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 km² to more than 360 000 km²; 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 (km²)	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 (km²)	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 (km^2)	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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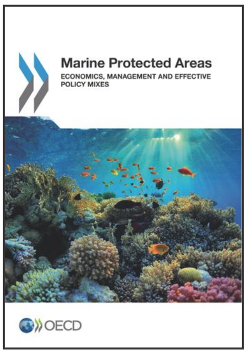
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