their respective management approaches and their effectiveness in achieving intended goals.

Compliance and enforcement methods also vary substantially across MPAs, with existing studies suggesting that few MPAs have a robust compliance and enforcement regime in place. Overall, adequately financing the conservation of coastal and marine areas is a major challenge and is likely to be exacerbated as countries strive to meet the 10% target under the CBD and the SDGs. MPA financing strategies, which include identifying the financing needs, and the possible instruments through which additional finance can be mobilised, should form an integral component of an MPA management plan.

Put in place effective policy mixes that can meaningfully address the full range of pressures on marine biodiversity. While MPAs are a crucial component of marine protection, they are not sufficient to ensure that the broader environmental goal is met. A comprehensive package of policy measures is required to ensure the sustainable use of marine resources, including policies that lie beyond the mandates of environment ministries.

Embed MPA design issues into other policy approaches, such as marine spatial planning and ecosystem-based management approaches, and establish inter-ministerial committees to develop national marine and coastal development strategies, which bring together multiple stakeholders. Stakeholders can help to ensure a better understanding of the costs and benefits of decisions to different users (i.e. the winners and losers), and the possible measures needed to address any vulnerable groups most adversely affected. Such measures can help to address political economy issues that arise for example between conservation and fishing communities, and can also help to foster policy coherence – a fundamental component of any strategy that can meaningfully contribute to the achievement of the Sustainable Development Goals, including those for oceans and marine biodiversity, for food security, and for poverty alleviation.

Chapter 1.

Marine biodiversity, the role of marine protected areas and good practice insights

This chapter provides an overview of the trends in the state of, and pressures on, marine biodiversity; the economic values associated with marine ecosystems; and the types of policy instruments that are available for the conservation and sustainable use of marine biodiversity. It then discusses the role of marine protected areas and summarises their current use and trends. Drawing on the key findings from the publication, the chapter concludes with good practice insights for more effective design and implementation of marine protected areas.

Marine biodiversity and the international context

Marine ecosystems are immensely varied both in type and geographical extent. They encompass oceans, salt marshes and intertidal zones, estuaries and lagoons, mangroves and coral reefs, the deep sea and the sea floor (Kaiser and Roumasset, 2002). Covering about 70% of the earth's surface, these ecosystems play a crucial role in human welfare, providing social, economic and environmental benefits to the earth's growing population. It is estimated, for example, that 3.1 billion people rely on oceans for almost 20% their animal protein intake (through seafood) (FAO, 2016), and that more than 500 million people are engaged in ocean-related livelihoods (UNDP, 2012). Marine ecosystems also provide a variety of other services that are critical for human well-being, such as coastal protection, marine biodiversity and carbon sequestration. Oceans, for example, contain nearly 300 000 identified species (though actual numbers may lie in the millions) and have absorbed one-third of the carbon dioxide resulting from human activities (Bijma et al., 2013), while mangroves and coral reefs provide valuable protection against extreme weather events such as storms and floods.

These ecosystems are under increasing pressure due to human activity. Today, 60% of the world's major marine ecosystems have been degraded or are being used unsustainably (UNEP, 2011). Many fisheries are over-exploited, with some stocks on the verge of collapse, and coral reefs are bleaching due to exposure to high temperatures and other pressures. Concurrently, pollution from land-based sources including marine litter is threatening species and marine habitats and climate change compounds these effects, altering both the thermal and chemical characteristics of the ocean as well as its dynamics and nutrient availability (Bijma et al., 2013). Since the 1980s, for example, an estimated 20% of global mangroves have been lost and 19% of coral reefs have disappeared (UNDP, 2012). The welfare costs that this imposes on society are high – estimates suggest that the cumulative economic impact of poor ocean management practices is in the order of USD 200 billion per year (UNDP, 2012).[1]

Growing awareness of the significance of the challenge as well as the need for more co-ordinated action to counteract these trends has put the conservation and sustainable use of the marine environment firmly on the international agenda. Marine biodiversity features among the Aichi Targets under the Convention on Biological Diversity (CBD), including Target 11 on the conservation of marine areas: "By 2020, at least … 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 …" (CBD, 2010). Marine ecosystems also feature as one of the UN Sustainable Development Goals (SDGs), i.e. to "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" (UN, 2015). Specifically, Target 14.5 states: "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". Moreover, Target 14.2 is to sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, and Target 14.4 is on effectively regulating, harvesting and ending overfishing.[2]

Marine protected areas (MPAs) are becoming an increasingly important element of marine conservation policies, and currently cover about 4.1% of the total marine environment (UNEP-WCMC and IUCN 2016).[3] This figure is based on the International Union for Conservation of Nature (IUCN) definition of MPAs, which is "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley, 2008).4 More concerted policy efforts will therefore be needed if these internationally agreed targets are to be achieved.

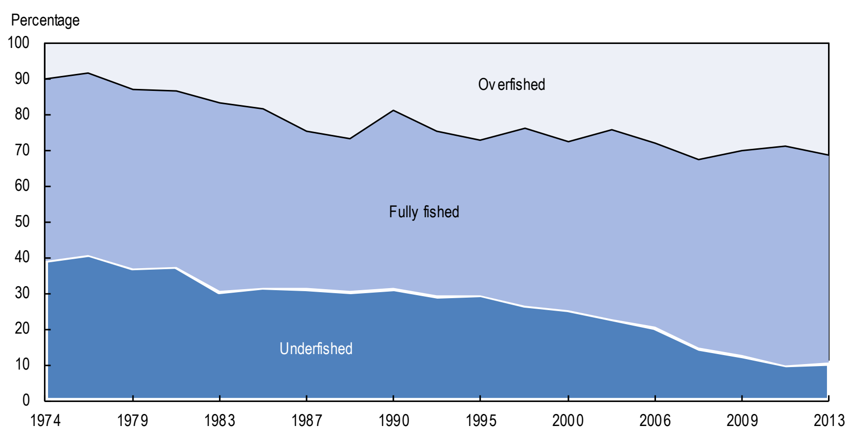
State of and pressures on marine biodiversity

The state of and pressures on marine biodiversity are alarming and available state indicators point overwhelmingly to declining trends.[5] According to the Living Planet Index, marine species declined by 39% between 1970 and 2010 (Loh et al., 2010) and currently over 550 species of fish and invertebrates are listed as threatened (critically endangered, endangered and vulnerable) on the IUCN Red List (Pitcher and Cheung, 2013).[6] According to the same list, coral species are moving towards increased extinction risk most rapidly and coral reefs have been singled out as an ecosystem that is probably under more immediate threat from human impacts than any other (Rogers and Laffoley, 2013). Up to 19% of coral reefs have been effectively destroyed and 24% are under threat due to human pressures such as unsustainable tourism, coastal development and overfishing (Wilkinson, 2008; 2004). Some hotspots are particularly fragile, such as within the Great Barrier Reef where hard coral cover has declined from 28% to 14% since 1986 and the rate of decline has increased substantially in recent years (De'ath et al., 2012).[7]

Turning to the state of world fish stocks, the Food and Agriculture Organization (FAO) (2016) finds that in 2013, 31.4% of fish stocks were estimated as fished at a biologically unsustainable level (and therefore overfished), compared to 10% in 1974 (Figure 1.1). Of the total number of stocks assessed in 2013, fully fished stocks accounted for 58.1% and under-fished stocks 10.5% (separated by the white line in Figure 1.1). Branch et al. (2011) find that at present 28-33% of all stocks are over-exploited and 7-13% of all stocks are collapsed. Excessive depletion poses risks to the viability of stocks and can threaten biodiversity, and from an economic perspective represents foregone yields.

Moreover, the Intergovernmental Panel on Climate Change (IPCC) (2014) finds that ocean acidification has increased by around 26% since pre-industrial times[8] and notes that, based on historical evidence, recovery from such changes in ocean pH can take many thousands of years. It is projected that continued anthropogenic carbon dioxide emissions will further increase ocean acidity to levels that will have widespread impacts, mostly deleterious, on marine organisms and ecosystems. Ocean acidification is particularly a threat to coral reefs and calcifying animals such as shellfish and plankton.

Figure 1.1. **Global trends in the state of world marine fish stocks, 1974-2013**



Notes: Dark shading: within biologically sustainable levels; light shading: at biologically unsustainable levels. The light line divides the stocks within biologically sustainable levels into two subcategories: fully fished (above the line) and underfished (below the line).

Source: Food and Agriculture Organization (2016), *The State of the World Fisheries and Aquaculture*. Reproduced with permission.

The main pressures driving marine biodiversity and ecosystems loss and decline include over-exploitation of fish and other resources, pollution, habitat destruction, climate change and invasive alien species. Each of these is summarised below. It is important to note, however, that these pressures can also re-enforce each other, exerting cumulative impacts on marine biodiversity.[9]

Over-exploitation of fish and other resources

With rising incomes, growing population and evolving diets, demand for fish has been steadily increasing. Global fish production is increasing at an average annual rate of 3.2%, outpacing world population growth at 1.6% (FAO, 2014). In 2014, total global fish capture production was 93.4 million tonnes with the share of fish production used for direct human consumption increasing from 70% in the 1980s to more than 85% in 2012 (FAO, 2016; 2014). Fish continues to be one of the most traded food commodities in the world, with annual exports rising to USD 148 billion in 2014 (FAO, 2016). Aquaculture is one of the fastest growing food-producing sectors and provides half of all fish for human consumption. Its production expanded at an average annual rate of 6.2% in the period between 2000 and 2012 (FAO, 2014). The total number of fishing vessels in the world was estimated to be about 4.72 million in 2012, with efforts to reduce overcapacity in fishing fleets not resulting in effective outcomes across the board (FAO, 2014). In addition, world fishery production is expected to be 17% higher by 2023 (OECD-FAO, 2014), mainly due to projected increases in aquaculture.

Illegal, unreported and unregulated (IUU) fishing also continues to present challenges. About 11-26 million tonnes of fish is lost to IUU annually, i.e. a mean loss of 18% across all fisheries (Agnew et al., 2009). Distinct from this is the issue of wastage, where 8%, or 7.2 million tonnes, of the global fisheries catch consists of non-target species, which are subsequently discarded (FAO, 2004), and thus has impacts on species and ecosystems.

Pollution

Marine pollution occurs when harmful, or potentially harmful, effects result from the entry into the ocean of chemicals; particles; industrial, agricultural and residential waste; noise; or the spread of invasive organisms.[10] Most sources of marine pollution are land based (80%; GOC, 2014), often from non-point sources such as agricultural runoff. The pathways of marine pollution include direct discharge, land run-off, ship pollution (e.g. ballast water and hot water discharge), atmospheric pollution and deep-sea mining (e.g. for oil and gas), with the resulting types of pollution consisting of acidification, eutrophication, marine litter, toxins and underwater noise. Carbon dioxide emissions are the main driver of ocean acidification, whereas excess nutrients lead to eutrophication. For example, 85% of the sewage discharged in the Mediterranean Sea is untreated, leading to eutrophication. Left unchecked, eutrophication can lead to the creation of dead zones, which is occurring in different parts of the world including the Gulf of Mexico, the Black Sea and the Baltic Sea.[11]

Habitat destruction

Habitat destruction along the coast and in the ocean results from harmful fishing practices such as trawling or dynamite fishing; poor land-use practices in agriculture, coastal development and forestry sectors; and other human activities such as mining,[12] dredging and anchoring, as well as tourism and coastal encroachment. For example, logging and vegetation removal can introduce sediments from soil erosion, and harbour development and other land-based activities (such as shrimp aquaculture) can lead to the destruction of mangroves, which serve as nurseries for species of fish and shellfish, and provide flood protection. Poor shipping practices and coastal tourist activities such as snorkelling, boating and scuba diving come in direct contact with fragile wetlands and coral reefs, consequently damaging marine habitats and degrading the ecosystem services they provide.

Climate change

Climate change is rapidly impacting species and ecosystems that are already under stress from overfishing and habitat loss. Rising sea surface temperatures and sea levels due to thermal expansion of water and melting of the continental glaciers is altering the behaviour and demographic traits of marine species. Tropical storms and heavy rainfall have physically damaged coral reefs, marine ecosystems and coastal regions. According to Doney et al. (2011), climate change impacts on marine biodiversity have already resulted in either a loss or degradation of 50% of salt marshes, 35% of mangroves, 30% of coral reefs and 20% of seagrasses worldwide. Coral reefs are one of the most vulnerable ecosystems to climate change impacts. Episodes of coral bleaching due to ocean acidification and anomalously high sea water temperatures have become more frequent in recent times, leading to coral mortality and declining coral cover, showing no immediate prospects of recovery. Cheung et al. (2009) (cited in the IPCC 5th Assessment Report) have projected climate change impacts to marine biodiversity to 2050 and predict numerous local extinctions, species invasion and turnover of over 60% of present biodiversity with implications for ecological disturbances that potentially disrupt ecosystem services.

Invasive alien species

The introduction of non-native marine species to marine ecosystems to which they do not belong constitutes another serious threat to the marine environment. Most of these alien species are rapidly introduced to a different habitat through ballast water from commercial shipping operations across the oceans. An estimated 7 000 marine species are carried around the world in ballast water every day (WWF, 2009). Coastal tourism, boat hulls, eutrophication and marine pollution also move marine species far from their natural ranges. These foreign organisms are responsible for severe environmental impacts, such as altering native ecosystem by disrupting native habitats, extinction of some marine flora and fauna, decreased water quality, increasing competition and predation among species, and spread of disease. Across the oceans, fish, crabs, clams, mussels and corals that were unintentionally introduced have also resulted in adverse economic impacts, such as collapse of fish stock, damage to coastal areas (smothering of beaches; decreased recreational opportunities) and cost for control. For example, the comb jelly in the Black Sea (and most recently invaded Baltic Sea) is held responsible for the collapse of fisheries worth several million dollars annually (Science Daily, 2008). Invasive alien species affect marine industries (including fishing and tourism) as well as human health (via the introduction of fatal pathogens such as cholera bacteria) (see Bax et al., 2003).

Economic value of marine ecosystems

Marine ecosystems degradation is arguably pushing beyond ecologically and economically sustainable thresholds. One of the underlying reasons for this is that many of the services provided by marine and coastal ecosystems[13] – such as coastal protection, fish nursery, water purification, marine biodiversity and carbon sequestration (see Table 1.1) – are not reflected in the prices of traditional goods and services on the market (and hence referred to as non-market values). While there is often a lack of scientific information to clearly understand the complex links between these marine ecosystem services and their economic value, this undervaluation of marine ecosystem services results in under-investment in their conservation and sustainable use, and lost opportunities for economic growth and poverty reduction.

Estimating and accounting for the economic values associated with some bundles of these ecosystem services is important to help improve decision- and policy-making processes, including management decisions and priority setting (i.e. to more efficiently allocate resources between competing uses) (Naber, Lange and Hatziolos, 2008), as well as the design of policy instruments for marine conservation and sustainable use. The Marine Ecosystem Services Partnership (MESP) provides information on more than 1 000 valuation-oriented studies worldwide, by ecosystem type.[14] In Sri Lanka, for example, greater conservation efforts of its salt water marsh, a natural buffer against flooding, were prompted when its ability to protect cities was valued at USD 5 million annually (Global Partnership for Oceans, n.d.).

A number of studies have estimated the economic value of marine ecosystems, examples of which are highlighted below. While these vary in terms of scope (e.g. different ecosystems, varying geographical scales), they serve to illustrate that the benefits are considerable.

Taking into account the number of people engaged in coastal livelihood activities, marine and coastal resources directly provide at least USD 3 trillion worth of economic goods and services annually (UNDP, 2012). The marine environment supports approximately 61% of world's total gross national product (GNP) by directly and indirectly providing fundamental goods and ecosystem services[15] (including coastal tourism, recreation and employment) upon which human well-being depends (UNESCO, 2012). Global aquaculture production (including food fish and aquatic algae) contributes about USD 162.2 billion towards the global economy (FAO, 2016); the shipping industry contributes to 90% of the global trade; the tourism industry, of which marine and coastal tourism is a major part, represents 5% of global GDP (UNDP, 2012).

Table 1.1. **Examples of marine and coastal ecosystem services and their scale**

Category (examples)	Geographic scale
Food (e.g. fisheries and aquaculture)	Local/regional/global
Fuel (e.g. mangrove wood)	Local/regional/global
Water	Local/regional
Natural products (e.g. sand, pearls, diatomaceous earth)	Local/regional/global
Genetic and pharmaceutical products	Local/regional/global
Lifecycle maintenance, habitat and gene pool protection	Global
Atmospheric composition, carbon sequestration and climate regulation	Local/regional/global
Shoreline stabilization/erosion control	Local
Natural hazard protection (e.g. from storms, hurricanes and floods)	Local/regional
Pollution buffering and water quality	Local/regional
Soil, sediment, and sand formation and composition	Local/regional
Tourism	Local/regional/global
Recreation	Local/regional/global
Spiritual values	Local/regional/global
Education and research	Local/regional/global
Aesthetics	Local

Source: Authors own work.

Coral ecosystems are estimated to provide an average value of approximately USD 172 billion a year to the world economy (Veron et al., 2009). The value is based on ecosystem services including food and raw materials, moderation of extreme ocean events, water purification, recreation, tourism, and maintenance of biodiversity. Moreover, about

500 million people directly or indirectly depend on coral reefs as their source of livelihood (Wilkinson, 2004).

The Global Ocean Commission estimates that the global economic value of carbon sequestration associated with seas and oceans ranges between USD 74 billion and USD 222 billion per year (GOC, 2014).

In a more comprehensive study, de Groot et al. (2012) provide global estimates of a number of ecosystems and services, including for open oceans, coral reefs, coastal systems, and coastal and inland wetlands. They find the total value of ecosystem services ranges between 490 int$/year[16] for the total bundle of ecosystem services that can potentially be provided by an "average" hectare of open oceans to almost 350 000 int$/year for the potential services of an "average" hectare of coral reefs.

There are numerous other valuation studies which have been undertaken at national or local scale and/or cover fewer ecosystem components. For example, a national level study for the United Kingdom provides "best estimates" of the monetary value of 8 of the 13 goods and services of marine biodiversity (Beaumont et al., 2008). These include food provision (GBP 513 million), raw materials (GBP 81.5 million), gas and climate regulation (GBP 0.4-8.4 billion), disturbance prevention and alleviation (GBP 0.5-1.1 billion), and leisure and recreation (GBP 11.77 billion). Similarly, Lange (2009) estimates the value of marine ecosystem services in Zanzibar and finds it accounts for 30% of GDP.[17] As the marine environment continues to be threatened, if corrective measures are not taken soon, the costs of inaction are anticipated to continue to increase (Box 1.1).

Instruments for the conservation and sustainable use of marine biodiversity

A number of policy instruments are available to promote the conservation and sustainable use of marine biodiversity. Table 1.2 categorises these in terms of regulatory, economic, and information and voluntary instruments. Each of these is discussed in turn.[18]

Regulatory (command-and-control) approaches

Marine protected areas are gaining increasing attention as a policy instrument for marine biodiversity conservation, and currently cover about 4.1% of the total marine environment. The number of MPAs is increasing at approximately 5% annually (Wood et al., 2008)[19]. This has been due, at least in part, to the calls at international level to scale up the conservation of marine areas (such as under the CBD) as well as other directives and regulations such as the 1992 European Directive on the conservation of natural habitats and of wild flora and fauna, and the more recent Marine Strategy Framework Directive. Studies have shown that MPAs can increase the density, diversity and size of species (Halpern, 2003; Gaines et al., 2010), protect habitats, and provide other economic benefits such as for tourism and recreation.

Box 1.1. **Examples of costs of inaction (global)**

- The cumulative economic impact of poor ocean management practices is about USD 200 billion per year (UNDP, 2012). For example, invasive marine species, especially those carried in ship ballast water and on ship hulls, cause an estimated USD 100 billion each year in economic damage to infrastructure, ecosystems and livelihoods (based on estimates in the UNDP-GEF GloBallast programme, as cited in UNDP [2012]). The World Bank and Food and Agriculture Organization estimated the economic losses due to overfishing at USD 50 billion annually (World Bank-FAO, 2008, cited in UNDP [2012]).
- The Intergovernmental Panel on Climate Change (IPCC) (2014) model projections suggest a potential loss of up to 13% to annual total fishery value in the United States, and globally over USD 100 billion annually, by 2100 (Cooley and Doney, 2009; Narita, Rehdanz and Tol, 2012).
- Brander et al. (2012) estimate that the loss of tropical reef cover due to ocean acidification will cause damages of between USD 528 billion and USD 870 billion (year 2000 value) by 2100.
- The total estimated costs of coastal protection, relocation of people and loss of land to sea-level rise ranges from about USD 200 billion for an increase of sea level of 0.5 metres to five times that – USD 1 trillion – for a 1-metre rise, to about USD 2 trillion for an increase of 2 metres (Nicholls and Cazenave, 2010).
- In the absence of proactive mitigation measures, climate change will increase the cost of damage to the ocean by an additional USD 322 billion per year by 2050 (Noone, Sumaila and Diaz, 2012).

The Convention on International Trade in Endangered Species (CITES) is also important for marine species, as many species that are traded internationally are highly migratory. CITES provides a legal framework to regulate the international trade of species and includes restrictions on commercial trade when species are threatened with extinction. As of October 2013, there were 16 fish species listed under Appendix I (trade is permitted only under exceptional circumstances) and 87 species in Appendix II (trade is allowed but must be controlled).[20]

Table 1.2. **Policy instruments for marine biodiversity conservation and sustainable use**

Regulatory instruments (i.e. command-and-control)	Economic instruments	Information and voluntary approaches
Marine protected areas	Taxes, charges, user fees (e.g. entrance fees to marine parks)	Certification, eco-labelling (e.g. Marine Stewardship Council)
Marine spatial planning	Individually transferable quotas	Voluntary agreements, including public-private partnerships (which can include, for example, voluntary biodiversity offset schemes)
Spatial and temporal fishing closures; bans and standards on fishing gear; limits on number and size of vessels (input controls); other restrictions or prohibitions on use (e.g. CITES)	Subsidies to promote biodiversity – and the reform of environmentally harmful subsidies	
Catch limits or quotas (output controls)	Payments for ecosystem services (PES)[1]	
Standards (e.g. MARPOL for ships); bans on dynamite fishing	Biodiversity offsets	
Licenses (e.g. aquaculture and offshore windfarms)	Non-compliance penalties	
Planning requirements (e.g. environmental impact assessments and strategic environmental assessments)	Fines on damages	

Notes: CITES: Convention on International Trade in Endangered Species; MARPOL: International Convention for the Prevention of Pollution from Ships ("marine pollution").
1. France uses the term payments for environmental services to emphasise that payments should only be made for services rendered that are additional to what the natural ecosystem would provide (i.e. in the absence of changes in management practices). This should, in fact, be a requirement for all PES programmes; see OECD (2010) for further discussion.

Source: Author's own work.

Another instrument that has been increasingly used over the past decade is marine spatial planning (MSP). MSP refers to a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives. MPAs can (and should) form an integral part of an MSP (see also Chapter 5 for further discussion). The main elements of an MSP include an interlinked system of plans, policies and regulations, which are generally accompanied by the use of maps.[21] MSPs are currently being used in about 50 countries worldwide including Canada, the People's Republic of China, Germany, New Zealand, the Netherlands, Norway and the United States.[22] Collie et al. (2013) examine 16 MSPs around the world to compare practical experience with formulaic guidance on MSPs. As the development of MSPs is still fairly recent, further progress is needed in areas such as identifying data needs as well as clear criteria or frameworks for developing planning options (see, for example, Jay [2015]).

Other regulatory instruments include the more traditional standards on fishing gear, quotas on fish catch, commercial fishing permits, emission standards for waterway engines, fuel sulphur limits for vessels, among many others. Habitat conservation bycatch limits (or individual habitat quotas) also exist though these are not yet common (for an application in British Colombia, Canada, see Wallace et al. [2015]). Planning tools such as environmental impact assessments (EIAs) and strategic environmental assessments (SEAs) are also used. EIAs can be required to assess the impacts of projects such as offshore windfarms, harbour expansion and dredging, marine aquaculture, and oil platforms and rigs. SEAs tend to be undertaken for larger activities, such as to inform a country’s strategy for the development of marine energy (e.g. Scotland).

Economic instruments

Probably the most commonly applied economic instrument to address marine conservation and sustainable use is individually transferable quota (ITQ) systems for fisheries or other variants to ITQs. As of 2008, 148 major fisheries around the world had adopted some variant of this approach (Costello, Gaines and Lynham, 2008), along with approximately 100 smaller fisheries in individual countries. Approximately 10% of the marine harvest was managed by ITQs as of 2008. ITQs for habitat also exist, though very few have been implemented in practice (see Innes [2015] for a discussion).

Other examples of economic instruments include the US 10% federal excise tax on sales of sport fishing equipment and motorboat fuel, which is used to finance the US Aquatic Resources Trust Fund. In Israel, a marine environmental protection fee is levied on ships calling at Israeli ports and oil unloading platforms. This fee varies according to the size of the ship and the amount of oil, with the revenues going to the Marine Pollution Prevention Fund (OECD, 2011a).

Entrance fees to marine national parks are being used in a number of countries, including Belize, Mexico, Thailand and the Galapagos Islands in Ecuador. Payments for ecosystem services (PES) in the marine context have also been introduced. For example, local hotels and tourism operators can pay for reef conservation due to the benefits associated with decreased beach erosion and species conservation (e.g. for scuba divers) (see Chapter 4 for a further discussion). The Great Barrier Reef Marine Park Authority requires the payment of bonds to manage certain approved activities within the park (e.g. marina development, dredge disposal, tourism and aquaculture facilities) (Lal and Brown, 1996).

Revenue from fines imposed on damages caused can also be used for MPAs. In Canada, for example, an environmental protection fund was created for the Gilbert Bay MPA through proceeds of fines imposed on business following an oil spill. Another concept that is being explored is marine biodiversity offsets, for industries such as petroleum exploration, renewable energy and seabed mining. Scoping work for such instruments has been undertaken for Belize and the United Kingdom.

Information and voluntary instruments

Information instruments aim to address informational asymmetries that often exist between business, government and society. Eco-labels and certification are instruments that have been fairly widely adopted in the case of fisheries. Two hundred and twenty-four fisheries have been independently certified as meeting the Marine Stewardship Council (MSC) standard for sustainable fishing with another 94 currently undergoing assessment (MSC, 2014). Friend of the Sea is another important certification scheme in terms of volume, though several others also exist (OECD, 2011b). Other voluntary instruments that have been used include negotiated agreements between government and fishers to establish voluntary marine conservation areas.

The role of marine protected areas and an overview of current status and trends

Each of the instruments described above within the broad headings of regulatory, economic, and information and voluntary instruments are able to help address one or more of the drivers of marine biodiversity loss discussed before. For example, MPAs can contribute to help address overfishing[23] and habitat destruction, and can help to minimise noise pollution, for example, if ships are not allowed to navigate through such areas. MPAs can also protect seagrass beds and salt marshes, which act as carbon sinks (Simard, Laffoley and Baxter, 2016). Instruments such as ITQs are able to contribute to addressing overfishing, and pollution abatement measures (including those targeting land-based pollution) are able to contribute to addressing issues such as plastics pollution, nutrient loading, greenhouse gas emissions and invasive alien species. A simplified (non-comprehensive) depiction of this is provided in Table 1.3.

Table 1.3. **Pressures on marine biodiversity loss and instruments to address them**

Pressures on marine biodiversity loss	Instruments			
	Marine protected areas	ITQs for fisheries	Pollution abatement measures	Other regulatory measures
Overfishing	2	2	0	1
Pollution	1	0	2	1
Habitat destruction	2	0	1	1
Climate change	1	0	2	1
Invasive alien species	0	0	1	1

Notes: ITQ: individual transferable quota.

0 implies not able to address this pressure; 1 implies has potential to help address pressure (depending on instrument and context); 2 implies has significant potential to address pressure. The ability of marine protected areas to help address the spread and impact of invasive alien species is not clear (see De Poorter [2007] and Otero et al. [2013] for further information). In certain cases, such as in the Bouche de Bonifacio marine reserve in France, it is prohibited to introduce non-native species without prior authorisation. Similarly, the impact of ITQs for fisheries on habitat destruction is not necessarily clear with some claiming positive, no or potentially negative impacts on habitat (though the latter can be avoided when complimentary measures are put in place).

Source: Author's own work.

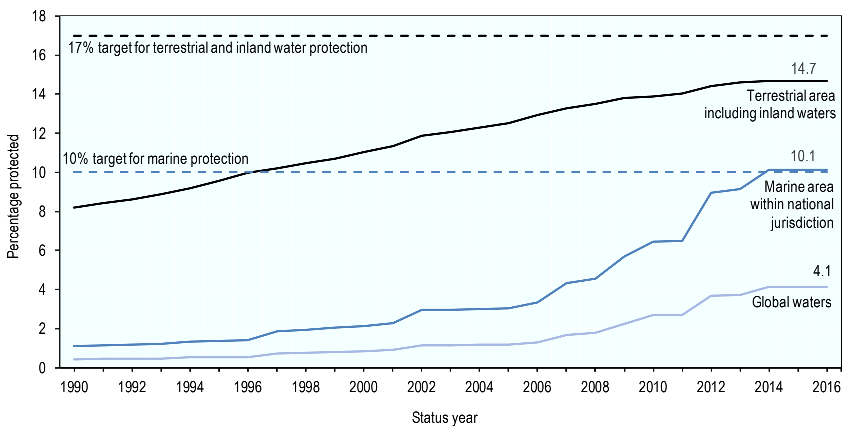
Despite the suite of policy instruments that is available to address marine conservation and sustainable use, current and projected trends in the state of marine biodiversity clearly highlight that the collective response to this challenge must be significantly scaled up and improved. Reflecting experience in the United States, for example, The Nature Conservancy (TNC) summarises:

> For years, there has been chronic underinvestment in marine conservation funding. Underfunding and shrinking budgets at the federal, regional, state, and local levels have left critical habitats unmapped and unprotected; reduced monitoring and scientific investments; hampered restoration efforts; and impeded new, effective national policy initiatives such as fishery reforms, regional ocean governance, marine spatial planning, large-scale coastal conservation, and ecosystem-based management. This situation persists despite longstanding and widespread recognition of the problem. (TNC, 2012)

These issues by no means only arise in the United States but are prevalent across many, if not most, OECD countries, and indeed worldwide.

As indicated above, MPAs are an important component of the suite of instruments for the conservation and sustainable use of marine biodiversity. Interest in MPAs as a management instrument has been increasing over the past two decades, with more than 14 600 MPAs in place around the world today. According to the *World Database on Protected Areas* (WDPA), they cover about 14.9 million km^2, or 4.1% of the global ocean area and 10.2% of coastal and marine areas under national jurisdiction, of the global marine area, with substantial variation on coverage between different regions (UNEP-WCMC and IUCN, 2016) (Figures 1.2 and 1.3). As indicated above, to be included in this database, MPAs must meet the IUCN definition of MPAs, which 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" (Dudley, 2008). The IUCN has developed six categories that classify areas according to their management objectives (Table 1.4). Mackie et al. (2017) examine the proportion of areas under each IUCN category, in OECD and G20 countries.

Figure 1.2. **Trends in global marine protected areas coverage over time**



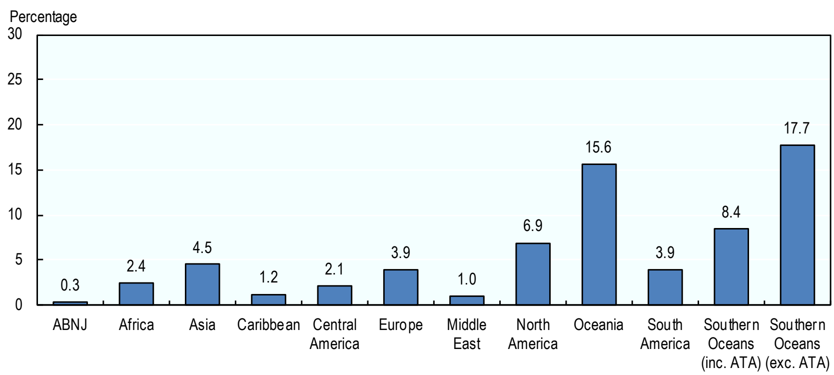
Source: Adapted from UNEP-WCMC and IUCN (2016), *Protected Planet Report 2016*.

While many different names have been given to marine areas that are, to some degree, protected by spatially explicit restrictions (see also Box 1.2), the definition adopted by the Ad Hoc Technical Expert Group on Marine and Coastal Protected Areas[24] for a marine and coastal protected area is:

- (a)"'Marine and coastal protected area' means any defined area within or adjacent to the marine environment, together with its overlying waters and associated flora, fauna and historical and cultural features, which has been reserved by legislation or other effective means, including custom, with the effect that its marine and/or coastal biodiversity enjoys a higher level of protection than its surroundings."

- (b)"Areas within the marine environment include permanent shallow marine waters; sea bays; straits; lagoons; estuaries; subtidal aquatic beds (kelp beds, seagrass beds; tropical marine meadows); coral reefs; intertidal muds; sand or salt flats and marshes; deep-water coral reefs; deep-water vents; and open ocean habitats."

Figure 1.3. **Percentage of marine area (0-200 nautical miles) covered by protected areas in the regions**



Notes: ABNJ: areas beyond national jurisdiction. ATA: Antarctic Treaty Area. The numbers indicate the percentage of marine area protected in each region.

Source: Deguignet, M. et al. (2014), *2014 United Nations List of Protected Areas*, www.unep-wcmc.org/system/dataset_file_fields/files/000/000/263/original/2014_UN_List_of_Protected_Areas_EN_web.PDF?1415613322.

MPAs have a wide range of potential ecological, social and economic functions, including biodiversity conservation, protecting sensitive habitats, maintaining tourism, providing refuge for intensively fished species and ensuring sustainable multiple uses. Accordingly, the levels of restriction associated with MPAs vary, from partial (e.g. focus only on benthic species, or only limiting one type of fishing gear or activity) to high (e.g. "no-take" zones, also often called "marine reserves") and almost total ("no-entry" zones). While some MPAs have a single level of protection, others are multi-use areas subdivided into zones of various levels of protection. According to the WDPA, of the 3.41% global MPA coverage in 2014, only 0.59% was established as no-take MPAs (Thomas et al., 2014). Instead, many MPAs allow extractive activities such as commercial trawling and oil and gas exploration and extraction. In Australia, for example, trawling is permitted in specific areas of the Great Barrier Reef Marine Park and also in the Shark Bay Marine Park (a Western Australian state MPA), although both are World Heritage Areas and highly valuable MPAs (Devillers et al., 2015).

Table 1.4. **Definition and primary objectives of IUCN protected area categories**

IUCN category	Definition	Primary objective
Ia	Category Ia are strictly protected areas set aside to protect biodiversity and also possibly geological/geomorphological features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring.	To conserve regionally, nationally or globally outstanding ecosystems, species (occurrences or aggregations) and/or geodiversity features: these attributes will have been formed mostly or entirely by non-human forces and will be degraded or destroyed when subjected to all but very light human impact.
Ib	Category Ib protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.	To protect the long-term ecological integrity of natural areas that are undisturbed by significant human activity, free of modern infrastructure and where natural forces and processes predominate, so that current and future generations have the opportunity to experience such areas.
II	Category II protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities.	To protect natural biodiversity along with its underlying ecological structure and supporting environmental processes, and to promote education and recreation.
III	Category III protected areas are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine caverns, geological feature such as a caves or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.	To protect specific outstanding natural features and their associated biodiversity and habitats.
IV	Category IV protected areas aim to protect particular species or habitats and management reflects this priority. Many category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.	To maintain, conserve and restore species and habitats.
V	Category V protected areas are where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.	To protect and sustain important landscapes/seascapes and the associated nature conservation and other values created by interactions with humans through traditional management practices.
VI	Category VI protected areas conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.	To protect natural ecosystems and use natural resources sustainably, when conservation and sustainable use can be mutually beneficial.

Source: Dudley, N. (ed.) (2008), *Guidelines for Applying Protected Area Management Categories*, https://cmsdata.iucn.org/downloads/guidelines_for_applying_protected_area_management_categories.pdf.

Box 1.2. **Different terminology for different types of marine protected areas across countries**

In the Philippines, marine protected areas (MPAs) in general take four forms: 1) marine sanctuary or no-take marine reserve, where all forms of extractive activities are prohibited; 2) marine reserve, where extractive and non-extractive activities are regulated; 3) marine parks, where uses are designated into zones; and 4) protected landscape and seascape, where protection may include non-marine resources (Cabral et al., 2014).

In the United States, a national marine sanctuary usually allows fishing but prohibits other activities such as oil exploration. Instead, no-take areas are called marine reserves. Various other terminology is used depending on objectives and the levels of protection, such as marine wildlife refuges, estuarine research reserves and ocean parks.[1]

In France, the Law of 14 April 2006 defined six MPA categories: 1) national parks; 2) natural reserves; 3) biotope protection areas; 4) marine nature parks; 5) Natura 2000 sites; 6) parts of the maritime public domain managed by the Coastal and Lake Shore Conservation Authority. The regulatory objectives assigned to the different categories of MPAs include good environmental status of species, and/or of marine waters; sustainable exploitation of resources; and preservation of maritime cultural heritage (French Ministry of Ecology, Sustainable Development and Energy, 2015). Nine additional categories were added via a Decree of 3 June 2011, including for the Convention on Wetlands sites, UNESCO World Heritage sites, sites under the Barcelona Convention (Mediterranean), OSPAR (North East Atlantic), among others.

Note: 1. See: http://marineprotectedareas.noaa.gov/pdf/helpful-resources/factsheets/mpa_classification_may2011.pdf.

A more recent trend has been the establishment of large-scale MPAs, often described as MPAs larger than 100 000 km^2. Data indicate that ten of the existing MPAs or those currently under creation account for more than 53% of the worlds' total MPA coverage (Devillers et al., 2015). Several of the very large MPAs recently created or planned in the Pacific Ocean (e.g. Phoenix Islands Protected Area) allow fishing across most of their extents (De Santo, 2013; Pala, 2013) (Table 1.5; and Table 2.A1.1 for zoning of other MPAs).

While some progress has been made towards meeting the CBD 2011-2020 Aichi Target for MPAs, the literature suggests that considerably more needs to be done to ensure their effectiveness and ecological representativeness, in addition to their geographic coverage (Ban et al., 2014; Juffe-Bignoli et al., 2014; Dunn et al., 2014; Fox et al., 2014, cited in Brander [2015]).

Table 1.5. **Examples of recent designations of large marine protected areas and potential sites under development**

Year	Marine protected area	Extractive activities allowed	Total size
2007	Benthic Protection Areas, New Zealand (17 sites)	Off-bottom trawl fishing permitted with strict controls in most sites. Kermadec Islands' territorial waters (7 450 km^2) is currently no-take but there is a proposal to make the entire 620 500 km^2 area no-take, which would represent 56% of total combined area of New Zealand's Benthic Protection Areas.	Combined area of: 1 100 000 km^2
2007	South East Commonwealth Marine Reserve Network, Australia (14 sites)	Depending on the area, recreational fishing, charter fishing, mining, some commercial fishing	68% (154 435 km^2) is no-take 226 458 km^2
2008	Phoenix Islands Protected Area (PIPA), Kiribati	1. Distant Water Fishing Nation tuna fishing 2. Domestic commercial fishing licenses 3.87% (15 800 km^2) is no-take, to be increased to 25% when trust fund becomes active	408 250 km^2
2009	Marine National Monuments, United States: 1. Marianas Trench (246 608 km^2) 2. Pacific Remote Islands (225 039 km^2) 3. Rose Atoll (34 838 km^2)	Commercial fishing is prohibited but recreational, non-commercial and traditional/sustenance fishing may be allowed	Combined area just under 500 000 km^2
2009	Prince Edward Islands MPA, South Africa	Commercial fishing: 34% (61 415 km^2) is no-take	180 633 km^2
2009	South Orkneys Marine Protected Area, British Antarctic Territory	100% no-take	93 787 km^2
2010	Motu Motiro Hiva Marine Park, Chile	74% (150 000 km^2) of the area is no-take	203 374 km^2
2012	Coral Sea Commonwealth Marine Reserve, Australia	51% (504 820 km^2) is proposed to be no-take. Recreational fishing and selected commercial fishing gear types allowed in remainder, but demersal trawling, demersal longlining and gillnetting are banned throughout.	989 842 km^2
2014	Coral Sea Natural Park, France/ New Caledonia	Multiple use area with various zones. No-take area is 3 236 km^2.	1 300 000 km^2
2015	Nazca-Desventuradas Marine Park, Chile	100% no-take	297 000 km^2
2015	Palau Marine Sanctuary, Palau	100% no-take	500 000 km^2
2015	Pitcairn Island, United Kingdom	100% no-take	800 000 km^2
2015	Kermadec Ocean Sanctuary, New Zealand	100% no-take	620 000 km^2
2016	Papahānaumokuākea Marine National Monument, North West Hawaiian Islands, United States	Initially established in 2006, bottomfish fishing was allowed. Since 15 June 2011, 341 362 km^2 area has been no-take. Area expanded fourfold in 2016.	1 509 000 km^2
2016	Ascension Island, United Kingdom	Proposed but not yet designated. 50% no-take.	234 291 km^2

Source: Adapted from De Santo, E.M. (2013), "Missing marine protected area (MPA) targets: How the push for quantity over quality undermines sustainability and social justice", http://dx.doi.org/10.1016/j.jenvman.2013.01.033; Jones, P.J.S. and E.M. De Santo (2016), "Viewpoint – Is the race for remote, very large marine protected areas (VLMPAs) taking us down the wrong track?", https://doi.org/10.1016/j.marpol.2016.08.015; with updates from www.mpatlas.org/mpa/sites.

Moreover, the economic aspects of marine protected areas have received less attention in the literature, with studies suggesting that MPA decision making and management may not be as efficient or cost-effective as it could be. Given that countries are supposed to increase MPA coverage to 10% by 2020, from a level of 4.1% today, issues that are relevant and that this report examines include:

- What are the costs and benefits associated with MPAs?
- Across nations, how and why have MPAs been chosen as the appropriate management response? How are MPAs being sited in practice? To what extent are siting decisions informed by economic considerations (i.e. cost-benefit analysis), as well as other factors such as climate change?
- What type of monitoring, compliance and enforcement regimes have been adopted across different MPAs and how do they compare in terms of effectiveness and cost?
- How are MPAs financed and what options are there to scale this up?
- How effective have MPAs been in addressing the threats caused by overfishing and habitat destruction, and in conserving biodiversity more broadly?
- How have MPAs been implemented together with other policy instruments, to more comprehensively and effectively address the multiple drivers of marine biodiversity loss?
- What are the political economy issues surrounding MPAs, including the interplay/competences between fishery and environmental institutions/ministries/agencies, and how can synergies best be used?

Key findings and good practice insights

MPAs can provide a wide variety of benefits. These benefits range from the conservation of areas that harbour important biodiversity, serving as nursery grounds for fisheries, protecting habitats that buffer the impacts of storms and waves, removing excess nutrients and pollutants from the water, and providing more sustainable tourism and recreational benefits. These benefits fall under the various components of the total economic value (TEV), which is the sum of all the use and non-use values for a good or service.

Clear measures and well-defined goals and objectives are necessary for MPAs to be successful. When considering the introduction of an MPA, it is first important to have a clear understanding of the state of, and pressures on a particular marine and/or coastal ecosystem, the likelihood that an MPA or network of MPAs can address these, and the range of stakeholders involved.

Secondly, the goals and objectives of the MPA must be clearly defined, as well as the required level of protection to achieve these. These should be stated at an operational level, so as to be specific, measurable, achievable, realistic and time-bound (SMART), and accompanying indicators should be identified that will enable the eventual assessment of whether the objectives are being met.

Information on the expected costs and benefits of the particular MPA is important for a number of reasons. It allows decision makers to better evaluate the net benefits to society from investing in an MPA and to prioritise efforts among various possible MPAs if resources are limited. It can also provide insights on how these net benefits are distributed (i.e. over time, different geographic scale and between different user groups), which is important for understanding the distributional implications of MPAs, and thus how they can best be managed. Understanding the costs associated with MPAs also enables planners to budget and to help secure sufficient finance for the effective long-term management of the MPA.

Looking across the establishment costs of 13 MPAs which varied in size, location, objectives and degree of protection, McCrea-Strub et al. (2011) find that variation in MPA start-up costs are most significantly related to MPA size and the duration of the establishment phase. MPA operating costs have been found to depend on several variables, particularly design, location, configuration, socio-economic context and zoning (Ban et al., 2011). In a global study, Brander et al. (2015) examine the net benefits of protecting marine habitats through expanding the coverage of MPAs to 10% and 30% and find that the ratios of benefits to costs are in the range 3.17-19.77.

While studies evaluating the benefits and costs of individual MPAs do exist, in general **economic valuation is not yet widespread** and is not being used to help inform the design and implementation of MPAs. Software tools such as Marxan and MarZone which aid systematic reserve design by analysing how given conservation objectives can be attained at least cost, have been used in several cases but could be adopted more widely.

More strategic siting of MPAs is needed, to enhance the environmental as well as cost-effectiveness of MPAs. While ecological criteria are the norm for determining where to locate an MPA (i.e. by identifying ecologically significant and representative areas), studies suggest that often MPAs are situated in locations that are not under direct threat of loss (Burke et al., 2011; Edgar, 2011; Deviliers et al., 2014). As noted by Watson et al (2014), large and remote MPAs may not necessarily avert imminent and direct threats in populated coastal waters where pressures on biodiversity often remain intense. This implies that resources are not allocated to areas where they will have the greatest environmental impact.

While MPAs are being established to address a variety of different (and often multiple) objectives, the primary objective is most commonly to conserve protected, rare or threatened species of populations and their habitats. The past few years have witnessed a marked increase in global MPA coverage. This has also been achieved, in large part, via the recent trend in the establishment of large-scale MPAs (larger than 100 000 km^2). Ten of the existing MPAs or those under creation accounted for more than 53% of the worlds' total MPA coverage (Devillers et al., 2015). The impetus for MPA creation is also likely to be attributable to the internationally agreed targets on marine and coastal protection, namely those under the Convention on Biological Diversity (CBD), and echoed in the Sustainable Development Goals.

Monitoring and reporting on MPAs needs to be more robust. Monitoring is important both initially in order to establish ecological and socio-economic baseline data, as well as regularly thereafter, to assess trends in performance over time, but has often not been undertaken as rigorously as needed. Challenges encountered include lack of sufficient human resources (staff, capacity), financial resources, equipment and infrastructure, and knowledge. Indicators selected should be able to determine whether the objective(s) of the MPA are being achieved. Monitoring protocols can help to provide guidance to MPA managers, as well as to streamline monitoring methods across MPAs so as to facilitate comparison. Reporting including via online databases with publicly available information can help to increase transparency and enable the sharing of information and lessons learnt across different MPAs, their respective management approaches, and their effectiveness in achieving the intended objectives.

Compliance and enforcement methods also vary substantially across MPAs. Approaches for assessing compliance include direct surveillance (e.g. air surveillance, vessel patrols), indirect observation (e.g. discarded gear on reefs) and law enforcement records. Methods that are able to attribute non-compliance to those directly responsible are best suited to applying sanctions. With regard to enforcement, either the probability of detection or the sanctions must be high so as to offset the potential economic gains from MPA violations. However, existing studies suggest that few MPAs have a robust compliance and enforcement regime in place, which has been cited as an important reason for lack of MPA effectiveness. While the costs of enforcement have traditionally been high, recent technological innovations such as vessel monitoring systems and remote sensing can help to drive the costs down.

Adequately **financing** the conservation of coastal and marine areas is often a major challenge and is likely to be exacerbated as countries strive to meet the 10% target under the CBD. Though not comprehensive, available information suggests that the main source of MPA financing in developed countries is government budget, whereas in developing countries, international donors as well as entrance fees to MPAs can constitute an important source of finance. Overall, **more comprehensive and diverse MPA financing portfolios are needed**, via the introduction of instruments such as taxes, fines and other revenue-generating mechanisms, which are also in line with the polluter-pays approach (and can therefore provide incentives to mitigate other pressures on marine biodiversity such as pollution) or which can serve as deterrents to non-compliance. MPA financing strategies, which include identifying the financing needs, and the possible instruments through which additional finance can be mobilised, should form an integral component of an MPA management plan.

Given the vastness, the multidimensionality and the ecological complexity of the oceans; the lack of internationally comparable and systematic indicators and databases that assess MPA effectiveness; the aforementioned management challenges that persist; as well as the continuously mounting pressures on marine ecosystems, it is not possible to ubiquitously say all MPAs have been effective in addressing threats such as overfishing and habitat destruction, and in achieving their conservation objectives. Many have been effective or partially so, though pressures still remain. No single policy instrument is a panacea, and the design and implementation features do matter. In the absence of perfect information, and while scientific understanding improves, there is increasing evidence to suggest that the benefits of MPAs are considerable and that the costs of inaction will continue to rise if further corrective measures are not taken. Adopting a precautionary approach in this context is therefore also relevant.

In addition to more effective design and implementation of MPAs, however, greater emphasis is also needed on putting in place **effective policy mixes** that can meaningfully address the full range of pressures on marine biodiversity conservation and sustainable use. While MPAs are a crucial component of this, they are not sufficient to ensure that the broader environmental goal is met. Complementary instruments need to be in place to manage pressures, such as overfishing (including outside MPA boundaries), marine pollution (including from land-based sources) and climate change. A full package of policy measures is needed to ensure the sustainable use of marine resources, including policies that lie beyond the mandates of environment ministries. Marine spatial planning is an instrument increasingly being used in a number of countries, and can help to obtain a broader understanding of the often competing demands on the ocean space and the diverse stakeholders involved.

The **political economy** of MPAs in this regard is also important and another area where a clearer understanding of the costs and benefits of MPAs, including inter-temporally, can help to alleviate potential conflicts. Opponents to MPAs, for example, tend to focus on the short-run opportunity costs, primarily the loss of fishing opportunities. Embedding MPA design issues into other policy approaches, such as marine spatial planning and other ecosystem-based management regimes, and the establishment of inter-ministerial committees to develop national marine and coastal development strategies, which bring together multiple stakeholders, can help to ensure a better understanding of the costs and benefits of decisions to different users, and the possible measures needed to address vulnerable groups most affected. Such measures can help to address political economy issues that arise, for example, between conservation and fishing communities. Such approaches can also help to foster **policy coherence** – a fundamental component of any strategy that can meaningfully contribute to the achievement of the Sustainable Development Goals, including those for oceans and marine biodiversity, for food security, and for poverty alleviation.

Notes

1. Invasive marine species, especially those carried in ship ballast water and on ship hulls, cause an estimated USD 100 billion each year in economic damage to infrastructure, ecosystems and livelihoods (based on estimates in the UNDP-GEF GloBallast programme, as cited in UNDP [2012]).

2. The importance of oceans has recently also received higher recognition at the United Nations Framework Convention on Climate Change (UNFCCC) COP21 and in the Paris Agreement. The IPCC Panel has also recently decided to prepare a special report on climate change and the oceans and the cryosphere.

3. A few MPAs have also been created in areas beyond national jurisdiction, notably in in the Mediterranean Sea, the north-east Atlantic and the southern Ocean, where regional initiatives and organisations have had the appropriate mandate to do so.

4. The Ad Hoc Technical Expert Group on Marine and Coastal Protected Areas adopted the following definition: "Marine and coastal protected area" means any defined area within or adjacent to the marine environment, together with its overlying waters and associated flora, fauna and historical and cultural features, which has been reserved by legislation or other effective means, including custom, with the effect that its marine and/or coastal biodiversity enjoys a higher level of protection than its surroundings. See the section on "Economic value of marine ecosystems" for further detail on this and other definitions of MPAs.

5. The UN World Ocean Assessment (2016) has also recently been released (www.worldoceanassessment.org).

6. While the marine data is poor, a first IUCN Red List of Threatened Species assessment available for all known species of marine shore-fish, marine mammals, seaturtles, seabirds, corals, mangroves and seagrasses in a major marine biogeographic region of tropical eastern Pacific, indicated that 12% are under threat (Polidoro et al., 2012).

7. The decline has been most severe on the reefs south of the latitude 20° (near Bowen) particularly since 2006. Since then hard coral cover has fallen from about 35% to 8% in the southern third of the region.

8. Measured as hydrogen ion concentration.

9. For example, compounding of human activities in areas where there is overfishing with bottom contact gear types in addition to other activities that damages benthic habitat (coastal/offshore development projects, dredging for shipping, etc.) can adversely affect the spawning grounds habitats for various species. Similarly, climate change effects may put pressure on ecosystems and also create a more conducive environment for invasive species to extend their range and thereby increase the pressure on marine biodiversity.

10. Marine pollution has been defined as "the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities" (Art.1 (4) UNCLOS).

11. There are reportedly 405 dead zones worldwide covering an ocean expanse of 250 000 km^2 (UNDP, 2012). According to another study, there are over 600 dead zones in the world's coastal areas covering more than 245 000 km^2 of sea bottom (Diaz and Rosenberg, 2008).

12. For example gravel extraction and oil exploration.

13. Ecosystem services refer to the benefits people obtain from ecosystems (Millennium Ecosystem Assessment, 2005).

14. http://marineecosystemservices.org.

15. Not necessarily confined to coastal activities but including coastal industries such as maritime equipment industry and many more.

16. Values converted to a common set of units, namely 2007 "international" $/year, i.e. translated into USD values on the basis of purchasing power parity (PPP).

17. This study only accounted for provisioning (fishing, seaweed farming, mangrove harvesting) and cultural services (tourism).

18. It is important to note, however, that since most of the drivers of marine biodiversity loss stem from land-based activities (as described above), instruments to address these activities are just as relevant. Moreover, issues such as building the necessary scientific and technical capacity, as well as ensuring stakeholder engagement in the policy-making process are important elements that need to be considered. These issues are examined in Chapter 3.

19. A few MPAs have also been created in areas beyond national jurisdiction, notably in the Mediterranean Sea, the north-east Atlantic and the southern Ocean, where regional initiatives and organisations have had the appropriate mandate to do so.

20. www.cites.org/eng/disc/species.php.

21. But note that Collie et al. (2013) state that, in fact, there is disagreement about what constitutes an MSP per se as opposed to coastal zone management, marine protected area networks and government frameworks to support marine spatial planning.

22. www.unesco-ioc-marinesp.be/msp_around_the_world.

23. A study by Halpern et al. (2010) indicates that, based on several small-scale fisheries, spillover effects from no-take marine reserves can partially or fully offset losses in catch due to reserve closure. The results suggest that reserves can simultaneously meet conservation objectives and benefit local fisheries adjacent to their boundaries. Similarly, Florin et al. (2013) find positive effects – such as lower mortality rate, higher densities and higher mean age within the area but also potential for spillover effects – in a no-take area in the Baltic Sea (i.e. Gotska Sandön, the largest no-take area in the Baltic covering 360 km²). They conclude that their results strengthen the findings from previous studies stating that no-take marine reserves provide a useful instrument not only for nature conservation but also for fisheries management in northern Europe.

24. UNEP/CBD/COP/Dec/VII/5 Marine and coastal biological diversity.

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Chapter 2.

The benefits and costs of marine protected areas

This chapter highlights the need to better understand the benefits and costs associated with marine protected areas (MPAs). It then provides a review of the valuation literature on marine protected areas, drawing on studies from around the world. It concludes with a brief overview on how cost-benefit analysis can be used to inform MPA decision making.

The benefits and costs of marine protected areas

Prior to making a decision on whether or not to create a particular marine protected area (MPA), it is important to have an understanding of the estimated benefits of the particular ecosystem, the effect of the spatial protection measure on the delivery of ecosystem benefits and other related socio-economic benefits, as well as the estimated costs of establishing and maintaining the MPA. This information allows decision makers to evaluate the net economic benefits to society from investing in an MPA. It can also provide insights on how these values are distributed, i.e. over time, at different levels of scale and between different user groups, which is important for understanding the distributional implications of MPAs, and thus how they can best be managed. Finally, understanding the costs associated with MPAs enables planners to budget and to help secure adequate finance for the effective long-term management of MPAs (see Chapter 4).

MPAs can provide a wide variety of benefits, ranging from the conservation of whole areas that harbour important biodiversity, serving as nursery grounds for fisheries, protecting habitats that buffer the impacts of storms and waves, as well as removing excess nutrients and pollutants from the water, and providing more sustainable tourism and recreational benefits, among others. These benefits fall under the various components of the total economic value (TEV), which is the sum of all the use values (direct, indirect and option) and non-use values for a good or service (Box 2.1). The direct use values can include market values of traded goods and services as well as non-market use values (e.g. recreational values), which may be captured by users' willingness to pay.

Box 2.1. **The total economic value of marine protected areas**

- Direct use values: raw materials, services and products that can be consumed, traded or enjoyed on site, e.g. fish, building materials.
- Indirect use values: maintenance of natural and human systems through, for example, coastal protection, storm control and for provision of habitat for economically important species caught off-site.
- Option values: the value of maintaining the area to allow for potential, but currently unknown, future uses, e.g. tourism, pharmaceutical uses, industrial activities.
- Non-use values: the intrinsic value of the area accruing to people who may not use the site, based on existence, bequest and altruistic motives, and sometimes including components of social, such as cultural, scientific and heritage, values.

The costs associated with MPAs can be divided into three categories, namely direct (resource) costs, other indirect (resource) costs and opportunity costs.

Direct costs cover both establishment and operational costs, where establishment costs include capital outlays – for example boats, offices, site delineation, planning activities, licence buybacks, land purchases and gazetting; operational costs include administration, supplies, maintenance, fuel, training and employment, monitoring, and enforcement (Ban et al., 2011; Butardo-Toribio, Alino and Guiang, 2009). Recurrent capital costs (e.g. purchases of vessels and replacements) may also be considered ongoing annual operational costs (Ban et al., 2011). A clear distinction is often difficult, as some establishment activities may continue into the operational phase, and vice versa (Butardo-Toribio, Alino and Guiang, 2009).

Other indirect costs refer to costs that are not directly related to the MPA design and management but that may arise as a result. These can include, for example, possible congestion costs to fishers if they are displaced to other areas and alternative livelihood training and vocational programmes. Concerns held by these affected groups may also increase social resistance or create other conflicts (Emerton, 2003; Butardo-Toribio, Alino and Guiang, 2009), and thus increase direct costs by requiring more outreach to build support, legal actions or responses, increased enforcement to counter illegal fishing, and so forth. The impacts of increased numbers of visitors, infrastructure developments or populations of certain species may also cause indirect costs (WWF, 2005).

Opportunity costs refer to the value of the next-best alternative that must be foregone, such as foregone commercial fishing income, or foregone tourism or recreation revenues from activities such as charter diving or fishing (CFA, 2003; Cook and Heinen, 2005; Emerton, 2003), or other foregone (non-market) benefits that are not realisable if the MPA is established. In general, it is difficult to estimate these costs, due in part to difficulties in establishing the counterfactual. It has been suggested that opportunity costs to industry, e.g. fishing losses, rerouting of shipping lanes, or mine closures, can constitute the largest proportion of MPA costs (Ban and Klein, 2009; Gravestock, Roberts and Bailey, 2008). However, in several cases they have found to be negligible (see below). Table 2.1 summarises the major benefits and costs.

Benefits of marine protected areas

A number of valuation studies have been undertaken to estimate the benefits of MPAs.[1] Table 2.2 highlights the objective of the studies and illustrates the types of services, the values and the methods used across several MPA valuation studies. Very few, if at all any, studies conduct comprehensive estimation of the change in total economic value as a result of an MPA but rather estimate components thereof. Estimating components of the TEV of MPAs, ideally those that are presumed to be the largest, can often be sufficient to make the case for an MPA, when compared with the estimated costs associated with them.

Table 2.1. **Major benefits and costs of marine protected areas**

Benefits	Costs
Biodiversity conservation: marine protected areas (MPAs) can lead to the: – recovery of exploited species in reserves – increased species diversity and improvements in habitat. These changes are expected to lead to greater resilience of populations to environmental perturbations, reducing the likelihood of local extinctions.	Direct costs, including costs of: – establishment – administration – employment – monitoring and enforcement.
Regulating services: protection of habitats such as reefs provides protection against storms and coastal erosion, and increases assimilative capacity for pollutants.	Other indirect costs: other costs that may be associated with MPAs, for example: – possible congestion costs to fishers if displaced to other areas (at least in short run) – alternative employment packages – infrastructure costs of increasing tourism as a result of an MPA – displaced communities, if relocated.
Fishery enhancement: after some time lag, the results of protection include larger, more valuable and variable fish species within the reserve, with transfer of benefits to fishing areas through adult spillover and larval export. Habitat protection increases production in reserves. Stock protection reduces the likelihood of fishery collapse.	Opportunity costs: value of foregone alternative, for example: – short-term fishery revenues – revenues from other activities forbidden in the MPA, such as coral mining, shell extraction and blast fishing – large-scale tourism and resort development – industrial and infrastructure development – recreational benefits lost if the MPA is closed to the public (and other non-market values).
Tourism and recreation: better opportunities for tourism and recreation is a major objective of many MPAs. Enhancement of fish stocks in reserves and the associated habitat protection increase appeal for tourism. This creates employment opportunities directly linked to the reserve (e.g. tour guides, wardens) and could stimulate a multiplier effect through the local economy (e.g. hotels, restaurants, infrastructure, taxi services, etc.).	
Biochemical informational services: there are potential gains from pharmaceutical bioprospecting – future discoveries of important medicinal components.	
Education and research: MPAs provide opportunities to learn about processes from "undisturbed" regions. Non-use values, including cultural and heritage values.	

Source: Adapted from CFA (2003), *Conservation Finance Guide*, www.conservationfinance.org/guide/guide.

Table 2.2. **Examples of marine protected area valuation studies**

Site	Objective	Type of service	Value	Method	Source
Bahamas	To identify the potential presence and relative importance of ecosystem services within the proposed protected areas	Indirect values of key habitat functions	USD 11 million	Benefits transfer	Clavelle and Jylkka (2013)
Marine protected area (MPA) network in Scottish offshore and territorial waters	To estimate the economic value arising from the designation of three theoretical networks of MPAs in Scottish territorial and offshore waters	Direct and indirect values (not option values)	GBP 6.3-10 billion over 20 years	Benefits transfer	Links Economics Forum (2012)
Scottish waters MPA	To estimate willingness to pay (WTP) for additional MPAs in the Scottish deep sea	Existence value for deep-sea species and option use values for future medicinal purposes	WTP GBP 70-77 for "best" option	Choice experiment and contingent valuation	Jobstvogt, Watson and Kenter (2014)
Lundy marine nature reserve, United Kingdom	To estimate the non-market recreational benefits arising from the marine nature reserve	Recreational benefits	Estimated consumer surplus GBP 359-574 per trip	Travel cost method	Chae, Wattage and Pascoe (2012)
Network of marine conservation zones (MCZs), United Kingdom	To estimate benefits, measured in terms of anticipated increases in the value of ecosystem goods and services provisioned by MCZs, relative to the counterfactual, i.e. no designation	Seven categories of ecosystem goods and services	GBP 10-23 billion for a 20-year time period	Benefits transfer	Hussain et al. (2010)

Table 2.2. **Examples of marine protected area valuation studies** (*continued*)

Site	Objective	Type of service	Value	Method	Source
Network of marine conservation zones, United Kingdom	To estimate the non-market benefits derived by UK residents from the conservation of ecosystem goods and services resulting from implementation of proposed marine conservation zones under the UK Marine and Coastal Access Bill (2008)	Non-market benefits of ecosystem services	WTP to halt loss of marine biodiversity and environmental benefits GBP 21 billion and GBP 16 billion respectively	Choice experiment	McVittie and Moran (2010)
Hon Mun MPA, Viet Nam	To compare management with "no management" scenario	Fishery, aquaculture and other (tourism)	USD 54-73 million	Travel cost method production function Contingent valuation	Kankh and van Beukering (2005)
Seychelles	To estimate tourists' WTP for visits to Seychelles marine national parks	Recreational benefits	WTP USD 12.20 Consumer surplus USD 88 000	Contingent valuation	Mathieu (1998)
Network of MPAs, Colombia	To estimate economic value of carbon sequestration provided by a proposed network of MPAs	Carbon sequestration	EUR 43-300 million depending on exogenous variables, for 2013-20	Based on market prices of carbon	Zarata-Barrera and Maldonado (2015)
MPAs along Garden Route, South Africa	To estimate costs and benefits associated with MPAs and how estimates might change under different scenarios of MPA size and management intensity	Fishing, recreational, existence	PV 600-800 million rand	Value per fish Travel cost method Contingent valuation	Turpie, Clark and Hutchings (2006)

Table 2.2. **Examples of marine protected area valuation studies** (*continued*)

Site	Objective	Type of service	Value	Method	Source
Seven marine areas in New Zealand	To review the ecosystem services provided by the marine environment in New Zealand, by analysing their supply, demand and value in New Zealand's marine and coastal environment and the current MPA network	Ecosystems goods and services	Areas generated an average ES value of NZD 403 billion per year for 2010	Benefit transfer	Van den Belt and Cole (2014)
Port-Cros National Park, France	To estimate the additional benefits in services as a result of the MPA	Some use values, distinguished between market and non-market values (ecosystem recreation services, carbon storage, effect on fishing resources) and a global non-use value	Total present value EUR 14 658 million (on 20-year window, 68% of which is the non-use value), compared to investment and management costs of EUR 161 million	Various methods including contingent valuation, visitor spending and travel cost method	Hamade (2013)
Guadeloupe National Park, France	To estimate the additional benefits in services as a result of the MPA	Some use values, distinguished between market and non-market values (ecosystem recreation services, carbon storage, effect on fishing resources) and a global non-use value	Total present value EUR 1 444 million (on 20-year window, 89% of which is the non-market value of recreation), compared to investment and management costs of EUR 149 million	Various methods including contingent valuation, visitor spending and travel cost method	Hamade and Hetier (2013)

Notes: PV: present value; ES: ecosystem service.

Source: Author's own work.

Challenges that can be encountered in conducting these studies include the attribution of benefits to specific MPAs (see OECD, 2014).[1] In an *ex ante* case study on benefits valuation of the Eastport MPAs in Canada, for example, a science assessment was undertaken to assess the abundance of American lobster within the MPA, and at comparable "control" sites outside the MPA over a 15-year time frame. Despite observed differences in the size structure of lobster populations, no definitive differences in abundance indices were found. As a consequence, there were no quantitative benefits to be valued in economic terms. For the Eastport MPA, the results could in part be attributable to the small size of the MPA, making it difficult to isolate the effects of the MPA from other factors affecting the lobster population in the area (DFO Canada, 2014).

A limited number of studies have estimated the global benefits of MPAs. Heal and Rising (2014) estimate global benefits of MPAs for harvested fish stocks. They find that on average, a 1% increase in protected area results in an increase in the growth rate of fish populations by about 1%. Brander et al. (2015) estimate that the total ecosystem service benefits of achieving 10% coverage of MPAs are in the range USD 622-923 billion over the period 2015-50, and for 30% coverage range between USD 719 billion to USD 1 145 billion. The ecosystem services covered include coastal protection, fisheries, tourism, recreation and carbon storage provided by coral reefs, mangroves and coastal wetlands. Variation in benefits across scenarios is largely due to differences in the provision of services from coral reefs.

Costs of marine protected areas

Direct costs

As discussed, direct costs cover both establishment costs and operational costs. McCrea-Strub et al. (2011) conducted one of the few available studies on establishment costs of MPAs. The 13 MPAs examined varied in size, ranging from less than 1 km^2 to more than 360 000 km^2; location, including near and offshore in both developed and developing countries; objectives; and degree of protection. Establishment costs ranged from USD 20 518 to USD 34 800 000 (2005 USD), with variation in MPA start-up costs shown to be most significantly related to MPA size and the duration of the establishment phase.

The pre-establishment and establishment costs have also been estimated for the Taputeranga Marine Reserve (TMR) in New Zealand (Rojas-Nazar et al., 2015). The TMR pre-establishment and establishment process cost was approximately NZD 508 000 and NZD 353 000, respectively. The study also highlighted how volunteer effort helped to considerably reduce the monetary cost of the TMR pre-establishment process.

A much larger number of studies are available that examine the operating costs of MPAs (see Annex 2.A1 for a summary). MPA operating costs depend on several variables, particularly design, location, configuration, socio-economic context and zoning (Ban et al., 2011). Balmford et al. (2004) analysed operating costs for 83 MPAs worldwide with sizes ranging from less than 0.1 km^2 to more than 300 000 km^2. They found that annual expenditure ranged from zero to more than USD 28 million per km^2, with a median of USD 775 per km^2 (year 2000 equivalent), and that the cost of MPAs in developed countries were significantly higher than those in developing countries (USD 8 976 per km^2 vs. USD 1 584 per km^2).

In general, smaller MPA sizes, proximity to inhabited land and low purchasing power parity are associated with higher operating costs per unit area, as larger MPAs are able to take advantage of economies of scale even though overall operating costs may somewhat increase (Balmford et al., 2004; Ban et al., 2011). For example, a minimum number of people may be required to manage an MPA regardless of size, but the same number of people may also be able to manage much larger areas (up to a reasonable limit), with only a few additional expenses such as fuel (Ban et al., 2011). Multiple zones also raise operating costs compared to uniform zoning, mostly due to increased surveillance requirements (Ban et al., 2011; Hunt, 2013). For example, zoning enforcement represented 32% of the total expenditure in 2004 of the Great Barrier Reef Marine Park (McCook et al., 2010).

Estimates for the Sulu-Sulawesi Seas Marine Eco-region indicate a total cost of approximately USD 32 million annually for an area of almost 13 000 km^2, and USD 17.4 million for full implementation of existing management plans and new MPAs, although cost reductions of 40-90% per square kilometre for law enforcement could be achieved by combining individual MPAs into a collaboratively managed network (ADB, 2011; MSR, 2012). This is particularly notable in projected management costs for the Coral Sea Marine Reserve (CSMR), where model estimates considering the CSMR a stand-alone MPA were almost double estimates assuming Great Barrier Reef management arrangements would be extended to the CSMR (Ban et al., 2011: Table 2.4).

In a regional study of MPAs in the Mediterranean, official data from 14 countries show that total available resources for MPAs of nearly EUR 52.8 million per year, or EUR 18 500 per km^2 per year on average (Binet, Diazabakana and Hernandez, 2016). Interestingly, it is also the first assessment of financing needs and gaps for the effective management of MPAs in the Mediterranean and for the achievement of Aichi Target 11. For effective management, they estimate a financing need of EUR 700 million a year, and for achievement of the Aichi Target, they estimate a need of EUR 7 billion until 2020.

Other indirect costs

Indirect costs can be difficult to quantify, especially with respect to incremental increases in funding and personnel for outreach or for programmes to build community support. However, transitional payments,[2] which often form a large proportion of the government budgetary cost of establishment, can be analysed. For example, reef fishermen in the Soufriere Marine Management Area in St. Lucia lost 35% of their original fishing grounds when an MPA was created. Compensation of USD 150 per month was therefore paid to 20 of the most dependent fishermen for the first year, and after six years, commercial fish biomass had increased fourfold inside the reserve and threefold in adjacent fishing grounds, leading to general support for the MPA (WWF, 2005).

Transitional payments, however, have also been noted to be far greater than the actual opportunity costs. Payments for the 2004 expansions of Great Barrier Reef no-take areas totalled over AUD 200 million, more than five times the affected gross value of production (GVP) of AUD 43 million. Similarly, compensation payments for the 2012 creation of the Coral Sea Marine Reserve were expected to be in the order of AUD 20 million for GVP impacts of AUD 3.5 million (Hunt, 2013).

Opportunity costs

Opportunity costs vary widely depending on the possible activities in place. In the Kisite-Mputungi Marine National Park, Kenya, opportunity costs were higher by a factor of ten than operating expenditures (Emerton, 2003). Gleason et al. (2013) estimated that the maximum potential net economic losses to fishermen of establishing California’s MPA network ranged 1-29% of revenue depending on the fishery, with the final MPA network proposal reflecting a maximum loss of 6.3% for eight fisheries. A socio-economic assessment of the Cod Grounds MPA in Australia (Schirmer, Casey and Mazur, 2004) found that fishers would lose 5-70% of gross commercial fishing income; that fishing co-operatives would lose 3-5.5% of currently landed catch; and that alternative fishing areas would be subject to higher pressures. However, it should be noted that the proposed Cod Grounds area was 3.1 km^2, supporting up to 14 owner-operator fishing businesses, meaning that these results were highly specific.

In contrast, estimated costs to the Scottish fisheries sector from establishing an MPA network were considered minimal, ranging from GBP 0.05 million to GBP 4.97 million, or 0-2% of gross value added output, under worst-case scenarios (Government of Scotland, 2013). In the Tortugas Ecological Reserve in Florida, impacts to commercial fisheries were expected to be negligible, approximately 1.16% of harvest revenue, although impacts to charter boat operators were 12-13% of revenue (Cook and Heinen, 2005).

The opportunity costs associated with MPAs can be minimized, however, through careful MPA design and zoning. Using the spatial prioritisation software Zonation, Leathwick et al. (2008) found that MPA siting models for New Zealand that controlled for both conservation and minimum fishing opportunity costs would deliver conservation benefits nearly 2.5 times greater than those implemented at the request of fishers, and at a lower cost to them[3] (see Chapter 3 for further discussion).

Box 2.2. **Global costs of marine protected area expansion and models to predict establishment and management costs at a marine protected area**

Global costs of marine protected area expansion

Based on operating costs, Balmford et al. (2004) estimated that a global marine protected area (MPA) network covering 20-30% of the world's seas would cost between USD 5-19 billion a year. More recently, Brander et al. (2015) estimated that the total cost of achieving 10% global coverage of MPAs is in the range of USD 45-47 billion over the period 2015-50 and the total costs of achieving 30% coverage are in the range USD 223-228 billion.[1] The cost categories included in these estimates are the set-up and operating costs of MPAs and the opportunity costs to commercial fisheries.

Models to predict marine protected area establishment and management costs

Based on the MPA data collected, McCrea et al. (2011) and Balmford et al. (2004) developed models to predict MPA establishment cost and management cost, respectively. These are:

- log (establishment cost) = 3.73 + 0.28 t (years) + 0.26 log (a, km^2)
- log (annual cost) = 5. 62 – 0.72log (protected area area, km^2) – 0.0002 (distance, km) – 0.30 (PPP)
- where all logarithms are of base ten.

The latter model, for example, states that the cost of managing a marine protected area is a non-linear function of the size of the proposed protected area, distance of area from land, and the purchasing power parity of the nation. Klein (2010) used this model to predict the management costs of MPAs in each ecoregion in the Coral Triangle and Ban et al. (2011) applied the model to estimate management costs of a proposed Coral Sea MPA in Australia. In the case of the Coral Sea MPA, the results were not considered realistic as the Balmford et al. (2004) model does not differentiate between no-take and multiple zone MPAs. Further applications of this approach are merited to assess the validity of the models, as would the development of alternative models that factor in MPA zoning.

Note: 1. All monetary values are expressed as present values computed over the period 2015-50 using a discount rate of 3% in USD at 2013 price levels.

Using cost-benefit analysis to inform marine protected area decision making

Cost-benefit analysis provides an organisational framework for identifying, quantifying and comparing the costs and benefits (measured in monetary terms) accruing to society as a whole of a proposed policy action.[4] In the case of MPAs, a cost-benefit analysis compares the benefits of protection with the costs of protection, including the costs and benefits which are "unpriced".[5] As benefits and costs flow over time rather than in just one period, discounting this flow gives the net present value (NPV) of an MPA, i.e. the discounted sum of all future costs and benefits (Hanley and Barbier, 2009).

In theory, an MPA should be considered when its NPV exceeds that of an alternative use:

NPV of MPA – NPV of alternative use > 0
or
PV of benefits > PV of costs

Examples of cost-benefit analysis studies of MPAs are highlighted in Box 2.3.

In a global study, Brander et al. (2015) examine the net benefits of protecting marine habitats through expanding the coverage of no-take MPAs. Using a baseline of 3.4% MPA coverage, they examine the benefits under scenarios increasing coverage to 10% and 30%. Two criteria are used to determine the spatial allocation of MPAs, namely: 1) marine biodiversity; 2) exposure of marine ecosystems to human impacts. Global data on species biodiversity were obtained from www.aquamaps.org and data on human impact on marine ecosystems were obtained from Halpern et al. (2008). The results of the cost-benefit analysis show that all six scenarios for expanding MPAs to 10% and 30% coverage are economically advisable. The ratios of benefits to costs are in the range 3.17-19.77. More specifically, under a 10% scenario targeting high biodiversity and low human impact, yields a benefit-cost ratio of 19.77, and under a high biodiversity, high human impact yields a ratio of 15.02.

In general, methodological issues that need to be considered when conducting a cost-benefit analysis are (UNEP-WCMC, 2011): the treatment of risk and uncertainty; avoiding the risk of double counting; scale dependence of values for certain services; and dealing with cumulative impacts.[6] Another issue that needs to be considered is the definition of the baseline, and the MPA designation scenario (i.e. "with" and "without" policy intervention), as well as the choice of the discount rate to be used.

Box 2.3. Examples of cost-benefit analysis of marine protected areas

Taka Bone Rate Marine Protected Area, Indonesia

The quantifiable net benefits of managing the Taka Bone Rate Marine Protected Area, Indonesia, as a protected area were estimated to be between USD 3.5 million and USD 5.0 million in net present value terms, at a 10% discount rate over 25 years. The creation of marine protected areas (MPAs) allowed fish stocks and yields to recover, and stopped destructive fishing practices (Cesar, 2002).

Designation of the second tranche of marine conservation zones in the United Kingdom

The impact assessment carried out by the United Kingdom for the second tranche of marine conservation zones in 2015 summarises the costs and benefits of expanding the area. The best estimate of total costs (present value) is GBP 31.4 million. Due to uncertainty concerning the scale of benefits, the present value of total benefits is not presented. The assessment does provide quantitative estimates of various benefits and presents these for illustrative purposes.[1]

Cost-benefit analysis in Sweden

In the programme of measures within the Marine Strategy Framework Directive for Sweden, the costs and benefits for an increase of the current 6.3% MPA coverage to the goal of 10% have been estimated (i.e. an increase of 570 000 hectares), together with the benefits of reaching "good environmental status". The main costs are establishment costs (i.e. inventory: SEK 240 million), followed by annual maintenance and management costs (SEK 30 million), and surveillance costs (SEK 7.8 million). Estimates of other costs (e.g. loss of income to fishing fleet) are still preliminary as the geographic siting of the additional MPAs has not yet been decided. The benefits estimated are those for commercial fishing and for tourism and recreation, and amount to SEK 200 billion (Risinger, 2015).

The Hecate Strait and Queen Charlotte Sound Glass Sponge Reefs Marine Protected Areas Regulations in Canada

The regulatory impact analysis statement provides both quantitative and qualitative information on the costs and benefits associated with the designation of the MPA. While most of the benefits discussed are qualitative and non-monetary, it considers that theses would greatly outweigh its costs, given the relatively small direct impact on the industry.[2]

Notes: 1. www.gov.uk/government/uploads/system/uploads/attachment_data/file/492534/mcz-second-tranche-consult-ia.pdf. 2. www.gazette.gc.ca/rp-pr/p1/2015/2015-06-27/html/reg6-eng.php.

While cost-benefit analysis should in theory be undertaken any time the establishment of an MPA is being considered in a particular location, very few seem to have been undertaken in practice. Though cost-benefit analysis can be time and resource intensive, it provides information that is crucial to ensuring that resources are allocated most effectively and can help to inform whether an MPA should be established in one particular site versus another. Notably, the 2008 EU Marine Strategy Framework Directive requires cost-benefit analysis prior to the introduction of any new measure.[7] Under Article 13, Programmes of Measures, the directive states: "…Member States shall ensure that measures are cost-effective and technically feasible, and shall carry out impact assessments, including cost-benefit analyses, prior to the introduction of any new measure".

Similarly, Canada's federal regulatory policy requires a detailed cost-benefit analysis of all regulatory proposals including the designation of MPAs under the Oceans Act. Cost-benefit analysis can also help to inform the more complex network design processes, including the possible MPA locations/configurations. These issues are examined in Chapter 3. While cost-benefit analysis is not a frequent requirement in MPA design, other countries seek for cost-effectiveness in the MPA network design (i.e. to minimise costs while attaining the conservation objectives), or prefer to use multi-criteria analysis (e.g. France).

Notes

1. Forty-six valuation studies are listed under the heading of "marine parks", for example, in the *Marine Ecosystem Services Partnership (MESP) Database*: http://marineecosystemservices.org. Another database with valuation studies is www.esvaluation.org.

1. Further information is available at: www.oecd.org/gov/regulatory-policy/framework-for-regulatory-policy-evaluation.htm.

2. It is important to note that, in economic terms, transitional payments are transfer payments, and should therefore not be included in a cost-benefit analysis.

3. For 96 demersal fish species.

4. In contrast, a financial evaluation is generally conducted from the perspective of an individual firm or agency.

5. Some of these costs and benefits can be difficult to measure, whereas they may be a core motive to implement an MPA. As for those that can genuinely not be measured, they should be drawn to decision makers' attention alongside the results of the cost-benefit analysis of those benefits and costs that can be measured (Australian Treasury, 2015).

6. How these issues can be addressed is described in UNEP-WCMC (2011). Further discussion here lies beyond the scope of this report.

7. In the EU Natura 2000, MPA designation is carried out in accordance with the provisions and criteria established under the Birds and Habitats Directives.

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Annex 2.A1.
Direct costs of marine protected areas

Table 2.A1.1. **Direct (establishment and operation) costs of marine protected areas**

Name	Size (km²)	Zoning	Cost	Currency	Notes
Coral Sea, Australia (before 2012 establishment) Ban et al. (2011)	972 000	100% no-take (IUCN Ia)	12 550 000 (O)	2009 AUD	Model estimate. Assumes managed as independent marine protected area (MPA).
Coral Sea, Australia (before 2012 establishment) Ban et al. (2011)	972 000	30% no-take	24 528 000 (O)	2009 AUD	Model estimate. Assumes managed as independent MPA.
Coral Sea, Australia (before 2012 establishment) Ban et al. (2011)	972 000	100% no-take (IUCN Ia)	7 800 000 (O)	2009 AUD	Expert estimate. Assumes extension of GBR management.
Coral Sea, Australia (before 2012 establishment) Ban et al. (2011)	972 000	30% no-take	13 400 000 (O)	2009 AUD	Expert estimate. Assumes extension of GBR management.

Table 2.A1.1. **Direct (establishment and operation) costs of marine protected areas** (*continued*)

Name	Size (km^2)	Zoning	Cost	Currency	Notes
Ashmore Reef, Australia Ban et al. (2011)	583	94% no-take 6% IUCN II	348 000 (O)	2009 AUD	
Cod Grounds, Australia Ban et al. (2011)	3	100% no-take	188 000 (O)	2009 AUD	Incorporated into larger new Cod Grounds Commonwealth Marine Reserve, 2012
Coringa-Herald, Australia Ban et al. (2011)	8 852	100% no-take	211 000 (O)	2009 AUD	Incorporated into Coral Sea Commonwealth Marine Reserve, 2012
Elizabeth and Middleton Reefs, Australia Ban et al. (2011)	1 880	76% no-take 24% IUCN II	100 000 (O)	2009 AUD	Incorporated into new Lord Howe Commonwealth Marine Reserve, 2012
Great Australian Bight, Australia Ban et al. (2011)	19 395	100% IUCN VI	259 000 (O)	2009 AUD	Incorporated into larger new Great Australian Bight Marine Reserve, 2012
Heard and McDonald Islands, Australia Ban et al. (2011)	64 658	100% no-take	620 000 (O)	2009 AUD	
Lord Howe Island, Australia Ban et al. (2011)	3 003	32% no-take 68% IUCN IV	152 000 (O)	2009 AUD	Incorporated into new Lord Howe Commonwealth Marine Reserve, 2012
Mermaid Reef, Australia Ban et al. (2011)	540	100% no-take	132 000 (O)	2009 AUD	
Ningaloo, Australia Ban et al. (2011)	2 435	100% IUCN II	148 000 (O)	2009 AUD	

Table 2.A1.1. **Direct (establishment and operation) costs of marine protected areas** (*continued*)

Name	Size (km²)	Zoning	Cost	Currency	Notes
Solitary Islands, Australia Ban et al. (2011)	152	0.5% no-take 24% IUCN IV 75% IUCN VI	232 000 (O)	2009 AUD	Replaced by Solitary Islands Commonwealth Marine Reserve, 2012
Great Barrier Reef, Australia Great Barrier Reef Marine Park Authority (2014)	344 520	34% no-take (IUCN 1a/II) 4.4% IUCN IV 62% IUCN VI	55 417 000 (O)	2014 AUD	For year ending 30 June 2014
Port Cros National Park, France IUCN (2006b)	18	0.16% no-take 99.84% IUCN IV	5 000 000 (O)	2006 EUR	Estimate
Miramare, Italy IUCN (2006b)	1.2	25% no-take 75% IUCN IV	400 000 (O)	2006 EUR	Estimate
MPA network, Italy IUCN (2006b)	120	x	250 000 (O)	2006 EUR	Estimate
Masia Blanca, Spain IUCN (2006b)	2.8	100% IUCN IV	120 000 (O)	2006 EUR	Estimate
Columbretes, Spain IUCN (2006b)	44	100% IUCN IV	1 235 000 (O)	2006 EUR	Estimate
Estrecho, Spain IUCN (2006b)	92.5	100% IUCN V	500 000 (O)	2006 EUR	Estimate
La Graciosa, High Seas IUCN (2006b)	707	x	600 000 (O)	2006 EUR	Estimate
Alboran, High Seas IUCN (2006b)	2 000	x	800 000 (O)	2006 EUR	Estimate

Table 2.A1.1. **Direct (establishment and operation) costs of marine protected areas** (*continued*)

Name	Size (km^2)	Zoning	Cost	Currency	Notes
Pelagos, High Seas IUCN (2006b)	87 492	100% IUCN IV	250 000 (O)	2006 EUR	Estimate
Mariana Trench, United States McCrea-Strub et al. (2011)	246 608	100% IUCN III	10 000 000 (E)	2005 USD	Estimate
Papahānaumokuākea, United States McCrea-Strub et al. (2011)	362 100	100% no-take	34 800 000 (E)	2005 USD	Estimate
Papahānaumokuākea, United States Papahānaumokuākea (2008)	362 100	100% no-take	48 402 407 (O)	2008 USD	Year 5, estimate to achieve desired goals
MPA Network, California, United States Gleason et al. (2013)	1 542	54% no-take	38 000 000	2013 USD	For a seven-year process. Size and % no-take refer to the area added to existing networks.
Seaflower, Colombia McCrea-Strub et al. (2011)	65 018	0.18% no-entry 3.6% no-take 3.2% sustainable use (IUCN VI) 93.02% buffer (IUCN VI)	14 795 169 (E)	2005 USD	Estimate
Lafken Mapu Lahual, Chile Gelcich et al. (2013)	44	100% IUCN IV	343 620 (O)	2009 USD	Estimate
MPA network, Belize WWF (2005)	x	Various	2 500 000 (O)	2003 USD	Includes management agency operating cost.
Saba, Netherlands Antilles McCrea-Strub et al. (2011)	8.7	15% no-take 85% IUCN VI	557 237 (E)	2005 USD	Estimate

Table 2.A1.1. **Direct (establishment and operation) costs of marine protected areas** (*continued*)

Name	Size (km2)	Zoning	Cost	Currency	Notes
Bonaire, Netherlands Antilles McCrea-Strub et al. (2011)	27	15% no-take 85% IUCN II	1 145 058 (E)	2005 USD	Estimate
Bonaire, Netherlands Antilles Thur (2010)	27	15% no-take 85% IUCN II	270 000 (O)	2002 USD	
Kayangel, Palau Ngedebuul (2012)	1 686	100% IUCN VI	185 563 (O)	2012 USD	Projected average, 2014-17
Kisite/Mpunguti, Kenya Emerton and Tessema (2001)	39	K: 100% no-take M: local fishing permitted	135 000 (O)	2000 USD	Projected average, 2000-04
Chumbe Island, Tanzania McCrea-Strub et al. (2011)	0.5	100% no-take	1 583 455 (E)	2005 USD	Estimate
Nha Trang Bay, Viet Nam McCrea-Strub et al. (2011)	160	10% no-take 90% unknown	2 370 832 (E)	2005 USD	Estimate
Pilar, Philippines Butardo-Toribio, Alino and Guiang (2009)	1.8	17% no-take	445 082 (E) 528 617 (O)	2006 PHP	Incurred average
Villahermosa, Philippines Butardo-Toribio, Alino and Guiang (2009)	0.69	43% no-take	377 867 (E) 237 353 (O)	2006 PHP	Incurred average
Bibilik, Philippines Butardo-Toribio, Alino and Guiang (2009)	0.2	100% no-take	799 159 (E) 445 297 (O)	2006 PHP	Incurred average
Tambunan, Philippines Butardo-Toribio, Alino and Guiang (2009)	1.03	100% no-take	840 778 (E) 710 180 (O)	2006 PHP	Incurred average
Talisay, Philippines Butardo-Toribio, Alino and Guiang (2009)	0.3	30% no-take	357 576 (E) 332 007 (O)	2006 PHP	Incurred average
MIISTA, Philippines Butardo-Toribio, Alino and Guiang (2009)	1.6	100% no-take	741 081 (E) 771 699 (O)	2006 PHP	Incurred average

Table 2.A1.1. **Direct (establishment and operation) costs of marine protected areas** (*continued*)

Name	Size (km²)	Zoning	Cost	Currency	Notes
Apo Reef, Philippines MSR (2012)	275	100% IUCN II/VI	185 978 (O)	2012 USD	Average, 2012-21
Tubbataha Reef, Philippines MSR (2012)	970	100% no-take	514 000 (O)	2012 USD	Average, 2012-21
Gilutongan, Philippines MSR (2012)	0.15	100% no-take	29 893 (O)	2012 USD	Average, 2012-21
Hinobaan, Philippines MSR (2012)	0.25	x	36 381 (O)	2012 USD	Average, 2012-21
Berau, Indonesia MSR (2012)	12 378	8% no-take (assumed) 92% IUCN VI	685 382 (O)	2011 USD	Average, 2011-20
Bunaken, Indonesia MSR (2012)	890 790 marine	100% IUCN II	1 417 723 (O)	2011 USD	Average, 2011-20
Taputeranga Marine Reserve, New Zealand Rojas-Nazar et al. (2015)			Pre-establishment cost NZD 508 000. Establishment process cost NZD 353 000. Annual management costs across the five reserves ranged between NZD 43 200 and NZD 112 500 between 2008/09 and 2010/11. Annual fishers displacement cost: NZD 22 000 per annum.		

Notes: GBR: Great Barrier Reef. USD: United States dollar. PHP: Philippine peso. E: establishment cost; O: operating cost. See Table 1.4 in Chapter 1 for a list of IUCN protected area categories.

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Chapter 3.

Effective design and management of marine protected areas

This chapter examines key issues that need to be considered for the effective design and management of marine protected areas (MPAs). These include setting clear goals and objectives; determining the appropriate siting, size and number of MPAs; robust monitoring and reporting; ensuring effective compliance and enforcement; and putting in place effective MPA governance frameworks.

Marine protected areas (MPAs) are intended to contribute to the conservation and sustainable use of marine ecosystems. However, their effectiveness varies and depends on how they are designed and implemented. This chapter examines the key features that need to be considered for these to be able to deliver on their intended objectives in an environmentally and cost-effective way. Key features include clearly defining the goals and objectives of the MPA; determining the location, size and number of MPAs; establishing robust monitoring and reporting frameworks that allow managers to determine whether the objectives are being met in practice; ensuring appropriate compliance and enforcement regimes; and ensuring effective governance.

Clear goals and objectives

The specific goals of individual MPAs vary, with some broader than others. Their primary objective is to help conserve and ensure the sustainable use of marine ecosystems. These environmental objectives can, for example, be to protect depleted, threatened, rare or endemic species or populations; conserve habitats; or prevent outside activities from adversely affecting the MPA. MPA objectives may also include social and economic elements, such as helping to ensure higher incomes, food security and better health, including via sustainable fisheries and tourism. In the Galapagos, for example, the marine reserve introduced in 2000 was intended to: 1) reduce conflicts between uses, principally tourism, fishing and scientific research; 2) protect marine biodiversity; and 3) promote sustainable uses. The goals of other MPAs are highlighted in Annex 3.A1.

The goals and objectives of an MPA will have distinct implications for its design and implementation, including on where to locate it, the size and type of zoning restrictions that may be appropriate, as well as the indicator and monitoring needs. In terms of zoning, for example, if an area is to be designated as an MPA with the sole objective to protect vulnerable corals and sponges on a deep ocean bottom, there would be little or no risk posed by allowing non-bottom contact fishing in the area.[1] The importance of establishing clear goals and objectives should therefore not be underestimated. The MPA objectives should also be stated at an operational level, so as to be specific, measurable, achievable, realistic and time-bound (SMART). SMART objectives can also help with the design of MPAs, including facilitating the identification of monitoring indicators. In this context, it is therefore helpful to also define key desired outcomes that the MPA is intended to achieve (Jones, 2009). A SMART objective could, for example, be to prevent further loss of key (defined) habitats by 2020.

Finally, when setting objectives it is also important to understand the main threats to marine biodiversity in the area (e.g. overfishing, pollution, habitat degradation, etc. – see Chapter 1) in order to gauge to what extent MPAs will be able to address these, and what additional policy instruments may be needed to complement MPAs (or otherwise, how MPAs can be used to complement other policy instruments (see Chapter 5 for a discussion on policy mixes).

Siting, size and number of marine protected areas

The appropriate location, size and number of MPAs will depend on the objectives of the MPA. With regard to location, as discussed in Chapter 2, the decision on whether or not to invest in a specific MPA should ideally be informed by cost-benefit analysis. In cases where there are multiple sites that merit designation as an MPA, but where resources are limited, priorities may need to be established. While marine ecosystems are generally more spatially and temporally complex than terrestrial ecosystems, the general principles for determining where to prioritise resources for an MPA should follow the same as those for terrestrial biodiversity. This implies identifying areas with: 1) the highest biodiversity benefits: 2) the highest risk of loss; and 3) the lowest opportunity costs (see OECD, 2010). This helps to ensure that the greatest benefits can be achieved given the resources available.

While ecological criteria are the norm for determining where to locate an MPA (i.e. by identifying ecologically significant and representative areas),[2] studies suggest, however, that often MPAs are situated in locations that are not under direct threat of loss (Burke et al., 2011; Edgar, 2011; Devillers et al., 2015). As noted by Watson et al. (2014), large and remote MPAs may not necessarily avert imminent and direct threats in populated coastal waters where pressures on biodiversity often remain intense. This implies that resources are not allocated to areas where they will have greatest environmental impact. Similarly, opportunity costs are also often not taken into account, implying that resources are not allocated in the most cost-effective manner.[3]

One example where these factors are being considered is in the United Kingdom and the designation of marine conservation zones. Sites are prioritised according to potential or actual adverse impacts of activities and management is being implemented first at sites most at risk of damage.[4] A few other exceptions that do this to some extent are academic studies, though it is not clear whether the results have been incorporated into public decision-making processes. Klein et al. (2008), for example, examine how to design a network of MPAs along the Californian central coast. The primary objective of the MPA design was to minimise the “cost” of the protected areas to the fishing industry while ensuring that the conservation and non-consumptive socio-economic goals were achieved. With the aim of cost-effectively protecting coral reef, Klein et al. (2010) use information on threats to marine ecosystems, effectiveness of management actions at abating threats, and the management and opportunity costs of two conservation actions (i.e. land-based and sea-based) to calculate the rate of return on investment in 16 ecoregions in the Coral Triangle.

A handful of studies have attempted to undertake this type of analysis at the global level. Combining data available on species diversity and the distribution of threats from human impact to coral reefs[5] (the most biologically diverse of shallow water marine ecosystems), Roberts et al. (2002) identified ten hotspot priorities for reef conservation, namely in south Japan, the Gulf of Guinea, the north Indian Ocean, eastern South Africa, the Cape Verde Islands, the west Caribbean, the Red Sea, the Philippines, the South Mascarene Islands and the Sunda Islands.

Pompa et al. (2011) used data on all marine and freshwater mammal species and find that the nine most biodiverse marine hotspots are located in: the coasts of Baja California, north-eastern America, Peru, Argentina, north-western Africa, South Africa, Japan, Australia and New Zealand. In addition, they identified 11 key conservation sites that were deemed irreplaceable because the presence of endemic species. These are the Hawaiian Islands, the Galapagos Islands, San Felix and Juan Fernández Islands, the Mediterranean Sea, the Caspian Sea, the Kerguelen Islands, the Amazon River, Lake Baikal, the Yang-Tze River, the Indus River, and the Ganges River. These sites had unique species, such as the Galapagos fur seal (*A. galapagoensis*) and the Mediterranean monk seal (*Monachus monachus*). Interestingly, six irreplaceable sites were continental (rivers and lakes), and five were marine.[6]

More recently, Stuart-Smith et al. (2013) used a modified approach, integrating abundance and functional traits of fish diversity to identify global marine hotspots. Their results suggest further unrecognised biodiversity value in some temperate and southern hemisphere marine regions.

In terms of risk of loss (or threat), Halpern et al. (2008) developed a global map of human impact on marine ecosystems[7] and suggested to overlay this with a map of hotspots to identify areas of possible conservation priority. This approach has subsequently been undertaken by Selig et al. (2014), who identified global priorities for marine biodiversity conservation. They used modelled spatial distribution data for nearly 12 500 species to quantify global patterns of species richness and 2 measures of endemism. By combining these data with spatial information on cumulative human impacts (from Halpern et al. [2008]), they identified priority areas where marine biodiversity is most and least impacted by human activities, both within exclusive economic zones (EEZs) and areas beyond national jurisdiction (ABNJ). Their analyses highlighted places that are both accepted priorities for marine conservation like the Coral Triangle, as well as less well-known locations in the southwest Indian Ocean, western Pacific Ocean, Arctic and Antarctic Oceans, and within semi-enclosed seas like the Mediterranean and Baltic Seas. They find, for example, that countries like the Philippines, Japan and the People's Republic of China (hereafter "China"), which have large areas of highly impacted priority areas, should be considered urgent priorities for conservation intervention.

Brander et al. (2015) combined this also with opportunity costs (see the discussion in Chapter 2), though they do not provide information on where the MPAs are located. While Selig et al. (2014) and Brander et al. (2015) are global studies, similar analysis conducted at the national level, using more refined data where available would allow for more informed and cost-effective decision-making processes. Prioritisation software and modelling tools such as Marxan and Marzone[8] should be used to help identify where MPAs should be located to maximise cost-effectiveness (see, for example, Giakoumi et al. [2011]; Micheli et al. [2013]; Mazor et al. [2014]). Other tools and initiatives currently under development which may be useful in this regard include marine InVest[9] and Mapping Ocean Wealth – a three-year initiative by The Nature Conservancy that intends to map monetary values and other benefits including jobs, fish production, food security and risk reduction (Spalding et al., 2014).

Size and number of marine protected areas

There are three basic MPA designs that are most commonly used and discussed: a small single area, a large single area or a network of areas. According to the International Union for Conservation of Nature (IUCN) and UN Environment World Conservation Monitoring Centre:

> …a small area may be appropriate if the objective is to protect a unique habitat, a site-specific life cycle event (such as spawning aggregation that occurs in a single area), or a unique shipwreck. A large single area may be used to protect species nursery grounds, or representative habitat from either fishing pressure or destruction of habitat. A network of MPAs may be used to protect habitats needed for the diversity of life stages common among marine species to ensure that larval transport occurs throughout an entire region". Project Planet Ocean (n.d.)

Scientific recommendations regarding size for marine reserves and MPAs range from at least 3 km^2 to at least 13 km^2. According to the IUCN, however, only 35-60% of existing MPAs meet these minimum size recommendations.[10] Agardy, Notarbartolo di Sciara and Christie (2011) highlight several examples where the size of the MPA has failed to guarantee the conservation of the species they were intended to protect. One of these is the Vaquita dolphin, an endemic species located in the northern Gulf of California, Mexico, and one of the most endangered mammals in the world. The boundaries of a biosphere reserve created in 1993 left 40% of the species' already greatly reduced habitat outside its designation, thereby allowing continued intense gillnet fishing which threatens its survival.

Edgar et al. (2014) shows that the conservation benefits of 87 MPAs investigated worldwide increase with the accumulation of 5 key features: large (>100 km^2), no-take, old (>10 years), well enforced, and isolated by deep water or sand. General recommendations for MPA design based on the work of Ban et al. (2011) are that larger MPAs are better; that 20-50% of any region should be designated as a no-take area; and that networks of MPAs should be comprehensive, adequate and representative. In contrast, they find that in many developing countries, coral reef MPAs are numerous but small with variable representation of habitats, and that MPAs are typically not planned to contribute to representative, connected networks (McCook et al., 2009; TNC et al., 2008; Weeks et al., 2010; Wood et al., 2008).

An important emphasis is also being placed on the development of MPA networks which can enhance benefits and contribute to broader ecosystem objectives (e.g. greater protection for highly migratory species, enhanced resilience against localised environmental change, among others). Well-developed and functionally connected MPA networks can also provide added protection "offering an insurance policy against climate change and other impacts" as they facilitate a range of shifts of populations and ecosystem types as well as the movement of individuals in response to adverse impacts in one MPA, and thus help to reduce risk (NOAA, 2013). The IUCN defines an MPA network as "a collection of individual MPAs or reserves operating cooperatively and synergistically, at various spatial scales, and with a range of protection levels that are designed to meet objectives that a single reserve cannot achieve" (IUCN-WCPA, 2008) and has developed a guide for developing national and regional capacity to build these (IUCN, 2007).

As noted by Green et al. (2014), various ecological guidelines have been developed for designing MPA networks. These focus on achieving fisheries (e.g. Fogarty and Botsford [2007]), biodiversity (e.g. Almany et al. [2009]) or climate change (e.g. McLeod et al. [2012]) objectives independently, or fisheries and biodiversity (Roberts et al., 2003; Gaines et al., 2010) or biodiversity and climate change (McLeod et al., 2009) objectives combined. Green et al. (2014) provide guidelines for how to achieve fisheries, biodiversity and climate change adaptation objectives together. These too, however, need to be integrated with economic considerations.

Overall, while there is an increasing plethora of initiatives to develop prioritisation approaches for MPAs, insufficient attention is being paid to incorporating economic aspects. In a review of 18 large-scale conservation plans for the Mediterranean Sea, for example, Micheli et al. (2013) find that most of these are nearly exclusively driven by biodiversity criteria, a few also incorporate threats, and none incorporate cost. To address this gap, Mazor et al. (2014) developed surrogates that account for revenue from multiple marine sectors: commercial fishing, non-commercial fishing and aquaculture. Such revenue can translate into an opportunity cost for the implementation of an MPA network. Using the software tool Marxan, they set conservation targets with the aim of protecting 10% of the distribution of 77 threatened marine species in the Mediterranean Sea. They compared nine scenarios of opportunity cost by calculating the area and cost required to meet these targets and also compared these spatial priorities with those that are considered consensus areas by the proposed prioritisation schemes in the Mediterranean Sea. They find that for less than 10% of the sea's area, the conservation targets can be achieved while incurring opportunity costs of less than 1%.[11]

Monitoring and reporting

Monitoring is important for three fundamental reasons, namely to establish baseline data, to assess whether MPA objectives are being met and to enable adaptive management. Monitoring should include both ecological and socio-economic aspects (see below), inside and outside the MPA. The information can ultimately help managers improve the management effectiveness and efficiency of an MPA.

Establishing baselines

Baseline data at the time of MPA designation provide a snapshot that can be used to evaluate future changes (Puotinen, 1994). This is important so as to enable the assessment of MPA effectiveness from an environmental standpoint, as well as from a cost-benefit analysis perspective. While the specific information that a baseline should cover will depend on the objectives of an MPA, in general, this should include (Pomeroy et al., 2005; Maxwell, Ban and Morgan, 2014):

- mapping the distribution and abundance of key species and habitats (such as coral reefs)
- the status of ecosystem communities, fish populations and fishing practices

- the size and structure of the human uses and threats, and the importance to communities
- government rules and regulations in the area, and understanding the decision-making processes in local communities.

According to MacNeil et al. (2015), few baselines have been established for determining when MPA objectives have been met, however. Exceptions include the Galapagos Marine Biodiversity Baseline (2002),[12] the First Report Card (2009 Baseline) of the Great Barrier Reef in Australia, and more recently, baseline monitoring of Southern California's MPAs which concluded in mid-2014. This 5-year baseline monitoring period for the south coast region began in 2012 after 36 new MPAs (and 12 pre-existing MPAs and 2 special closures at the Channel Islands). The baseline projects characterised a range of ecosystems including rocky intertidal, kelp forests and sandy beaches. Other elements of the baseline assessment included surveys of human usage (such as fishing and wildlife viewing), studying waters deeper than 100 metres via remotely operated vehicle surveys, and conducting aerial surveys to map nearshore habitats.[13] In another recent study focusing specifically on the impact of an MPA on coral health, Hein et al. (2015) conducted a baseline analysis both inside and outside a proposed MPA in Thailand. Data were therefore collected on coral health, levels of sedimentation, diving pressure, snorkelling pressure, wastewater run-off and boat traffic.

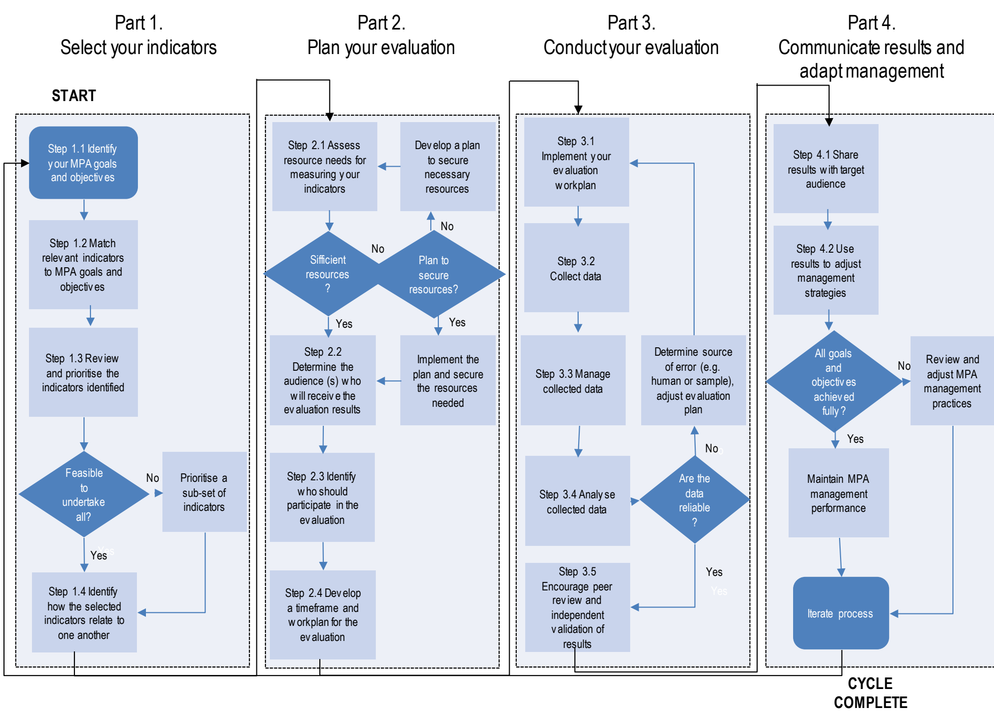
Monitoring to assess effectiveness

To assess whether an MPA is effectively meeting its objectives, monitoring needs to be conducted at regular intervals, so as to be able to detect changes and trends over time. At a minimum, the steps involved in preparing for ecological and socio-economic monitoring include identifying the purposes of monitoring, selecting the relevant indicators, defining the methods and process to conduct the monitoring, identifying and consulting with stakeholders, and identifying the monitoring team.

This is important because MPA monitoring has often been hampered by constraints including human resources (staff, capacity), financial resources, equipment and infrastructure, geographical characteristics of MPAs (e.g. secluded, extended), and knowledge (e.g. uncertainties associated with marine ecosystem complexities), To this end, a clear understanding of the constraints will help to establish realistic monitoring plans, where resources may need to be prioritised, as well as the need for training and capacity building.

Several types of assessment frameworks are available for evaluating effectiveness in MPAs. These include the Marine Protected Area Management Effectiveness Initiative (MPA-MEI),[14] the MPA Performance Assessment System (PAS), the driver-pressure-state-impacts-response framework, and goal-objective-indicator-success (Hilborn et al., 2004; Pomeroy, Parks and Watson, 2004; Ojeda-Martínez et al., 2009; Stelzenmüller and Pinnegar, 2011). These frameworks take into account objectives and goals, realistic benchmarks or indicators to measure success, simple and organised monitoring programmes, and continuous feedback by all interested parties (Pomeroy, Parks and Watson, 2004, Ojeda-Martínez et al., 2009). More recently, the Integrated MPA Socio-Economic Assessment (IMPASEA) framework has been developed to assess the socio-economic impacts of MPAs.[15]

Figure 3.1. **Conducting a marine protected area management effectiveness evaluation**



Source: Pomeroy, R.S. et al. (2005), "How is your MPA doing? A methodology for evaluating the management effectiveness of marine protected areas", https://doi.org/10.1016/j.ocecoaman.2005.05.004.

Moreover, several countries have developed specific monitoring protocols or plans for MPAs, such as in Palau[16] and in the Channel Island in the United States.[17] In other countries, monitoring plans are being developed to support national strategies for marine protected areas, such as in Lebanon. Several guidance documents have also been developed to help MPA managers conduct effective monitoring (e.g. Pomoroy, 2004; MedPan, 2014) (Figure 3.1).

As indicated above, while the specific elements to be monitored should be based on the objectives of the MPA (see Box 3.1 for an example of objectives), common elements that these tend to include are listed in Table 3.1. Information on the number of tourists visiting the site, for example, can enable managers to take appropriate management measures, such as the establishment of visitor quotas, site developments (organised moorage for example), pricing policies and waste management. As local stakeholders are likely to be more impacted by an MPA, information on the local population size (and for example employment), can also be useful.

Table 3.1. **Possible monitoring elements for marine protected areas**

	Examples	Notes or method
Ecological	Species abundance	Underwater visual census by snorkel or SCUBA
	Pollution loads	
	Health of ecosystem (e.g. live coral vs. non-live coral)	
	Density and size of commercial fish	e.g. if goal is fisheries management
	Export of larval and adult fish from marine protected area (MPA)	e.g. if goal is fisheries management
	Seagrass community	
	Visibility	
	Temperature	
	Sediment	
	Bathymetry/bed level	For climate change impacts
Socio-economic	Existence and adoption of a management plan	Yes/no
	Local population size	
	Number of tourists visiting site	Recorded at entry
	Fish catch or catch per unit effort	Within and outside MPA to evaluate displacement effects
	Costs of MPA management (e.g. staff, equipment, training)	Management annual report
	Revenue from for example user fees, and other sources of MPA finance (e.g. national budget, reduction of environmentally harmful subsidies, non-governmental organisations, official development assistance)	
	Compensation of potential income losses for fishermen	
	Level of resource conflict	
	Degree of information dissemination to encourage compliance	
	Level of compliance	See section 3.5

Different monitoring approaches and frameworks have been used across different MPAs. While these may be partly influenced by the institutional structures in place and the level of capacity, developing a monitoring framework should be guided by the need for accuracy, cost-effectiveness, efficiency and ease of collection (Maxwell, Ban and Morgan, 2014).

Box 3.1. **Management objectives of the Iroise Marine National Park, France**

- Improving and disseminating knowledge of marine ecosystems.
- Maintaining populations of protected, rare or threatened species and their habitats in a good state of conservation.
- Reducing land-based pollution and risks of non-point source or accidental maritime and port pollution.
- Controlling material extraction activities.
- Sustainable harvesting of fishery resources.
- Support for professional near-shore fishing.
- Sustainable exploitation of algae fields.
- Supporting maritime activities on the islands to maintain a population of permanent inhabitants.
- Protecting and promoting the landscape and the architectural, maritime and archaeological heritage, particularly underwater, as well as local know-how.
- Rationally developing tourist activities, water sports and recreational activities, compatible with marine ecosystem protection.

Source: Decree No. 2007-1406 of 28 September 2007 establishing the Iroise Marine Natural Park, www.parc-marin-iroise.com.

Perhaps one of the longest running monitoring programmes is that for the Great Barrier Reef in Australia. More than 50 different monitoring programmes are underway, which are either publicly or privately funded. These include Seagrass Watch, AIMS Long-term Monitoring Program, Reef and Health Impact surveys, among many others.

To assess whether MPAs are effectively meeting their goals, the French Marine Protected Areas Agency, which was established in 2006, subsequently initiated a project in 2007 to develop an MPA Dashboard. The dashboard is composed of 7 key steps (Box 3.2) and is being piloted in 22 MPA sites.

To evaluate management effectiveness of 3 MPAs in the Calamianes Islands, Philippines, Garces et al. (2013) used 23 indicators: 6 biophysical indicators that largely measured the status of capture fisheries and coastal habitats; 8 socio-economic indicators that assessed the economic status and the perceptions of coastal communities; and 9 governance indicators that measured the various facets of MPA management.[18]

Box 3.2. **The seven key steps of the MPA Dashboard**

1. Defining and quantifying the marine protected area's (MPA's) long-term goals (responsibility, expected results and targets to be reached in 15 years' time).
2. Defining indicators to achieve the expected results identified in Step 1.
3. Analysis and summary of the monitoring systems implemented in the MPA and those to be developed to calculate the indicators identified in Step 2.
4. Analysis and summary of the databases and reference standards used by the manager to secure the data of the monitoring systems identified in Step 3.
5. Implementing, upgrading or securing the IT tools used to analyse and process data to facilitate indicator calculation.
6. Review and audit of the dashboard developed by the manager following the five steps above (analysis of inconsistencies, gaps, needs, costs, etc.).
7. Developing communication interfaces to report on the dashboard results to decision makers, users, the general public (pictures, pictograms).

Source: www.aires-marines.com/Ressources/Marine-protected-areas-dashboard.

In 2006, MPAs were implemented along the Norwegian Skagerrak coast offering complete protection to shellfish and partial protection to fish. By 2010, European lobster (*Homarus gammarus*) catch-per-unit-effort (CPUE) had increased by 245% in MPAs, whereas CPUE in control areas had increased by 87%. Mean size of lobsters increased by 13% in MPAs, whereas increase in control areas was negligible. Partial protection of Atlantic cod (*Gadus morhua*) was followed by an increase in population density and body size compared with control areas. By 2010, MPA cod were on average 5 cm longer than in any of the control areas (Moland et al., 2013).

Marine protected area reporting

With regard to reporting, MPA managers should aim to (IUCN-WCPA, 2008):

- develop long-term and reliable databases and integrated information systems
- co-ordinate and standardise data collection among individual MPAs within a defined region so that managers can compare data over time and sites
- maximise data access, analysis and reporting to support public processes
- build flexibility into systems to manage for change and new technologies.

Examples of databases with information on MPAs include MAPAMED and HELCOM[19] and the MPA Inventory in the United States, administered by the National Oceanic and Atmospheric Administration.[20] In other areas, procedures to harmonise monitoring across different MPAs have been agreed upon, such as at the regional Baltic Sea level,[21] where monitoring manuals are also being developed to accompany the strategy. A comprehensive national online database has also recently been established in the Philippines, with information on more than 1 800 MPAs.[22] The database also includes results from the MPA Effectiveness Assessment Tool (MEAT) and assigns a MEAT level/score (Cabral et al., 2014).

Compliance and enforcement

Assessing compliance and ensuring enforcement of MPAs is another crucial component of effective MPA management. This involves both measures to promote voluntary compliance, as well as applying clear penalties and sanctions for non-compliance. While it can be difficult to obtain a clear measure of the extent of non-compliance with MPA regulations owing to the inherent difficulty of quantifying clandestine activities, Le Quesne (2009) found that non-compliance with MPA regulations has been reported from Europe, North America, South America, Africa, Asia and Australia, and intertidal, coastal and offshore locations. In a global review of coral reef MPAs, Mora et al. (2006) concluded that medium to high levels of poaching occur in 65% of these.

Methods used to assess compliance include direct observation (e.g. air surveillance, vessel patrols), indirect observation (e.g. discarded gear on reefs), law enforcement records, stakeholder surveys, expert opinions and scenario modelling (Bergseth, Russ and Cinner, 2015). Moreover, compliance performance measures for MPAs are often categorised as either input, output or outcome indicators (see Read, West and Kelaher [2015] for further discussion).

Promoting voluntary compliance involves ensuring that locals and other stakeholders understand and accept the rules. Education, information dissemination and awareness raising are therefore important elements. In this context, it is also helpful to understand the motivations behind non-compliance (Box 3.3), information which can then be used during adaptive management of the MPA.

Box 3.3. **Most common drivers of non-compliance in marine protected areas in the Coral Triangle Region**

- Lack of awareness and understanding about the protected area or rules.
- Food or cash requirements.
- Disagreement or disputes of rights and rules (e.g. ownership).

Source: Pomeroy, P. et al. (2015), "Status and needs to build capacity for local compliance and community-supported enforcement of marine resource rules and regulations in the Coral Triangle region", http://dx.doi.org/10.1080/08920753.2015.1030330.

With regard to enforcement, either the probability of detection or the sanctions must be high so as to offset the potential economic gains from MPA violations. The probability of detection will generally depend on the type of monitoring that is in place and the frequency with which data can be collected. Overall, a balance will also need to be struck with the costs of compliance monitoring. If, for example, costs of continuous monitoring are prohibitively high, this can be done more strategically instead so as to target specific activities, time periods or individuals that are believed to have the greatest negative impact. Thus, enforcement efforts may be higher during peak tourism seasons, for example, or periods of high market values (NOAA, 2005).

Sanctions can include criminal penalties, civil penalties, catch and vessel seizures, and permit sanctions. Despite the obvious need for sanctions, however, some MPAs in the Mediterranean have never imposed these (up to 30% in North Africa and EU). Sanctions have been imposed gradually after a period of information in around 40% of the MPAs (MedPan, 2013). In line with Ostrom (1990) on managing the commons, including to use graduated sanctions for rule violators, sanctions can range to reflect the magnitude of the violation. For repeat offenders, the maximum penalty has often been issued in the United States for the pending violation. In the case of repeat violators illegally trawling for shrimp in the Tortugas Shrimp Sanctuary, the respondents were fined a penalty of USD 25 000 (the maximum authorised penalty at that time). The same maximum penalty was imposed as a result of a violation occurring in an area closed to surf clamming, because of two prior violations of the Magnuson-Stevens Act (NOAA, 2005).

Costs of MPA management tend to be higher with multiple zone MPAs, partly due to the additional complexities associated with enforcement. As discussed in Chapter 2, zoning enforcement of the Great Barrier Reef Marine Park in Australia, for example, represented 32% of total expenditure in 2004. One challenge in multi-zone MPAs is that it can sometimes be difficult to know where the boundaries lie. Traditional methods include markers on shorelines, in-water markers in areas that are relatively shallow and low energy, and maps at key access points or in park publications. Studies from the Mediterranean have found, however, that only one of every three MPA boundaries are marked at all (MedPan, 2013). Advances in technology can help in this context: to help recreational fishers keep track of their position in Parks Victoria in Australia, the agency introduced a recreational fishing guide app for mobile phones in 2013. This uses the geolocational ability to show fishers whether they are in a no-take zone (red warning message), close to one (orange message) or safely clear from one (green message).

Overall, however, insufficient enforcement has been cited as an important reason for lack of MPA effectiveness (Agardy, Notarbartolo di Sciara and Christie, 2011; Edgar et al., 2014). In 15 MPAs in Italy, for example, only 3 were identified as having high levels of enforcement (Guidetti et al., 2008). Sufficient budgeting of resources for surveillance and enforcement is an important element of this (Agardy, Notarbartolo di Sciara and Christie, 2011). The emergence of new technical options to ensure the surveillance and enforcement of remote maritime areas (Brooke, Lim and Ardron, 2010; Game et al., 2009) can help to enhance effectiveness and reduce the costs. Recent initiatives to use satellite data (e.g. in the Galapagos), massive data processing and advanced software to detect illegal behaviour of shipping vessels may play a big role in boosting enforcement. Examples include initiatives such as the Global Fishing Watch by Oceana with Google, and Project Eyes on the Sea by the Pew Charitable Trusts in co-operation with the UK Satellite Catapult Centre.

Marine protected area governance

The importance of effective governance has also been increasingly recognised. While several definitions of governance exist, the term here is used to refer to the range of political, institutional and administrative rules, practices and processes (formal and informal) through which decisions are taken and implemented, stakeholders can articulate their interests and have their concerns considered, and decision makers are held accountable for MPA management (OECD, 2015). Key principles relevant for governance include stakeholder engagement, integrity and transparency, clear roles and responsibilities, and policy coherence.[23] Ensuring adequate conflict-resolution mechanisms is also an important component of this.[24]

The benefits of stakeholder engagement and collaboration include: greater understanding, and thus also public support and commitment, increased transparency and accountability, better informed decision making, and improved public/private sector relationships.[25] Potential issues with stakeholder involvement may include delays in decision making, increased expenses, tension among stakeholder groups and lack of consensus (NOAA, 2004).

Stakeholder engagement can be undertaken in various ways, depending also on the type of overarching governance approach that has been taken for the MPA. Looking across 20 MPAs, Jones et al. (2014) compared and classified the governance approaches into five categories (Table 3.2). The various strengths and weaknesses identified with these different approaches are also summarised in the table, many of which also relate to how stakeholders are engaged.

Christie and White (2006) point out that, as a starting point, it is critical that MPA designers recognise that effective MPA governance is heavily influenced by the particular socio-political, historical and socio-economic context of a site. Overall, however, some combination of top-down and bottom-up governance approaches is likely to be more effective than single approaches (De Santo et al., 2013).

Even in more centralised MPA governance frameworks, there are a number of way to engage with local stakeholders, including workshops and consultations, websites with transparent information, and soliciting views on draft proposals, among others. Challenges in effectively engaging stakeholders remain, especially in times of, for example, budget constraints, as discussed in De Santo (2016). An example of how local communities are able to engage in the management of the Great Barrier Reef Marine Park is provided in Box 3.4.

Establishing clear roles and responsibilities, for example with respect to an MPA management board, or between national and local agencies involved in MPA management, is also important (Christie and White, 2006). In France, for example, the Marine Protected Areas Agency was created by the law of 2006 and is tasked with the following responsibilities: 1) supporting public policies for the creation and management of MPAs in the entirety of French maritime waters; 2) running the French MPA network; 3) technical and financial support of natural marine parks; and 4) presence on an international level. Currently placed under the governance of the Ministry of Ecology, Sustainable Development and Energy, the French Marine Protected Areas Agency is to be integrated into the French Agency for Biodiversity as of 2017.

Table 3.2. **Strengths and weaknesses of different marine protected area governance approaches**

Marine protected area (MPA) governance approach	Strengths	Weaknesses
1. Managed primarily by the government under a clear legal framework	Can more easily harness benefits of efficiency and scientific grounding	Unequal balance of power with respect to local users
2. Managed by the government with significant decentralisation and/or influences from private organisations (or co-management)	Potentially the best of both models – engaging resource users and government officials in an equitable and transparent planning process that is formally recognised and sanctioned	Risk of lack of responsiveness in decision making; and delays due to greater number of stakeholders
3. Managed primarily by local communities under collective management arrangements	Tends to engage resource users more directly; leads to a sense of trust, collaboration and ownership among participants. Responsive to local conditions that users know intimately	Lack of scalability of bottom-up management to address large-scale processes affecting coastal environments and communities (including climate change, overfishing and pollution)
4. MPAs managed primarily by the private sector and/or non-governmental organisations granted with property/management rights		Private management may struggle to compete with the "subsidised management" of other MPAs that benefit from grants; possibility of vested interests capturing the public interest Funding horizons and non-governmental organisations' planning timelines are generally not long term
5. No clearly recognisable effective governance framework in place.	x	x

Source: Christie, P. and A.T. White (2006), "Best practices in governance and enforcement of MPAs"; Jones, P., W. Qui and E. De Santo (2013), "Governing marine protected areas: Social-ecological resilience through institutional diversity", https://doi.org/10.1016/j.marpol.2012.12.026.

Box 3.4. Local marine advisory committees and the Great Barrier Reef Marine Park Authority

The Great Barrier Reef Marine Park Authority is advised on management issues about the Marine Park at a local level by voluntary community-based committees called local marine advisory committees.

Established in 1999, the local marine advisory committees enable local communities to have effective input into managing the Great Barrier Reef Marine Park and provide a community forum for interest groups, government and the community to discuss issues around marine resources.

The purpose of the local marine advisory committees is to:

- improve the involvement and support of local communities in managing the ecologically, socially and economically sustainable use, and the conservation of the Great Barrier Reef World Heritage Area (hereafter "World Heritage Area")
- advise the Marine Park Authority and other World Heritage Area agencies on issues and policies relating to specific activities, conservation, environment, public information and public education concerning their local catchment, marine and coastal region
- facilitate communication between user groups in the local community
- promote the exchange of information and raise awareness of issues impacting on the Great Barrier Reef ecosystem.

Source: www.gbrmpa.gov.au/about-us/local-marine-advisory-committees.

Strong scientific guidance is yet another component that contributes to effective MPAs, hence there should also be clearly defined roles for scientists, including environmental economists.

With regard to policy coherence, marine spatial planning (MSP), which is a plan-led framework that enables integrated, forward-looking, consistent decision making on the use of the sea, and has a much broader remit that MPAs, can help to ensure that policies across different sectors are better aligned. MSP can also provide a more transparent process of conflict resolution in a situation where there are many demands for the use of marine resources and sea space. Whatever the building blocks, the essential consideration is that MSP must work across sectors and give a geographic context in which to make decisions about the use of resources, development and the management of activities in the marine environment (Gubbay, 2004) (see Chapter 5 for further discussion on policy mixes).

Looking beyond MPA governance, Garcia, Rice and Charles (2014) have examined the interaction and co-evolution of the governance of marine fisheries and biodiversity conservation. They conclude that there are limits to how much the two governance streams can merge due to value perspectives on what is the right outcome. It suggests that a third governance stream – a multi-sectoral governance stream – might be a way to deal with the multifaceted interests of marine usage and its many challenges (Kjellrun, 2015). Domestic institutional frameworks that facilitate continuous interaction among the various stakeholders may help to bridge this gap. In Canada, for example, responsibility for fisheries and oceans (including MPAs) lie primarily under Fisheries and Oceans Canada under the Fisheries Act and the Oceans Act. However, a number of legislative and policy tools are available to other federal departments and agencies – Parks Canada and Environment and Climate Change Canada – for the purpose of establishing and managing MPAs and which collaborate with the Department of Fisheries and Oceans on these issues.

In this context, the establishment of inter-ministerial commissions may also be useful, providing a multi-stakeholder platform to assess and evaluate whether national and sectoral policies and strategies are coherent. A Multi-sectoral Commission for Environmental Management of Coastal Marine Environment exists in Peru, for example, with a similar commission in Brazil and Ecuador. In France, besides the Ministry of Ecology, Sustainable Development and Energy and the Ministry of Food, Agriculture and Fisheries, several other ministries are involved in the management of the marine area, i.e. the Ministry of Economy and Finance, the Ministry of Foreign Affairs, the Ministry of the Interior, the Ministry of Defence, and the Ministry of Justice. The Secrétariat Général de la Mer provides for the co-ordination between the different ministries and the Comité Interministériel de la Mer is responsible for deliberating on government policy in the area of the sea in its various national and international aspects and to set guidelines for government action in all areas of maritime activities, including the use of space, environmental protection, sustainable management of marine resources, its soil, its subsoil and the coastline. The committee brings together the ministers of: Economy and Finance, Foreign Affairs, Defence, Industry, Environment, those responsible for overseas territories, Budget, Equipment and Transport, Fisheries, Tourism, Planning, Research and if necessary other members of the government. It is a non-permanent structure which meets at least once a year to make the appropriate decisions at inter-ministerial level.[26]

Notes

1. Such approaches provide flexibility in finding MPA or network configurations that can meet conservation objectives while minimising costs on economic users.

2. This is the approach taken in most countries (e.g. the European Union, Lebanon), and is the criteria specified in Convention on Biological Diversity Aichi Target 11 for marine protected areas.

3. In situations where the benefits of establishing an MPA and the risks are equivalent, and if finance is limited, one would ideally prioritise those sites with the lowest opportunity cost first.

4. www.gov.uk/government/collections/marine-conservation-zone-designations-in-england.

5. From Bryant et al. (1998).

6. More specifically, the authors defined key areas for conservation based on species richness (9 areas) and irreplaceability (i.e. presence of endemic species; 11 areas). With these two criteria all known species, including endemic and threatened ones, are represented in the key conservation areas. This is because the number of marine mammals is relatively low and species richness includes most threatened species and some endemic species; the missing endemic species were represented in the irreplaceable sites. Their analyses also showed that species richness was correlated with human threats (e.g fishing), hence key conservation areas defined by species richness also reflected human threats (personal communication, 18 August 2016).

7. They find that there are large extents of heavily impacted ocean in the North Sea, the South and East China Seas, and the Bering Sea. Much of the coastal area of Europe, North America, the Caribbean, China and Southeast Asia are also heavily impacted. The least impacted areas are largely near the poles, but also appear along the north coast of Australia, and small, scattered locations along the coasts of South America, Africa, Indonesia and in the tropical Pacific.

8. For a description of the Marxan conservation planning software, examples of its applications in the United Kingdom, and good practice insights on using Marxan, see e.g. Smith et al. (2009) and Ardron, Possingham and Klein (2010). For a description of MarZone, see Watts et al. (2009).

9. www.naturalcapitalproject.org/pubs/marine/MarineInVEST_Apr2010.pdf.

10. www.protectplanetocean.org/collections/introduction/introbox/globalmpas/introduction-item.html.

11. If the effort that operated in areas to be closed is to be bought out, information on how profitable areas are (i.e. net revenues) would be better than gross revenue, as with the latter there is a risk of overcompensating the industry. While this might be deemed necessary from a political perspective, it should be at least noted that it might then mean more has to be spent to establish the MPA or a smaller MPA is established instead (for a given budget). If there is no intention to buy out effort but fishers are going to be compensated for the opportunity cost, it would be preferable to have an idea of how fishing effort is expected to redistribute and what this then means for profitability. This can be important if a closure might mean that in order to access fishing grounds a vessel has to travel substantially further than before – and incurs greater costs than previously (some anecdotal evidence of this in the Great Barrier Reef). Conversely, if all the vessels end up being able to easily redistribute and don't result in excessive fishing pressure elsewhere, the cost might be lower than GVP would indicate. The extent of any difference between the alternative approaches will all be case-specific and depend on the habitat, the species and the size of the fishery. If there is unlikely to be much difference then it may not be worth the cost of undertaking the analysis (J. Innes, personal communication, 25 August 2016).

12. www.galapagospark.org/documentos/DPNG_linea_base_rmg.pdf.

13. https://cdfwmarine.wordpress.com/2015/02/04/south-coast-mpa-baseline-monitoring.

14. A primary product of the MPA-MEI is a guidebook designed to provide step-by-step guidance to managers and other practitioners in: 1) selecting the relevant biophysical, socio-economic and governance indicators for the evaluation of a particular MPA; 2) developing a process for planning for and implementing this evaluation; and 3) using the results generated to inform and adaptively manage the MPA.

15. http://ec.europa.eu/environment/integration/research/newsalert/pdf/impasea_a_new_framework_to_assess_marine_protected_areas_437na3_en.pdf. See also Rodríguez-Rodríguez et al. (2015). The study uses geo-statistical analysis, multiple-paired-before-after-control-impact design, to evaluate the efficacy of the MPA.

16. **Error! Hyperlink reference not valid.**http://picrc.org/picrcpage/wp-content/uploads/2016/01/Monitoring_Protocol.pdf.

17. **Error! Hyperlink reference not valid.**http://marineprotectedareas.noaa.gov/nationalsystem/framework/final-mpa-framework-0315.pdf.

18. The majority of the indicators were developed by the International Union for Conservation of Nature's (IUCN) World Commission on Protected

Areas (WCPA) and the World Wide Fund for Nature (WWF) in a joint initiative aimed at improving the management of MPAs (Pomeroy, Parks and Watson, 2004; Ehler et al., 2002).

19. www.medpan.org/en/mediterranean-mpa-status, www.helcom.fi/action-areas/marine-protected-areas/database/

20. http://marineprotectedareas.noaa.gov/dataanalysis/mpainventory.

21. See the HELCOM Monitoring and Assessment Strategy at: www.helcom.fi/Documents/Action%20areas/Monitoring%20and%20assessment/Monitoring%20and%20assessment%20strategy/Monitoring%20and%20assessment%20strategy.pdf.

22. http://database.mpasupportnetwork.org.

23. Some of these are interlinked. For example, stakeholder engagement helps to ensure transparency. Policy coherence also relates to effective policy mixes, which is discussed in Chapter 5.

24. The Lisbon Principles for the Sustainable Governance of the Oceans are broader than this, but in effect encompass issues addressed in other sections of this report. The Lisbon Principles are (Costanza et al, 1998): Principle 1: Responsibility. Access to environmental resources carries attendant responsibilities to use them in an ecologically sustainable, economically efficient, and socially fair manner. Individual and corporate responsibilities and incentives should be aligned with each other and with broad social and ecological goals. Principle 2: Scale-matching. Ecological problems are rarely confined to a single scale. Decision-making on environmental resources should: (i) be assigned to institutional levels that maximize ecological input, (ii) ensure the flow of ecological information between institutional levels, (iii) take ownership and actors into account, and (iv) internalise costs and benefits. Appropriate scales of governance will be those that have the most relevant information, can respond quickly and efficiently, and are able to integrate across scale boundaries. Principle 3: Precaution. In the face of uncertainty about potentially irreversible environmental impacts, decisions concerning their use should err on the side of caution. The burden of proof should shift to those whose activities potentially damage the environment. Principle 4: Adaptive management. Given that some level of uncertainty always exists in environmental resource management, decision-makers should continuously gather and integrate appropriate ecological, social, and economic information with the goal of adaptive improvement. Principle 5: Full cost allocation. All of the internal and external costs and benefits, including social and ecological, of alternative decisions concerning the use of environmental resources should be identified and allocated. When appropriate, markets should be adjusted to reflect full costs. Principle 6: Participation. All stakeholders should be engaged in the formulation and implementation of

decisions concerning environmental resources. Full stakeholder awareness and participation contributes to credible, accepted rules that identify and assign the corresponding responsibilities appropriately.

25. www.car-spaw-rac.org/IMG/pdf/MPA_Stakeholder_Engagement_Brief.pdf.

26. http://ec.europa.eu/maritimeaffairs/documentation/studies/documents/france_01_en.pdf.

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Annex 3.A1.
Goals of different marine protected areas

Table 3.A1.1 **Goals of different marine protected areas**

Marine protected area	Goals	References
Aching Reef Flat Preserve (Guam)	To protect nursery area for juvenile animals located in mangroves and seagrass beds	Pomeroy, Parks and Watson (2004)
Baltic Sea Protected Areas	To protect the environment from human perturbations	Helcom (2008)
Banc D'Arguin National Park (Mauritania)	To protect seagrass beds and mudflats that act as nursery and rearing grounds for numerous species	Pomeroy, Parks and Watson (2004)
Bancho Chinchorro Bioshpere Preserve (Mexico)	To protect the country's largest reef formation	Pomeroy, Parks and Watson (2004)
Bird Island (Commonwealth of the Northern Mariana Islands)	To protect coral reefs, dive sites and caves, and seabird nest colonies	Pomeroy, Parks and Watson (2004)
Bunaken National Park (Indonesia)	To protect coral communities, diversity, abundance, essential habitat, seaturtle and dugong populations	Pomeroy, Parks and Watson (2004)
Cebu Island (Philippines)	To sustain fisheries, maintain diverse coral habitat and to ensure intact food chain	Laffoley, Gjerde and Wood (2008)
Channel Islands MPAs (United States)	Address biodiversity, socio-economic well-being, fisheries, natural and cultural features, and public education	Davis and Lopez (2004)
EU Marine Strategy Framework	To achieve "good ecological status" of waters	
Far Eastern Federal Marine Preserve (Russian Federation)	To protect coastal marine islands and over 2 700 species	Pomeroy, Parks and Watson (2004)
Florida's Aquatic Preserves System (United States)	To protect Florida's coastal resources by using education, resource management, research, monitoring and partnerships	Davis and Lopez (2004)
Galapagos Island Marine Reserve (Ecuador)	To reduce conflicts between uses, principally tourism, fishing and scientific research; protect marine biodiversity; and promote sustainable uses	Castrejon and Charles (2013)
Great Barrier Reef (Australia)	To protect and restore the reef's biodiversity; to safeguard the reef's heritage values; to ensure use of the region is ecologically sustainable and the socio-economic benefits derived from the reef are maintained	GBRMA (n.d.)
Hol Chan Marine Reserve (Belize)	To protect unique channel formations, fish resources and habitat	Pomeroy, Parks and Watson (2004)
Kimbe Bay Marine Protected Area (Papua New Guinea)	To conserve marine biodiversity and natural resources and to address local marine resource management needs	Laffoley, Gjerde and Wood (2008)
Lenger Island Marine Protected Area (Micronesia)	To protect spawning and aggregation sites, a turtle hatchery, diverse species, and a World War II base	Pomeroy, Parks and Watson (2004)

Table 3.A1.1 **Goals of different marine protected areas** (*continued*)

Marine protected area	Goals	References
Loreto Bay National Park (Mexico)	To protect diversity of species	Pomeroy, Parks and Watson (2004)
Mafia Island Marine Park (Tanzania)	To protect diverse species, habitat and species aggregations	Pomeroy, Parks and Watson (2004)
Mediterranean Marine Mammals Sanctuary	To conserve marine mammals and habitat from negative impacts	Scovazzi (2004)
Michigan's Underwater Preserves System (United States)	To protect and preserve shipwrecks and stimulate local economy through tourism	Davis and Lopez (2004)
Miramare Marine Protected Area (Italy)	To promote education and research about reproductive biology of species and water quality	Pomeroy, Parks and Watson (2004)
Ngemelis (Palau)	To protect a diverse habitat	Pomeroy, Parks and Watson (2004)
North Carolina's Primary and Secondary Nursery Areas (United States)	To protect nursery areas that support juvenile seafood species	Davis and Lopez (2004)
Oregon's Natural and Conservation Management Units (United States)	To protect essential habitats and preserve natural resources in dynamic habitats	Davis and Lopez (2004)
Palau Protected Areas Network (Micronesia)	To protect biodiversity, important habitats and vulnerable resources essential to stability	Laffoley, Gjerde and Wood (2008)
Piti Bomb Holes Preserve (Guam)	To protect habitat for marine mammals	Pomeroy, Parks and Watson (2004)
Saguency-St. Lawrence Marine Preserve (Canada)	To protect feeding grounds for numerous protected species	Pomeroy, Parks and Watson (2004)
Sasanhaya Fish Reserve (Commonwealth of the Northern Mariana Islands)	To protect coral features, dive sites and World War II wrecks	Pomeroy, Parks and Watson (2004)
Sian Ka'an Biosphere Reserve (Mexico)	To protect coral habitats	Pomeroy, Parks and Watson (2004)
Tubbataha Reef National Marine Preserve (Philippines)	To protect nesting sites and pristine reef habitat	Pomeroy, Parks and Watson (2004)
Upper Gulf of California and Colorado River Delta Biosphere Reserve (Mexico)	To protect marine and coastal habitats, dunes, and deserts	Pomeroy, Parks and Watson (2004)
Washington's Aquatic Reserves (United States)	To conserve and enhance aquatic resources, enhance biodiversity, foster stakeholder representation, and increase educational and research opportunities	Davis and Lopez (2004)
Network of Marine Protected Areas on the Pacific Coast of Canada	To protect and maintain marine biodiversity, ecological representation and special natural features; to contribute to the conservation and protection of fishery resources and their habitats; to maintain and facilitate opportunities for tourism and recreation; to contribute to social, community and economic certainty and stability; to conserve and protect traditional use, cultural heritage and archaeological resources; to provide opportunities for scientific research, education and awareness	www.dfo-mpo.gc.ca/oceans/publications/mpabc-cbzpm/page05-eng.html

Source: Adapted from Boeker, C. (2012), "Marine protected areas in the 21st century: Breakthrough or static?", http://fw.oregonstate.edu/system/files/u3034/CapstoneProject_Boeker.doc.

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Chapter 4.

Sustainable financing of marine protected areas

A frequently cited challenge for more effective management of marine protected areas (MPAs) has been their inability to secure sufficient and sustainable financing. This chapter examines the various financing instruments and approaches that are available, ranging from traditional government budget and donor funding to user fees, taxes and fines, and payments for ecosystem services, among others. The chapter concludes with a discussion on the need to develop finance strategies for MPAs, drawing on examples from different countries.

While the number and coverage of marine protected areas (MPAs) has increased over the last few decades, a frequently cited challenge has been their inability to secure sufficient and sustainable financing. This significantly undermines their ability to achieve their management objectives and MPAs have therefore sometimes been described as "paper parks" (Gelcich et al., 2013; Thur, 2010).[1] For an MPA to be effective, it is important to understand the financing needs associated with their design and implementation (see discussion in Chapter 2 on the costs of MPAs), to identify the possible sources of finance that may be available to support the MPA, and consequently to develop sustainable financing strategies that will be able to mobilise sufficient resources in both the short and longer term.

Financing instruments and approaches

Domestic government budgets and international donor assistance have formed the bulk of protected area financing worldwide (Emerton, Bishop and Thomas, 2006). This holds true when looking only at MPAs as well (Table 4.1). Other sources of finance include user fees, fines, debt swaps, biodiversity prospecting, trust funds and donations. More novel financing sources either underway or being explored include marine payments for ecosystem services (PES), marine biodiversity offsets and blue carbon finance. Each of these is discussed below.

Government budgets

National government funding tends to be the primary source of finance for MPAs in developed countries. In developing countries, government funding also plays a major, albeit perhaps smaller, role, as governments often have more pressing priorities (Thur, 2010). Government budget allocations for MPAs are, however, often insufficient to cover total costs. A 2012 report to the Auditor General of Canada, for example, stated that budget cuts and "insufficient resources" impede Canada's ability to meet its MPA targets (OAGC, 2012). In Australia, in 2002 the Great Barrier Reef Marine Park Authority estimated that actual management costs were approximately twice the budget (Ban et al., 2011). Similarly, the US Papahanamokukea Marine National Monument Management Plan provided funding estimates for desired outcomes, but noted that these estimates are "sometimes substantially above current budget allocations" (Papahanamokukea, 2008). Sabah Parks in Malaysia received 80% (4.2 million Malaysian ringgits) of its funding from the state government to manage four marine parks (Table 4.1), but still reported a 13% (740 000 ringgit) gap between revenues and expenditures in 2009 and a predicted shortfall of 10 million ringgits over the following five years[2] (PE Research, 2010). In the Caribbean, most governments are subject to chronic budgetary shortfalls,[3] and the most financially secure MPAs do not primarily depend on government grants (Reid-Grant and Bhat, 2009).

Table 4.1. **Financing of marine protected areas: Selected examples**

Marine protected area	Financing sources
Mariana Trench, United States McCrea-Strub et al. (2011)	Government allocations (91%) National non-governmental organisation (NGO) donors (6%) Local NGO donors (3%)
Papahanaumokuakea, United States McCrea-Strub et al. (2011)	Government allocations (95%) National NGO donors (4%) Local NGO donors (1%)
California MPA network, United States (establishment) Gleason et al. (2013)	NGO donors (51%) State government allocations (49%) Over a seven-year process. Does not include staff or in-kind contributions.
4 MPAs, Mexico González-Montagut (2003)	National Commission of Protected Areas (55%) Other public and international sources, civil society, academia, private industry (24%) Protected Areas Fund (12%) European Commission (5%) Entrance fees (3%)
Seaflower, Colombia McCrea-Strub et al. (2011)	Multilateral donors (33%) Regional government allocations (19%) International NGO donors (11%) National voluntary donations (6%) National NGO donors (2%) Bilateral government donations (1%) Government allocations (1%) Local voluntary donations (26%) Local NGO donors (< 1%)
Saba, Netherlands Antilles (establishment) McCrea-Strub et al. (2011)	Government allocations (69%) National NGO donors (21%)
Saba, Netherlands Antilles (operating) Morris (2002)	Entry fees (50%) Souvenir sales (32%) Local voluntary donations, etc. (17%)
Menai Bay, Tanzania Lindhejm (2003)	NGO donors (90%) Government allocations (10%)
Misali, Tanzania Lindhejm (2003)	International donors (NGOs, foreign development agencies, etc.) (84%) Entry fees (15%) Government allocations (1%)
Chumbe Island, Tanzania (establishment) McCrea-Strub et al. (2011)	Private investment (49%) Bilateral government (26%) Bilateral voluntary donations (24%) Multilateral donors (< 1%) International NGO donors (< 1%)
Chumbe Island, Tanzania (operating) Lindhejm (2003)	Tourism entrance fees (90%) International donors (10%)

Table 4.1. **Financing of marine protected areas: Selected examples** (*continued*)

Marine protected area	Financing sources
Mnemba, Tanzania Lindhejm (2003)	Entry fees (85%) Government allocations (15%)
Jozani Chwaka, Tanzania Lindhejm (2003)	International donors (Global Environment Facility, foreign agencies, NGOs) (70%) Entry fees (25%) Government allocations (5%)
Nha Trang Bay, Viet Nam McCrea-Strub et al. (2011)	International donors (52%) Bilateral government donations (38%) Government allocations (6%) Local voluntary donations, etc. (5%)
4 MPAs, Sabah, Malaysia PE Research (2010)	Government allocations (80%) International donors (11%) Fees and charges (8%) Fines (< 2%, no data)
Sugud Islands (SIMCA), Malaysia PE Research (2010)	NGO donors (46%) Entry fees (30%) Concessions (25%)
Pilar, Philippines Butardo-Toribio, Alino and Guiang (2009)	Municipality (59%) Outside grants (37%) Barangay (2%) Community (1%) MPA collections (1%)
Villahermosa, Philippines Butardo-Toribio, Alino and Guiang (2009)	Community (30%) Outside grants (28%) Barangay (27%) Municipality (8%) NGA (Bureau of Agriculture and Fisheries Resources, etc.) (4%) Province (2%) MPA collections (1%)
Bibilik, Philippines Butardo-Toribio, Alino and Guiang (2009)	Municipality (46%) Outside grants (44%) Barangay (5%) Province (3%) NGA (Department of Natural Resources, Coast Guard, etc.) (2%)
Tambunan, Philippines Butardo-Toribio, Alino and Guiang (2009)	Municipality (59%) Outside grants (37%) NGA (Department of Natural Resources, Coast Guard, etc.) (2%) Barangay (1%)
Talisay, Philippines Butardo-Toribio, Alino and Guiang (2009)	Outside grants (59%) Community (36%) Municipality (4%) Barangay (2%)
MISTTA, Philippines Butardo-Toribio, Alino and Guiang (2009)	Municipality (59%) Outside grants (30%) Barangay (8%) NGA (3%)

Table 4.1. **Financing of marine protected areas: Selected examples** (*continued*)

Marine protected area	Financing sources
Port-Cros National Park, France	Government allocations (72.5%) Donations and philanthropy (2.3% Fiscal revenues (Barnier tax[1]) (4%) Self-financing (service delivery sales) (21%)

Note: 1. This tax, created in 1995 ("Barnier Law"), applies to maritime transport passengers when they purchase a ticket to travel across the national park. The tax amounts to 7% of a "one-way" ticket price before tax and cannot amount to more than EUR 1.57. The tax is currently being collected in Port-Cros and Calanques National Parks. For practical reasons, its implementation has been delayed in the Guadeloupe National Park.

Conservation budgets in both developing and developed countries have tended to stagnate or decrease in recent years, especially when the government is under strain (Emerton, Bishop and Thomas, 2006; Thur, 2010; Hunt, 2013). Given the public good characteristics associated with many marine ecosystem service benefits, national government funding should continue to be an important contributor to MPA budgets in both developed and developing countries. Valuation studies and cost-benefit analysis should help to make the case to Ministries of Finance that greater investment in MPAs is needed. However, broader finance portfolios for MPAs should be developed, including revenue-generating instruments that are based on the polluter-pays approach.

Donor funding

Many MPAs in developing countries rely on bilateral and multilateral development assistance for financial support, including from national foreign aid agencies, multilateral banks and agencies such as the Global Environment Facility (GEF) and the World Bank. Additional funding can come from private donors, philanthropic foundations, non-governmental organisations (NGOs) and communities. Donor funding is normally part of a wider portfolio of finance, and tends to support establishment costs, training and other forms of capacity building necessary to set up an MPA, as well as to put frameworks in place for them to become financially self-sufficient. Donor funding is generally not intended to support ongoing, long-term expenses of MPAs (Emerton, Bishop and Thomas, 2006; Erdmann et al., 2003; McClanahan, 1999).

The GEF, for example, contributes about USD 100 million annually to the protection of marine ecosystems (Reid-Grant and Bhat, 2009) and has supported more than 1 000 MPAs worldwide. In Samoa, for example, a GEF grant was used to establish a sequence of multiple district-level MPAs. Revenues from charges and fines were used post-grant to seed a trust fund (WWF, 2005). Funding such as that by the GEF is clearly limited, however, (donors pledged USD 1.3 billion towards the biodiversity focal area for the GEF-6 replenishment period) and for protected areas is targeted to those areas that are globally significant, based on vulnerability and irreplaceability criterion (GEF, 2014). Philanthropic foundations have also engaged in MPAs, such as Pew's Global Oceans Legacy, including partners such as Bloomberg and the Lyda Hill Foundation.

Trust funds and debt-for-nature swaps

Several MPAs have established trust funds to help ensure a more long-term sustainable, source of finance. Three types of trust funds exist: endowment funds, which maintain a capital base while paying only interest; sinking funds, which use both capital and interest and are thus eventually extinguished; and revolving funds, which are designed to be continuously replenished.

In Belize, a Protected Area Conservation Trust (PACT) was established in 1996, funded principally via a conservation fee on visitors to Belize upon departure and a 20% commission from cruise ship passengers (Drumm et al., 2011). In Mexico, a remnant worth USD 16.5 million from a USD 25 million GEF grant was used to capitalise a Protected Areas Endowment Fund in 1997. This grew to USD 42 million in 2003 following several donations. Interest from the fund, along with federal allocations, entrance fees and an EU grant, was channelled annually to various protected areas, including four marine parks (González-Montagut, 2003). In Mauritania, an endowment fund BACOMAB was established in 2009 to finance the conservation of the Banc d'Arguin and other Mauritanian coastal and marine protected areas. Its capital will be invested for perpetuity on capital markets and only the interest will be used to finance marine and coastal protected areas. The Mauritanian government made an initial contribution to BACOMAB during 2010-11 by mobilising EUR 1.5 million of revenues from the fisheries agreement with the European Union. French Development Agency and French Facility for Global Environment have contributed an additional EUR 2.5 million and EUR 1 million respectively. BACOMAB's funding objective was to reach EUR 35 million by 2016. Other funding sources to be explored include:

- Contributions from the oil and gas sectors through voluntary compensations or fees attached to concessions.
- Fiscal mechanisms such as a share of fines for fishing infractions or of fishing licences; part of tourism-related taxes; environmental fees or licences for industries with possible impacts on marine ecosystems; or a tax on the use of ecosystem services.

- Carbon finance, in particular related to the sequestration of carbon in marine ecosystems such as seagrass beds in the Banc d'Arguin ("blue carbon") (French Facility for Global Environment, 2013).

The Mesoamerican Barrier Reef (MAR) Fund[4] is an example of a pooled fund, with contributions from Belize, Guatemala, Honduras and Mexico. Its central focus is on 14 MPAs in the Mesoamerican Reef ecoregion, which contains the largest barrier reef system in the western Atlantic.

In Kiribati, the government's approach to ensuring the long-term financing of the Phoenix Islands Protected Area (PIPA) is based on the purchase of "reverse fishing licenses" by charitable donors. The goal is to capitalise an endowment fund, at a level that would generate an income stream sufficient to cover the operating and management costs of the trust, and the foregone revenues from fishing associated with the closure or restriction of activities within the PIPA region in Kiribati. The funding target was USD 25 million, with an interim target of USD 13.5 million by 2014, based on 25% of the PIPA area under a no-take-zone. The protected area also receives the support of the "PAS: Phoenix Islands Protected Area (PIPA)" project (GEF: USD 870 200, co-finance: USD 1.7 million) implemented by the United Nations Environment Programme. An endowment fund is also being developed for the Bird's Head Seascape in West Papua.

A Global Conservation Fund (GCF) was also established in 2001 in which about USD 13 million (of a total of USD 65 million) has been invested in important marine regions (Bonham et al., 2014). The GCF was made possible by a grant from the Gordon and Betty Moore Foundation and has leveraged more than USD 200 million.

Debt-for-nature swaps entail the reallocation of a developing country's funds from repayment of debts to natural resource protection. Debt swaps and trust funds have often been used in conjunction. The US government funded the purchase of USD 19 million of Philippine debt in 1992, of which USD 17 million was used to set up the Foundation for the Philippine Environment endowment fund (ADB, 2011). NGOs have also been active in this field. In 2015, The Nature Conservancy (TNC) brokered a USD 31 million swap between the Seychelles, its Paris Club creditors and South Africa to finance marine conservation and climate adaptation, capitalise an endowment fund and repay impact investors over a 20-year timeframe. The marine conservation component includes the creation and management of over 400 000 km^2 of new MPAs (TNC, 2015). Similarly, Jamaica was able to create a trust fund for its national parks through a direct swap with TNC, although the interest is not sufficient for all of its protected areas (Reid-Grant and Bhat, 2009).

User fees

User fees are collected from resource users, including tourists, who chose to access a service or facility. These types of fees are already being applied in a number of MPAs worldwide (Table 4.2) and are set at various levels depending on their purpose (e.g. cost recovery vs. visitor management to reduce congestion and/or ecological damage), type (e.g. general entrance fees, diving/snorkeling or research fees) and the prevailing local socio-economic characteristics of the region (e.g. number of visitors, income levels, price elasticity of demand[5]). Though tourism revenues, for example, can also be unreliable due to the inherently volatile nature of the industry, which fluctuates with the state of the global economy, natural disasters, political turmoil and other considerations (Erdmann et al., 2003; PE Research, 2010), revenues can be sizable.

Indeed, some MPAs have been mostly or entirely financed via user fees. Malaysia’s Kota Kinabalu National Park, for example, raises approximately 80% of its operating expenses from user fees (ADB, 2011). The Bonaire Marine Park in the Netherlands Antilles had, as of 2010, self-financed all operations since 1992 through dive entrance fees, boat entrance fees and mooring fees (Forest Trends, 2010; Thur, 2010). A 2005 raise in Bonaire’s annual fees to USD 25 and USD 10 for divers and non-divers, respectively, created a revenue stream conservatively estimated at USD 760 000, far higher than the 2002 operating budget of USD 270 000. The surplus was used for the nearby Washington-Slagbaai terrestrial park, which also provides upstream ecological benefits to the marine park (Thur, 2010). In the Philippines, the Gilotongan Marine Reserve appeared to meet all of its funding needs through tourism fees, in fact realising a profit on the order of USD 85 000 in 2012 (MSR, 2012).[6]

Scope may thus exist for wider application of user fees into MPA finance portfolios, though they must be well designed. One challenge cited for expanding the scope of user fees to other marine parks is that there are not always easily defined entry points at which to charge the fee. At the Bunaken Marine Park, a dual fee/ticket system was used which worked effectively in an open access MPA that has no single entry point. The fee is charged per person for an annual waterproof tag. Tags are individually numbered to prevent illegal resale and data from the receipts are entered into a database to help prevent corruption and to gather tourist statistics.

Social acceptability of a fee has been another issue, as there can be a perception that everyone should have access to natural areas free of charge. Visitors generally accept the imposition of entry fees if they are made aware that revenues are intended for MPA management. Raising awareness and ensuring transparency are therefore important (IUCN, 2004; ADB, 2011).

Users should be consulted to determine the level of fee they are willing to pay, sufficient user numbers must exist (ADB, 2011), and the fee should be targeted at the correct tier of visitor, e.g. international vs. domestic tourists, as the former may have a higher ability and willingness to pay. Many MPAs charge domestic residents reduced fees, or no fees at all, including Belize (Hol Chan and Half Moon Caye), Ecuador (Galápagos), Egypt (Ras Mohammed), Kenya, Netherlands Antilles (Saba), Philippines (Tubbataha and Gilutungan), Tanzania, Thailand and the United States (Hanauma Bay).

Revenues that are retained at park level are more effective at generating funding sources. In many cases, revenues collected at MPA sites are largely allocated to central agencies and do not return to the MPA, creating a disincentive for generating new revenues and increasing instability (Emerton and Tessema, 2001; Emerton, Bishop and Thomas, 2006; Reid-Grant and Bhat, 2009). For example, Malindi Marine Park in Kenya could potentially self-generate 20% of its operating costs, but revenue was returned to the Kenya Wildlife Service (IUCN, 2004), and Kisite Marine National Park in Kenya earned revenues from tourism that are more than seven times higher than its operating budget, but still suffered from a lack of sufficient finance as all revenues were centrally retained (Emerton, Bishop and Thomas, 2006). Sabah Parks' four marine parks raised approximately 2.1 million ringgits in 2009 from entrance fees, 39% of total revenues and 35% of total expenditure; however, only 20% was retained at park level, with the rest allocated to the Indonesian government, partly as compensation for security services (PE Research, 2010).

Diving or research fees are generally set higher than regular entrance fees. Divers have paid as much as EUR 120 per day in Mediterranean marine protected areas (Emerton, Bishop and Thomas, 2006). Zanzibar's Misali Island Conservation Area charged staggered entry rates of USD 5 per day for internationals, USD 20 for large boats, USD 200 for filming and USD 50 per week for research (Lindhjem, 2003). Cousin Island Special Reserve in the Seychelles also covered its 2002 operating costs of USD 209 520 through visitor revenue totalling USD 279 860; collected from daily fees of USD 25, USD 300 and USD 450 for foreign tourists, photographers and film crews respectively; and USD 800 per quarter for research crews (WWF, 2005).

Some fee increases have caused divers to move to equivalent sites outside the MPA, resulting in decreased funding to the management authority (IUCN, 2004), while others have caused visitor numbers to increase, as divers seek well-managed areas (van Beukering et al., 2006) (Table 4.2).

For MPAs in Chile, revenues from tourism are not sufficient to finance running costs and enforcement. For example, Lafken Mapu Lahual, one of the largest multiple-use MPAs in continental Chile, could only achieve around 10% of running costs, in the most favorable conditions, under current management scenarios (Gelcich et al., 2013).

Other types of user fees also exist. Where fishing is allowed in MPA boundaries, revenue generated from license fees can be used to fund MPA management activities. In cases where licenses are not accompanied by entry limits, the fees can be set higher to appropriately capture economic rents (ADB, 2011). Berau Marine Conservation Area in Indonesia charges one-year fishing permits ranging from IDR 10 000 to IDR 109 500 for local boats, and USD 54-247 for foreign boats, depending on tonnage and the type of boat; other taxes from the fisheries sector amounted to IDR 112 million in 2006 (MSR, 2010). In Israel, for example, a marine environmental protection fee is levied on ships calling at Israeli ports and oil unloading platforms. This fee varies according to the size of the ship and the amount of oil, with the revenues going to the Marine Pollution Prevention Fund (OECD, 2011).

Table 4.2. **Examples of marine protected area user fees**

Site	Fee	Notes	Reduced visitation
State marine protected areas, Australia	USD 2/day, max USD 6	Opposition by tourism industry due to lack of notification	Yes, at local use sites in Tasmania
Abrolhos & Fernando de Noronha, Brazil	USD 4.25/day	Retained by environmental agency; 50% to parks	No
Ras Mohammed, Egypt	USD 5 (foreigners) USD 1.20 (locals)		No
Red Sea, Egypt	USD 2/day (diving, snorkelling)	Initial fee USD 5, lobbying reduced to USD 2	Yes, caused shift to nearby non-fee areas
Bunaken, Indonesia	USD 0.20/day (locals) USD 5/day (foreigners) USD 17/year (foreigners)	80% park, 10% each local/national governments	No
Koror State, Palau	USD 15/fortnight (diving)	Raises USD 1million/year, enough for all costs	
Soufriere, St. Lucia	USD 4/day, USD 12/year (diving) USD 1/day (snorkelling)	Support has increased	No, numbers increased

Source: Adapted from Van Beukering, P. et al. (2006), "The economic value of the coral reefs of Saipan, Commonwealth of the Northern Mariana Islands".

Mooring buoy fees are another potential source of revenue (WWF, 2005). Reid-Grant and Bhat (2009) suggest that the Montego Bay Marine Park in Jamaica could realise significant savings by passing through the costs of deployment and maintenance of mooring buoys to hoteliers and other individuals that use the buoys.

Taxes and fines

Taxes and fines are another means of raising finance for MPAs. Taxes have been defined as compulsory unrequited payments to general government[7] (OECD, 2009), though revenues from taxes can also be earmarked. Belize, for example, charges all departing visitors a USD 3.75 fee and takes a 20% commission on all cruise ship passenger fees, both of which are applied to the Protected Areas Conservation Trust (PACT, 2010). Recreational operations such as cruise ships, tourism and local industries are logical initial targets. In 2001, Switzerland's Hotelplan group established a EUR 3 fee for patrons of their Mediterranean tourism packages to support cetacean and seaturtle conservation projects in the region (Emerton, Bishop and Thomas, 2006), and the US Dingell-Johnson Sport Fish Restoration Program charges excise taxes on a variety of fishing equipment (10% on fishing supplies; 3% on electric outboard motors; and an additional tax on small boat fuel) to fund sport fishery projects throughout the nation (TNC, 2012). Such taxes can also be partially earmarked to MPAs if appropriate. In France, the 1995 Barnier Act has set up a tax on maritime passenger ships that are destined to natural protected areas, and revenue is earmarked for these areas.

In response to declining salmon stocks, Iceland implemented levies on both rod and commercial salmon fishing licenses in 2006. Revenue (USD 16.6 million in 2008) is invested in wild salmon management programmes for stock and habitat improvement (WWF, 2009). In Alaska, salmon fishermen in some areas have voted to institute a 2% or 3% tax on themselves through the state budget to fund stock enhancement programmes. Proceeds are returned to regional aquaculture associations, incorporated as private non-profits, which operate hatcheries for stock supplementation (Knapp, Roheim and Anderson, 2007). Where MPAs are expected to create spillover effects or to improve the health of fish stocks, this approach could be replicated, with tax revenues being directed to MPA management.

MPAs with nearby boat traffic may also generate revenue by collecting fines from ships violating restrictions by, for example, running aground on reefs (MSR, 2012) or fishing illegally. Apo Reef Natural Park in the Philippines collects fines from apprehended fishing vessels, which are deposited into the Integrated Protected Areas Fund, though their contributions to MPA management costs have not been quantified.

Subsidies

MPAs often enhance fisheries by either explicitly protecting fish stocks or the biodiversity that stocks depend on, resulting in increased fish yields, increased sustainability of extractive activities and increased recreational quality (Cook and Heinen, 2005). For example, average annual fisheries benefits of the two largest MPAs in the Seychelles were estimated to be approximately USD 200 000 each (Cesar et al., 2004).[8] MPA costs can thus be considered a subsidy to fisheries (Cullis-Suzuki and Pauly, 2010). Financial support could be diverted from direct fisheries subsidies to MPAs under this assumption, including by converting jobs from the fisheries sector to MPA management. This would also aid in reducing financial stress in the fishing community (Gell and Roberts, 2003), thereby increasing political acceptability.

However, many of the subsidies received by fisheries may also be environmentally harmful, such as non-taxation of transport fuels. This leads to less efficient fishing methods and operations. In OECD countries, the fisheries sector has received approximately USD 6.4 billion a year in transfers from the government (OECD, 2006). The majority of this support is for management services, R&D and infrastructure, the effect of which is ambiguous, but it also includes support to inputs such as for bait, gear and fuel which can be environmentally harmful when they lead to increases in fishing effort due to lower marginal costs (Van Winkle et al., 2015; Borello et al., 2013).

A tax credit system can also be developed, in which private entities' payments towards conservation can be claimed against their tax payments (ADB, 2011).

Payments for ecosystem services, including blue carbon

Payments for ecosystems[9] (PES) programmes in the context of marine and coastal ecosystems are also being introduced. Based on the beneficiary-pays approach, those who would benefit from the enhanced provision of ecosystem services (i.e. above that of the status quo) can pay resource owners or managers to change their management practices so as to incentivise higher (or additional) ecosystem service provision.[10] Some particular challenges may arise in the context of applying PES in the marine environment: marine resources, particularly fish, are mobile and hard to monitor, and property rights are often poorly defined and insecure, increasing the difficulty of programme uptake (IIED, 2012). As PES programmes are based on the beneficiary-pays approach (rather than polluter pays), they may be more appropriate when the existing resource users are poorer population groups.

Potential buyers may include the fishing, tourism, recreation and marine renewable energy industries; municipalities and governments; and so forth (Lau, 2013; IIED, 2012; Forest Trends, 2010). For example, local hotels and tourism operators could pay for reef conservation due to the benefits associated with decreased beach erosion and species conservation (e.g. for scuba divers). Castano-Isaza et al. (2015) examine PES options for Colombia's Sunflower MPA, the largest MPA in the Caribbean. PES has been used for seaturtle conservation efforts in Kenya, Tanzania and the Solomon Islands (Ferraro, 2007) and more recently, Binet et al. (2013) conclude that the European Union-Mauritania fisheries agreement, which allocates part of Europe's financial contribution to the conservation of marine ecosystems located within the Banc d'Arguin National Park, can be regarded as the first international PES of its kind.

PES programmes also show potential for involving local communities. The Luis Echeverria community in Mexico is protecting about 48.5 km^2 of grey whale habitat in exchange for USD 25 000, used to finance small-scale development and alternative income generation (IIED, 2012), and the government of Seychelles, with co-funding from the GEF, instituted a buyout and retraining programme for tortoiseshell artisans prior to banning commercial sales (Lau, 2013). Tanzania's Marine Legacy Fund derives revenues from commercial fishing licences, marine ecotourism revenue sharing, and oil and gas taxation that is used to pay coastal communities for conservation and to finance some operational expenses (Forest Trends, 2010).

Marine and coastal ecosystems also have climate mitigation potential. Coastal ecosystems such as salt marshes, seagrass beds and mangroves all store sizable amounts of carbon, creating potential for usage with UNFCCC mechanisms under developing "blue carbon" programmes. This would constitute an international PES and could be useful for MPA financing in cases where MPAs include coastal zones. Loss by conversion from marshes, mangroves and seagrasses can imply a release of 0.15-1.02 billion tonnes of carbon dioxide (Lavery et al., 2013). Mangroves and seagrasses support fish habitats and increase fish production, stabilise shorelines, filter land-based pollution, and influence and shelter the fish populations of nearby reefs, and reefs in turn act as wave and current breakers and erosion protectors for coastal ecosystems. In Kenya, for example, the Mikoko Pamoja community-based mangrove conservation project has been certified for entry into the voluntary carbon market, and it is expected that one-third of funds generated – about USD 4 000 – will be used for mangrove conservation (AGEDI, 2014).

Studies are also beginning to investigate the carbon sequestration capacity of marine species (Lutz and Martin, 2014). Sea otters, predators of sea urchins which are grazers, therefore maintain and increase the health and carbon storage capacity of seagrass and kelp beds; marine vertebrates, especially large ones, stimulate phytoplankton production, fish productivity and carbon uptake; and food chain processes transport carbon away from the surface of the ocean. The carbon service value of sea otter influence on kelp beds has been estimated at USD 205-408 million (one-time payment), or USD 16-33 million (one-time payment invested at 8% return) (Wilmers et al., 2012), while that of marine life in the high seas has been estimated at USD 148 billion (Lutz and Martin, 2014; Rogers et al., 2014).

Marine bioprospecting

The biological diversity of reefs and of marine environments may provide opportunities for collecting marine bioprospecting fees, especially under the Convention on Biological Diversity's Nagoya Protocol on Access to Genetic Resources. In 1992, the US National Cancer Institute paid the Coral Reef Foundation USD 2.9 million for reef samples to be used in cancer research (Spurgeon and Aylward, 1992). Costa Rica's National Biodiversity Institute (INBio) is permitted to undertake bioprospecting in protected areas in collaboration with academia and private enterprise, with the stipulation that 10% of research budgets and 50% of any future royalties be donated to the Ministry for Conservation. In 2006, INBio entered into an agreement to be paid USD 6 000 per year by a biotech company for two natural resource-based materials, one of which was a protein derived from a marine organism (WWF, 2009). Similarly, a USD 30 000 agreement between a pharmaceutical company and Fiji's Verata District helped to sustain marine conservation work in the area (WWF, 2005).

Marine biodiversity offsets

Coastal development, such as urban expansion, port development to support exporting industries and the development of seabed mining, can adversely impact biodiversity and habitats. Biodiversity offsets in the marine context could be explored in such cases. Based on the polluter-pays approach, any excess damage caused after the application of the mitigation hierarchy would need to be compensated by restoration elsewhere. Such restoration efforts could be targeted to areas where new MPAs need to be developed. An example of an offset programme applied in the coastal context can be found in the Australian province of Queensland that instituted a fish habitat offsetting policy in 2002 (Queensland Government, 2002).[11] Other examples exist often involving coastal habitats such as eelgrass and intertidal reefs (Dickie et al., 2013), and a voluntary blue carbon offset programme, called SeaGrass Grow, has been established by the Ocean Foundation in the United States to restore seagrass meadows, which are among the most effective natural ecosystems for sequestering carbon.

Dickie et al. (2013) and Dickie (2014) suggest further applications, for example allowing marine development such as a pipeline or cable to be placed in a sensitive area to avoid an expensive re-routing, and compensating any residual damage by recreating habitat several times greater than that damaged for a much lower cost. Marine renewable energy installations, such as for tidal and wave generation, may also be appropriate candidates for offsets, especially as attention to the ocean's potential for renewable energy generation continues to increase. Similarly, offsets could be applied to oil and gas drilling and exploration, or to deep seabed mining, and sections of coral reefs expected to be damaged by development could be removed, stored and then transplanted to protected areas, or funding could be directly allocated to reef restoration.

Belize has recently produced a framework for marine and coastal offsets (Belize Coastal Zone Management Authority & Institute and Australia-Caribbean Coral Reef Collaboration, 2014).

Private sector partnerships

Partnerships with the private sector may take several forms, ranging from direct corporate social responsibility-based investments to collaborations between private entities and NGOs or protected area management bodies, although it should be noted that the private sector may not always offer long-term funding (Erdmann et al., 2003).

In the Philippines, a corporation partnered with an NGO to fund parts of a management programme for the Verde Island Passage MPA network (ADB, 2011), while in Indonesia, Misool Eco Resort established and maintains a 1 220 km^2 MPA, including two separate no-take areas totaling 828 km^2, through tourism revenue, institutional donors, and partnerships with local communities and other industries (Misool Baseftin, n.d.; Forest Trends, 2010).

MPAs can also earn revenues by charging concession fees for the sole right to operate inside their boundaries, thereby delegating some aspects of management to the private sector or NGOs. Alternatively, private sector entities with an economic interest in preserving the MPA – e.g. tour operators depending on MPA quality – may consider cost-sharing arrangements with the publicly funded MPA management body. These approaches can aid in day-to-day operations by providing patrol and monitoring assistance, maintenance, or other day-to-day duties that can be completed at lower cost by tour operators, in return for service improvements or concessions from the management body (Emerton and Tessema, 2001).

To ensure transparency and long-term security, public-private partnerships may formalise their legal and financial agreements, such as was done in California for the Marine Life Protection Initiative through a binding agreement and a jointly managed endowment fund (Living Oceans Society, 2012). Private operators have also become involved in the management of the Great Barrier Reef MPA through a variety of mechanisms: resorts provide rangers, commercial fishers pay mooring fees, dive operators monitor illegal fishing, and so forth (CFA, 2003). The Great Barrier Reef Marine Park Authority administers the Eye on the Reef monitoring and stewardship programme in collaboration with scientists, tourism operators, park rangers and other users (Great Barrier Reef Marine Park Authority, 2014), and tourism operators are building their capacity to undertake starfish management through diver training, in conjunction with the Australian government's Reef Trust Program (Government of Australia, 2014). Similarly, protection for the Jardines de la Reina national park in Cuba was supported by a public-private venture between the government of Cuba and a private company operating a catch-and-release fishing camp, whose best interest was to ensure the area remained pristine (Morris, 2002).

Several similar agreements exist in the Sulu-Sulawesi Seas Marine Ecoregion. The Gilutongan Marine Sanctuary in the Philippines entered into an agreement with a private firm in 2007 to market and manage the sanctuary's 20-metre buffer zone, in which the local municipality was entitled to receive a total of 18 million Philippine pesos over three years. The agreement was renewed in 2011, and was still in place as of 2012 (MSR, 2012). In Malaysia, the Sabah Wildlife Department has outsourced the management of an MPA to a private company, in which the firm pays the state 60 000 ringgits per year and is required to invest in conservation and protection, in exchange for tourism rights (PE Research, 2010). Lastly, in Indonesia, the North Sulawesi Watersports Association provides in-kind support to the Bunaken Marine National Park. Dive operators have sponsored a range of programmes aiding park management, including education scholarships for locals, handicraft sales that create extra sources of income and conservation education activities. Operators also regularly participate in beach and reef cleanups, fish monitoring, enforcement activities and other management operations, resulting in significant savings for the management authority (Erdmann et al., 2003).

In some cases, the private sector may be able to drive the creation of new MPAs (Box 4.1).

Engaging industries such as oil and gas, or others aiming to meet corporate social responsibility requirements, is another option for sourcing funding for MPAs (MSR, 2012; PE Research, 2010). For example, in 2008 the Malaysian infrastructure conglomerate YTL Corporation Berhad donated more than MYR 700 000 (Malaysian ringgits) raised from a climate change fundraising event to Reef Check Malaysia, a reef monitoring non-profit. In 2010, it launched a fellowship of USD 2 million to be donated from 2010 to 2014 for community-based conservation programmes in Asia. In its first year, it identified 22 outreach campaigns in the Coral Triangle to be conducted by YTL fellows (YTL Community, 2010).

Developing a finance strategy for marine protected areas

Given the severe finance shortage across many MPAs, greater efforts are needed to secure the resources that are required to ensure effective MPA management. Developing an MPA financing strategy can help to identify needs and structure the required steps to do this. At a minimum, an MPA finance strategy should be composed of:

Box 4.1. **Chumbe Island Coral Park, Zanzibar**

Chumbe Island Coral Park, comprised of a 22-hectare coral island and part of a fringing reef, was gazetted by the government of Zanzibar in 1994 as a protected area following an investment proposal by a private entity, Chumbe Island Coral Park Ltd. (CHICOP), which was allocated management rights. Establishment costs were initially estimated at USD 200 000, with payback expected to begin after three years at an internal rate of return of 27%, but a three-year delay and unexpected administrative difficulties caused cost overruns which resulted in a final establishment outlay of USD 1.2 million, in addition to a significant amount of volunteer work. Approximately 36% of this outlay was funded by various donors, with the rest funded privately by the project initiator. CHICOP developed eco-tourism facilities which as of 2006 were sufficient to cover recurrent management costs – but not capital payback – at an occupancy rate of 30-40%.

CHICOP has pursued unconventional approaches for operational and business development goals. Local fishers were retrained as park rangers, and in addition to patrolling the island, have rescued over 160 vessels with between 2-16 fishermen each since 1994, likely saving several lives. As private employees, rangers are unarmed, and "enforce by informing" local fishers on the value of the protected area. Spillover catches have indeed been reported, enhancing local support for the park. Today, Chumbe Island is one of the most biodiverse reefs in the region.

With respect to business development, as a small company, traditional marketing costs to leverage the tourism market would have been prohibitive. Instead, CHICOP applied for and won several international environmental awards, providing marketing exposure equivalent to USD 10 million.

CHICOP's example provides insight into some enabling conditions that aid in effectively engaging the private sector, including the existence of an attractive investment climate and little competition from large, donor-funded projects. Furthermore, tourism, fishing and other uses often coexist in the same area, resulting in a need to negotiate, and CHICOP's small, local nature may have afforded it an advantage over a central authority in this regard, due to co-dependencies between it and the local communities.

Sources: Emerton, L., J. Bishop and L. Thomas (2006), "Sustainable financing of protected areas: A global review of challenges and options" https://cmsdata.iucn.org/downloads/emerton_et_al_2006.pdf; Lindhjem, H. (2003), "Sustainable financing of marine protected areas in Zanzibar", www.lindhjem.info/FinanceZan.pdf; Riedmiller, S. (2003), "Private sector investment in marine protected areas: Experience of the Chumbe Island Coral Park in Zanzibar/Tanzania".

1. an assessment of financing needs (see Chapter 2)
2. identification of stakeholders, including the polluters and the beneficiaries (and at what scale – local/regional/global)
3. assessment of different finance sources available for MPAs (see above), and which offer the greatest potential and long-term source of revenue, given the socio-economic and other characteristics in the area
4. assessment of barriers to implementation and procedures for operationalisation.

According to the French National Strategy for the Creation and Management of Marine Protected Areas, the estimated annual costs for an MPA network covering 20% of French waters will amount to around EUR 170 million by 2020 (Table 4.3). Based on current financing principles for MPAs in France, the majority of this will be financed by the government.

Table 4.3. **Estimated cost of the marine protected area network in French waters**

	Estimated annual cost for the marine protected area network (20% by 2020) million EUR
Surveillance (monitoring and control)	70.3
Studies, expert assessment	37.6
Interventions	36.3
Awareness raising	25.8
Total	170

Source: French Ministry of Ecology, Sustainable Development and Energy (2015), "National Strategy for the Creation and Management of Marine Protected Areas: Summary", www2.developpement-durable.gouv.fr/IMG/pdf/National_strategy_for_the_creation_and_management_GB_Web.pdf.

The identification of the polluters (i.e. those causing adverse impacts to the existing or proposed MPA) can help to determine whether mechanisms are in place to internalise the externalities and whether there is additional scope for additional taxes and fines to help address these. Part of the revenues obtained from such instruments could be earmarked for MPA management. The beneficiaries of MPAs can include a larger number of stakeholders including up to the global level. Examples include international tourism benefits from biodiversity conservation, habitat for endangered and migratory species, replenishing fish stock for commercial fisheries, carbon sequestration and mitigation of natural disasters and impacts related to climate change. User fees and international payments for ecosystem services can be considered as additional means to mobilise finance for MPAs.

Despite the finance challenge for MPAs, few examples exist of MPA finance strategies. A few exceptions include a financing scoping exercise in the Sulu-Sulawesi Seas Marine Ecoregion, Indonesia (MSR, 2010) and a finance strategy and plan in Belize (Box 4.2).

Box 4.2. **Sustainable finance strategy and plan for the Belize Protected Area System**

A study was undertaken in 2011 for the government of Belize to help develop a finance strategy for the national protected area system. This consisted of the following components:

- financial analysis – needs and gaps
- review of existing financial mechanisms (e.g. PACT, government budget, development aid, debt for nature swaps)
- market analysis of revenue-generating options
- enabling conditions (e.g. legal, institutional, barriers)
- pre-feasibility of revenue-generating options
- scenario analysis (projections for revenue and expenditures)
- financial plan/strategy (including recommendations and timeline).

Source: Drumm, M.E. et al. (2011), "Sustainable finance strategy and plan for the Belize Protected Area System".

In a recent financial analysis of Mediterranean MPAs (Binet et al., 2015; see also above), where only 8% of the financing needs for effective management of MPAs are covered by current resources, the authors recommend that additional financing needs could be partly covered by local mechanisms, including local public support; and that additional financing mechanisms should be developed, such as entrance and users fees, earmarking of charges collectable under the occupation of public land, among others. They also recommend strengthening regional co-operation to achieve more complementary and joint management, optimising the consumption of resources.

Spergel and Moye (2004) have developed a list of feasibility criteria for the finance mechanisms (Box 4.3).

The IUCN-WCPA (2008) suggests several main components of sustainable financing strategies: sharing responsibilities with stakeholders to build support and ownership; building diverse funding portfolios; improving financial administration; comprehensively addressing all costs and benefits; instituting transparent governance; creating an enabling framework by overcoming market, price and policy distortions; and building capacity to use financial tools and mechanisms.

Box 4.3. **Feasibility criteria for the financing mechanism**

Financial

- How much money will actually be needed each year to support the particular marine conservation programmes and activities that are envisaged?
- How much revenue is likely to be generated each year by the new financing mechanisms?
- Will the revenues generated be worth the cost of setting up the new system of user fees, taxes, debt-for-nature swaps or trust funds?
- Could the revenues vary substantially from year to year depending on global and national economic, political and natural conditions?
- How will a highly variable revenue flow affect the conservation programmes that the financial mechanism is intended to pay for?
- What other sources of funds might be available, either on a long-term or a one-time basis?

Legal

- Can the proposed financing mechanisms be established under the country's current legal system? Some legal systems do not recognise concepts such as easements or development rights. In other legal systems, there may be a constitutional prohibition against earmarking tax revenues or fees for specific purposes.
- Will new legislation be required in order to establish the proposed financing mechanism?
- How difficult and time-consuming will it be to pass such legislation?
- Could the new financing mechanism be established under current legislation, by simply issuing an administrative or executive order?

Box 4.3. Feasibility criteria for the financing mechanism (*continued*)

Administrative

- In the particular country, how difficult will it be to administer, enforce, collect or implement a particular type of user fee, tax, or quota and trading system?
- Will it be too complicated or costly to administer?
- Are there enough trained people (or how difficult will it be to train enough people) to administer and enforce the system?
- Will implementing the particular user fee, tax or quota depend too much on the discretion of individual officials and therefore present too many opportunities for corruption?
- Can safeguards be devised to limit potential problems?
- How difficult will it be to collect, verify and maintain the data upon which a particular user fee, tax or trading system is based? For example, how difficult will it be to keep track of the amount of fish that are caught each day or each month by particular individuals, communities or commercial fishing vessels; or the number of people who visit a marine protected area (MPA), or who use particular products or ecological services provided by the MPA?

Social

- What will be the social impacts of implementing a particular system of generating revenues for conservation?
- Who will pay, and what is their willingness and capacity to pay?
- Will the new financing mechanism be perceived as equitable and legitimate?

Political

- Is there government support for introducing the new financing mechanism?
- Can the government be relied upon to spend the new revenues only for the purposes intended, or is there a strong likelihood that the money may end up being used for other purposes?
- Can this be monitored and ensured by the courts or the media or non-governmental organisation "watch-dog" groups or particular user groups or an independent board of directors or an international agency?

Box 4.3. **Feasibility criteria for the financing mechanism** (*continued*)

Environmental

- What will be the environmental impact of implementing the new financing mechanism? For example, for tourism-based mechanisms will the desire to increase revenues from tourism compromise conservation objectives or exceed the carrying capacity of the MPA?

Source: Spergel, B. and M. Moye (2004), *Financing Marine Conservation: A Menu of Options*, http://awsassets.panda.org/downloads/fmcnewfinal.pdf.

Table 4.4. **Financing marine conservation and sustainable use**

Financing mechanism (source of revenue)
Government revenue allocations
Direct allocations from government budgets (government budget revenues)
Government bonds and taxes earmarked for conservation (investors, taxpayers)
Lottery revenues (gamblers)
Premium-priced motor vehicle license plates (vehicle owners)
Wildlife stamps (postal customers, hunters, fishers)
Debt relief (donors, government, non-governmental organisations)
Grants and donations
Bilateral and multilateral donors (donor agencies)
Foundations (individuals, corporations)
Non-governmental organisations (NGO members and supporters)
Private sector (investors)
Conservation trust funds (multi-source)
Tourism revenues
Protected area entry fees (visitors to parks)
Diving and yachting fees (divers, boaters)
Tourism-related operations of protected area (agencies, tourism operators, tourists)
Airport passenger fees and cruise ship fees, taxes and fines (tourists, cruise lines)
Hotel taxes (hotel clients)
Voluntary contributions by tourists and tourism operators (tourism operators, tourists)
Real estate and development rights
Purchases or donations of land and/or underwater property (property owners, donors)
Conservation easements (property owners, donors)
Real estate tax surcharges for conservation (property owners, donors)
Tradable development rights and wetland banking (property developers)
Conservation concessions (conservation investors)

Table 4.4. **Financing marine conservation and sustainable use** (*continued*)

Fishing industry revenues
Tradable fishing quotas (commercial fishers)
Fish catch and services levies (commercial fishers)
Eco-labelling and product certification (seafood producers, wholesalers, retailers and end-use purchasers of ornamental tropical fish and corals)
Fishing access payments (governments, associations of and/or individual fishers)
Recreational fishing license fees and excise taxes (recreational fishers)
Fines for illegal fishing (fishers)
Energy and mining revenues
Oil spill fines and funds (energy companies, donors)
Royalties and fees from offshore mining and oil and gas (energy and mining companies)
Right-of-way fees for oil and gas pipelines and telecommunications infrastructure (private companies)
Hydroelectric power revenues (power producers)
Voluntary contributions by energy companies (energy companies)
For-profit investments linked to marine conservation
Private sector investments promoting biodiversity conservation (private investors)
Biodiversity prospecting (pharmaceutical companies)

Source: Spergel, B. and M. Moye (2004), *Financing Marine Conservation: A Menu of Options*, http://awsassets.panda.org/downloads/fmcnewfinal.pdf.

Notes

1. For example, in a study of 83 MPAs worldwide, Balmford et al. (2004) found that, on average, the funding shortfall was approximately one-half of requirements (median value of USD 2 698 per km² per year). A similar study by Gravestock, Roberts and Bailey (2008) on the financing requirements of 79 MPAs in 36 countries found that a median of 15% and 74% funding increases were required to meet minimum and ideal requirements, respectively.
2. This was partly because the parks were unable to retain a large enough proportion of revenues raised from user fees.
3. Government allocations to the Montego Bay Marine Park in Jamaica, for example, decreased from JMD 1.2 million in 1998 to less than JMD 100 000 in 2004.
4. www.marfund.org.

5. When price elasticity of demand is relatively inelastic, the percentage change in quantity demanded is smaller than that in price. Hence when the price is raised, total revenue increases. The opposite holds when price elasticity of demand is relatively elastic. Pascoe et al. (2014), for example, estimate the price elasticity of demand for dive tourism in Indonesia, Malaysia and Thailand and find this to be highly inelastic.
6. Though the authors caution that this is atypical, and that hidden and unaccounted costs may have existed.
7. They are unrequited in the sense that benefits provided by the government to taxpayers are not normally in proportion to payments.
8. Assuming high reef productivity and spillover; assuming one hectare of reef closure provides equivalent yield to three open hectares.
9. As noted earlier, France uses the term payments for environmental services to make a distinction between when payments for services should be warranted (i.e. when changes in management practices result in additional services). Additionality should in fact be a pre-requisite for any payment; see OECD (2010) for a discussion.
10. For a detailed discussion of key features that need to be considered in designing a PES programme, including establishing baselines, ensuring additionality, addressing potential leakage and ensuring permanence, see OECD (2010).
11. Absorbed into the Queensland Environmental Offsets Policy of 2014.

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Chapter 5.

Effective policy mixes for marine biodiversity

Though marine protected areas are often necessary to ensure the conservation and sustainable use of marine resources, they are not always sufficient. This chapter highlights the need for effective policy mixes to address the multiple and sometimes cumulative pressures on marine biodiversity. It provides a framework for designing and evaluating policy mixes. The role of marine spatial planning, and other instruments, such as fish catch regulations and water pollution control measures, are discussed.

The need for policy mixes in marine biodiversity conservation and sustainable use

Marine protected areas (MPAs) are just one instrument in the policy toolkit to help ensure the conservation and sustainable use of marine biodiversity resources. As highlighted in Chapter 1, the pressures on marine biodiversity are multiple, and stem from different actors (public and private), sectors, and occur at different geographical scales (Table 5.1). The diverse set of actors and sectors, including for commercial fisheries, aquaculture, renewable energy, tourism, and shipping transport, recreation, among others, often compete for resources and space. Sectoral policies, such as fisheries, agricultural, forestry or infrastructure-related policies, that most commonly lie outside the remit of environment ministries, also impact marine biodiversity (Schröter-Schlaack and Ring, 2011), although often in a negative way (OECD, 2015a; 1999).

A mix of policy instruments (regulatory, economic and information/ voluntary) is therefore necessary to address the multiple externalities emanating from the different actors and sectors, and to account for numerous pressures on and objectives for the ocean and marine environment.

Table 5.1. **Multiple challenges and considerations for marine biodiversity**

Pressures	Actors/sectors	Objectives	Governance levels
– Overfishing – Pollution and acidification – Habitat destruction – Invasive alien species – Climate change	– Environment – Fisheries and aquaculture – Shipping, transport, ports – Telecommunication cables – Oil, gas and minerals – Tourism – Renewable energy – Desalination – Pharmaceutical – Research and education – Engineering, architecture, environmental services – Agriculture and forestry – Non-governmental organisations – Cultural and recreational users – Military	– Marine biodiversity conservation and sustainable use – Economic growth and poverty alleviation – Navigation and exploration – Trade and development – Food security – Water security – Waste disposal (sewage, industrial waste, dredged material) – Research and development – Climate change mitigation (clean energy, carbon sequestration) – Social (e.g. recreational, religious, historical, cultural) – National security – Intrinsic value	International National Regional Local

While MPAs are necessary to help achieve biodiversity conservation and sustainable use, they are not sufficient on their own to address all of the pressures on marine biodiversity. For example, the displacement of fishing vessels to adjacent sea areas as a consequence of MPA establishment may result in an increase in pressures on species and habitats elsewhere, thus reducing the aggregate benefits of the MPA (Hoffmann and Perez-Ruzafa, 2008), particularly if the MPA is too small (Gaines et al., 2010; Green et al., 2014). The absence or ineffective use of additional accompanying policy measures has been cited as a reason for why some MPAs do not benefit fish productivity or recovery (Gruss et al., 2014). The design and implementation of MPAs, and how they fit in a wider policy mix, are therefore fundamental for achieving broader economic, social and environmental objectives.

Social and economic factors influence whether and how stakeholders exploit resources, or co-operate to conserve and/or sustainably use them (Rees et al., 2015). An effective policy mix, with a range of incentives for different actors, can provide for a superior outcome that is more effective, efficient and/or equitable than a single policy for instance by:

- Stimulating greater efficiency through price signals and least cost solutions to environmental problems (Lehmann, 2012; OECD, 2007).
- Incorporating compensation tools, which can provide for no-net loss in policies, or even create net-gain solutions (Lehmann, 2012).
- Generating additional public revenues that, if earmarked, can support pro-biodiversity measures (Lehmann, 2012).
- Providing incentives for compliance with regulatory norms, limit compliance-cost uncertainty, and ensure that the benefits and costs of controls over marine biodiversity and resources are distributed more evenly among stakeholders. Furthermore, overlap in the incentive measures can provide essential backup in case any one measure fails to provide sufficient incentives (OECD, 1999).
- Achieving a higher degree of acceptance by all stakeholders, when compared to single regulatory measures (OECD, 2007; Schröter-Schlaack and Ring, 2011; TEEB, 2011). For example, by coupling MPAs with awareness campaigns and income compensation tools to alleviate any potential hardships caused.

A portfolio of potential policy instruments for marine biodiversity conservation and sustainable resource use are discussed in Chapter 1. Examples of policy instruments to address the different drivers of marine biodiversity loss are summarised in Table 5.2.

Table 5.2. **Examples of policy instruments to address the different drivers of marine biodiversity loss**

Policy mechanism/pressure	Overfishing	Pollution	Habitat destruction	Invasive alien species	Climate change
Regulatory					
Marine spatial planning (spatial restrictions for specific activities)	X	X	X	X	X
Marine protected areas	X	x	X		
Temporal restrictions (seasonal, temporary closures)	X	X	X	X	X
Total allowable catch	X				
Individual catch quotas	X				
Territorial use rights	X				
Property rights	X				
Effort quotas (limits on the number of days at sea)	X				
Fishing standards	X				
Fishing licenses	X				
Gear restrictions	X		X		
By-catch restrictions	X				
Discard restrictions/bans	X				
Landing limits (restrictions on fish quantities and size)	X				
Vessel restrictions (number, size, horsepower)	X	X			
Ship construction standards	X				
Specification of “best available technology” or “best environmental practice” for fishing	X	X	X	X	X
Planning requirements (i.e. environmental impact assessments and emergency response plans)		X	X	X	X
Standards (e.g. pollution/emissions/ construction)		X	X	X	X
Emission permits		X			X
Restrictions on mineral extraction		X			
Restrictions on ballast water discharges		X		X	
Restrictions on volume and concentration of discharged pollutants from onshore and offshore		X			
Limitation on oil, gas and other mining operations		X	X		X
Limitation on number of freight and cruise ships operating		X		X	
Restrictions on tourism operations		X	X		

Table 5.2. **Examples of policy instruments to address the different drivers of marine biodiversity loss** (*continued*)

Policy mechanism/pressure	Overfishing	Pollution	Habitat destruction	Invasive alien species	Climate change
Economic					
Individually transferable quotas	X				
Resource tax	X				
User fees	X	X	X	X	
R&D subsidies	X	X	X	X	X
Non-compliance fees/penalties	X	X	X	X	X
Insurance measures	X				
Removal or reform of harmful subsidies	X	X	X	X	X
Buy-back and decommissioning schemes	X	X	X	X	X
Taxes on fertilisers and pesticides (inputs)		X			
Pollution taxes or emissions trading schemes		X	X		X
Payments for ecosystem services	X	X	X		
Information and voluntary					
Certification and eco-labelling	X	X	X		X
Industry codes of practice	X	X	X	X	X
Marine charts, navigation aids, other marine services	X	X	X	X	X
Awareness campaigns and education	X	X	X	X	X

To maximise the contribution of MPAs and ensure the long-term sustainability of marine resources and the ecosystem benefits they provide, MPAs must be embedded within broader management frameworks that address all drivers of biodiversity loss while aligning with human uses and values, and legal, political and institutional requirements (Christie et al., 2009; Green et al., 2014). For example, MPAs should be:

- **Integrated within spatial planning and ecosystem-based management regimes** (such as marine spatial planning and integrated coastal zone management) that address multiple threats, including those arising from land (Álvarez-Romero et al., 2011; Green et al., 2014). Clear objectives and carefully targeted measures reduce policy spillovers, as well as the likelihood and impact of poor policy coherence (OECD, 2013).
- **Implemented in combination with incentive measures** (regulatory, economic and/or voluntary) to encourage the sustainable use of biological resources, such as the assignment of property rights over the use of the commercially viable species, restrictions on the methods of fishing and the use of the surrounding MPA, the removal or reform of environmentally harmful subsidies which encourage unsustainable fishing activities, compensation to address the economic and social consequences of displacement of fishers

and other users, and measures to minimise or avoid local threats (such as land-based pollution and the introduction of invasive alien species) (OECD, 2015a).

- **Accompanied with capacity building and communication** among regulatory agencies, researchers, authorities, sector jurisdictions and stakeholders; paramount for effective action and reducing information gaps (Gruss et al., 2014).
- **Integrated into governance mechanisms** that are already in place within marine spatial planning or ecosystem-based management regimes to avoid duplication/gaps and stakeholder fatigue.
- Finally, policy mixes need to be **flexible** to adapt to socio-economic changes and changes in climate and ocean chemistry (Green et al., 2014).

The remainder of this chapter examines the following two questions:

1. How to assess the environmental effectiveness, economic efficiency and distributional implications of a given policy mix?
2. What is the role of different policy instruments, and how can they help in the design and implementation of an effective MPA? Marine spatial planning, catch regulations and water pollution control methods, in combination with MPAs, are highlighted as examples.

A framework for the design and evaluation of policy mixes

Whether designed on purpose or evolved more *ad hoc* over time, the existence of policy mixes to address marine biodiversity conservation and sustainable use is now probably prevalent everywhere. Often, however, policies are introduced consecutively, with little attention given to potential interactions and to maximising their contribution to protecting marine biodiversity (Green et al., 2014).

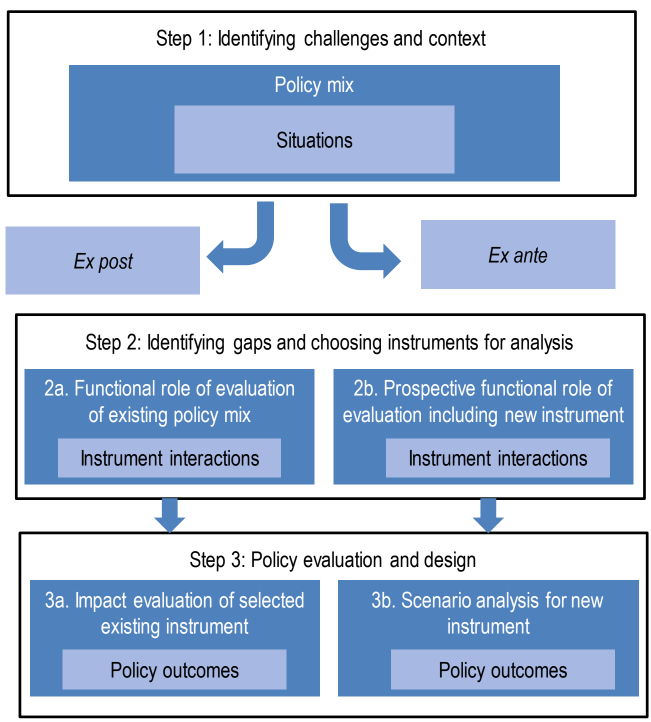
An integrated set of guidelines can assist policy makers to maximise benefits. Schröter-Schlaack and Ring (2011) have developed a three-step framework[1] for evaluating and designing policy mixes for biodiversity and natural resource management (Figure 5.1). The framework seeks to assist the decision maker in extracting the information on which to base a rational decision and determine management action, given the objectives, preferences and attitudes to risk of stakeholders. The three steps of the framework are:

1. **Scoping phase** to identify the challenges and context (such as those listed in Table 5.1), and the trade-offs between multiple objectives, such as between marine biodiversity conservation and economic development of marine resources.

2. **Evaluating the functional role of instruments** in the policy mix, by identifying gaps and choosing new instruments for analysis, evaluating the context-specific strengths and weaknesses of instruments, assessing instrument interaction, and assessing existing policies in place (including different sectoral policies) versus new instruments under consideration. To do this, the overall objectives should be clearly defined, and relevant stakeholders made aware and engaged in this process.

3. **Policy evaluation and design** to evaluate the impact and effectiveness for existing instruments (*ex post*) and scenario analysis for new instruments (*ex ante*). Assessment categories should include conservation effectiveness and resource status, cost-efficiency, community outcomes, distributive impacts and legitimacy, and institutional options and constraints (Anderson et al., 2015).

Figure 5.1. **A framework for evaluating a policy mix or selecting new instruments for a policy mix**



Source: Schröter-Schlaack, C. and I. Ring (2011), "Towards a framework for assessing instruments in policy mixes for biodiversity and ecosystem governance", http://policymix.nina.no/Portals/policymix/POLICYMIX%20Report_No%202_2011.pdf.

Step 1 involves the identification of stakeholders, sectoral activities and resulting pressures on marine biodiversity (e.g. through overfishing, habitat degradation, pollution, invasive marine species, climate change); their impacts on marine ecosystems, the economy and social welfare; and their underlying causes (e.g. market, information, institutional and enforcement failures, and perverse subsidies). In Australia, for example, due to continuing marine biodiversity loss, ministers requested the establishment of a Marine Biodiversity Decline Working Group to identify the threats and causes of marine biodiversity decline and to identify high-level gaps in information (Marine Biodiversity Decline Working Group, 2008). The five most significant threats identified were: climate change, resource use, land-based impacts, marine biosecurity and marine pollution. The recommendations of the working group in response to these threats focused on the need for better co-operation and co-ordination of responses across jurisdictions, and improving the understanding of the current condition of marine biodiversity to enhance the capacity to respond to these threats.

In considering the policy mix, it is also important to examine the prevalence of potentially harmful subsidies which can promote, rather than prevent, wasteful and environmentally destructive behaviour resulting in marine biodiversity loss (OECD, 2015a). In the fishing industry, one example is government support to help fishers purchase more efficient equipment (e.g. boats, nets and technology) when catches decline in order for them to sustain a certain level of profitability. More efficient fishing equipment can, however, also contribute to more rapid stock depletion and thus adds policy failure to market failure (Coria and Sterner, 2011; OECD, 2012). Restricting fishing seasons aimed at protecting fish stocks and marine biodiversity is common practice but can also encourage "overcapitalisation" or "capital stuffing" when the season is declared open, which can lead to high storage costs (Homans and Wilen, 1997) and lower commercial value of catch, if it has to be sold frozen most of the year (Coria and Sterner, 2011). Box 5.1 illustrates the example of fuel subsidies in Mexico. Perverse subsidies should be removed or reformed where clear benefits in terms of budgetary, economic efficiency and/or environmental goals can be identified and potential compensatory and awareness measures exist to facilitate and support the removal process.

Step 2 then assesses existing policies for their comprehensiveness and performance regarding overcoming the challenges identified in Step 1, recognises gaps and selects instruments from the policy instrument toolbox (see Table 5.2) that are capable of dealing with the challenges. Taking stock of existing policies may point to shortcomings, unaccounted for trade-offs and blind spots of the currently applied instruments. It is then necessary to identify the functional role, objective and reason of each policy instrument and their interactions, and if necessary, identify new instruments complementary to the policies already in place (Schröter-Schlaack and Ring, 2011). A clear understanding of the interrelations between the biodiversity issue and other related environmental and non-environmental policy issues across different sectors is also required (OECD, 2007).

Box 5.1. **The impact of fishing subsidies on Mexico's marine protected areas**

Mexico's fisheries are important to the national economy. They are a vital source of nutrition for Mexicans, provide essential income for coastal communities, and are an important source of foreign currency. Such values are reflected in the Mexican government's long-term vision to encourage the national development, competitiveness and strategic planning for fisheries. This vision is articulated through the National Development Plan; the Sectorial Program of Farming and Fishing of the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food, a unit of the federal executive branch of the government of Mexico; and the National Sector Program of Fisheries and Aquaculture. There is a particular focus on improving the competitiveness of the fisheries sector.

Fuel subsidies for fisheries in Mexico have the purpose of increasing the profit margin of fishing activities (and therefore reduce the marginal cost of fishing compared to other economic activities) to increase the welfare of fishing communities. However, such subsidies have created multiple market distortions and externalities; in essence they encourage more fishing and discourage investment in fishery resources, such as more efficient and environmentally friendly technologies. This has contributed to over-exploitation of fish stocks, stagnated production and external costs to others, such as bycatch of non-targeted species, marine pollution, CO_2 emissions and a reduced effectiveness of marine protected areas.

Sources: OECD (2015b), *OECD Review of Fisheries: Policies and Summary Statistics 2015*, http://dx.doi.org/10.1787/9789264240223-en; Rivera-Planter, M., C. Muñoz-Piña and M. Montes de Oca-Leon (2014), "Economic instruments for sustainability in Mexico's marine protected areas and the perverse subsidy challenge".

The decision to commit resources can be guided by a cost-benefit framework that measures whether the potential benefits of protection, adjusted to account for risks, outweigh the potential costs (Rees et al., 2010; Sanchirico, Cochran and Emerson, 2002; Schmiing et al., 2014). For example, there are sectors of the marine recreation and tourism industry (e.g. scuba diving, sea angling and wildlife watching), which depend on the presence of natural marine resources in order to carry out their activity. Estimating the value of this direct use (using both monetary and non-monetary methods) can provide an evidence base for the conservation or sustainable use of marine biodiversity when set against other competing economic interests (Rees et al., 2010). Decision makers should account for multiple users' costs and benefits when designing and implementing marine policy. When the opportunity cost and benefits are considered, this can lead to conservation targets that are better informed and achieved more cost-efficiently (Schmiing et al., 2014). Cost-benefit analyses and non-market valuation methods can also be useful tools to assist in identifying the trade-offs. A trade-off analysis approach, developed from economic theory, can reveal inferior management options, demonstrate the benefits of comprehensive planning for multiple, interacting services over managing single services, and identify "compatible" services that provide win-win management options (Lester et al., 2013).

Step 3 then leads to two options: a) to improve the environmental, economic and/or social performance of the existing individual instruments, or interaction between instruments, within a policy mix (*ex post* analysis); or b) to introduce a new instrument to the existing policy mix in order to account for yet unconsidered challenges, or in acknowledgement of changing circumstances through scenario evaluation (such as evolved ecological and technological knowledge; public preferences; new actors; and other environmental, social and economic changes) (*ex ante* analysis) (Schröter-Schlaack and Ring, 2011). The objective of Step 3 is to determine how the value of an existing, or a new, instrument can be maximised, and to identify any potential for conflict in a policy mix, given the criteria outlined in Box 5.2. Depending on the policy-relevant outcomes of the evaluation and design of instruments in Step 3, it may be necessary to reconsider the functional role of the relevant instruments in the policy mix (Step 2) (Figure 5.1). Note that trade-offs are likely to occur whichever instrument is used (Schröter-Schlaack and Ring, 2011).

When choosing which policy instruments to use, decision makers must take into account issues such as data availability, monitoring and surveillance abilities, costs and benefits of different instruments, and cultural issues and traditions. Certain types of management measures can prove to be cost prohibitive and/or non-enforceable due to the lack of monitoring and surveillance, as well as having to rely on data which are not available. Cultural issues and traditions may create opposition to an otherwise well-designed marine policy, while national and international law may prohibit certain types of management actions (OECD, 2012).

Box 5.2. **Criteria to evaluate the functional role of instruments in a policy mix**

Possible criteria for policy instrument evaluation or selection include:

1. Environmental effectiveness, which assesses an instrument's ability within a policy mix to attain a level of marine biodiversity conservation/sustainable use that maximises environmental benefits. For example, were the environmental objectives reached by the use of the instruments in the policy mix? Do the policies in place adequately address the irreversibility of biodiversity loss? Are the drivers of biodiversity loss and ecosystem degradation identified and addressed by the existing policy instruments?
2. Cost effectiveness, which assesses an instrument's ability in a policy mix to achieve a given policy objective at the lowest cost. For example, were the environmental objectives reached at the lowest possible cost (including opportunity costs, and implementation and transaction costs)? Do the instruments in place address the trade-offs between marine biodiversity conservation and marine resource development? Are any particular instruments within the policy mix mutually reinforcing, redundant or counterproductive with other instruments? Have cost-benefit analyses been undertaken? Is adequate financing available for compliance monitoring and enforcement?
3. Other economic and non-economic criteria, including distributional equity and political process transparency. For example, are there any positive or negative social impacts associated with the use of the policy mix, and how are benefits and costs distributed among social actors? Have all actors participated, or at least been invited to participate, in the policy development process? Is information readily available to the public, and the costs and benefits clear and easy to understand?
4. Flexibility, which assesses the ability of instruments in a policy mix to address uncertainty, to adapt to changing circumstances and to exploit possibilities for various instruments to mutually underpin each other. For example, does the application of one instrument enhance the effectiveness and efficiency of another? Are conservation and management objectives, and the instruments of the policy mix adaptable to new knowledge and environmental and socio-economic changes? Do any instruments within the policy mix act as an insurance against knowledge gaps, policy or implementation failures?
5. Institutional arrangements and setting. The institutional setting where marine protected areas (MPAs) are being considered is another important component in determining whether and how the benefits will persist over space and time, and it has direct implications for the level of support MPAs could receive in the implementation process. For example, which institutions are necessary for successful implementation and operation of the instrument? Are the relevant governance levels (local to global), domains (e.g. public to private) and the different modes of decision making within these governance spaces addressed? Are there any institutional barriers associated with certain instruments or the existing policy mix?

Box 5.2. **Criteria to evaluate the functional role of instruments in a policy mix** (*continued*)

6. Policy coherence, which assesses the promotion of mutually reinforcing policy actions across different sectors. For example, are policies in other sectors conducive or harmful to marine biodiversity conservation and sustainable use? Do existing instruments, such as subsidies and tax incentives, establish perverse incentives and amplify negative environmental externalities? Does the policy mix encompass other sectoral policies, like fisheries, agriculture, energy, transport or tourism?

A final consideration when evaluating a policy mix or selecting new instruments is to assess the lessons learnt and experience gained from other biodiversity policy mixes and other policy sectors. For example, can experience available at international, national or regional level on how to successfully introduce certain instruments provide guidance? Can lessons be learnt from policy failures that may hamper the introduction of certain policy instruments?

Sources: Bennear, L.S. and R.N. Stavins (2007), "Second-best theory and the use of multiple policy instruments", http://dx.doi.org/10.1007/s10640-007-9110-y; OECD (2007), *Instrument Mixes for Environmental Policy*, http://dx.doi.org/10.1787/9789264018419-en; Schröter-Schlaack, C. and I. Ring (2011), "Towards a framework for assessing instruments in policy mixes for biodiversity and ecosystem governance", http://policymix.nina.no/Portals/policymix/POLICYMIX%20Report_No%202_2011.pdf; Sanchirico, J.N., K.A. Cochran and P.M. Emerson (2002), "Marine protected areas: Economic and social implications", www.cbd.int/financial/values/usa-valuemarine.pdf.

Placing marine protected areas in the wider policy mix

If managed in isolation, MPAs are vulnerable to natural resource development and exploitation occurring outside these areas, in particular overfishing, alteration and destruction of habitats, pollution, the introduction of invasive alien species, and climate change (Cicin-Sain and Belfiore, 2005; McClenachan et al., 2012). As noted by Kelleher (1999), "because of the highly connected nature of the sea, which efficiently transmits substances and forcing factors, an MPA will rarely succeed unless it is embedded in, or is so large, that it constitutes an integrated ecosystem management regime".

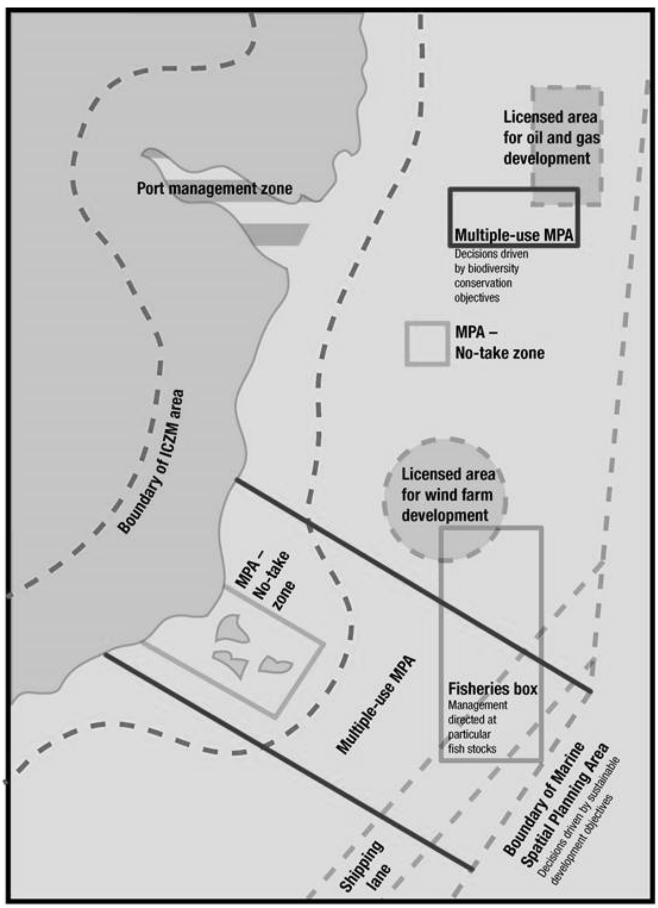
The role of marine spatial planning

Marine spatial planning (MSP) (also known as maritime spatial planning, or marine planning) is coming to prominence globally as an approach to the management of the seas and oceans (Halpern et al., 2012; Ehler and Douvere, 2009; Jay, 2015). UNESCO defines MSP as: a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process.

Characteristics of marine spatial planning include ecosystem-based, area-based, integrated, adaptive, strategic and participatory.

MPAs and MSP share several features as they are predominantly spatial allocation instruments, where MPAs can be considered a subset of MSP (see Figure 5.2). There are also strong links to integrated coastal zone management (ICZM) which aims to *inter alia*, address the problems of fragmented governance in marine settings, and have similar principles, such as the importance of stakeholder participation (Halpern et al., 2012; Smith et al., 2010).

Figure 5.2. **Schematic illustration of how marine protected areas might fit into a regional marine spatial plan**



Source: Gubbay, S. (2004), *Marine Protected Areas in the Context of Marine Spatial Planning: Discussing the Links*.

MSP can support the sustainable use of marine resources and protect MPAs from human activities that lie outside their boundaries (Christie et al., 2014; Schmiing et al., 2014; UK DEFRA, 2008). It is a process that coastal nations are being encouraged to adopt for the waters under their jurisdiction, including internal and territorial waters and, in many cases, extensive exclusive economic zones and continental shelf areas (Schaefer and Barale, 2011). For example, the 2014 European Union Maritime Planning Directive 2014/89/EU requires all coastal Member States to implement MSP by 2021 (see also Box 5.3). In the United States, the National Ocean Council advocates MSP and in 2013 released a *Marine Planning Handbook*.

Box 5.3. **EU marine legislation**

The 2008 Marine Strategy Framework Directive 2008/56/EC, the 2014 Directive on Establishing a Framework for Maritime Planning 2014/89/EU, and the 2002 EU Recommendation on Integrated Coastal Zone Management 2002/413/EC offer a comprehensive and integrated approach to the protection of all European coasts and marine waters. In addition, there are a number of complementary policies: the EU Habitats Directive, the EU Directive on the Conservation of Wild Birds, the regulation of fisheries through the Common Fisheries Policy (CFP), EU Biodiversity Strategy to 2020, EU Regulation 1143/2014 on Invasive Alien Species, and the control of input of nutrients and chemicals into waters through the Water Framework Directive (WFD), the Nitrates Directive and the EU Common Agricultural Policy (CAP).

The European Union sees marine spatial planning as a fundamental requirement for the integrated management of a growing and increasingly competing maritime economy, while at the same time safeguarding marine biodiversity. The EU Marine Strategy Framework Directive, the environmental pillar of the EU maritime policy, introduced the principle of ecosystem-based marine spatial planning and provides a supportive framework for national initiatives toward spatial planning, designed for achieving a good status for the environment.

EU member countries have their own policy instruments to implement and comply with those at the EU level. For example, in the United Kingdom, marine plans (inshore and offshore) are required for all English seas by 2021 to plan for sustainable use of marine resources. This includes designating areas as European marine sites (special areas of conservation and special protection areas), sites of special scientific interest with marine components, and marine conservation zones (MCZs). There is also a marine licensing system to prevent pollution in UK seas, and a number of land-based policies that affect sea water quality, including the UK Farm Waste Grant Scheme, the Nitrate Sensitive Areas Scheme, the Organic Farming Scheme and the Voluntary Initiative on Pesticides Use.

Table 5.3. **Potential benefits of marine spatial planning**

Ecological/environmental benefits	– Identification of biological and ecological important areas (hotspots) will inform the allocation of space (marine protected areas, MPAs) – Incorporation of biodiversity objectives into planning and decision making – Identification and reduction of conflicts between human use and nature – Ensures space for biodiversity and nature conservation – Establishes contact for planning a network of MPAs – Identification and reduction of the cumulative effects of human activities on marine ecosystems
Economic benefits	– Enhanced effectiveness of public and private financial and resource investment, and facilitation of economic growth – Greater certainty of access to desirable areas for new private sector investments – Identification of compatible uses within the same area for development – Identification and early resolution of conflicts between incompatible uses – Improved capacity to plan for new and changing human activities, including emerging technologies and their associated effects – Promotion of the efficient use of resources and space – Streamlining and transparency in permit and licensing procedures – Resolution of conflicts at planning level instead of individual project review – Enables government, industry and non-governmental organisations to work together to identify suitable locations for development and to identify areas where environmental values need to be protected and conservation should take precedence
Social benefits	– Improved opportunities for local community and citizen participation – Identification of effects of decisions on the allocation of ocean space (e.g. closure areas for certain uses, protected areas) on communities – Identification and improved protection of cultural heritage – Identification and preservation of social, cultural and spiritual values related to ocean use
Administrative benefits	– Improved consistency and compatibility of regulatory decisions – Improved information collection, storage and retrieval, access, and sharing – Improved integration and reduce duplication of effort and its associated waste of resources – Improved speed, quality, accountability and transparency of decision making – Reduction of transaction costs – the costs of information, regulation, planning and decision making

Sources: Ehler, C. (2008), "Conclusions: Benefits, lessons learned, and future challenges of marine spatial planning", https://doi.org/10.1016/j.marpol.2008.03.014; European Commission (2011), *Study on the Economic Effects of Maritime Spatial Planning: Legal and Socio-economic Studies in the Field of the Integrated Maritime Policy for the European Union*, http://dx.doi.org/10.2771/85535.

MPAs are one of many "interests" which will need to be integrated into any future system of MSP. MSP can provide a more comprehensive or holistic framework within which to address a range of spatial planning issues, and allows for the consideration of marine resource industries as having their own role within the region as a whole, rather than solely in relation to marine conservation. The MSP process can provide information on where pressures are greatest, where specific management is needed and where MPAs may best be placed. Both monetary and non-monetary (spatial) valuations have a role in MSP. Non-monetary values represented spatially provide a baseline by which to plan with multiple stakeholder groups. Proportional monetary values of different sites can provide a baseline against which the costs and benefits of MPAs can be measured to determine future MSP scenarios and an analysis of the trade-offs among planning options (Halpern et al., 2012; Rees et al., 2010). The development of an MSP can provide opportunities to expand the role and design of individual and networks of MPAs and clarify this role to other user groups. The potential benefits of MSP are summarised in Table 5.3.

Box 5.4. **Examples of economic, environmental and social benefits of marine spatial planning**

Economic, social and environmental benefits of marine spatial planning in Massachusetts, Rhode Island, the Great Barrier Reef Marine Park, Norway and Belgium

A study of five government-approved marine spatial plans (Massachusetts, Rhode Island, the Great Barrier Reef Marine Park, Norway and Belgium) demonstrated that marine spatial planning (MSP) resulted in multiple net benefits:

- Environmentally, MSP increased marine protection, ensured industrial uses avoided sensitive habitats, cut carbon emissions and reduced the risk of oil spills.
- Economically, each of the marine plans delivered on average USD 60 million in new economic value. In particular, the new offshore wind farms in Belgium (which were previously publically opposed due to blocked coastal views) are providing approximately USD 230 million in annual gross revenues. Each of the five plans also sought to retain the economic value from fishing and tourism, amounting to on average USD 260 million per year. Government spending on MSP was negligible.[1]
- Socially, MSP increased broad stakeholder engagement (thus improving the design and administration of plans), while building trust that will likely improve the sustainable future use of marine resources.

Note: 1. Generally, governments used existing staff. Slightly more money was spent on research and stakeholder engagement, but this was thought to be offset by a reduced risk of appeals and litigation, particularly in the United States (Blau and Green, 2015).

Source: Blau, J. and L. Green (2015), "Assessing the impact of a new approach to ocean management: Evidence to date from five ocean plans", https://doi.org/10.1016/j.marpol.2015.02.004.

As marine spatial planning is intended to focus on long-term management of marine areas, it is not a one-time plan; it is a continuing, iterative process that learns and adapts to changes over time through an ongoing cycle of applied research, stakeholder participation, plan making/adjustments, implementation, monitoring and evaluation (Ehler and Douvere, 2009). For example, there may be limited information on habitat and species, and it may be necessary to adapt MSP to accommodate new information that becomes available. Likewise, new technologies may allow industry to carry out activities without having a detrimental impact on the integrity of MPAs or their features, by demonstrating negligible impact of any short-, medium-, long-term, cumulative or in-combination effects (Gubbay, 2004). It may also be necessary to adapt MSP and MPAs to respond to the likely impacts of climate change, as new markets emerge, and as social preferences change. Norway provides a good example of MSP in practice (Box 5.5).

Box 5.5. **Marine spatial planning: The case of Norway**

Norway provides an example that has successfully integrated all major economic activities – oil and gas development, fisheries, and marine transport, together with nature conservation, in its marine spatial planning (MSP) activities for the Barents Sea (Ehler and Ocean Visions, 2014).

In 2003, a government-appointed inter-ministerial steering group chaired by the Ministry of Climate and Environment and with representatives of relevant ministries initiated work on an integrated marine management plan for the Barents Sea. One of the major issues in the Barents Sea was the potential expansion of oil and gas activities into areas used by fisheries and living marine resources. The development of the plan (completed in 2006, updated in 2010-11) included an evaluation of the cumulative effects of development up to 2020 and followed a four-phase process:

1. Evaluation of the current marine environment. Status reports were prepared by governmental management and research institutions or by consultants, covering the state of the marine environment, the coastal zone, fisheries, aquaculture – especially valuable and vulnerable areas (for biodiversity and for biological production), oil and gas, and shipping. The initial reports uncovered major gaps in current knowledge. Therefore, a key principle of the planning process was to use caution in the face of uncertainty. The plan also had to be adaptive to allow the evaluation of new knowledge as it became available.
2. Analysis of environmental impacts. Reports of marine activities *ex post* and *ex ante*. Four extensive government-funded environmental impact assessments were carried out, covering the impact of fisheries, shipping, hydrocarbon extraction and external pressures (e.g. pollution) on the environment, resources and local communities. Impacts were assessed relative to a base year (2003) and relative to expected future impacts up to 2020, with uncertainty increasing over time.

Box 5.5. **Marine spatial planning: The case of Norway** (*continued*)

3. Analysis of the cumulative impacts and management goals. This included an analysis of: 1) the total impact of all human activities combined, both for the current situation and up to 2020; 2) the area conflicts among human activities, and between human use and ecologically valuable areas; 3) the definition of management goals required for implementation; and 4) identification of gaps in current knowledge.
4. Environmental quality objectives and progress monitoring. Operational environmental quality objectives were developed based on the management goals. These covered climate, ice edge, phytoplankton, zooplankton, commercial fish species, non-commercial fish species, benthic organisms, marine mammals, seabirds, alien species, threatened and vulnerable species, and pollutants. Progress toward the objectives is monitored annually.

Since the management plan was presented in 2006, additional research has focused on mapping of the seabed, seabird populations and the geology of the area. Furthermore, the knowledge base on the impacts, scale and pace of climate change and ocean acidification has been strengthened. MSP is at the core of the plan, identifying particularly valuable and vulnerable areas, either from ecological and/or human perspectives. Within the plan, access to specific areas for human activities is carefully managed, for example, by moving shipping lanes outside Norwegian territorial waters (12 nautical miles), limiting trawling in sensitive areas, not opening most particularly valuable and vulnerable areas to petroleum activities, including the ice edge, and extending marine protected areas and fishery closure areas to protect spawning aggregations, fish eggs and larvae, and juvenile fish and shellfish.

The main management challenges identified in the 2010-11 update of the Integrated Management Plan for the Marine Environment of the Barents Sea-Lofoten Area are related to long-range transboundary pollution, climate change and ocean acidification, the decline in seabird populations, the risk of acute oil pollution, and further development of the different elements of an ecosystem-based management regime.

A central concept of the plan is that it is based on the best available scientific information and takes a precautionary approach, implying a need for revision as new knowledge becomes available. The plan represents a synergy of previously separate management regimes: management of fisheries, shipping and the hydrocarbon industry are brought together under one umbrella to co-ordinate efforts and to achieve a healthy ecosystem. One of the shortcomings of the Barents Sea planning process was its lack of consultation with the Saami parliament.

Similar management plans have now been established for all Norwegian sea areas. An important feature of the management plan system is that relevant agencies and key research institutions co-operate in drawing up the scientific basis and carry out cross-sector assessments for the plans. Numerous sector representatives with very different interests and goals have worked together toward agreement in the end. Although demanding, the process of developing a coherent knowledge base has created better understanding, ownership and commitment across the sectors. The benefits of integrated marine management plans include:

Box 5.5. **Marine spatial planning: The case of Norway** (*continued*)

- moving away from a sectorial to an integrated holistic approach
- co-ordination and co-operation between different sectors
- addressing the cumulative impacts of various activities on the ecosystem
- managing and balancing multiple and sometimes conflicting objectives and competing interests
- enabling the identification and focus on critical issues.

Sources: Olsen, E. et al. (2016), "How integrated ocean governance in the Barents Sea was created by a drive for increased oil production", https://doi.org/10.1016/j.marpol.2015.12.005; Ehler, C.N. and Ocean Visions (2014), *Marine Spatial Planning in the Arctic: A First Step Toward Ecosystem-based Management*; Olsen, E. et al. (2007), "The Norwegian ecosystem-based management plan for the Barents Sea", https://doi.org/10.1093/icesjms/fsm005; Royal Norwegian Ministry of the Environment (2006), *Integrated Management of the Marine Environment of the Barents Sea and the Sea Areas off the Lofoten Islands*; Norwegian Ministry of Climate and Environment (2011), "First update of the integrated management plan for the marine environment of the Barents Sea-Lofoten area", https://www.regjeringen.no/contentassets/d6743df219c74ea198e50d9778720e5a/en-gb/pdfs/stm201420150020000engpdfs.pdf.

Marine protected areas and other instruments

Beyond the strong links between MPAs and MSP, other key instruments to complement MPAs include catch regulations (to control for overfishing) and water pollution control measures (to address poor water quality).

Catch regulations

A key area for co-operation is between MPAs and other policy instruments for fisheries management. The principal direct benefit to fisheries from no-take MPAs is the potential to restore, safeguard, sustain and enhance some of the fish stocks on which the industry depends (Halpern, Lester and Kellner, 2010). This in turn can increase fishery profit if the MPAs are strategically placed and managed (Rassweiler, Costello and Siegel, 2012; White et al., 2008). However, MPAs alone are commonly not a comprehensive solution for the recovery of depleted fisheries and need to be coupled with other efforts to reform the fishery itself (Barner et al., 2015) (Box 5.6).

Combining MPAs with properly designed rights-based fisheries management strategies (Wilen, Cancino and Uchida, 2012; Hilborn, Micheli and De Leo, 2006) has the potential to optimise both conservation and fishing goals (Barner et al., 2015; Yamazaki et al., 2015; Sala et al., 2013; Costello and Kaffine, 2010). For example, individually transferable quota (ITQs) and territorial rights have shown success in preventing fisheries collapse (Costello, Gaines and Lynham, 2008), improving compliance with catch limits (Grimm et al., 2012), stabilising catches (Essington, 2009) and reversing some of the damage of overfishing (Chu, 2009). Modelling by Little et al. (2011) of the effects of MPAs coupled with ITQs for managing the coral reef fin fisheries of the Great Barrier Reef demonstrated that total allowable catches (TACs) could be marginally lowered and result in increased biomass and economic returns if the no-take area is large. Conversely, the no-take area could be marginally increased with little effect on economic returns, if the no-take area is small or non-existent. And net financial returns tended to be lower in the absence of ITQs. Such results demonstrate that integration of no-take MPAs with rights-based catch shares can promote both marine conservation and economically sustainable fish harvests.

Box 5.6. **The need for effective management beyond the boundaries of marine protected areas in the Medes Islands, Spain**

The Medes Islands, situated in the heart of the Costa Brava, Catalonia, Spain, constitute one of the principal marine protected areas (MPAs) in the western Mediterranean and an important source of income (i.e. scuba diving represents up to 70% of gross domestic product for some villages). Protection of the marine area dates back to a decree of 1983, which prohibits fisheries and the extraction of live marine resources in a zone of 75 metres around the islands. This protection was extended in 1990 establishing the Marine Partial Nature Reserve which prohibits all forms of fishing and marine resources harvesting, and the possession of fishing gear. In 2010, the reserve was transformed into a much larger marine and terrestrial (coast, river mouth and mountain area) natural park allowing integrated regulation and protection of the area. Certain restricted traditional and recreational fishing activities are permitted within the natural park and buffer zone. The extension was important to improve the environmental status of the MPA, to enable integrated management, and to help lower the tourism pressure on the Medes by encouraging nature-based responsible tourism.

Outside the Medes Island MPA there are several pressures affecting biodiversity and fishery production. While it is recognised that the MPA has met its objective of protecting vulnerable fish species and recovery populations to the level of its carrying capacity, this effect is not seen outside the strictly protected zone, which is likely due to illegal fishing practices in the buffer zone and the less restricted nature park. The cumulative effects of overfishing (and the problem of controlling and regulating fishing at a compatible level with the resource base), pollution, climate change and other stressors on the socio-economic system are causing: a reduction in the importance of the fishing sector as profits decrease, the extinction of traditional ways of fishing as a cultural heritage, and a possible loss of visitors due to an increase in jellyfish blooms or reduction in the quality of the touristic experience. These blooms also impact on the fishing industry as jellyfish are interacting with marine food-webs and interrupting some of the early stages of commercial fish species development by predation.

Sources: Sastre, S., B. Tomlinson and F. Maynou (2015), "Western Mediterranean Sea: The Catalan Sea", http://marine-vectors.eu/factsheets/FS-23-med-catalan.pdf; Arcadis, EUC and University of Bath (2012), *Economic assessment of policy measures for the implementation of the Marine Strategy Framework.*

There is evidence that co-operative fishery management has the potential to bridge the gap between MPAs and rights-based approaches (e.g. Ovando et al., 2013; Costello and Kaffine, 2010). From a global database of 67 co-operative fisheries (i.e. co-operation occurring between owners of territorial use rights in fisheries [TURFs]), 31% had set up private MPAs voluntarily as part of their management strategy. In addition, the study showed that fishery co-operatives often take actions directed toward co-ordinating harvest activities, adopting and enforcing restrictions on fishing methods and effort, and taking other direct conservation actions such as research support, changes in gear, by-catch avoidance and restocking (Ovando et al., 2013). For example, New Zealand's commercial Challenger Scallop Enhancement Company uses a system of rotating private MPAs to ensure the targeted scallop beds do not become depleted over time (Mincher, 2008).

A major concern focuses on the effects of fishing activity displaced from areas closed to fishing to alternative locations, particularly around the fringes of MPAs (Greenstreet, Fraser and Piet, 2008; Dinmore, 2003). Such displaced fishing activity may have unintended consequences, perhaps even resulting in net losses for the marine ecosystem rather than gains (Greenstreet, Fraser and Piet, 2008). A lack of enforcement and a lack of any incentive for fishermen not to fish inside no-take MPAs can also threaten the effectiveness of the MPA (Yamazaki, Hoshino and Resosudarmo, 2015; Jones, 2006).

Indeed, several modelling studies show that MPA implementation may not improve overall stock abundance or increase harvest, unless catch is simultaneously reduced in the areas outside the MPA (Van Wynsberge et al., 2013; Greenstreet, Fraser and Piet, 2008; Hilborn, Micheli and De Leo, 2006). For example, in a study modelling the effects of fishing effort displacement in the North Sea, fishing effort increased regionally, resulting in increased benthic invertebrate fishing mortality at the North Sea regional scale to compensate for landings normally taken in the MPAs. When TACs were reduced by amounts equivalent to the landings normally taken from the MPAs, then substantial reduction in North Sea regional-scale fish, benthic and invertebrate mortality was achieved (Greenstreet, Fraser and Piet, 2008). Therefore, no-take MPAs combined with appropriate catch limitation measures outside the MPA boundaries may be much more effective in achieving ecological objectives within a marine area.

Water pollution control measures

Marine water quality will undoubtedly play a role in the success of MPAs. Achieving more successful MPA networks will require an understanding of the magnitude and distribution of anthropogenic pollution pressures and their spatially oriented implications for MPAs (Partelow, von Wehrden and Horn, 2015).

Many pollution sources originate on land and flow into marine ecosystems through terrestrial watersheds, wetlands, through airborne particles (Partelow, von Wehrden and Horn, 2015), and from marine output sources (such as oil spills; ballast water; discharges from aquaculture; dredging; and littering, noise and artificial lighting[2]). However, MPAs are not necessarily protected from pollution that occurs outside of their boundaries, even if they have special measures in place, because the dynamic, fluid nature of the marine environment makes it difficult, if not impossible, to prevent pollution from crossing MPA boundaries (Delpeche-Ellmann and Soomere, 2013; Jameson, Tupper and Ridley, 2002; Boersma and Parrish, 1999). Therefore, protection of the marine environment at large scales is necessary, and may even be required across country boundaries (transboundary co-operation and co-management) because ocean circulation and airborne pollutants often exceed the influence of any one nation or group of nations.

When MPAs are located along coastlines, within shipping lanes and near human centres of activity, the chance of chemical and biological pollution is high (Boersma and Parrish, 1999). Degraded water and sediment quality results in impacts to marine life, including undesirable changes to community structure and function (Hughes et al., 2010; California Master Plan Science Advisory Team, 2008). It also reduces the resiliency of MPAs to moderate disease (Lamb et al., 2016), outbreaks of invasive alien species (McCulloch et al., 2003) and the effects of climate change (McCulloch et al., 2003).

Examples of water pollution-related challenges associated with MPAs include the following:

- Eklöf et al. (2009) suggested that improved seagrass recruitment and growth could be better protected in Kenyan MPAs if nutrient enrichment from land runoff were controlled.
- Community distributions of coral reef fish in the Nha Trang Bay MPA of South-Central Viet Nam were influenced from polluted rivers (Van Nguyen and Kim Phan, 2007).
- Local pollution is likely to have impacted recovery of seahorses in MPAs in the central Philippines (Yasue, Nellas and Vincent, 2012).
- Pollution from land runoff of sediment and nutrients has been linked to the loss of coral cover and decline in the general reef health of the Great Barrier Reef, Australia (Brodie and Waterhouse, 2012; Hughes et al., 2010; McCulloch et al., 2003).
- The historic use of polychlorinated biphenyls in Italy have been traced in the sediment of the Miramare MPA, which is in close proximity to industrial and port activities (Pozo et al., 2009).

- Localised hotspots of chronic metal pollution in areas influenced by industrial facilities, desalination plants and oil refineries have been reported in the Arabian Gulf (Naser, 2013; 2011).
- MPAs in close proximity to highly urbanised areas along California's coast are subject to elevated concentrations of polycyclic aromatic hydrocarbons, chromium and copper (Schiff, Luk and Gregorio, 2015).

The predominantly land-based pollution sources affecting MPAs have the potential to be mitigated through ICZM spatial planning and enforcement (Partelow, von Wehrden and Horn, 2015). The Great Barrier Reef Water Quality Protection Plan is an example where combined marine and terrestrial spatial conservation planning is being utilised to better manage the impacts of pollution to the Great Barrier Reef (Box 5.7).

Box 5.7. **Addressing water quality concerns in the Great Barrier Reef Marine Park, Queensland, Australia**

The Great Barrier Reef Marine Park (GBR) stretches 2 000 kilometres along the northeast coast of Australia. It was declared a World Heritage Area in 1981 and contains extensive areas of coral reef, seagrass meadows and fisheries resources. Despite the protected status, however, coral cover and seagrass meadows are both declining, in part due to agricultural runoff of sediments and nutrients, which have also been associated with crown-of-thorn starfish outbreaks (invasive alien species that cause decline in coral cover). Other factors attributed to the decline in coral cover include coral bleaching, ocean acidification and increasing intensity of extreme events associated with climate change, and coral diseases.

Agricultural activity, which comprises more than 80% of the Great Barrier Reef catchments, is recognised as the major cause of poor water quality (sediments, nutrients and pesticides) in the GBR. In response to the concerns of pollution of the GBR from agricultural runoff (first identified by the Great Barrier Reef Marine Park Authority as a critical issue in the 1990s), four policy measures have been implemented by the Australian and Queensland governments:

1. The Reef Water Quality Protection Plan in 2003 (updated 2009), is a whole-of-government programme addressing the critical issue of declining water quality in the Great Barrier Reef. The aim of the plan is to ensure that by 2020 the quality of water entering the GBR from adjacent catchments has no detrimental impact on the health and resilience of the GBR. The plan outlines specific targets and actions to achieve this. The Paddock to Reef Monitoring, Modelling and Reporting Program gives responsibility to the Great Barrier Reef Marine Park Authority to measure and report on progress towards Reef Water Quality Protection Plan goals and target. Between 2008 and 2013, the Australian and Queensland governments invested AUD 375 million to reduce pollutant loads entering the reef lagoon. In June 2014, the governments committed a further AUD 375 million to implement the plan through to 2018.

Box 5.7. **Addressing water quality concerns in the Great Barrier Reef Marine Park, Queensland, Australia** (*continued*)

2. Reef Rescue, an incentive-based voluntary management initiative released in 2007 to increase the adoption of land management practices that reduce the runoff of nutrients, pesticides and sediments from agricultural land. The Australian government invested AUD 200 million for its implementation, including monitoring, research and partnerships, over five years.
3. The Great Barrier Reef Protection Amendment Act 2009 (also known as the Reef Protection Package), introduced by the Queensland government and regulated in 2010. The act includes regulations to sugarcane and cattle farming in particularly areas draining to the GBR. Requirements include farm environmental risk management plans, sustainable fertiliser management (calculation of fertiliser rates), erosion control (maintain pasture cover) and pesticide management (calculation of pesticide rates and establishment of riparian buffer strips).
4. The Reef 2050 Long-Term Sustainability Plan, released in 2015 and currently under public consultation. The plan, developed by the Australian and Queensland governments with input from scientists, communities, traditional owners, industry and non-governmental organisations, has the vision to "ensure the Great Barrier Reef continues to improve on its outstanding universal value every decade between now and 2050 to be a natural wonder for each successive generation to come". The plan identifies threats, policy measures, actions, targets, objectives and outcomes to improve water quality, ecosystem health, biodiversity, indigenous and non-indigenous heritage, community benefits, economic benefits and governance of the GBR. The plan specifically addresses not only immediate threats, such as diffuse pollution from agriculture, but also the need to mitigate and adapt to the long-term impacts of climate change. A committee structure, investment plan, partnership, and comprehensive, integrated monitoring, reporting and review processes have been established to support the plan. Government investment in the GBR over the next ten years is projected to be more than AUD 2 billion.

A number of indicators are monitored by the Queensland Government (2015), including land and catchment indicators for each of the 35 catchments draining to the Great Barrier Reef, and marine indicators – both chemical and biological:

- the area of land in each catchment managed using best practice systems
- riparian vegetation, ground cover and wetlands, all of which are important to help reduce pollutant flow to waterways and prevent erosion
- the catchment pollutant loads of sediment, nutrients and pesticides (estimated by modelling)
- remote sensed marine water quality – chlorophyll *a* (indicator of nutrient availability and productivity) and total suspended solids (indicator of particulate matter in water)
- seagrass monitoring – abundance (percentage cover and change in cover), reproduction (indicator of the potential of seagrass meadows to recover from disturbances) and nutrient status (indicator of the response of seagrass to nutrient conditions in the surrounding waters)

Box 5.7. **Addressing water quality concerns in the Great Barrier Reef Marine Park, Queensland, Australia** (*continued*)

- seagrass monitoring – abundance (percentage cover and change in cover), reproduction (indicator of the potential of seagrass meadows to recover from disturbances) and nutrient status (indicator of the response of seagrass to nutrient conditions in the surrounding waters)
- coral monitoring – percentage cover (indicator of the capacity of coral to persist under the current environmental conditions and its potential to recover), coral change (indicator of coral resilience to disturbance), macroalgal cover (indicator of poor water quality and negatively affects the resilience of coral communities) and coral juvenile density (indicator recovery potential form disturbances).

For the first time, in 2011, the Great Barrier Reef Marine Park Authority (2014) demonstrated pollutant loads in catchment run-off could be reduced through an improvement in farm management practices. However, water quality and ecosystem functions both remain in poor condition and it may be decades before improvements are seen. Improving water quality remains a "no regret" action to protect coral cover, reduce outbreaks of crown-of-thorns starfish and improve marine biodiversity. The implementation of the Reef 2050 Long-term Sustainability Plan is intended to further assist in addressing the issues related to water quality.

Sources: Australian Government and Queensland Government (2015), *Reef 2050 Long-Term Sustainability Plan*, www.environment.gov.au/marine/gbr/publications/reef-2050-long-term-sustainability-plan; Queensland Government (2015), "Great Barrier Reef Report Card 2014: Reef Water Quality Protection Plan", www.reefplan.qld.gov.au/measuring-success/report-cards; Great Barrier Reef Marine Park Authority (2014), *Great Barrier Reef Marine Park Authority Annual Report 2013-14*, http://hdl.handle.net/11017/2885; Brodie, J.E. et al. (2012), "Terrestrial pollutant runoff to the Great Barrier Reef: An update of issues, priorities and management responses", http://dx.doi.org/10.1016/j.marpolbul.2011.12.012; Brodie, J. et al. (2008), "Scientific consensus statement on water quality in the Great Barrier Reef", www.reefplan.qld.gov.au/about/assets/scientific-consensus-statement-on-water-quality-in-the-gbr.pdf; Davis, J.B. (2002), "Managing water quality in MPAs: How practitioners are handling the challenges", www.spcsrp.org/sites/default/files/csrp/ressouces_documentaires/MPA27.pdf.

Key policy considerations around the management of water quality in MPAs include upscaling the spatial coverage of MPA implementation, including the provision of buffer zones; the development of more integrated networks with integrated land, coastal and marine management; and support for developing the institutional capacity necessary for informed policy mix design, communication, monitoring and enforcement (Partelow, von Wehrden and Horn, 2015). MPA and water quality monitoring efforts (which frequently use the same methods) should be co-ordinated and collaborative in nature in order to leverage and stretch finite monetary resources while developing the best information possible (California Master Plan Science Advisory Team, 2008).

Although it is possible to promote the recovery of marine biodiversity through the establishment of MPAs and a reduction/elimination of fishing pressures, these interventions alone cannot protect marine biodiversity from the additional impacts of pollution (water, sediment, light and noise), the introduction of invasive alien species, and ocean warming and acidification from climate change. Efforts to address all of these pressures simultaneously, through a policy mix, need to be intensified in order to improve the effectiveness and resiliency of MPAs in achieving their intended objectives.

Notes

1. The framework of Schröter-Schlaack and Ring (2011) was designed for effective forest management but the framework and the messages are equally applicable to marine biodiversity and the sustainable use of marine resources.
2. Davies et al. (2015) show that light pollution is increasing across the world's MPAs. Night-time lighting from cruise ships, oil rigs and coastal developments is altering the composition of marine epifaunal communities, such as such as squid and zooplankton, which are guided by natural light patterns. Suggested prevention measures include avoiding blue lighting (which penetrates deeper in seawater) to minimise ecological impacts and establishing "marine dark sky parks", similar to what the International Dark-Sky Association has done for terrestrial parks.

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