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 km²), 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.

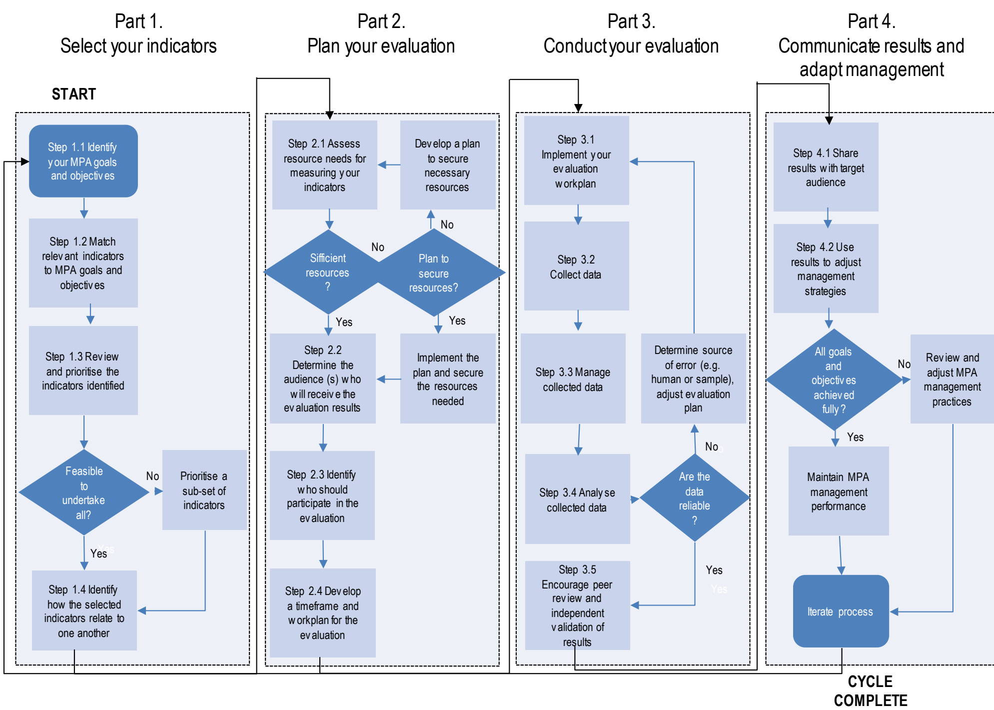
Monitoring to assess effectiveness

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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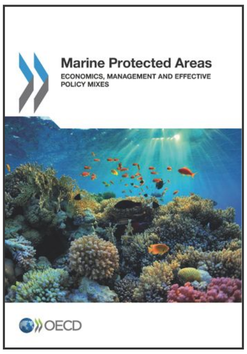

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