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Socio-Economic Benefits of the EU Marine Protected Areas

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Executive Summary

European Marine Protected Areas (MPAs), including the EU marine Natura 2000 network and areas protected under other regional or national legislation, covered 7,725 sites and an area of 338,623 km^2, i.e. 5.9% of the EU waters in 2012[1]. Almost 70% of these MPAs (228,000 km^2) are included in the Natura 2000 network. While the coverage of MPAs in the EU has been increasing over time, especially during the past 10 years, the marine network is still considered far from complete.

MPAs play a key role in the protection of marine biodiversity and ecosystems. As with terrestrial protected areas, this is the principal objective of their establishment. As European experience in managing MPAs is increasing, it is becoming more and more evident that MPAs also provide benefits beyond biodiversity conservation. They can help to maintain and improve the provision of a wide range of ecosystem services and related socio-economic benefits provided by coastal and marine ecosystems. This realisation is supported by emerging data from existing sites that have now been in place long enough to assess their effects.

This report collects, systematises and discusses the available evidence on the socio-economic benefits provided by the protection of European coastal areas and seascapes. The focus is on benefits associated with MPAs. However, when such information is not available, the report draws from studies documenting benefits associated with protection or restoration of coastal and marine ecosystems in general, considering this as indirect evidence for MPAs.

The report explores a wide range of different benefits that are outlined below.

Food provisioning: The EU fishing fleet generates over €6.7 billion in revenue and €3.4 billion in gross value added per year, providing €2.1 billion in wages (European Commission, 2016; 2013 data). It employs over 5.4 million people per year across the EU (Scientific, Technical and Economic Committee for Fisheries (STECF), 2015). According to the European Red List, 425 marine fish species are impacted by fishing

[1] European Environment Agency (2015a), based on the last available data from 2012.

activities, 58 of which are listed as threatened. Many of these affected species are the direct target of commercial fisheries and/or small scale artisanal fisheries. While overexploitation in European waters has diminished, it still remains a major problem for many marine fish species. For example, Atlantic Salmon (*Salmo salar*) is assessed regionally as in serious decline, and Atlantic Halibut (*Hippoglossus hippoglossus*) is assessed regionally as vulnerable[2] (Nieto et al., 2015). Furthermore, many ecosystems that commercially-targeted stocks depend on are exposed to high pressures from human activities, including fishing, coastal development and point source pollution. MPAs can provide direct or indirect protection to fish stocks targeted by commercial or artisanal means, depending on the scope of the MPAs, the specific conservation measures that are applied and how well these are enforced. In particular, imposing explicit restrictions on fishing or different fishing gear has been proven to have significant positive effects on the conservation of species, especially in cases where all industrial-scale fishing has been prohibited. Notable effects include, for example, higher biomass of large fish with higher reproductive potential within the MPA, production of larvae with higher survival rate and spillover of adult fish to nearby fishing grounds. These effects may compensate parts of the compromised fishing opportunities for some fishermen. Nevertheless, such "no-take MPAs" cover less than 0.5% of European waters and are often controversial due to their relatively high level of coercion on the fishing sector. Instead, European MPAs – Natura 2000 sites included – are generally "multi-use" MPAs. The effects of the network of European multi-use MPAs on fish stocks are less understood. In one of the few studies exploring this issue, Moland et al. (2012) show that population density and body size of Atlantic cod have increased in MPAs outside the Norwegian Skagerrak coast established in 2006, despite cod fishing being restricted to only certain types of gear. By 2010, cod inside the MPA were on average 5 cm longer than in any of the control areas. Imposing restrictions on certain fishing gear within MPAs, accompanied by different zoning schemes, could help to reconcile socio-economic and conservation objectives with MPAs.

Climate change mitigation: Marine and coastal ecosystems and species, such as saltmarshes and seagrasses, are important carbon sinks. While a limited number of

[2] For 21% of the assessed European species (204 species) no information is available to assess their risk of extinction.

studies on MPAs in the context of climate change mitigation is available, it is clear that MPAs can contribute to the protection and restoration of these ecosystems and species, thereby contributing to climate change mitigation. At the global level, marine organisms absorb around 55% of all carbon that is captured via photosynthesis (Nellemann et al., 2009). Different estimates are available on the storage capacity of marine ecosystems. Globally, the carbon stored in salt marshes and seagrass beds has been calculated at 5–87 Tg C[3] and 48–112 Tg C per year respectively (McLeod et al., 2011). The yearly amount of carbon stored per hectare has been estimated at 0.18 – 17.3 tonnes for salt marshes and 0.56 – 1.82 tonnes for seagrasses (Nellemann et al., 2009). In Europe, *Posidonia oceanica* meadows in the Mediterranean Sea store about 2 Tg of carbon per year. However, primarily due to infrastructure development and other human activities, these marine and coastal ecosystems are being degraded, undermining their role as sinks and instead becoming sources of carbon dioxide emissions. The degradation of tidal marshes, mangroves and seagrasses at the global level causes an average annual release of 0.45 Pg[4] CO_2, i.e. emissions at about the same magnitude as the annual fossil fuel emissions of the UK (Pendleton et al., 2012).

Nature-based tourism and recreation: Coastal and marine nature-based tourism employs over 3.2 million people and generates €183 billion per year in gross value added in the European Union (half of which is in the Mediterranean) (Ecorys, Mrag and SPro, 2013). The designation of an MPA can translate into increased business opportunities for the tourism and recreation sector, as it has been shown to result in increased attractiveness of a specific site. Revenue gained from increased tourism could be used to finance the maintenance and monitoring of the protected area. However, an increased number of visitors can also have destructive impacts on coastal and marine ecosystems. This illustrates the importance of ensuring good management of the protected area and that its establishment and objectives are well-founded and supported by the local coastal community. When this is achieved, an MPA can instead help to ensure that the environmental impacts of tourism and recreational activities on marine and coastal areas is kept within acceptable limits, thereby working to ensure

[3] 1 teragram (Tg) = =10^{12} grams
[4] 1 petagram (Pg) = 10^{15} grams

both environmental protection and the long-term sustainability of the European coastal tourism sector.

Coastal security: Seagrass beds, mudflats, saltmarshes and biogenic reefs[5] can stabilise sediments and reduce erosion, thereby mitigating the impact of tidal surges, storms, waves and floods. These natural defence mechanisms provide important benefits to coastal populations, natural landscapes and infrastructure and will be increasingly important in contributing to climate change adaptation. For example, Junta de Andalucía (2014) has estimated that the destruction of all *Posidonia oceanica* meadows in southern Spain would, hypothetically, result in a cost of €96 million due to the need to build alternative coastal protection infrastructure and regenerate coastal areas. In another example, Beaumont et al. (2010) calculated the value of UK coastal ecosystems in terms of coastal defence at between £21 and £42 billion, as an attribute of the costs avoided for replacing natural protective barriers with man-made structures. While a limited number of studies on MPAs in the context of coastal security is available, it is clear that MPAs can play a key role in ensuring the protection and restoration of the species and ecosystems improving coastal security.

Opportunities for blue-biotech, bioprospecting and research: While marine species and ecosystems in the EU seas are still relatively poorly understood, existing data indicates that both the biological and genetic diversity is rich. Consequently, as the interest in bioprospecting for different materials and substances at sea continues to increase, the EU seas provide vast opportunities for a wide range of sectors, including, for example, alginate extraction for the food and textile industry, the production of biofuels using algae and the preparation of medicines based on marine species. The establishment and good management of MPAs can help support this expanding market in a sustainable way, by providing platforms for innovation while also ensuring sufficient consideration and protection of marine biodiversity. For example, at Kosterhavet marine Natura 2000 areas in Sweden, pioneering research is taking place in developing sustainable industrial production of macro algae with a range of different applications (see Annex). By imposing restrictions on development, extraction and exploitation in certain areas, MPAs can also help to ensure that the impacts of the

[5] Biogenic reefs are biological structures created by species like oysters or blue mussels.

rapidly emerging blue-biotech sector on potentially fragile marine ecosystems is minimised, thereby ensuring their long-term resilience.

Broader socio-economic benefits: By contributing to the protection of marine and coastal ecosystems, well-managed MPAs can support or improve opportunities for cultural, spiritual, educational and recreational activities. They can also generate or support value-creation more broadly in the local economy. For example, MPAs in southern Europe generate an estimated €640,000 per MPA in income to industries that provide services to non-resident recreational users (Roncin et al., 2008). MPAs can also offer improved opportunities for research and education by ensuring long-term conservation of marine species and ecosystems.

The non-use value of MPAs: In addition to the direct benefits listed above, the protection of marine ecosystems can also be valued by coastal communities and others as a way of ensuring *future* fishing opportunities, educational or aesthetic experiences – i.e. option values. In addition, non-users may assign a value to the conservation of marine areas, regardless of whether they intend to use them in the future or not, as the mere existence of these areas is valuable to them.

By maintaining and enhancing the wide range of benefits provided by marine ecosystems in the long term, designation and good management of MPAs can improve not only livelihood opportunities and income for different categories of stakeholders, but also provide other less tangible benefits linked to the sense of importance of marine and coastal ecosystems to wider society.

Some of the benefits provided by MPAs are more understood and studied than others, but in general the information available on the socio-economic benefits of EU MPAs remains limited. For the EU to pursue these benefits in the future, it is important to continue to improve the evidence base and fill the information gaps. Further investment in research is important, as is improved multidisciplinary collaboration among different categories of experts, including biologists, ecologists, economists, sociologists and statisticians, in order to pursue an ecosystem-based approach to designation and management of EU MPAs. Importantly, this collaboration will have to also include local stakeholders and communities with practical insight and understanding of local social and political conditions.

Exploring socio-economic benefits of MPAs in more detail can support the future designation of MPAs and illustrate cases where overall benefits of designation outweigh the potential losses imposed on certain stakeholders or developments. Better understanding of these different benefits can also improve the management of existing MPAs, the development of future policy related to marine conservation and/or management strategies in this field, and support awareness-raising activities. Importantly, this can help with buy-in of different stakeholder groups, particularly of those opposing MPAs purely on the grounds of potential costs (e.g. potential restrictions on income opportunities). Finally, an increased understanding of the benefits associated with MPAs can promote actions that simultaneously improve conservation and socio-economic benefits, thereby increasing the political and social support to MPAs, or even facilitating the establishment of innovative financing programmes like Payment for Ecosystem Services.

The existing evidence, while incomplete, clearly indicates that MPAs can contribute to the development of a sustainable blue-green economy in Europe, where the long-term sustainability of marine ecosystems, as well as the associated livelihood opportunities and wellbeing of different stakeholders are ensured. This further illustrates the importance of MPAs as a tool to achieve existing EU policy, such as the Marine Strategy Framework Directive. Understanding the socio-economic benefits of MPAs can also assist the ongoing development of marine spatial planning and integrated coastal management in Europe and help illustrate that the value of protecting ecologically important marine and coastal areas goes beyond that of biodiversity conservation.

1 Introduction

A growing number of Marine Protected Areas (MPAs) (see Box 1.1) are being established in Europe. The EU network of MPAs currently includes 7,725 sites covering 5.9% of EU waters[6], or a total area of 338,623 km^2[7]. Almost 70% of these MPAs (228,000 km^2) are included in the Natura 2000 network, established under the EU Habitats (92/43/EEC) and Birds (2009/147/EC, codified from 79/409/EEC) Directives, with the objective of protecting vulnerable species and habitats of EU-wide importance. Other European MPAs are designated under the regional sea conventions, i.e. the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), the Baltic Marine Environment Protection Commission (HELCOM), the Barcelona Convention for the Mediterranean Sea and the Bucharest Convention for the Black Sea. In addition, some EU states have national MPA networks, covering about 1.9% of the EU waters (European Environment Agency, 2015a).

Box 1.1 Definition of MPAs

There are a number of different definitions and classification systems for what constitutes an MPA. The most widely applied, and also the one referred to by the European Environment Agency (EEA), was established by the International Union for Conservation of Nature (IUCN). According to this definition, a protected area (including marine areas) is *"a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values"*[8].

It is important to note that the scope of the IUCN definition for MPAs is wider than the one established by the EU Birds and Habitats Directives and therefore the marine Natura 2000 network. The key conceptual difference is that the IUCN definition considers the maintenance of ecosystem services (e.g. food provisioning) and cultural values as (possible)

[6] The geographical coverage of MPAs is not evenly distributed, as which 51% of the covered area is in the north-east Atlantic Ocean, 34% in the Mediterranean Sea, 15% in the Baltic sea and 1% in the Black Sea.
[7] These figures and the ones in the following paragraph refer to the information reported by EU Member States to the EEA by the end of 2012.
[8] Dudley, N. (editor) (2008) Guidelines for Applying Protected Areas Management Categories. (IUCN), URL: https://portals.iucn.org/library/efiles/documents/PAPS-016.pdf).

explicit objectives of a protected area, whereas Natura 2000 sites focus on the conservation of rare and threatened and/or endemic species and habitats of EU-wide importance, with maintenance and enhancement of ecosystem services as co-benefits. Given its primary scope, Marine Natura 2000 sites also have limited importance as a tool targeting fish species of commercial importance*. Instead, the primary benefits to fisheries of the network of marine Natura 2000 sites mainly arise from providing protection for commercially targeted fish stocks inside an area that has been established with other primary conservation purpose in mind (see Chapter 2).

It is to be noted that the other EU policy related to MPAs has wider scope than the marine Natura 2000 network. The Marine Strategy Framework Directive (MSFD), for example, obliges EU Member States to include spatial protection measures in their measures taken to achieve good environmental status of their marine waters. "Spatial protection measures" include not only Natura 2000, but also marine protected areas under other international or regional agreements to which they are parties. The objective of "good environmental status" is determined by 11 different descriptors of the environmental quality of the marine environment, including eutrophication, pollution and underwater noise. The scope of the spatial protection measures required by MSFD is therefore closer to the IUCN definition than Natura 2000 is.

*A number of fish species with commercial interest are protected under the EU Habitats Directive Annex II. For these species, core areas of their habitat (designated as Sites of Community Importance) must be protected under the Natura 2000 network and managed in accordance with the ecological requirements of the species. These species include, for example, Atlantic salmon (only in fresh water) and Adriatic and Atlantic Sturgeon. Management of commercial fisheries is instead guided by the EU Common Fisheries Policy.

MPAs are important tools for the conservation of marine and coastal biodiversity, but they are also an example of the ecosystem-based management approach enshrined in current EU policy[9]. MPAs provide a range of co-benefits in the form of ecosystem services (i.e. direct and indirect contributions of ecosystems to human wellbeing). In fact, the establishment and good management of MPAs can improve the provision of regulating ecosystem services (e.g. carbon storage and mitigation of natural hazards) and cultural ecosystem services (support to recreational activities and tourism). They may also provide protection for commercially targeted fish stocks inside the protected area as well as a certain degree of

[9] See, e.g. the Marine Strategy Framework Directive (MSFD).

“spillover” of adult fish into nearby fishing grounds, thereby improving the food provisioning ecosystem services related to fishing. MPAs can also play an integral role in fostering and trialling novel ideas for future blue bioeconomy, for instance through bioprospecting.

Depending on their type of designation and conservation objectives, the primary aim of MPAs might be to protect specific vulnerable marine species and habitats or to maintain well-functioning ecosystems and related ecosystem services in a broader sense (see Box 1.1). However, the provision of socio-economic benefits is not the primary aim of establishing MPAs and assessments about which areas to protect are primarily driven by ecological consideration, particularly in the case of marine Natura 2000 sites. Similarly, specific conservation objectives and management measures of individual sites are designed on the basis of, and adapted to, relevant ecological data.

The collection and systematisation of information about the wider benefits provided by MPAs can nevertheless be important to boost support from different stakeholder groups for the designation and management of MPAs (e.g. guiding the choice of management measures). For example, the potential value provided by MPAs – especially in monetary terms – to local communities and the local economy can be important information for political and commercial stakeholders, leading to decisions with potential conservation and socio-economic “win-wins”.

Interest in the valuation of MPA benefits – monetary valuation in particular – in Europe is increasing. Monetary valuation can be useful in certain contexts and under certain circumstances. For example, it can help to argue in favour of establishing an MPA in a specific area by quantifying the related benefits in terms of protection from natural hazards (see Chapter 5), or facilitate the setting of tourist visitor fees with allocations of revenues for the management of the sites (see Chapter 4). However, it is important to be aware of the limitations of monetary evaluations of ecosystem services, both in terms of methodological challenges and data gaps (see Chapter 9).

The ecosystem services and related socio-economic benefits provided by the European marine environment remain poorly understood and unappreciated. For this reason, rather than a source of local and global benefits, MPAs are often perceived as primarily imposing costs or restrictions on communities and economies (Kettunen & ten Brink, 2013). This report provides an analytical synthesis of the ecosystem services and related socio-economic benefits associated with the conservation of marine and coastal ecosystems in Europe, with particular focus on the European MPAs and the EU marine Natura 2000 network. When information on MPAs is not available, the report draws from studies documenting benefits associated with protection or restoration of coastal and marine ecosystems in general, considering this as indirect evidence for MPAs. The report collects and systematises available evidence on benefits related to food provisioning (Chapter 2), climate change mitigation (Chapter 3), opportunities for nature-based tourism (Chapter 3), coastal security (Chapter 5), opportunities for blue-biotech and research activities (Chapter 6), broader socio-economic benefits (Chapter 7), and non-use values (Chapter 8). It also illustrates these benefits by means of the six case studies included in Annex 1.

2 Food provisioning

2.1 Role of MPAs in supporting food provisioning

When considering the role of EU marine Natura 2000 sites in supporting food provisioning (e.g. commercial and artisanal fishing), it should be understood that, from a legal perspective, the marine Natura 2000 network protects only the species and/or habitats listed in the Annexes of the Birds and Habitats Directives for which the respective site has been designated. In principle, marine Natura 2000 areas may also have an "umbrella effect" on other species and habitats within the borders of the site, although these are not formally protected. With few exceptions (see Box 1.1), there are no major commercially harvested marine species represented in the Annexes of the nature Directives. Consequently, such species are supported by marine Natura 2000 sites mainly indirectly, i.e. to the extent that they benefit from the umbrella effect or are dependent on a habitat or other species under protection and therefore benefit from their improved state.

Furthermore, MPAs in general (including non-Natura 2000 sites), are per definition, spatial protection measures that primarily protect benthic ecosystems as opposed to mobile species. Depending on what restrictions have been imposed on extractive activities within a particular MPA (e.g. fishing), populations of mobile species (e.g. commercially harvested species) may be supported by MPAs as long as that they reside within the MPA boundaries and thereby avoid being caught, either as primary catch or by-catch.

MPAs of various protection levels may therefore support human food provisioning to the extent that they are able to support the condition, fitness and/or resilience of populations of species targeted directly or indirectly[10] for human consumption. This can be characterised as support occurring inside versus effects occurring outside of a MPA (Lester et al., 2009; Buxton et al., 2014).

Effects occurring <u>inside an MPA</u> include – depending on what level and type of fishing is allowed – enabling individual specimens to grow older and larger and thereby contribute to the genetic resilience of the population thanks to their greater reproductive potential and ability to produce larvae with better survival rate (Howarth et al., 2011; Birkeland and

[10] E.g. to use them in animal feed.

Dayton, 2005). This can be important for reversing trends of severe population decline of commercial species where overfishing has led to stocks being dominated by immature fish. For example, according to data from the International Council for the Exploration of the Sea (ICES), 93% of cod in the North Sea are caught before reaching reproductive age (European Commission, 2009). Fernández-Chacón et al. (2015) have found that, in a partially protected marine area off the coast of Norway, the state of the local population of Atlantic cod improved over a period of eight years – the number of fish deaths due to fishing decreased, survival increased and movement to surrounding areas was stimulated. This partially protected area only allowed hook and line fishing and research sampling (which involve fixed nets that do not harm the fish, so they can be captured and released alive).

There are primarily two types of effects on areas outside an MPA. Firstly, an MPA that protects spawning grounds of targeted species may secure an undisturbed level of production of eggs and larvae that in turn may serve as recruitment to neighbouring fishing grounds (Harrison et al., 2012). At spawning grounds, adult fish are easier to catch and restricting fishing in these areas may therefore also be particularly effective in reducing fish mortality. Secondly, healthier stocks inside MPAs due to reduced fishing pressure, may result in spillover of adult fish into adjacent fishing grounds (Vandeperre et al., 2011).

These effects, within and outside MPAs, may benefit the local fishing sector and compensate, at least in part, for technical restrictions imposed on fishing or reduction of fishing opportunities due to the designation of an MPA.

In addition to these benefits for the commercial fishing sector, in cases where well-managed MPAs can achieve improvement in the condition of fish stocks, this can also benefit recreational fishing[11], an activity enjoyed by 8 million anglers in Europe (Hyder et al., 2014).

2.2 Synthesis of the existing evidence

Internationally, there is a significant body of literature illustrating empirical examples of the role of MPAs in supporting fisheries and human food provision, primarily from small-scale

[11] The opportunity for such benefits depends, for instance, on to what extent recreational fishing is allowed within the MPA. FAO (2012) defines recreational fishing as "fishing of aquatic animals (mainly fish) that do not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets."

tropical MPAs. A large share of the literature presents effects of marine reserves (or "no-take zones") in particular, i.e. areas which typically exclude all fishing and other activities that may be potentially harmful to the environment. Marine reserves are the strictest type of MPAs. Since marine Natura 2000 sites and other EU MPA designations are almost exclusively multi-use[12] areas where fishing and other activities are allowed to various degrees, global studies of marine reserves provide only limited evidence as regards the food provisioning-related benefits of the EU MPA network. While some EU Member States have introduced large no-take zones in distant waters (such as, for example, French reserves in Kermandec and French Polynesia; UK reserves around the Pitcairn Island), within the territorial waters of Europe, this level of protection is merely used for a few very small areas as parts of networks of activity zoning[13].

Empirical assessments of impacts of EU MPAs, and Natura 2000 in particular, on fish stocks – both inside and outside the protected areas – are scarce. This is potentially because of the relatively young age of many marine Natura 2000 sites. In addition, many marine Natura 2000 sites still lack management plans (or equivalent measures) detailing the site's conservation objectives and how to achieve them (European Commission, 2014a), which means that not enough rules have been put in place to be able to have a significant impact, nor to have any objectives to assess.

2.2.1 Evidence on impacts inside MPAs

In a recent international study, Edgar et al. (2014) performed a meta-analysis of 87 MPAs, demonstrating an exponential increase in conservation benefits to fish populations resulting from five key features of MPAs: no take, well enforced, old (>10 years), large (>100 km^2), and isolated by deep water or sand. The authors found no significant difference between areas not protected from fishing and MPAs featuring only one or two of these five determining features. However, positive effects of conservation to fish rose rapidly when the number of features increased from three to five. MPAs identified as being effective (i.e.

[12] Fishing and other activities are allowed, although certain restrictions might apply, such as permit requirements for infrastructure projects or prohibition of certain types of fishing gear.

[13] The WWF defines zoning in the context of protected areas: *Zoning is a management tool for spatial control of activities with defined activities permitted (sometimes with associated conditions) or prohibited from specified geographic areas* (Gubbay, 2005).

including four or five of the identified features) had twice as many large (>250 mm total length) fish species, five times more biomass of large fish, and 14 times more shark biomass, compared to fished areas.

The importance of the level of restrictions imposed as the key determinant of conservation outcomes is supported by evidence from the Mediterranean. Guidetti et al. (2014) have recently conducted a study of data from 30 MPAs of various protection levels in the Mediterranean. Similar to Edgar et al. (2014), the findings indicate a significantly higher fish biomass in no-take MPAs than in multi-use MPAs and open access areas, especially for high trophic species (predators and carnivores). The increase in total fish biomass was driven by increases in commercially valued species (both high and low values), while species without commercial value showed no significant difference in biomass between the three types of areas under study. This indicates that no-take MPAs can play a key role in the recovery of commercially targeted fish species. Fenberg et al. (2012) present a meta-analysis of 46 peer-reviewed studies of marine reserves (no-take areas) in the Mediterranean, finding significant mean increases in biomass (+238%), density (+116%), species richness (+13%) and organism size (+19%) for European no-take zones.

Existing studies further indicate that protection measures can have rapid positive effects on stocks relatively soon after they have been imposed. Noted as one of the most northern assessments of European MPAs, Moland et al. (2012) present effects on Atlantic cod and European lobster populations from MPAs established in 2006 outside the Norwegian Skagerrak coast. By 2010, the catch-per-unit-effort (CPUE) of lobster – which enjoyed full protection inside these MPAs – had increased by 245% inside the MPAs, compared to an 87% increase in control areas.[14] The mean size of individual lobsters had increased by 13% inside the MPAs. Interestingly, both population density and body size of cod had increased, although cod enjoyed merely partial protection within the MPAs. By 2010, cod inside the MPA were on average 5 cm longer than in any of the control areas. Gear restrictions were imposed with only hook and line fishing allowed in the protected areas, which resulted in reduced fishing pressure on cod which is otherwise caught in the area using a range of different techniques.

[14] Lobsters were fished within the MPAs and in control areas by the researchers using standard 'parlour' traps. The lobsters were measured and tagged immediately upon capture and released at the site of capture.

Beare et al. (2010) present an interesting historical review of unintended protection following fishing closures in the North Sea during World War II. Results from unintended protection can give an idea of the resilience of stocks, thereby providing useful knowledge for the designation of MPAs. Based on data between 1928 and 1958, the authors are able to demonstrate that these large closed areas were effective in supporting stocks of migratory commercial species, including cod and haddock, and that older fish benefited more and faster than juvenile. This data indicated that recruitment took a long time to respond despite the absence of fishing pressure. However, it should be noted that when studying the effects of the no-take area, Mona Island MPA in New Zealand, Mateos-Molina et al. (2014) found the opposite result on recruitment: following four years of protection, a significant increase of early life stages where found both inside and outside the MPA. This was primarily observed for small fish species, however, with less expected fishing pressure. Overall, species subject to high fishing mortality and species with low rates of movement relative to the size of the MPA, are expected to demonstrate a particularly strong response to protection measures (see e.g. McCook et al. 2010), dependent on natural stock and environmental variabilities.

2.2.2 Evidence on impacts outside MPAs

Most international studies on spillover of adult fish from marine reserves (no-take zones) to nearby fishing grounds show positive effects[15] (see e.g. Mateos-Molina et al. 2014; Halpern et al. 2010; Follesa et al., 2009).

Evidence of recruitment effects of larvae and eggs, however – both from no-take and multi-use MPAs – is very rare. This is because it is difficult to detect and measure due to the temporal variability of larval survival and settlement and the large areas where this occurs for many species (Goñi et al., 2010; Buxton et al., 2014). Box 2.1 summarises the results of a study that found higher abundance of juvenile scallops in a recently-established no-take marine reserve in the UK, potentially benefiting neighbouring fishing grounds.

[15] Lowe et al. (2003) do not find such effects, however, when studying the Catalina Marine Science Center Marine Life Reserve (CMLR) in California.

The net change of income for fishing communities or industry as a result of the establishment of MPAs (no-take or multi-use) is also poorly explored to date. The study published by Goñi et al. (2010) (see Box 2.2) is one of the first to empirically demonstrate a net spillover benefit. More similar studies are required, especially looking at long-term effects, in order to assess to what extent the loss of fishing activities due to restrictions imposed by an MPA, is compensated by an increase in specimen size and quantity of catches in nearby areas (Kerwath et al., 2013).

In general, the potential positive impact of MPAs – no-take zones and multi-use MPAs alike – on surrounding fisheries, depends on how they are managed. MPAs can be beneficial particularly in cases where a fishery has been previously mismanaged and stocks depleted (see e.g. Buxton et al., 2014).

Box 2.1 The recruitment effect of scallops in Lamlash Bay, Isle of Arran (UK)

Lamlash Bay (Isle of Arran, UK) was declared a fully protected marine reserve in 2008, which means that any kind of fishing is prohibited in the area. Even though the reserve is very recent, Howarth et al. (2011) argue that it may already have benefitted the scallop population in nearby fishing grounds. Dive surveys in the reserve have showed a greater abundance of juvenile scallops within the reserve compared to surrounding areas, due to the greater presence of macroalgae and maerl inside the reserve boundaries. This supports the idea that marine reserves can enhance the recruitment of commercially exploited species near the reserve in two ways. On the one hand, the greater amount of nursery habitats in the marine reserve substantially increased the settlement levels of commercial scallop species. On the other, the protection provided by the reserve allowed a greater number of individuals to reach larger and older sizes. Since the reserve is very young, both these improvements are likely to increase over time.

Source: Howarth et al. (2011).

Box 2.2 An empirical analysis of the spillover effect of lobster from the Columbrete Islands Marine Reserves (Spain)

A study by Goñi et al. (2010) quantified the number and biomass of lobsters spilling over from the Columbretes Islands no-take Marine Reserves (Spain), by using tag-recapture data for the *Palinurus elephas* lobster gathered between 1997 and 2007. In order to do so, individuals tagged inside the reserve and recaptured in the surrounding fisheries were used to track the origin of the lobsters harvested within 1,500 m from the boundary of the reserve. The authors show that harvested spillover offsets the loss of yield due to the reduction of fishing grounds. In fact, even if the number of lobsters spilling over do not compensate for the loss of fishing grounds in the reserve, the mean size of the lobsters emigrating from the reserve was larger than the size of those outside, resulting in a mean annual net benefit of 10% of the catch in weight. This study is the first attempt found in the literature to quantify the species-specific spillover from an MPA and its net contribution to local fishery catches.

Source: Goñi et al. (2010)

2.3 Discussing the existing evidence

The debate about the ability of MPAs to support mobile commercially targeted stocks of marine resources and adjacent fisheries has long been polarised. The main conflict has arisen between those arguing that MPAs can support sustainable fisheries and those arguing that recruitment and spillover effects of MPAs have not been sufficiently well documented empirically to justify imposing restrictions on economic activities. The latter position is often taken by commercial fishermen, although several studies suggest that a blanket assumption that all fishermen are categorically negative towards MPAs is false (see e.g. Yates 2014; Hattam et al. 2014; Pita et al. 2013; Katsanevakis et al., 2011; and Mangi and Austen 2008).

There is also an ongoing discussion about which aspects of the design of an MPA have the greatest impact on their conservation potential, including support to sustainable food provisioning. A number of studies explore the optimal size of individual MPAs as regards the effectiveness of the network overall – some arguing for a network of few large sites and others arguing for a network consisting of many smaller and connected sites (Claudet et al., 2008; Lester et al.,2009 and De Santo, 2013). Others discuss age as a factor defining MPA effectiveness, where most authors conclude that the longer the protection has been in place, the larger the ecological benefits (Vandeperre et al., 2011; García-Charton et al., 2008; Claudet et al., 2008). The most recent studies seem to conclude, however, that no one design factor is more important than another, but that effectiveness depends on a combination of factors adjusted to fit site conditions (see e.g. Edgar et al. 2014).

Perhaps the most controversial is the discussion about the level of restrictions required to achieve sufficient conservation effects. A number of authors, together with several international conservation organisations, argue that in order to secure long-term harvesting of wild fish, a large network of well-managed and ecologically connected no-take zones will have to be established (Russ et al. 2008; Roberts et al. 2005; Sala et al. 2002). The evidence identified in this report suggests that the stricter the restrictions imposed on fishing are, the larger the conservation or recovery related benefits for targeted fish stocks. The existing evidence also indicates that for certain species, a reduced level of fishing pressure and related fish mortality may also be achieved by using different fishing methods rather than banning fishing altogether. This could help to balance the social, economic and conservation trade-offs of MPAs in the context of food provisioning. Studies on the response of different stocks to different gear restrictions are scarce, however, and more research is needed to be able to integrate such insights into management activities, e.g. establishment of appropriate restrictions for different industrial activities, based on their actual impact on fish stocks (Pantzar, 2014; Fock, 2011). Another potential avenue for better balancing socio-economic and conservation objectives of MPAs and managing these difficult trade-offs could be to introduce different zoning systems within and around MPAs with varying levels of restrictions on fishing.

Ultimately, the effectiveness of any type of MPA in supporting conservation of marine resources, is dependent on a well-functioning management regime, including the establishment and enforcement of specific rules. Consultation and engagement with local stakeholders can help to identify the most suitable solutions.

It is finally important to acknowledge that the ability of MPAs to support food provisioning is also dependent on some indirect factors. All potential benefits that MPAs can provide to fisheries include an evident time gradient, as it may take certain species years, or even decades, to become successful breeders (Vandeperre et al., 2011). Even in well-managed MPAs, species and site-specific factors impact the effects of protection, including longevity, species interaction and exploitation levels prior to protection (Edgar et al. 2014). The types and levels of external stressors to the ecosystem will also have an effect, including for instance climate change impacts, such as warmer waters and acidification, and terrestrial sources of pollution and eutrophication (Jameson et al., 2002). Similarly, if surrounding fisheries are mismanaged, any spillover from an MPA will provide limited support to the fitness of fish stocks (Jessup and Power, 2011).

To conclude, the lack of existing evidence hinders drawing general, overarching conclusions on the food provisioning benefits of MPAs in European waters. With regards to existing sites, there is clear evidence of no-take MPAs providing, for example, increased production of fish larvae and fitness of adult specimen in different ecosystems and regions in Europe. Importantly, the existing studies also suggest that applying different zoning schemes within MPAs, accompanied by the application of different gear types, could help to reconcile socio-economic and conservation objectives. More research is needed, however, to understand the potential food provisioning benefits and the stock response to different gear types.

At this point, the existing evidence indicates that, while there is a potential for European MPAs to support food provisioning and fisheries, the main current benefits associated with the EU marine Natura 2000 network and other European MPAs – as they are currently established as multi-use sites – are primarily related to maintaining and enhancing other ecosystem services and broader socio-economic benefits (see below and following chapters). In order to have any significant effect on food provisioning, the evidence suggests that the European MPAs would need to impose stronger restrictions on extractive activities within their boundaries.

2.4 Link with other benefits

If in the future, European MPAs were to be established and/or managed with the aim to generate spillover to surrounding fisheries (as per outlined in Section 2.3), one could expect improved or more secure job opportunities for local fishermen. This would have clear links to broader socio-economic benefits, including the conservation of culture, identity and lifestyles of coastal communities (see Chapter 7). By allowing individual specimens of fish and other species to grow larger and older inside no-take marine reserves, divers and others interested in experiencing nature may be attracted to visit the site, which may thereby support alternative livelihoods in nature tourism for local communities (see Chapter 4). Depending on the statutes of individual sites, controlled levels of recreational fishing could be another source of tourism revenue for locals, as well as an opportunity for recreation for visitors. Recreational marine fishing is a common and highly valuable activity in Europe (Hyder et al. 2014). This opportunity could represent the primary alternative when trying to balance opportunities lost for commercial fishermen with nature conservation. Finally, well-managed MPAs – especially when accompanied with comprehensive restrictions on fishing – can be crucial for longer term food security in Europe as they can help to maintain and restore genetic diversity of marine resources. Stronger genetic resilience – both within populations and across ecosystems – can be an important factor for ensuring the longevity of species when facing different external pressures.

3 Climate change mitigation

3.1 Role of MPAs in supporting climate change mitigation

Marine and coastal ecosystems contain a large amount of carbon and act as carbon sinks in different ways. Only a few studies have explored the direct effects of MPAs on these climate regulatory services in the EU. Consequently, this chapter draws from the broader existing research on the nature and magnitude of climate-related services provided by protecting marine and coastal ecosystems. While the existing evidence exploring direct links with MPAs with climate change mitigation is limited, it can be argued that MPAs help to ensure good conservation status of these ecosystems and protect them from further degradation and thereby effectively contribute to maintaining their climate change mitigation services.

It has been estimated that oceans absorb around one third of the anthropogenic emissions of carbon from the atmosphere (Orr, 2001), and they store and circulate about 93% of the planet's carbon (Nellemann et al., 2009). For example, Takahashi et al.'s (2002) estimate of the global oceanic carbon rate of absorption, carried out on the basis of about 940,000 observations of surface-water concentration of CO_2, is at about 2.2Pg[16] C per year. The ocean zones between 40 and 60 degrees latitude in both southern and northern hemispheres (the latter comprising Europe) provide the largest contribution to this carbon sink mechanism. This is because in these areas, warm waters flowing towards the polar regions meet and mix with cold subpolar waters that are rich in nutrients.

Marine organisms absorb around 55% of all carbon that is captured via photosynthesis (Nellemann et al., 2009). Vegetated marine and coastal ecosystems such as saltmarshes, seagrasses and mangroves sequestrate and store a high share of this "blue carbon". Combined, those ecosystems cover approximately an area of 49 million hectares globally (The Blue Carbon Initiative, 2015). As an example, the carbon stored in marine and coastal seagrass at the global level has been estimated at between 4.2 and 19.9 Pg of organic carbon (Fourqurean et al., 2012). In Europe, *Posidonia oceanica* meadows, the most important carbon sink in the Mediterranean Sea, have been estimated to store 400 grams of

[16] 1 petagram (Pg) = 1,000,000,000 tonnes.

carbon per hectare per year (Gacia et al., 2002) - see Box 3.1 and the case-study on *Posidonia oceanica* meadows in the Annex of this report.

Even though vegetated coastal ecosystems only cover around 0.5% of the seabed, they contain more than 50% of the carbon contained in sea sediments. In Europe, the most important coastal blue carbon sinks are salt marshes and seagrass beds, with an estimated extent of 3 million hectares and about 1.5 to 4% of the total global blue carbon storage in coastal vegetated habitats[17] (Luisetti et al., 2013). For example, the net carbon sequestration in saltmarshes in East England has been estimated at between 0.94 and 1.15 tonnes of carbon per year (Adams et al., 2012). Compared to terrestrial ecosystems, the information on the role of coastal vegetated ecosystems in carbon capture and storage is limited, and despite their major role in the global carbon cycle, they are yet to receive similar attention as other important ecosystems, such as tropical rainforests.

Box 3.1 The role of *Posidonia oceanica* meadows as a carbon sink in Andalusia (Spain)

The carbon sequestration capacity of the Andalusian *Posidonia oceanica* meadows have recently been calculated to 31,531 CO_2 tonnes (8,592 tonnes of carbon) per year by multiplying the average CO_2 sequestration capacity of this species by its extension in the region. This amount represents 0.2% of the emission reduction target established within the Andalusian climate protection plan 2007-2012. The total carbon stock in Andalusian *Posidonia oceanica* meadows is about 24,730,185 tonnes of CO_2, i.e. about 34% of the total CO_2 emissions of the Andalusian region in 2012.

The authors also estimate the monetary value of the role of the *Posidonia oceanica* meadows as a carbon sink in Andalusia to €83,854,149 if traded in the voluntary carbon market, and €315,850,629 if traded in the Kyoto carbon market.

Posidonia oceanica meadows are currently in decline in Europe and therefore they are one of the key habitats protected by the marine Natura 2000 network.

Source: Díaz-Almela, E. (2014)

[17] Mangroves are not found in continental Europe.

3.2 Synthesis of the existing evidence

The information available on blue carbon varies significantly, depending on the type of plant, location and conditions. Estimates of the global coverage of seagrass beds vary between 0.12 million km^2 (Green and Short, 2003), 0.32 million km^2 (Siikamaki et al., 2013) and 0.6 million km^2 (Duarte and Chiscano, 1999). The coverage of salt marshes has been estimated to be 51,000 km^2 (of which 3,306 km^2 in Europe), although this aggregate estimate should be treated with caution given the lack of comprehensive data. Marbà and Duarte (2010) report that *Posidonia oceanica* covers an area of 50,000 km^2 in the Mediterranean Sea.

Estimates of the capacity of marine plants to store carbon also vary significantly. For example, the total global carbon (C) burial of salt marshes and seagrass beds has been estimated at 5–87 and 48–112 Tg C[18] per year, respectively (McLeod et al. 2011). The global carbon storage rate has been calculated to be 0.83 and 2.1 tonne C/ha per year for seagrass meadows and tidal salt marsh soils, respectively (Laffoley and Grimsditch, 2009). Nellemann et al. (2009) report values of 0.18 – 17.3 tonne C/ha per year for salt marshes and 0.56 to 1.82 tonne C/ha per year for seagrasses. Again, at EU level comprehensive data are missing. One of the few studies available estimates that the net carbon burial of the salt marshes in the Blackwater estuary (UK) is of 1.15 tC/ha per year (Luisetti et al., 2014).

The marine surface covered by seagrass meadows, mangroves and salt marshes is significantly smaller than the terrestrial area covered by forests, but in terms of long-term (millennial time scale) carbon sequestration the marine ecosystems are more efficient (Mcleod et al., 2011) (see Fig 1 – note the logarithmic scale; sequestration rates more than 10 times higher for marine ecosystems).

[18] teragram (Tg) = =10^{12} grams

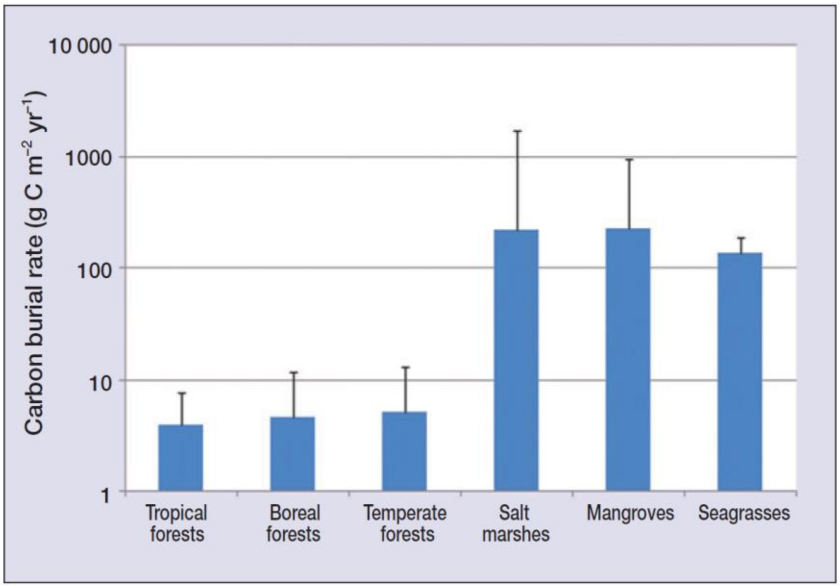

Figure 3.1 Carbon burial rate in different ecosystems

Source: Mcleod et al. (2011)

Pendleton et al. (2012) estimate that the degradation of tidal marshes, mangroves and seagrasses releases an average of 0.45 Pg CO_2 per year, which is roughly equivalent to the annual fossil fuel emissions of the United Kingdom. It should be noted that this value is an underestimate of the overall effects of ecosystem degradation on carbon storage as it only refers to the release of retained carbon, and does not take into account the loss of active carbon sequestration.

Given the fundamental role that marine species and ecosystems play in carbon sequestration and storage, the deterioration and lack of protection of these areas is directly resulting in the loss of carbon sequestration capacity in marine and coastal areas as well as release of stored carbon. For example, *Posidonia oceanica* meadows are currently in decline in Europe (see for example Marbà and Duarte, 2010; Marbà et al, 2014) and therefore they are one of the key habitats protected by the marine Natura 2000 network. Consequently, MPAs play a crucial role in ensuring the maintenance of these habitats and their important ecosystem functions for climate change mitigation. Estimates of the magnitude of blue carbon lost include both aggregated estimates and individual studies. Pendleton et al. (2012) estimate that 0.5 to 3% of the area covered by vegetated coastal ecosystems, like seagrass beds and mangroves, is lost each year. Fourqurean et al. (2012) calculate that since the beginning of the 20th century, seagrass has been lost at an annual rate of 1.5% globally, accelerating in recent decades. Waycott et al. (2009) have estimated a rate of decline at the global level of 7% annually for seagrasses from the early 1990s. In terms of carbon release, the degradation of tidal marshes, mangroves and seagrasses annually results in an average release of 0.45 Pg CO_2 (Pendleton et al. 2012). This value is only related to the release of retained carbon and does not take into account the carbon storage service loss. The loss of seagrass equates to a loss in carbon sequestration by seagrass ecosystems of 6 to 24 Tg C per year (Fourqurean et al., 2012).

The designation and successful management of MPAs can help to retain existing, and support additional, carbon storage by ensuring the protection and improvement of these ecosystems which play an important role in performing this key ecosystem service. Research on the role of MPAs in carbon storage and sequestration, while currently limited, is slowly increasing (Campbell, 2008). Global mechanisms to systematically protect the regulatory services of "blue carbon" sequestration (i.e. instruments similar to the REDD+ programme to protect forests) are not yet available, although they are being gradually introduced in some countries such as the US (Pendleton et al., 2013). Generally, it is acknowledged that the potential impact of MPAs on carbon sequestration is significant and that more research and analysis is needed (Fox et al., 2012).

The number of studies that have explored the economic value of carbon sequestration and storage in coastal and marine vegetated ecosystems, including the benefits of avoided degradation, is also very limited. Generally, these estimates vary widely, explained both by uncertainties about the amount of carbon stored and/or released, and by the lack of common value assigned to a unit of carbon[19].

A few examples do exist, however. Beaumont et al. (2014) have analysed the economic value of carbon storage and sequestration in coastal habitats in the UK. For a scenario with a decline of saltmarshes between year 2000 and 2060 from 47,683 ha to 41,369 ha, the

[19] Different methodologies can be used to give a monetary value to the carbon sequestered in biomass. One possible approach is to use the price in carbon markets, which however tends to fluctuate markedly and therefore is not a reliable benchmark. Other options, especially for flows of carbon, are based on estimates of marginal abatement costs (i.e. the cost of reducing carbon emissions, which is avoided by well-functioning ecosystems that are able to storage carbon in their biomass) or marginal damage costs (i.e. the avoided costs related to damages to buildings and infrastructure due e.g. increased extreme weather events caused by climate change).

authors estimate a loss of £179 million (€201 million[20]) discounted net present value, based on the marginal abatement cost for non-traded carbon. Luisetti et al. (2013) present a similar study on the loss of carbon storage and sequestration services of saltmarshes and seagrass beds in the EU-27 due to environmental degradation, using both marginal cost of abatement and marginal damage cost. They value the stock of carbon storage in currently existing saltmarshes in Europe at US$ 11.2 million and in currently existing seagrass beds at US$169.7 million. A report released in 2012 stated that MPAs in the UK produced climate regulation benefits of £8.2 billion (€12 million) in 2006 and £7.1 billion (€10.4 billion) in 2011 (González-Álvarez J., 2012).

3.3 Link with other benefits

The capacity of vegetated ecosystems to sequester and store carbon is linked to several other ecosystem services provided by seagrasses and marshlands. As vegetated structures, they play an important role in the stability and resilience of coastal zones. This is important for mitigating risks associated with storm surges, coastal flooding and erosion (see Chapter 5). Depending on the specific characteristics of the protected sites, ecosystems providing carbon sequestration can also support recreational uses or, in some cases, also benefit fisheries (see the case study on *Posidonia oceanica* meadows in the Annex, Chapter 2 and 4).

[20] This figure is obtained using the average exchange rate of 2009 (the year of the analysis), as reported by the Bank of England. All the figures in pounds in the remaining of this report are translated into euro using the exchange rate of the relevant year, as reported in the Bank of England database (http://www.bankofengland.co.uk).

4 Nature-based tourism

4.1 Marine protected areas and opportunities for nature-based tourism

Marine and coastal tourism is by far the largest sector of the European maritime economy, employing over 3.2 million people and generating €183 billion per year in gross value added (Ecorys, Mrag and Spro, 2013). The diverse and unique natural landscapes of European coastlines and sea basins attract European and international visitors, especially during the summer months. With over 40% of the EU-27 population living in coastal areas (Eurostat, 2015), European sea basins also provide vast recreational benefits for local residents year-round.

Tourism and recreational benefits are closely linked to the quality of the natural environment. Therefore high levels of environmental degradation, whether caused by tourism or other pressures, may have adverse effects on the economic value of tourism and recreation. For this reason, the EU Strategy for more Growth and Jobs in Coastal and Maritime Tourism highlights the importance of pursuing economic growth in this field in a sustainable manner (European Commission, 2014b). Well-managed MPAs play a role in reconciling economic development and ecosystem protection and thereby support the long-term sustainability of the marine and coastal tourism and recreation sectors in Europe (Ecorys, Mrag and Spro, 2013).

Coastal tourism and recreation include beach activities, bathing, and diving, whereas activities away from the coast include sailing and wildlife watching. Recreational fishing is exercised both in coastal and offshore areas. These activities are examples of direct use values of marine and coastal ecosystems[21], providing job opportunities, and in some Member States contributing to a large share of the national economy (see Chapter 7).

While all regional seas in the EU enjoy a certain degree of marine tourism, foreign visitors are primarily attracted to coastal destinations in southern and eastern Europe (Eurostat, 2015; Knights et al. 2011), with the Mediterranean accounting for half of coastal tourism

[21] Marine and coastal recreation also provides non-use values to locals and visitors, e.g. in shaping personal and communal identities and providing psychological and cultural inspiration. These benefits are discussed in Chapter 8 of this report.

jobs and value added in the European Union (European Commission, 2014b). The importance of marine and coastal tourism has been identified as a catalyst for economic development in the EU and the Commission has adopted the Strategy for more Growth and Jobs in Coastal and Maritime Tourism to encourage further development in this sector across Europe (European Commission, 2014b).

However, it is important to note that high levels of tourism and related coastal development is having a destructive environmental impact in many marine and coastal areas in Europe (European Environment Agency, 2015b; Knights et al. 2011), especially in the Mediterranean Sea (Plan bleu, 2012). It is crucial that existing and future marine and coastal tourism in the EU minimises its negative impacts on the environment, for example in order to achieve the ambitious goals set out in the EU Marine Strategy Framework Directive (MSFD).

4.2 Synthesis of the existing evidence

There is a growing body of literature that attempts to quantify the monetary value of recreational and tourism benefits provided by MPAs (see e.g. Alban et al. 2008; Liquete et al. 2013b). For example, Roncin et al. (2008) studied 12 MPAs in southern Europe estimated that each MPA is visited by approximately 110,000 people on average annually (see box 7.1 and case-study in the Annex). Their findings suggest that scuba diving has a larger annual local economic impact than recreational fishing (€374,000 versus €71,000 for the 12 MPAs) and that incomes generated in the local area by ecosystem service users' activities (including professional fishing) are significantly higher than the yearly management costs of about €600,000 for the MPAs in question. The authors furthermore confirm that the "designation effect" – when designation of an MPA attracts visitors who come for the sake of experiencing the protected area – has been an important factor for attracting divers at these sites, although not as clearly influencing visits by recreational fishermen.

Similarly, protection of Lyme Bay in the UK has had a positive impact on local leisure and recreation, including scuba diving, sea angling and wildlife watching. The total monetary value of these recreational activities has been estimated to over £18 million (€23 million) per year, based on user expenditure and related businesses' turnover (Rees et al. 2010). Finally, Blom et al. (2012) have estimated the local income generated from recreation at the

Waterdunen MPA in the Netherlands to be €20 million, and García-Charton et al. (2013) show how the number of dives in Cabo de Palos MPA in Spain (designated in 1995) has increased by 225% between 1998 and 2010, which has resulted in a local added value of €870,000 per year and an additional 20 local jobs.

Two methodologies are primarily used to estimate the monetary value of recreational and tourism benefits provided by MPAs, beyond the jobs and income generated: the Travel Cost Method (TCM) and Contingent Valuation Method (CVM). The former estimates the value that individuals assign to protected areas based on the amount of time and money spent to visit it. CVM assessments are instead based on survey respondents' preferences, trying to determine their willingness to pay (WTP) for improved environmental conditions or their willingness to accept (WTA) compensation for a reduction in environmental quality. For example, Kenter et al. (2013) analyse the recreational use of UK divers and sea anglers of 25 Scottish potential Marine Protected Areas, 119 English recommended Marine Conservation Zones and 7 existing Welsh marine Special Areas of Conservation, using an online survey with 1,683 divers and sea anglers. In order to estimate the recreational values, the authors used a travel cost choice experiment method. They found that the monetary value associated with recreational aspects increases if conservation measures are put in place through the designation and management of MPAs. In fact, improving biodiversity increases the interest of divers and recreational anglers for a certain area and consequently the associated economic returns for businesses providing services for them. In addition, the study concludes that the assessed monetary benefits are likely to outweigh best estimates of the cost of MPA designation. Further to this, Alban et al.'s (2008) literature review of the economics of MPAs also found that divers' WTP increases with the quality of the ecosystem and that greater probability of seeing rare or large species is an incentive for divers to visit MPAs more frequently.

Jobstvogt et al. (2014) explored 1,332 British divers' and anglers' WTP for hypothetical MPAs in the UK, using an innovative combination of travel cost-based choice experiments and CVM. They discovered that travel distance had a significant negative impact on the likelihood to visit a site. The WTP in travel cost for going diving at a site was £7.52 and was £20.78 for going angling. Protection of species of conservation interest (even without potential of catching or encountering these species when visiting the site) increased the

WTP by £0.44 (divers) and £0.30 (anglers) per species. Presence of large fish was valued by both groups, although it was higher among anglers (£23.58) than divers (£7.64).

In addition to monetary estimates, existing non-monetary valuations include both qualitative and quantitative studies of perceptions, importance, needs, uses and demands of different user groups. An example of a qualitative assessment of MPAs is provided by Jobstvogt et al.'s (2014) survey, that shows that a majority of British divers and anglers support further extension of the British MPA network, especially divers (82% strongly supportive).

Assessments of tourism and recreational benefits explicitly related to marine Natura 2000 sites are still few. This could partly be a result of the relatively short period in which the majority of marine Natura 2000 sites have been in place. Geographically, a majority of existing studies are conducted in the Mediterranean (Fenberg et al., 2012). This could be explained by the fact that, in addition to biodiversity conservation objectives, the establishment of MPAs in the Mediterranean is commonly motivated by expected gains for local communities through the attraction of tourists and tourism-related revenue to a specific site (Sorensen and Thomsen, 2009). There is also a growing body of literature assessing the values of British MPAs, including research by Rees et al. (2010) from Lyme Bay MPA and by Jobstvogt et al. (2014).

The evidence of nature-based tourism occurring in and around existing MPAs is case and site-specific, with limited grounds for generalisation. However, multiple studies show that the designation effect of MPAs alone can generate tourism in a previously unvisited area (see, e.g. Alban et al. 2008; Lemelin and Dawson, 2014). Finally, most evaluation studies focus on coastal areas as deeper offshore waters that are less accessible (Armstrong et al. 2014; Pantzar, 2014). In their review of existing international literature, Liquete et al. (2013b) found that most assessments of marine and coastal ecosystem services deal with coastal habitats, with less than one fifth assessing areas beyond the shelf edge.

4.3 Discussing the existing evidence

There is clear evidence that the designation and management of MPAs can support nature-based tourism and thus form an integral part of the sustainable use of marine and coastal areas in Europe. Recognising these benefits can be seen as an important part of an ecosystem-based approach[22] to marine management (Fletcher et al. 2014).

To improve the uptake of tourism and recreational opportunities provided by MPAs, there are clear needs to better understand the relationship between MPAs and different recreational user groups. For example, recreational fishers are a major interest group in many European seas and fishing tourism is discussed for its potential to help diversify income for fishermen when an MPA is put in place, depending on the level of fishing restrictions imposed. The idea is that fishing tourism, such as fishing tours etc., could help compensate for reduced commercial fishing opportunities and thereby potentially limit the risks for conflicts between fishermen and conservation objectives (see Chapter 2). Fishing tourism could generate a range of associated economic activities in the region, for instance, in hospitality and infrastructure. According to Ounanian et al. (2012), turning to coastal tourism as a means of diversifying income when commercial fishing is reduced is already common in the Black and Baltic Sea.

Using revenue and fees generated from tourism to help finance management of MPAs is another opportunity to reconcile economic and ecological objectives in coastal and marine areas (Angulo-Valdes and Hatcher, 2010; Emerton et al., 2006). Gusmerotti et al. (2013) find examples of this type of "self-financing" in Italian MPAs, emphasising that tourism revenues are an important mechanism to address the decrease in public funding. Some of the evidence presented earlier in this chapter shows that revenues generated may well exceed total MPA management costs (see for example the analysis of the impact of European MPAs on local economies in the Annex). As the technology for monitoring marine areas becomes more advanced over time, there are greater opportunities for achieving cost-effective MPA management.

4.4 Link with other benefits

If not appropriately managed, recreation and tourism in MPAs may result in trade-offs with conservation goals or the delivery of other ecosystem services addressed in this report. For

[22] An ecosystem-based management approach is enforced in both the new Common Fisheries Policy (1380/2013) and the Marine Strategy Framework Directive (2008/56/EC).

example, depending on the conservation goals and related restrictions imposed within the MPA, tourism might need to be limited on the basis of securing conservation outcomes. In other cases, commercial fishing activities may threaten the quality of ecosystems and thereby the attractiveness of a site for tourists (see Chapter 2).

As discussed earlier in the chapter, tourism itself may have negative impacts on the health of ecosystems, thereby degrading the coastal and marine areas and diminishing their attractiveness for recreation and tourism in the longer term while also reducing their capacity to deliver other benefits, such as protection from natural hazards (see Chapter 5) and climate change mitigation (see Chapter 3). There are examples of too high levels of tourism and coastal development having negative impacts on marine Natura 2000 areas (Montefalcone et al. 2009; Luna et al. 2009), indicating that in order to support conservation goals, tourism and related coastal development activities need to be carefully managed and maintained at a sustainable level.

5 Coastal security

5.1 Role of MPAs in mitigating natural hazards

A range of different habitats and species in marine and coastal areas can play an important role in protecting the coastline by reducing the impact of tidal surges, storms, waves and floods (Natural England, 2012). Species form the first line of this natural defence by stabilising sediments in habitats such as seagrass beds, mudflats, saltmarshes and biogenic reefs (biological concretions created by species like oysters and blue mussels). Such habitats and their sediment structures protect the coastline by providing a barrier to coastal erosion.

The existing evidence exploring the role of MPAs in supporting coastal security is limited. However, it can be argued that MPAs play an important role in maintaining the integrity of coastal zones, including their natural ability to mitigate natural hazards. According to Liquete et al. (2013a), the regulating ecosystem service of coastal protection from natural hazards is declining in Europe because natural buffers are increasingly being lost. For this reason, the designation of MPAs in coastal areas and the establishment of suitable management measures can play an important role in improving coastal security, by protecting the ecosystems and habitats that reduce the impact of extreme weather events.

For example, the four European species of seagrasses representing the largest protected submerged aquatic vegetation ecosystem in Europe (*Zostera marina* (eelgrass), *Zostera noltii* (dwarf eelgrass), *Cymodocea nodosa* and *Posidonia oceanica*) play an important role in coastline protection by stabilising sediments, thereby reducing erosion. Furthermore, the accumulation of detached leaves of *Posidonia oceanica* in the Mediterranean and eelgrass in northern Europe, dissipate the energy of waves, and thereby these two species protect beach sediments from the impact of waves (Terradoos and Borum, 2004). As highlighted in Chapter 3, *P. oceanica* meadows are one of the key habitats protected by the marine Natura 2000 network with MPAs, which thereby contributes to the sediment stabilisation.

Protection of saltmarshes contributes to coastal protection because, as with seagrasses, they reduce wave energy, increase sedimentation and reduce erosion and movements of sediments (Spalding et al., 2014; Gedan et al., 2010). Saltmarshes also have an important role in the prevention of coastal floods, because they absorb vast amounts of water when inundated, and releasing it afterwards at a slow pace and thereby prevent flooding (Beaumont et al., 2006).

In the future, it is foreseen that protecting and restoring this regulating function of coastal habitats will play an increasingly important role in the adaptation of coastal zones to the impacts of climate change, such as the increased prevalence of storms (Spalding et al., 2014), sea level rise, and an increase in the number and strength of cyclonic storms (EASAC, 2013).

The immediate beneficiaries of protecting the regulating functions of coastal zones are the populations living near the sea. Were these habitats to be degraded, storms and surges could result in increasing damages and infrastructure loss in coastal areas. Furthermore, national governments benefit from the protection of this ecosystem service to the extent that in the case of storms and surges, they would need to provide financial assistance to the affected areas and help invest in the replacement or repair of damaged infrastructure.

In the European context, the role of natural habitats – and MPAs providing protection to the habitats - in reducing the impact of storms and extreme weather events, can be considered particularly valuable in areas of high probability of occurrence of storm surges, i.e. the North Sea coast, some areas of the Baltic coast and of the Iberian west coast, the Gulf of Lyon and areas of the northern shores of the Adriatic (EASAC, 2013).

5.2 Synthesis of the existing evidence

A number of existing studies shed light on the important role of specific habitats and species in attenuating the impact of waves, storms and surges. Consequently, while studies explicitly exploring the role of MPAs in mitigating natural hazards on coastal zones are limited, the evidence does imply that the protection of such habitats – several of which are in decline (e.g. *Posidonia oceanica* meadows) – through the establishment of MPAs can contribute to coastal security.

There is a comprehensive body of scientific evidence on the contribution of ecosystems like saltmarshes and seagrasses to the stabilisation of sediments and thereby the protection of coastal areas from the impact of weather events. However, the protective action of these habitats may not be enough in the case of extreme events like very strong storms and high waves. There is less evidence on the role of such habitats in floodwater attenuation, and more research is needed to clarify this point. Also, scientific evidence shows that species like oysters and mussels are able to trap sediments and attenuate the impact of waves, thereby protecting coastal areas.

A meta-study conducted by Gedan et al. (2010) collected evidence on the protection function of saltmarsh vegetation against erosion and storm surges. They found that in many cases coastal vegetation protects coastlines from erosion and storm surges, and plays a critical role in attenuating waves by reducing turbulence and slowing water velocity. For example, Neumeier and Ciavola (2004) analysed *Spartina maritima* salt marshes in Ria Formosa (Portugal) and found that *Spartina* canopies protects the coastline form erosion during storms. Marshes can also slow erosion by strengthening soil and favouring the formation vertical scarps and overcut banks (Mariotti and Fagherazzi, 2010).

A literature review carried out by Shepard et al. (2011) analysed 75 publications that provided evidence on the protection of coastlines by saltmarshes, and their consequent contribution to human wellbeing in terms of natural hazard mitigation and climate change adaptation. The review concluded that saltmarshes have a significant positive effect on wave attenuation and shoreline stabilisation. The review did not however find specific studies quantifying floodwater attenuation, even though research existed that noted the negative effects of wetland degradation on water quantity regulation in coastal areas. In a similar study, Feagin et al.'s (2009) literature review concluded that saltmarshes are not effective in reducing erosion during extreme events, but they provide benefits in terms of coastal protection by longer term modification of sediment dynamics.

Ondiviela et al.'s (2014) review of existing evidence on the contribution of seagrasses to coastal protection concluded that seagrasses provide an important coastline protection function in shallow waters and low wave energy environment, with high interaction surface between water flow and seagrasses. According to the review, large, long-living and slow-growing seagrass species provide the highest level of protection. As an example, Bos et al.'s (2007) experiment in the Wadden Sea (Denmark) shows how seagrasses reduce flow velocities in their canopies, leading to increased net sedimentation rates. Another example is provided by Manca et al.'s (2012) experiments with artificial *Posidonia oceanica* seagrass meadows in Barcelona (Spain), which concluded that the species is effective at reducing the energy of both regular and irregular waves, especially under low wave energy conditions and small wave amplitudes. According to the authors, this kind of seagrass is less efficient at reducing wave energy of large waves. However, it is very efficient at reducing oscillatory flows near the bed, thereby reducing sediment transport and promoting sediment stabilisation.

Further to the vegetation-related evidence above, Borsje et al.'s (2011) literature review on the use of ecosystems to improve coastal protection, shows that oyster and mussel beds play an important role in coastal protection by trapping sediments and dampening waves. They conclude that these species can protect coastal areas as an alternative to traditional engineering approaches.

As regards monetary estimates of the importance of natural hazard mitigation by coastal ecosystems, the literature review carried out by Fletcher et al. (2012) on both UK and international literature, shows that despite increasing ecological evidence (see above), there is still a substantial data gap in the monetary estimation of the protection role of coastal areas from waves, storms, surges and floods provided by marine and coastal ecosystems. A few tentative estimates can be found in the literature that are based on defence costs (i.e. the costs of the defensive work necessary in case the ecosystems protecting the coastline are degraded), see the examples in Box 5.1 and 5.2.

Box 5.1 An estimation of the service of coastal defence provided by the *Posidonia oceanica* meadows in southern Spain

A number of studies provide evidence of the important role of the *Posidonia oceanica* meadows in attenuating the height and energy of waves (see for example Koftis et al., 2013). For example, a recent experiment in a large flume on wave and flow attenuation of a *Posidonia oceanica* seagrass meadow in shallow water, showed an average reduction of wave-induced flows of 12.1% near the seagrass leading edge and of 58.7% further shore-ward (Manca et al., 2012).

Junta de Andalucía (2014) provides a rough estimate of the economic value of these meadows and the protection they provide by multiplying the average cost of regeneration and protection of coastal areas in the Andalusian provinces of Málaga, Granada and Almería (€1,200 per metre) by the entire coastal zone currently benefiting from this ecosystem service (about 80 km of beaches). This results in a hypothetical cost of €96 million, should all existing *Posidonia oceanica* meadows degrade and/or disappear.

Source: Junta de Andalucía (2014)

Box 5.2 An estimation of the value of UK saltmarshes in terms of coastal defence

Beaumont et al. (2010) assessed the ecosystem service of coastal defence provided by coastal ecosystems in the UK using the avoided costs method, e.g. the cost of 'manmade' protection of coastal areas with sea walls.

Using this approach, they calculated the value of coastal ecosystems to be between £20,921 and £41,841 million (€24,402 and €48,803 million) in avoided capital cost and £418 million (€488 million) in avoided maintenance costs (i.e. maintenance of artificial defence structures). This estimate was obtained by multiplying the total extent of UK saltmarshes, i.e. 44,512 ha, by the costs of artificial coastal defence estimated by King and Lester (1995), i.e. between £0.47 and £0.94 million (€0.55 and €1.10 million) per hectare in terms of capital costs, and £9,400 (€10,964) per ha in terms of annual maintenance costs (adjusted to 2010 prices).

Source: Beaumont et al. (2010)

5.3 Link with other benefits

Protecting coastal ecosystems' ability to mitigate against natural hazards (e.g. via MPAs) also provides positive impacts on other ecosystem services and related socio-economic benefits. The important role of coastal ecosystems in preventing coastal erosion and protecting coastal areas from storms and extreme weather events benefits the tourism and recreation sector (see Chapter 4 and 7), as it protects beaches and prevents damage to buildings and infrastructure.

In addition, the ecosystems that contribute to coastal security also tend to provide two other kinds of ecosystem services. On the one hand, they can act as spawning grounds and primary biomass producers, thereby playing a key role in the sustainability of fish stock (see Chapter 2). On the other, they contribute to the storage of large amounts of carbon (see Chapter 3). Good examples of providers of both these ecosystem services are saltmarshes and seagrasses.

6 Blue biotech, bioprospecting and research

6.1 MPAs and opportunities for bioprospecting

Bioprospecting and the development of blue biotechnology are per definition dependent on the availability and state of marine genetic biodiversity. As a key conservation instrument to safeguard marine ecosystems and biodiversity (European Environment Agency, 2015a), MPAs can therefore help support the success and long-term sustainability of this expanding market.

European sea basins are home to diverse marine life that creates potential for research and prospecting for biotechnology[23] applications (i.e. bioprospecting). Marine, or "blue", biotechnology is an emerging industry with application in a wide range of sectors, such as food (e.g. alginate extraction), energy (e.g. production of biofuel using algae), health (e.g. development of Thiocoraline, an anti-tumour drug derived from marine Actinomycetes), environment and industrial products and processes (e.g. the characterisation of a green fluorescent protein from the jellyfish *Aequorea victoria*) (European Science Foundation, 2010; Sathyan et al., 2012; Jang et al., 2013; Glöckner and Joint, 2010; Marine Biotech, 2013; see also the Kosterhavet National Park case-study in the Annex of this report).

There are few robust estimates of the current size and potential trajectory of the blue biotechnology market, both in global terms and in the EU, mainly because of a lack of common definitions and the consequent difficulty in drawing market boundaries (i.e. to have a common understanding of what is to be considered a blue biotechnology sector) (Ecorys, 2014). Estimations for bioprospecting potential in the marine context are difficult to carry out because merely a fraction of marine ecosystems and biodiversity, especially in the deep seas, are currently known to science (European Commission, 2012; National Oceanic and Atmospheric Administration (NOAA), 2014). However, some experts believe that blue biotechnology and its range of applications will increase in size and importance as a result of advances in related technologies (European Commission, 2007). On the other hand, public

[23] The OECD defines biotechnology as "the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living and non-living materials for the production of knowledge, goods and services" (OECD, 2013).

and private investments in blue biotechnology have been limited due to the relatively high risks involved (Leal et al, 2012; Ecorys, 2014).

Bioprospecting could, in principle, help finance MPAs, as is already done in some pioneering experiences at global level. For example, Costa Rica's National Biodiversity Institute (INBio) carries out bioprospecting in protected areas in exchange for 10% of research budgets and 50% of any future royalties to be donated to the Ministry for Conservation. In 2006, INBio signed an agreement which allowed it to be paid US$6,000 per year by a biotech company for two natural resource-based materials, including a protein derived from a marine organism (WWF, 2009; OECD, 2015). As another example, a US$30,000 contract between a pharmaceutical company and Fiji's Verata District supported marine conservation work in the area (WWF, 2005; OECD, 2015). Bioprospecting needs to be carefully regulated in order to be sure that local populations benefit from it in order to avoid biopiracy and moral hazards (Efferth et al., 2016; Hemmings, 2010).

6.2 Synthesis of the existing evidence

Despite its recent advent, biotechnology and bioprospecting are already attracting a lot of attention and are envisaged to grow fast in the future (European Commission, 2012; ten Brink et al., 2011; ten Brink et al., 2012; Bhatia and Chugh, 2015). The total global value of the blue-biotechnology market was €2.2 billion in 2002 (European Commission, 2012; Marine Institute, 2006) and €2.8 billion in 2010, with a cumulative estimated annual growth rate of between 4-5% and 10-12% (ESF, 2010). According to an estimate released at the beginning of 2015, the total global value of biotechnology is projected to reach US$4.8 billion by 2020 (Global Industry Analyst Inc., 2015).

While no study has been found for this report explicitly related to the impact of European MPAs and Natura 2000 on blue biotechnology and bioprospecting it is possible to envisage that MPAs can play a key role in the development of these sectors. If blue bioprospecting is developed further, it needs to take due consideration of conservation objectives and commitments made in different pieces of EU and international legislation with regard to protecting marine life and habitats. Areas potentially targeted for blue biotechnology purposes in the EU are often highly sensitive environments and many are already under pressure from human impacts. For example, Salomidi et al. (2012) have studied 56 types of

European seabed biotopes, identifying widespread degradation and loss of biodiversity, due mainly to human activities. If blue bioprospecting is not conducted with sufficient caution so as to prevent environmental damage, there are risks of overexploitation as well as detrimental side effects (Richmond, 2008).

In order to protect marine ecosystems, further measures and specific policies are needed, both at a national and an international level (Salomidi et al. 2012). Designation of MPAs can benefit blue biotechnology to the extent that they help preserve biodiversity (Keller at al. 2009; European Environment Agency, 2015a) and promote more sustainable use of the natural resources within their boundaries (Brander et al. 2015).

6.3 Link with other benefits

As blue biotechnology and bioprospecting are dependent on biodiversity, their future developments in the EU may be compromised as the biological status of marine and coastal areas is deteriorated. For example, the expansion of coastal built areas and infrastructure due to the tourism sector can have negative impacts on sensitive seabed biotopes, thereby reducing the potential for blue biotechnology (Salomidi et al. 2012) (see Chapter 4). In addition, climate change and extreme weather events have negative impacts on marine biodiversity and ecosystems, substantially reducing their resilience (NOAA, 2013). Furthermore, depletion of land-based deposits of certain raw materials (e.g. rare-earth metals) and the resulting effects of commodity prices, increasingly attracts prospectors to explore ocean-based deposits (e.g. manganese nodules, poly-metallic sulphides and cobalt-rich ferromanganese crusts) (UN, 2014; Rademaekers et al. 2015), with potential negative impacts on the marine environment.

Therefore, the benefits of protected and healthy marine ecosystems in terms of reducing the impact of natural hazards (see Chapter 4) and mitigating climate change (see Chapter 3) can also benefit the blue biotechnology sector. Finally, in certain areas, there may be a trade-off between the food provisioning ecosystem service provided by marine ecosystems and the potential for blue biotechnology, because of the impacts on ecosystems and food webs caused by overfishing.

7 Broader socio-economic benefits

7.1 Role of MPAs in providing wider social and economic benefits

While protection of marine habitats and species is the key mandate for designating MPAs, contribution to regional and local development is arguably a precondition for gaining local support for the intervention (Bennett and Dearden, 2014).

By contributing to an improvement of the state of the marine environment and its resources, a well-managed MPA may generate new or retrieved opportunities for local employment. Chapters 2 and 4 of this report discuss two kinds of direct local employment generated by MPAs. Protection of marine ecosystems from overfishing and other negative impacts can improve the state of commercial fish stocks available to local fisheries. The "designation effect" of the MPA may attract non-locals to visit the site and thereby offer opportunities for the local tourism sector, while the restoration and management of sites can provide direct job opportunities for people (Edwards et al., 2013; BenDor, 2015). This includes, for instance, assessment and monitoring activities.

Successful MPAs may also create indirect income for sectors providing goods and services to the fishing and tourist operators (Gantioler and ten Brink, in Kettunen and ten Brink, 2013). They can generate positive upstream and downstream impacts in the economic value chain, including sectors which profit from the sustainable provision of fish (e.g. fish canning industries) or tourism (e.g. travel agencies). While the direct increase in job opportunities tends to benefit local communities, indirect impacts can benefit different groups of stakeholders also at the regional and national scale.

Besides the economic benefits mentioned, there are additional, less tangible benefits linked to the designation of an MPA, including cultural, spiritual and recreational aspects. MPAs can contribute to the conservation of areas that can be used for sightseeing, diving and snorkelling, thereby providing wellbeing and spiritual enrichment to those enjoying them (the impact of MPAs on the tourism sector is discussed in more detail in Chapter 4). The environmental protection that can be ensured by a well-managed MPA may furthermore contribute to a sense of identity among communities living in coastal areas, who may feel a strong emotional link to the area in question. In fact, the designation of an MPA and the direct and indirect benefits it can bring may play an important role in maintaining the culture, identity and lifestyle of local communities.

Finally, MPAs can contribute to improved opportunities for research and education (see the Kosterhavet marine national park case study in the Annex) by ensuring the long-term sustainability of key marine ecosystems and contributing to the recovery of stocks that have been negatively affected by overfishing and other human activities with high environmental impact.

7.2 Synthesis of the existing evidence

Given that a significant part of the marine Natura 2000 network was established relatively recently, there are yet few empirical assessments of their direct impacts, let alone their broader socio-economic benefits. One of the few studies analysing the impact of MPAs on local economies shows that MPAs in southern Europe generate an estimated €640,000 per MPA in income to industries providing services to non-resident recreational users (Roncin et al., 2008; see Box 7.1 and the related case study in the Annex).

Mascia et al. (2010) reviewed 150 empirical MPA studies at the global level (13% of which were in Italian waters) assessing five indicators of human welfare: food security, resource rights, employment, community organisation and income. The three latter indicators generated data sample sizes which were too small for the authors to be able to carry out statistical analysis on. The authors did, however, identify that older and smaller MPAs correlated positively with an increase in food security. The authors argue that this may be due to the fact that – all else being equal – older MPAs have built up fish biomass over time and smaller MPAs mean higher rates of spillover to adjacent waters (see also Chapter 2). At some sites, part of the explanation appeared to be related to decreased competition between fishermen due to reallocation of fishing rights (allowing a smaller number of fishermen to harvest the same number of fish). Based on a collation of the empirical material, the authors found that 44% of fishermen said that they had gained greater control over marine resources after an MPA had been put in place, whereas the same percentage felt that they had experienced a loss of resource control. The authors emphasise that the ways in which MPAs can shape the rights of resource users is an important indicator for social wellbeing. Designating MPAs can be a viable strategy for empowering local communities, although it is important to acknowledge that its success in doing so is dependent on MPA management practices in each particular case (see the discussion on the Kosterhavet marine national park in the Annex).

The contribution to regional and local development is commonly identified as a key precondition for the success of an MPA. If enough attention is not given to local development needs and interests, designation of an MPA may result in conflicts between the stakeholders and possibly failure of the protection measures (Bennett and Dearden, 2014). Mackelworth et al. (2013) show an example of such events in the case of the Cres-Lošinj Special Marine Reserve (CLSMR) – one of the first and hence strategically important marine reserves in Croatia. The CLSMR was designated to protect the local dolphin population and archipelago, which are both nationally important for tourism and foreign revenues. The CLSMR was for some years the largest MPA in the Adriatic Sea and an important step for Croatia in trying to live up to international conservation commitments. As Croatia was in the accession process of becoming an EU member at that time, harmonising national measures with EU requirements was a priority, and the CLSMR was intended to later become a Natura 2000 site. There were clear biological arguments, supported by international scientific committees, for the need to designate special protection in the area. However, the objectives of the MPA were conflicting with the local political plans to develop a new marina to boost tourism development. This led to a loss of support for the CLSMR and eventually to a considerable downgrading of its protection level.

The ability of MPAs to generate wider socio-economic benefits at the local and regional level can evidently depend on the perceptions towards the MPA of local communities. If the local community generally understands and supports the objectives of designating the MPA, diversification of livelihoods and entrepreneurship may be more likely to occur (see the Kosterhavet marine national park case-study in the Annex of this report). A precondition is that the local community are aware of, or indeed, the initiators of, the intentions behind establishing the MPA (Ressurreição et al., 2012). For this reason, awareness-raising activities generally play a key role in supporting the wider socio-economic benefits related to the designation of an MPA.

In general, wider cultural benefits of marine and coastal ecosystems, such as aesthetic appreciation, identity and spirituality, are highly valued by coastal communities, and well-managed MPAs that are able to prevent degradation of marine environments can support such values. For example, when analysing responses from surveys conducted in Istanbul and the coastal Turkish town Şile, Fletcher et al. (2014) found that the most frequently mentioned cultural ecosystem service provided by the Black Sea is related to cultural heritage and identity. The study included 14 workshops with between four and 30 respondents per workshop, all Turkish nationals, answering an open question about the sea. The results underlined how a healthy environment is key to many important elements of culture, including aesthetic appreciation, identity and spirituality. For example, some respondents' fathers had been fishermen, which created a sense of identity and interaction with the Black Sea. There is also a lot of traditional Turkish poetry, songs and dancing related to the Black Sea and its fish. The authors emphasised the importance of protection of these values for many Turks. As another example, Pike et al. (2010) investigate the social value of MPAs in the eye of UK citizens through twenty-four semi-structured interviews in a variety of MPAs in Wales and England. They conclude that a range of factors influence the social value people give to MPAs, including, for instance, spirituality (defined as a sense of place that is an emotional connection between people and their environment, providing peace and tranquillity), the degree of community involvement, the research and education activities in place and the market and promotion activities carried out. Similarly, Brown et al. (2016) analysed ecosystem values and management preferences in protected areas in Norway and Poland, and found that whereas Norwegians are more interested in values related to the use of resources, including hunting, fishing and gathering, Polish consider more important environmental values such as scenery, biological diversity and water quality.

Box 7.1 The number of companies depending on MPAs in Italy

In Italy, there are about 180,000 companies that depend on the sea, i.e. 3% of the total number of companies in Italy. Almost 29% of them are related to MPAs, mostly in the tourism (48%) and recreation sectors (20%). The shipbuilding sector represents 12% of the total number of companies, and the seafood chain only 10% of the total number of businesses in MPAs. See Table 7.1 for more details.

Table 7.1 Number of companies that depend on the sea and on MPAs (2013)

Sector	Companies that depend on MPAs		Companies that depend on the sea		% of companies depending on MPAs
	Number	%	Number	%	
Seafood chain	5,094	10.0	33.952	18.9	15.0
Seabed mining industry	127	0.2	528	0.3	24.1
Shipbuilding sector	6140	12.0	28.139	15.7	21.8
Movement of goods and passengers by sea	3676	7.2	11.017	6.1	33.4
Accommodation and food services	24420	47.7	71.845	40.0	34.0
Research, regulation and environmental protection	1552	3.0	5.915	3.3	26.2
Sport and recreation	10.161	19.9	28,188	15.7	36.0
Total blue economy	**51.170**	**100.0%**	**179.584**	**100.0%**	**28.6**

Source: Ministero dell'Ambiente e della Tutela del Territorio e del Mare and Unioncamere (2014)

7.3 Link with other benefits

As explained in this chapter, the broader socio-economic benefits provided by the designation and management of an MPA derive from the direct and indirect impacts, some of which are closely related to other ecosystem services discussed in this report. The potential improvement and long-term sustainability of fish stocks following designation of a well-managed MPA (see Chapter 2) can improve and secure livelihoods for communities of local fishermen and their families, thereby increasing their wellbeing and preserving their cultural identity and lifestyle. Also, an MPA can provide opportunities for the development of businesses in the nature tourism sector for local entrepreneurs; thereby providing job opportunities for people living in coastal areas (see Chapter 4). Finally, the protection of coasts from tidal surges, storms, waves and floods (see Chapter 5) can ensure the wellbeing and sense of security of local communities, besides protecting businesses and infrastructure along the coastline.

8 The non-use value of MPAs and limitations of socio-economic valuation

8.1 Indirect benefits of MPAs

Up to now, this report has analysed the benefits that the protection of marine and coastal areas provides to communities and society via ecosystem services, often linked to the use of a site. However, not all values attributed to the conservation of marine and coastal ecosystems come from the use of ecosystems at certain locations. In fact, non-users tend to attribute value to nature, although not directly benefitting from it. Non-use values, that accrue off-site primarily, refer to the bequest, existence, or altruistic value attributed to nature (Jones-Walters and Mulder, 2009; ten Brink et al., 2011).

Non-use benefits related to marine and coastal protected areas include, for example, those related to maintaining future fishing opportunities, educational opportunities or aesthetic experiences (Angulo-Valdes and Hatcher, 2010), and also the value of knowing that the site is protected for future generations, and for the species that live there in their own right (Kumar, 2010).

Throughout the years, researchers have carried out several studies to define the propensity of non-users to value nature. Several methods can be used to assess non-users' values. The choice modelling method (CM) and contingent valuation method (CV) are the most common ones. Usually, CV is based on a willingness to pay (WTP) or willingness to accept (WTA) questionnaire to assess the value that people attribute to nature. CM is similar to CV but respondents are presented with a series of questions (choice sets) instead of a single WTP question (Gillespie and Bennett 2011, see also Chapter 4).

A few studies have explored how non-users value existing or proposed MPAs, often with reference to iconic species or unique habitats (see Box 7.1). Other examples include the work of Jobstvogt et al. (2014) on public support from UK citizens to protect deep-sea biodiversity, the study of Wattage et al. (2011) on the willingness of Irish citizens to pay for deep-sea coral protection in Irish waters, and the research of Kenter et al. (2013). The latter aimed at estimating the non-use value of 22 Scottish potential MPAs, 120 English recommended Marine Conservation Zones (MCZs) and 7 Welsh Special Areas of Conservation (SACs).

Box 7.1 Marine Protected Areas and Non-User Value: the case of Dogger Bank

Börger et al. (2014) have looked at the willingness of UK citizens to pay for an increase of species diversity in the Dogger Bank offshore marine area, which is protected as a Special Area of Conservation in the UK under the EU Habitat Directive. By means of a choice experiment survey, the authors surveyed around 1,000 UK citizens to elicit their support for different options for improving biodiversity in general and in the Dogger Bank in particular. The results show that citizens are willing to pay around £7.2 to £7.6 per year (i.e. between €8.5 and €8.9 per year, using the average exchange rate of 2013, the year of the survey) for a 25% increase in species diversity.

8.2 From benefits for humans to benefits for nature

The estimates presented above are generally specific to the site, though allow us to conclude that MPAs overall can be regarded as valuable and/or beneficial to humans. Research on such perceptions is evolving and comprises e.g. cultural differences across countries on the perceived benefits of protecting marine biodiversity or the connectedness of humans to nature (Ressurreição et al., 2012; Restall and Conrad, 2015).

Capturing the benefits of MPAs for non-users widens the perspective of marine conservation and introduces consideration of, for example, future generations or sites remote to the beneficiaries. Non-use values remind us that the value of nature is not only related to its economic value and direct human benefits and, in the process of assessing protected areas, this aspect should be taken into consideration. Nonetheless, prevailing approaches to estimate these values remain anthropocentric, not any less so than ones focussing on direct benefits. In fact, it tries to assess the value that humans attribute to the marine environment, and not its intrinsic value.

Valuing nature comes with limitations as it is associated, per definition, with a number of assumptions, given the partial understanding that we have of nature (see for example ten Brink (ed.) et al., 2011, Kumar (ed.) et al., 2010 and Chapter 9 of this report). Several elements hinder our capacity to value nature. In fact, not only our knowledge of it is limited, but also our perception of nature is strongly biased by elements such as culture, religion and education that undermine the objectivity of such values (Kumar, 2010). Valuation approaches can capture interesting aspects, but their practical and ethical limitations have to be recognised and results needs to be considered in the context of what can and cannot be captured.

9 Conclusions and way forward

9.1 Socio-economic benefits of MPAs in Europe

A convincing body of evidence shows that the protection of European marine and coastal ecosystems helps to provide and maintain a wide range of ecosystem services, including food provisioning, climate change mitigation, nature-based tourism and recreation opportunities, coastal security and climate change adaptation, blue biotech, bioprospecting, and research. These ecosystem services and related socio-economic benefits can play an integral role in a sustainable, blue-green economy in Europe, by both providing livelihood opportunities and income to different stakeholders and helping marine and coastal communities to adapt to climate change. MPAs – including the EU marine Natura 2000 network – are an important tool to protect and maintain these ecosystem services and associated benefits in the long term.

Based on the existing literature, the following key conclusions can be drawn on the socio-economic benefits associated with European MPAs:

- **Food provisioning**: MPAs can provide direct or indirect protection to fish stocks targeted by commercial and artisanal fishing. The levels of protection – and associated socio-economic benefits – depend on the scope of MPAs, what specific conservation measures are applied in the MPA and how well these are enforced. Imposing explicit restrictions on fishing or different fishing gear has been proven to have significant positive effects on the conservation of species, especially in cases where all industrial-scale fishing has been prohibited. These effects include, for example, higher biomass of large fish with higher reproductive potential within the MPA, production of larvae with higher survival rate and spillover of adult fish to nearby fishing grounds. These effects may compensate part of the compromised fishing opportunities for fishermen, especially in the long term.
- **Climate change mitigation**: Marine and coastal ecosystems and species, such as saltmarshes and seagrasses, are important carbon sinks. However, primarily due to infrastructure development and other human activities, these marine and coastal ecosystems are being degraded, undermining their role as sinks and becoming

sources of carbon dioxide emissions. MPAs – such as Natura 2000 sites protecting the Mediterranean *Posidonia oceanica* meadows – can contribute to the protection and restoration of these ecosystems and species, thereby contributing to climate mitigation.

- **Nature-based tourism and recreation**: The designation of a MPA can translate into increased business opportunities for the tourism and recreation sector, as it tends to increase the attractiveness of a specific area. However, increased numbers of visitors can also have destructive impacts on coastal and marine ecosystems. The designation and good management of MPAs, with the appropriate precautions in place, can help to ensure that the environmental impacts of tourism and recreational activities on marine and coastal areas is kept within acceptable limits, thereby ensuring both environmental protection and the long-term sustainability of the sector.
- **Coastal security**: Seagrass beds, mudflats, saltmarshes and biogenic reefs can stabilise sediments and reduce erosion, thereby mitigating the impact of tidal surges, storms, waves and floods. These natural defence mechanisms provide important benefits to coastal populations and infrastructure and will be increasingly important in contributing to climate change adaptation. The protection of these habitats, including through the establishment of MPAs, can play a key role in ensuring the protection and restoration of the species and ecosystems that improve coastal security.
- **Opportunities for blue-biotech, bioprospecting and research**: As interest in bioprospecting at sea continues to increase, European seas can provide vast opportunities for a wide range of sectors. The establishment and good management of MPAs can help support this expanding market, by providing platforms for innovation while also ensuring sufficient consideration and protection of marine biodiversity. MPAs can also ensure that the impact of the blue-biotech sector on potentially fragile marine ecosystems remains low, thereby ensuring their long-term sustainability.
- **Broader socio-economic benefits**: By contributing to the protection of marine and coastal ecosystems, well-managed MPAs can support or improve opportunities for

cultural, spiritual, educational and recreational activities. In this way, MPAs can play an important role in supporting the culture, sense of identity and lifestyle of coastal communities.

- **<u>Non-use-value of MPAs</u>**: In addition to the direct benefits listed above, the protection of marine ecosystems can also be valued by some as a way of ensuring *future* fishing opportunities, educational or aesthetic experiences i.e. option values. In addition, non-users can assign a value to the conservation of marine areas, regardless of whether they intend to use them in the future or not, as the mere existence of these areas is valuable to them.

9.2 Increasing the evidence base – the role of valuation

The socio-economic benefits associated with protecting marine and coastal ecosystems and ecosystem services can be shown in biophysical terms (e.g. number of tonnes of carbon stored in seagrass beds; improved size and number of fish in fishing grounds near no-take MPAs; increase in the number of visits after designation as MPAs). In addition to biophysical indicators, these benefits can also be illustrated through monetary valuation.

Monetary valuation can contribute to environmental awareness-raising, targeting stakeholder groups who are not particularly interested in environmental conservation per se, by providing single figures that are easy to read and to disseminate. For example, estimating the savings associated with the avoided impacts of extreme weather events in coastal areas due to healthy seagrass beds, mudflats, saltmarshes and biogenic reefs can help make the case for enhanced protection of such ecosystems and species. Showing how the designation of MPAs can attract tourists and thereby provide alternative income opportunities can increase the support of coastal populations. An assessment of economic benefits can also be useful to show how in many cases the upfront investment costs related to the good management of marine and coastal areas is outweighed by the related benefits (not only, but also, in economic terms) and can even generate revenues (e.g., in the tourism sector).

In certain cases, monetary valuation may help to identify and support the development of innovative financing mechanisms, such as PES schemes. This is a necessary development given the existing financing gap for biodiversity conservation in the EU (Kettunen et al., 2011; Milieu, IEEP and ICF, 2016). In several cases, public funding (e.g. funding from the EU budget) is unlikely to be enough to secure appropriate management of MPAs. Consequently, uptake of innovative financing mechanisms, such as PES schemes, is foreseen to be required.

For example, monetary valuation may be used to calculate how much money may be saved though the good management of a marine area, e.g. in terms of avoided damage in case of an extreme weather event or in terms of carbon stored in marine ecosystems. This may in principle help design future PES programmes to remunerate those who actively ensure the sustainability of the related ecosystems.

Finally, monetary valuation may be useful to identify winners and losers of protection measures established in MPAs, and to design compensation measures and increase acceptance levels.

It is, however, important to acknowledge the uncertainties and methodological challenges related to monetary valuation of natural resources (see Box 9.1), and to interpret the results whilst being aware of its limitations.

Box 9.2 Limitations of monetary valuation

Many monetary valuation exercises are based on stated preferences (willingness to pay for improved environmental conditions or accept a monetary compensation for a certain degree of environmental degradation) or revealed preferences (shown by people's behaviour, as for example the money they are willing to pay to visit a location, or the difference in the housing price of a specific area after a change in the quality of the surrounding environment). There are different limitations with this kind of valuation. People may, for example, not be aware of the benefits they receive from ecosystems. Methodologies based on costs may give a better idea of some of the benefits people obtain from ecosystems (e.g. the avoided costs of prevented environmental damage thanks to ecosystems protecting coastal areas from extreme weather events). However, these methodologies also entail limits. For example, if technological advancement reduces the costs of man-made protection infrastructure, the value of the related ecosystem service will appear lower.

In addition, if different methodologies are used to estimate the monetary value of environmental resources, summing up the final results may be controversial, as they give very different information. One of the reasons is that methodologies based on costs measure what economists call exchange values (i.e. based on market prices), whereas methodologies based on stated preferences assess welfare values (i.e. the contribution of a good or service to human welfare, or, in other words, changes in the perception of individual utility). This means that consumer surplus is included in welfare values, but not in exchange values.

Other limitations of monetary valuation include poor data availability, lack of a scientific baseline, the large time span that may be needed to observe benefits due to environmental protection and the risk of double counting.

These limitations may explain why monetary valuation is not currently used in practice to inform policy making (Laurans et al. 2013) or to establish Payment for Ecosystem Services (PES) programmes and other economic tools used for environmental management (Liu et al., 2010).

9.3 Next steps: from improved understanding to policy integration and uptake

Some of the benefits provided by MPAs are currently more understood and studied than others. For example, while there is a significant body of literature showing how no-take MPAs can support the state of fish stocks, the effects of the prevailing multi-use MPAs in Europe on fish stocks are still largely unknown. Similarly, on the one hand, there is a comprehensive body of evidence on the contribution of saltmarshes and seagrass ecosystems to the protection of coastal areas from the impact of weather events. On the other hand, there are still few monetary estimates of this value that could feed into economic assessments and investment decisions. Neither is there clear evidence on the impact of the EU MPAs on these ecosystem services. There is also very limited information on the concrete potential of MPAs for blue technology.

It is important to improve our understanding of the socio-economic benefits provided by MPAs. Increasing the evidence base and filling in the information gaps can help to inform decisions on the designation of a MPA at a particular site, possibilities for zoning activities within and outside MPAs, and which management measures to adopt – while at the same time paying due attention to the conservation objectives of the site. In order to do that, there is a need to increase investment in research and further encourage a multidisciplinary collaboration among different experts and sectors.

An increased evidence base will play an important role in the protection and improvement of management of MPAs and will be increasingly used for awareness-raising activities on the benefits provided by MPAs. Such activities are key for the buy in and engagement of a wide range of stakeholders, including those who in some occasions may be against the designation of MPAs or the establishment of strict rules for their management (e.g. fishermen, coastal communities).

By understanding, maintaining and enhancing the wide range of benefits provided by marine ecosystems in the long term, designation and good management of MPAs can improve not only livelihood opportunities and income for different stakeholders, but also other less tangible benefits linked to the sense of importance of marine and coastal ecosystems to the wider society. As such, MPAs can play an integral part in the future framework for European blue-green economy, with multiple synergies with a range of relevant EU policy sectors as outlined below.

The **EU Blue Growth strategy** supports sustainable growth in the marine and maritime sectors in the EU. It is the maritime contribution to the Europe 2020 strategy for smart, sustainable and inclusive growth. The Blue Growth strategy supports the development of sectors that have high potential for sustainable jobs and growth including, for example, aquaculture, coastal tourism and marine biotechnology. As highlighted in Chapters 2, 4, 6 and 7, MPAs can play an active role in developing sustainable fisheries, tourism and blue biotechnology innovations. Furthermore, as Chapters 3 and 5 show, MPAs can help to maintain processes that underpin the environmental stability of marine and coastal areas, contributing to an enabling environment for sustainable growth.

Linked to the development of blue economy, the **EU policy agenda for research and innovation (Horizon 2020)** includes a dedicated component targeted to promote the conservation and sustainable use of aquatic living resources and marine research, including the development of blue biotechnologies and innovative bio-based products. As demonstrated in Chapter 6, MPAs with their knowledge base and existing governance framework can support sustainable bioprospecting and the development of sustainable blue biotechnology innovations.

The **Common Fisheries Policy (CFP)** aims to ensure that the EU fishing and aquaculture sectors are environmentally, economically and socially sustainable. Its goal is to foster the fishing industry and wellbeing of fishing communities. As regards fisheries management, the policy aims to ensure the long-term viability of fish populations. As highlighted in Chapter 2, Natura 2000 sites and MPAs could play a more integral role in supporting fisheries management in the EU.

Finally, a **common EU legislative framework for maritime spatial planning** was adopted in 2014 (Directive 2014/89/EU). The aim of this framework is to ensure a coherent approach to the multiple uses of marine areas within the EU shared seas. One of the objectives is to establish a more coherent and spatially systematic approach to the protection of the shared marine environment, including encourage investment in MPAs. This recently established framework for EU maritime spatial planning can play an important role in encouraging the identification and realisation of MPA socio-economic benefits. The lessons learned in the context of the EU shared seas could help to inspire integrated planning also at national and local level in the Member States.

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11 Annex – case studies

The Columbretes Islands

Mediterranean Sea / Spain

Daniela Russi

KEY MESSAGE

The designation of a marine reserve in the Columbretes Islands resulted in an increase in size and biomass of commercial fish species inside the reserve, and benefits for the nearby fishing grounds. The reserve also provides opportunities for recreational activities like diving, which results in a source of income for the tourism and related sectors.

SHORT SUMMARY

The Columbretes Islands (almost 50 km from the central eastern coast of Spain) were declared a marine reserve (5,493 ha) in 1990 and also designated as a Natura 2000 site (12,306 ha[24]) including the marine environment. The marine reserve includes a no-take zone (3,112 ha), where virtually no commercial or recreational fishing is allowed, and a buffer area (2,381 ha) where only customary artisanal fishers are allowed. The protection provided by the ban on fishing allowed an increase in both size and abundance of the fish community inside the reserve, and also resulted in a spillover effect to nearby fishing areas. According to Goñi et al. (2010), the benefits obtained by fishermen from the spillover of the spiny lobster *Palinurus elephas* offset the reduction of fishing grounds by 10% in terms of weight of lobsters captured.

In addition, the reserve provides important cultural ecosystem services, including opportunities for diving and research. In fact, the area attracts 3,500 scuba divers per year (almost 60% of which are non-residents), who spend on average about €350 per person during their stay. This results in a local income of about €211,000 and the creation of five jobs per year.

1. The Columbretes Islands

The Columbretes Islands are an archipelago of uninhabited small islands of volcanic origins (L'illa Grossa, La Foradada, La Ferrera and El Carallot), which are situated almost 50 km from the central eastern coast of Spain. The archipelago was declared a wildlife reserve in 1988 and a marine reserve in 1990.

The marine reserve protects 44 km^2 of volcanic rock and coralligenous habitats (maërl beds). It includes important ecosystems and species, including deep algae communities, turtles and cetaceans. Among the most emblematic species are the red gorgonian (*Paramuricea clavata*) the *Cystoseira* and *Laminaria* algae, the bottlenose dolphin and the loggerhead sea turtle (ERENA, S. L., 2014).

Source: http://www.castellonturismo.com/en/oferta-de-ocio/parques-naturales/islas-columbretes

[24] A new proposal has been prepared to enlarge the site to 15.017,25 ha

The establishment of the reserve resulted in a ban on all kinds of commercial fishing, whereas recreational fishing was allowed until 2002. At the moment, the marine reserve legislation prohibits all fishing activities, with the exception of very limited recreational and commercial fishing of pelagic species, which makes the entire area a no-take zone. These rules are well enforced and respected (Stobart et al., 2009).

The reserve was created to protect, together with other species, the *Palinurus elephas* population (Stobart et al., 2009). *P. elephas* is the most important spiny lobster in the Mediterranean and North-eastern Atlantic (Goñi et al., 2006). It is a slow-growing species with a maximum estimated life of more than 20 years, and limited adult movements (most individuals move less than 5 km) (Goñi et al., 2010). Its population has been depleted by overfishing and is still being targeted by small artisanal boats, in particular around archipelagos and islands (Goñi and Latrouite, 2005).

2. SOCIO-ECONOMIC BENEFITS PROVIDED BY THE AREA

2.1 The increase in fish abundance and size inside the reserve and the spillover to nearby fishing grounds

The designation of the marine reserve resulted in a higher fish abundance and size with respect to similar fished areas, as shown by Stobart et al. (2009). The authors collected data on the commercial fish community in the Columbrete Islands Marine Reserve through sampling activities conducted from June to September of the years between 1998 and 2006, covering 51 species. They found that abundance and biomass of the exploited fish species inside the reserve grew at an average rate of between 14 and 16% per year during the study period, without indication of an asymptote, indicating that the fish communities have not yet reached a stable state.

The effect of the designation of the reserve on a specific species was studied by Reñones et al. (2001), who found that the population of *Scorpaena scrofa* was bigger in size and more abundant inside the reserve than in similar areas. As another example, a study by Goñi et al. (2001) showed that the marine reserve designation resulted in an increase in the abundance of the spiny lobster *Palinurus elephas* inside the reserve, which was found to be 5 to 20 times higher than in comparable fishing areas.

According to Goñi et al. (2010), the reserve also resulted in a spillover effect of *P. elephas* to the nearby fishing areas. Between 1997 and 2007, the authors tagged individuals inside the reserve and recaptured them in the surrounding fishery areas, thereby being able to track the origin of the lobsters harvested within 1,500 metres from the MPA boundary. They found that approximately 7% of the *P. elephas* protected in the reserve emigrated annually to the nearby fishing grounds. Their contribution to the annual commercial catch was between 31% and 43% by weight. This means that the benefits obtained by fishermen from the spillover of lobster from the reserve to nearby fishing grounds offset the loss of yield resulting from the ban on fishing in the reserve, producing a mean annual net benefit of 10% of the catch in weight (not in the number of lobster captured). This result can be explained by the fact that the average size of the lobster emigrating from the reserve was higher than that of lobsters outside the reserve. When looking at such results, it is important to underline the short period of protection as compared with the long life span of the spiny lobster, meaning that further improvements may be observed in the future (Goñi et al., 2003).

A spillover effect to adjacent fishery areas was also detected by the study by Stobart et al. (2009) mentioned above. In fact, the authors found a continuous increase in the fishery yields near the reserve boundaries (contrary to the study mentioned above, more marked in abundance than biomass), without a sign of reaching an asymptote and leading to local overfishing at the border of the reserve. They concluded that the improvements showed by the exploited fish community both inside and near the no-take area after 16 years of the designation of the reserve were manifest and continued to evolve without signs of reaching equilibrium. This can lead to an expectation that further improvements will be observed in the coming years, as the exploited fishing community recovers thanks to the protection status provided by the reserve.

2.2 Other benefits

The Columbrete Islands Marine Reserve also provides cultural ecosystem services, including opportunities for recreational and tourism activities, diving and research. The area is enjoyed by 3,500 scuba-divers per year, almost 60% of which are non-residents (i.e. their stay is mainly motivated by the opportunities for diving offered by the area). The divers are estimated to spend about €350 per person during their stay, which results in a local income of about €211,000 and the creation of five jobs per year (Roncin et al., 2008).

3. CONCLUSIONS

The case of the Columbrete Islands Marine Reserve shows that the designation of a no-take marine zone can result not only in an improvement of the fish abundance and size inside the reserve, but also in a spillover effect to nearby fishing areas. Such an effect in some cases can even compensate the loss of fishing grounds due to the restrictions imposed by the reserve, which seems to have been the case in the Columbrete Islands with the *Palinurus elephas* spiny lobster (but only in terms of weight, not of number of individuals caught).

The designation of a marine reserve can also result in improved opportunities for recreational and touristic activities, as well as for research. This brings an increased economic income to the tourism sector, which benefits from the increased number of visits caused by the designation of the reserve and the improved conservation status.

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Posidonia oceanica meadows

Andalusia (Mediterranean Sea / Spain)

Giulia Gitti

KEY MESSAGE

Posidonia oceanica is a seagrass species endemic to the Mediterranean Sea and a priority habitat type for conservation under the Habitats Directive (Dir 92/43/CEE) (Díaz-Almela and Duarte, 2008). This species of seagrass is the best marine carbon sink in the Mediterranean (Luisetti et al. 2013). In the Andalusian region it stocks around 24.7 M tonnes of CO_2 and sequesters about 31,531 tonnes CO_2 per year Diaz Almela (2014).

SHORT SUMMARY

The waters of the Spanish region of Andalusia contain about 6,700 ha of seagrass meadows, 90% of which are included in 12 Natura 2000 sites. These meadows provide several benefits such as carbon storage, improved fish stocks and protection of the coasts and of the marine ecosystems. In spite of their importance, such meadows are diminishing throughout the Mediterranean sea for several reasons. In Spain, the rate of decline is suggested to be up to 5% per year. In order to preserve these meadows, MPAs have proved to be a valuable tool. Recently, it has been shown that MPAs, when properly implemented, can positively impact *Posidonia oceanica* meadows (Marbà et al. 2002). Amongst the benefits provided by *Posidonia oceanica*, carbon storage is important, since *Posidonia oceanica* is considered the best carbon sink in the Mediterranean Sea. A recent study estimated that the carbon stock of the area amounts to around 24.7 M tonnes CO_2. In addition, the sequestration capacity is 31,500 tonnes CO_2 per year. The Natura 2000 areas are managed by the Andalusia Environment Council (Consejería de Medio Ambiente de la Junta de Andalucía) and by the Spanish Ministry of Agriculture, Food and Environment.

1. POSIDONIA OCEANICA MEADOWS

Posidonia oceanica is an endemic Mediterranean species of seagrass. It grows in the coastal area between the surface and a maximum depth of 40 m (Mateo et al., 2002; Junta de Andalucía, 2014). This species of seagrass covers a total basin extension of 25,000-50,000 km^2 (Pasqualini et al, 1998), sequestering around 2 Tg[25] C per year (Marbà, 2008). It provides several services to the marine environment and ecosystems: it works as a carbon sink, stabilises the sediments, protects the coastline from erosion, supports biodiversity and enhances living resources (Marbà et al. 2014). Despite the important role that *Posidonia oceanica* plays in the Mediterranean basin, recent studies have highlighted a regression of seagrass. It has been estimated that 46% of the *Posidonia oceanica* meadows in the Mediterranean have experienced some reduction in range, density and/or coverage and that 20% have severely regressed since the 1970s (Díaz Almela and Duarte, 2008). Marbà et al. (2014) estimate that in the last 50 years *Posidonia oceanica* meadows have lost between 13% and 50% of their total extension. There are several reasons for this loss. On the one hand, *Posidonia oceanica* is characterised by slow growth and limited production of sexual recruits (and Duarte, 2010). On the other hand, external factors such as climate change (e.g. heat waves and ocean acidification) and human impacts (e.g. tourism, coastal development and fishing activities) are negatively impacting this ecosystem (Marbà and Duarte, 2010; Junta de Andalucía, 2014). *Posidonia oceanica* meadows have consequently been defined as a priority habitat type for conservation under the Habitats Directive (Dir 92/43/CEE) and several European countries have put it under specific

[25] 1 teragram (Tg) =10^{12} grams

legal protection.

In the Andalusia region, *Posidonia oceanica* covers an area of 6,739 ha[2] (Diaz Almela, 2014) and 90% of the total area is included in 12 Natura 2000 sites (Junta de Andalucia, 2014). There is no comprehensive analysis available of the improvement in conditions in the area compared to the period before the Natura 2000 sites were created. However, according to a similar study carried out by Marbà et al. (2002) for the Cabrera National Park in the Balearic Islands, the implementation of appropriate management strategies for *Posidonia oceanica* meadows positively affects their protection and growth.

2. SOCIO-ECONOMIC BENEFITS PROVIDED BY THE AREA

2.1 Climate change mitigation

Posidonia oceanica meadows are considered the best marine carbon sink in the Mediterranean Sea. This seagrass species has an estimated carbon sequestration rate of 1.82 t C ha^{-1} per year (Gacia et al. 2002). Barron et al. (2006) estimate that this specific meadow can fix 400 g C m^{-2} per year. Pergent et al. (2012) estimate that the carbon storage capacity varies between 8 and 487 g m^{-2} per year for the short term (1-6 years) and 6 to 175 g m^{-2} per year for the long term (> 100 years). *Posidonia oceanica* sequesters carbon through two different systems: organic and inorganic. On the one hand, the meadows directly sequester carbon and sequester a part of it; on the other hand they help to increase the pH of the water. A high pH, together with a low water temperature, supports the dissolution of CO_2 from the atmosphere (Diaz Almela, 2014).

In a recent study, Diaz Almela (2014) calculated the total sequestration capacity of the *Posidonia oceanica* meadows in Andalusia by using a mean value of the CO_2 sequestration capacity and the extent of these meadows in the region. To assess the total value of carbon stored, the author uses two mean prices, assuming that they will be constant throughout the years. The study calculates that the *Posidonia oceanica* meadows in Andalusia sequester 31,531 tonnes CO_2 (8,592 C tonnes) per year, equivalent to a total value of €83,854,149 if traded in the voluntary carbon market, and €315,850,629 if traded in the Kyoto carbon market. In addition, these meadows already contain a carbon stock of 24,730,185 tonnes CO_2 (4,952,775 C tonnes). To put these numbers into perspective, it is useful to note that the total carbon stock equals 34% of the CO_2 emissions in Andalusia in 2012 and the annual sequestration corresponds to 0.2% of the objective of emission reductions established within the Andalusian Climate Protection Plan (*Plan Andaluz de Acción por el Clima 2007-2012*).

2.2. Other benefits

Posidonia oceanica also brings other benefits to the marine ecosystems and to human beings. In particular, these meadows have a positive impact on fisheries and on coastal ecosystem protection. A study conducted throughout 2013 showed the connection between the presence of the meadows and the quantity of fish caught. The total value was estimated using the existing systems of location of fishing boats and statistical data about fish catches (Sistema de Localización y Seguimiento de Embarcaciones Pesqueras Andaluzas (SLSEPA), and Sistema de Información de Estadísticas Pesqueras de Andalucía (Fishery Statistics Data of Andalusia)). This showed an improvement in the fishery in the area above the *Posidonia oceanica* meadows, compared to areas far from them (Junta de Andalucia, 2014).

Posidonia oceanica meadows contribute to the protection of coasts in different ways. Each year, meadows can produce up to 125 kg of dry seagrass material that accumulate on the beach, developing cushions. These structures sustain an invertebrate food web, protect the shoreline from erosion, deliver sand and work as sediment for dune formation (Borum et al., 2004). In addition, *Posidonia oceanica* oxygenates coastal waters and, through particle retention, improves water transparency (Díaz-Almela and Duarte, 2008). Junta de Andalucia (2014) estimated the total loss of *Posidonia oceanica* in Andalucia and associated it with a total annual cost of €1,200 per metre to restore the coasts, equivalent to a total amount of €96 million. This value is indicative and based on assumptions. However, it illustrates well the value of the services provided.

2.3 Management of benefits

The 12 Natura 2000 areas are managed by the Ministry of Environment of the Andalusian Council (Consejería de Medio Ambiente de la Junta de Andalucía) and by the Spanish Ministry of Agriculture, Food and Environment. Presently, the MPAs are managed with public funds that are sufficient to maintain and protect the area. In addition, a recent study has estimated that, if the carbon storage was traded in a carbon market, it could produce positive revenue that could be invested in the creation of new MPAs and the maintenance of existing ones. If traded, the actual carbon stock could produce a revenue of around €316 million in the Kyoto carbon market and around €84 million in the voluntary carbon market (Diaz Almela, 2014). These figures refer to carbon storage in *Posidonia Oceanica* in general, not only to carbon stored in *Posidonia Oceanica* meadows located in MPAs. However, as argued in Chapter 2 of this report, MPAs can play a key role in the protection of these key ecosystems, thereby contributing to climate mitigation.

3. CONCLUSIONS

The available data about *Posidonia oceanica* in general, and the 12 Natura 2000 areas in Andalusia specifically, show that these meadows produce several benefits. First of all, *Posidonia* meadows provide a significant service as a carbon sink, especially in the long term. In addition, they support local fisheries, contribute to the protection of the coastal area from storms and tides and have a positive impact on local ecosystems. In spite of their key role, these meadows are constantly diminishing. In Spain, the rate of decline could be up to 5% per year (Marbà, 2008). The designation and good management of MPAs can play a key role in reversing this trend.

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Farmer at Sea – MPAs as sources for industrial algae production

Kosterhavet National Park (Skagerrak / Sweden)
Mia Pantzar

KEY MESSAGE

Kosterhavet marine national park in Sweden is an interesting example of how marine protected areas (MPAs) can generate wider socio-economic benefits in combination with nature conservation. The ongoing ecotourism, education and research projects that are being carried out in this MPA can act as an inspiration and incentive for other MPAs in Europe, besides showing the importance of pro-active management and stakeholder collaboration.

SHORT SUMMARY

Kosterhavet comprises two marine Natura 2000 areas and was designated as Sweden's first marine national park in 2009. The area was established to protect rare cold water corals and other vulnerable species and habitats, but has also gained recognition for its "sustainable use". Kosterhavet has boosted ecotourism, educational services and local entrepreneurship, but also innovative industrial algae production. The project "Seafarm" is part of the European Blue Growth initiative and the project aims to develop sustainable large-scale production of macro algae and to identify the most economically viable combination of its different applications. Enabling innovative sustainable business models like Seafarm may be one way of successfully merging the conservation, social and economic interests of MPAs.

1. KOSTERHAVET NATIONAL PARK

Kosterhavet marine national park covers almost 400 km^2 with 98% marine environments. It contains two marine Natura 2000 areas designated in 2001 and 2006 respectively to protect several vulnerable species and habitats. The area was designated as a national park in 2009 to protect species and habitats unique to Sweden and to accommodate a sustainable use of biological resources in the area. Other objectives are to facilitate education, nature-based tourism and research related to sustainable use of marine areas (Vastra Gotalands County Administration, 2015a).

Inspection of growth of *Saccharina latissimi* Photo: L. Näslund/Sveriges Radio

Key threats to the area include eutrophication, pollution and sedimentation. An assessment in September 2015 showed significantly higher number of taxa within the protected areas compared to outside, and especially in areas closed for trawling compared to trawled areas (Vastra Gotalands County Administration, 2015b), indicating that the MPA was delivering conservation benefits. Thanks to national funding, a comprehensive program is currently underway for mapping and assessing the area's species and habitats.

2. SOCIO-ECONOMIC BENEFITS PROVIDED BY THE AREA

2.1. Algae production

The project Seafarm, run by five Swedish universities, is seeking to develop a closed loop macro algae (S*accharina latissima*) production model that produces zero waste, primarily by introducing additional steps in the biorefinery of algae to produce a wider range of marketable products. These include: 1) **food**: the algae is rich in nutrients, sugars, minerals, amino acids and lipids and is part of recent culinary trends in Europe; 2) **animal fodder**: algae is a potential substitute for fish meal used in aquaculture and animal feed production; 3) **medicine**: algae has a natural system for protecting itself from parasites which makes it interesting for medical bioprospecting; 4) **biogas/biofuel**: algae is a high quality third generation substrate for biogas production (see e.g. Allen et al., 2016), ethanol production (Philippsen et al., 2014) or as a manure substitute; and 5) **industrial materials**: algae has applications such as plastic, rubber or textile production (Seafarm, 2014; Radio Sweden, 2015).

Cultivation of macro algae for energy and fuel generation, as occurs for example in Norway and Scotland, has not proven economically feasible (see e.g. Kraan, 2013). However, several studies have found that financial viability can be achieved by combination with other production processes (see e.g. Philippsen et al., 2014). Seafarm is currently evaluating whether their multi-output model will be profitable at a large scale, and which combination of the above applications are the most profitable while ensuring environmentally sustainable production. The project has received significant funding from the Swedish Research Council, the EU, Swedish authorities and private companies.

According to Fredrik Gröndahl, manager of Seafarm, the project is located within an MPA for clear reasons. Namely, the project wants to ensure positive attitudes towards algae production through dialogue with users of the area and the local community. Gröndahl believes that Kosterhavet is gaining more acceptance among the local community because projects like Seafarm illustrate that the area can be used and is not set aside as a "marine museum" (Gröndahl, personal communication, 18 December 2015).

Algae cultivation offers other benefits as well. For example, algae take up dissolved nutrients from the water which may alleviate local environmental impacts of the production as well as eutrophication in surrounding waters. Algal colonies may also serve as habitat for other species – an additional ecosystem service which scientists are currently trying to value in monetary terms. In addition, as algae break down relatively quickly following the harvest, it will be valuable to have the refinery in relatively close proximity to the production site (Seafarm, 2014). This could add local value in terms of employment possibilities.

2.2 Other benefits: Tourism and recreation

Prior to being designated as a national park, Kosterhavet attracted around 90,000 visitors annually and generated around 20 part time jobs (Vastra Gotalands County Administration, 2008; Hambrey, 2008). Sustainable use and socio-economic values are part of the management plan and objective of the national park, and in 2014 the area attracted approximately 500,000 visitors (National Parks of Sweden, 2015). It has also boosted local tourism-related businesses (Pantzar, 2014). Whilst there may be potential trade-offs between tourism and industrial algae production, e.g. in terms of spatial requirements and aesthetics, it is hoped the established dialogue between MPA stakeholders will identify and alleviate such problems.

2.3 Management of benefits

The management at Kosterhavet has received attention for its successful interaction with local stakeholders. Following conflicts between fishermen, scientists and local authorities in the late 1990s, a series of consultations led to the establishment of the *Koster-Väderö Fjord Agreement* and the steering committee for co-management of Northern Bohuslän[26]. The Agreement included, among other things, limitations on trawling (Seafarm, 2014). These rules were later included into national Swedish fisheries legislation. When the national park was established in 2009, fishermen were included in the national park board, and in turn, board representatives became members of the steering committee for co-management.

[26] The Koster-Väderö Fjord Agreement was developed with support from local councils, WWF, and the European Maritime and Fisheries Fund. The steering committee includes fishermen, researchers, the County Administration, the Swedish Agency for Marine and Water Management, and politicians from Strömstad and Tanum local councils (Samforvaltning Norra Bohuslan, 2015).

In order to encourage participation, a board of local inhabitants was established to protect the interests of the local community in the planning of the national park. The board is elected every four years. The administration and management of the national park is locally based. Meanwhile, a representative of the national park is included in the local stakeholder consultation group and the group is the official consultant on fisheries issues for the park. Furthermore, adaptive management applies and whatever was originally agreed with local stakeholders may be revised depending on the change in quality of the natural values that the park aims to protect. According to manager Anders Tysklind, this is crucial for making sure that use and development of the area is not at the expense of the environmental values it has been established to protect (Pantzar, 2014). For example, in 2015 the official protection of Kosterhavet was strengthened following an initiative by fishermen and the park management. The new rules include, for instance, permit requirements for fishermen and more extensive trawling bans (Vastra Gotalands County Administration, 2015c).

Whether the stakeholder consultation management approach at Kosterhavet has in fact accomplished sustainable use of the protected area is still to be attested. Environmental effects of the protection status have not yet been assessed.

3. CONCLUSIONS

Kosterhavet national park provides a range of socio-economic benefits, including local tourism and local entrepreneurship. It is also a platform for innovation and research related to sustainable use of marine areas, such as the project Seafarm, which explores sustainable and closed-loop business models for industrial cultivation of macro algae. The MPA allows Seafarm to develop a positive attitude towards the production among the local community, and Seafarm provides an example to relevant stakeholders of how marine areas can be used sustainably and generate income and jobs.

The management of Kosterhavet, based on close stakeholder engagement, is one of the reasons for the relatively positive public attitude towards the MPA. Finding a sustainable balance between conservation and different uses of MPAs can be crucial for gaining political commitment and local acceptance for further expansion of the network of MPAs in Europe. Enabling innovative business models aiming to find sustainable solutions, like Seafarm, may be one way to reconcile conservation, social and economic interests in the establishment and management of European MPAs.

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The impact of southern European MPAs on local economy

Southern Europe (Atlantic and Mediterranean sea / Spain, France, Italy)

Based on Roncin et al (2008), as summarised by Daniela Russi

KEY MESSAGE

Recreational uses of southern European MPAs can generate a considerable income and create new jobs, in particular related to scuba-diving.

SHORT SUMMARY

According to a study covering 12 southern European case studies, MPAs generate on average €710,000 per year to (small-scale) commercial fishers and €88,000 per year to businesses providing services to non-resident recreational users, i.e. recreational fishers and scuba divers. On average, each MPA generates approximately 43 full time-equivalent jobs related to professional fishing and 15 due to recreational activities (13 of which are linked to scuba diving). The total income generated locally is on average 2.3 times higher than the MPA management costs. These estimates are highly conservative, because they do not take into account non-cash income and indirect and induced effects, and only cover non-resident recreational users.

1. THE ANALYSED SOUTHERN EUROPEAN MPAS AND THE METHODOLOGY ADOPTED

Source: http://www.catalunyavanguardista.com/catvan/perdidas-economicas-por-el-cambio-climatico/

Roncin et al (2008)[27] explored the impact of MPAs on local economies through a survey in 12 southern European MPAs (1,836 questionnaires completed). On average, only 5% of the area covered by the analysed MPAs was a no-take zone (i.e. an integral reserve). Three of the case studies were in the Atlantic sea (two in the Canary Islands and one in the Azore Islands), whereas the other nine were Mediterranean MPAs (three in France, four in Spain and two in Italy). Only one of the case study MPAs is a Natura 2000 site (Monte de Guia, Portugal). The analysed MPAs are all located in highly touristic areas. They are relatively small, ranging between 443 and 80,000 ha (21,094 on average), with 8 MPAs below 2,000 ha and 4 below 1,000 ha.

The survey collected information on the kind of users, the activities they carry out inside the MPAs and their attitudes towards the MPAs. Based on the results, the income and jobs generated by the MPA were calculated[28].

[27] This research was carried out in the context of the EMPAFISH project (http://www.um.es/empafish).

[28] In the case of commercial fishing boats, the overall turnover was calculated by multiplying the number of fishing boats (as declared by MPA managers) by the share of their annual turnover provided by activities carried out inside the MPA (information collected through the survey). In order to calculate the corresponding added value, this figure was multiplied by 70% for boats under 12m and by 50% for boats between 12 and 24 m (these shares were calculated by the French marine research institute Ifremer). The number of jobs related to commercial fishing was calculated by multiplying the information about the yearly visits to the MPAs (as indicated by MPA managers) by the average number of fishermen per boat, as declared in the answers to the survey. The income and jobs created by recreational users included those that local businesses (hotels, restaurants and diving or charter-fishing operators) derive from the expenditures of non-resident recreational users of the MPA during their stay. They were calculated by multiplying the share of non-resident users who visited the MPA to dive or fish, as resulting from the survey, by the total yearly number of users, as declared by

2. SOCIO-ECONOMIC BENEFITS PROVIDED BY SOUTHERN EUROPEAN MPAS

The study analysed the impact of MPAs on both commercial fishing and recreational activities (recreational fishing and scuba-diving). As regards the latter, the assessment focused on the local expenditures related to non-resident users who were mainly attracted to the area by the motivation of fishing or diving[29]. Such users represented the majority of all divers frequenting the MPAs, but only a low share of recreational fishers. In other words, focusing on non-resident users meant that most of the benefits brought to the area by divers were included in the analysis, but the income and jobs created by recreational fishing were underestimated.

The authors adopted a conservative approach which only covered direct generation of income and jobs related to commercial and recreational fishing and scuba-diving, i.e. the added value of activities carried out inside the MPA (the value of production, minus consumption of intermediate goods and services) and the local jobs required to run these activities[30]. In other words, they did not include in the analysis the indirect income and jobs created by the designation and management of MPAs, such as those related to goods and services provided to the fishing and tourist operators and those up- and down-stream in the related economic value chains (e.g. fish canning industries and travel agencies).

The results of this analysis show that divers and recreational fishers were the most important beneficiaries in the analysed MPAs, with on average respectively almost 2,000 and more than 7,000 visits per year per site. In comparison, commercial fishing plays a relatively minor role. One of the reasons is that commercial fishing boats are small, with an average boat length under 12 m in most analysed MPAs[31].

Table 1 summarises the results of this study as regards the estimated income and jobs generated per year by the commercial and recreational use of the analysed MPAs. The local income was estimated at approximately €710,000 per year per MPA on average for commercial fishing, €88,000 per year for recreational fishing and €551,000 for scuba-diving. This means that the added value generated by recreational uses (recreational fishing and scuba-diving) was comparable in size to that of professional fishing. The jobs generated were on average respectively 54.2, 2.1 and 13 full time jobs per year per MPA. These results show a considerable contribution of recreational uses to local income. Job generation is a particularly important factor, given the high rate of unemployment in Southern Europe.

Interestingly, the scale of income generated is in most cases more than enough to match the scale of management costs of a given MPA, though cost-recovery is not carried out in any of the analysed MPAs (i.e. management costs in the analysed MPAs are not financed through the income generated by the MPAs themselves). In fact, on average the locally generated income from MPAs represents 2.3 times the MPA management costs.

MPA managers. The local expenditure of these non-resident users was estimated through the survey, and the related added value and number of local jobs were calculated based on the standard ratios derived from statistical data concerning the French seaside tourism industry.

[29] Recreational users were considered non-resident if the distance between the MPA and their permanent home was more than 50 km. All commercial fishers were assumed resident.

[30] The authors adopted this restrictive focus because of the difficulty of calculating indirect income and jobs.

[31] With the exception of the Columbretes MPA where the average size is almost 20 m.

Table 1. Estimated local annual incomes and jobs generated by MPA ecosystem services uses

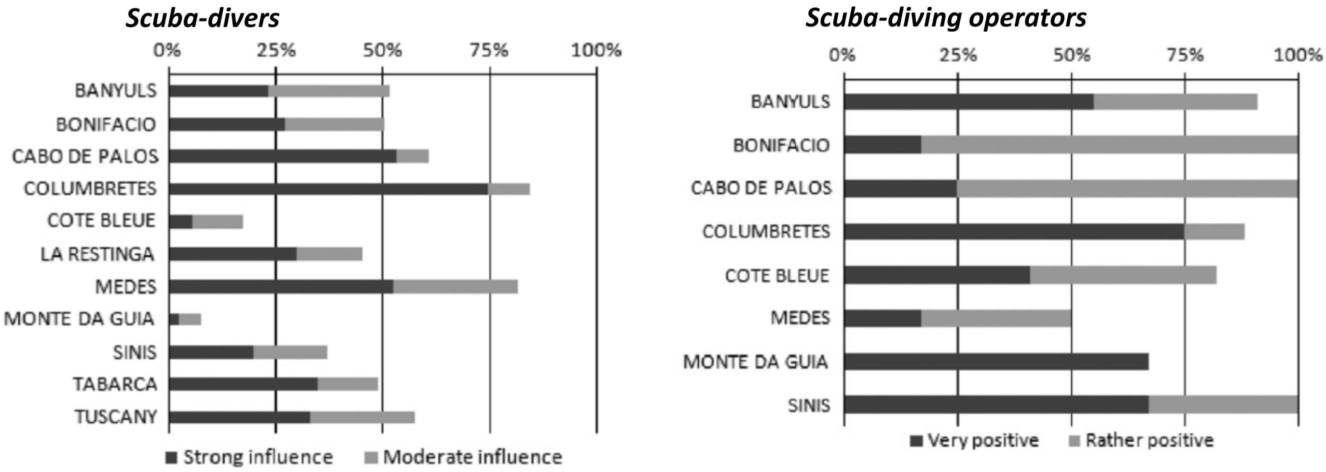
MPA	Professional fishing[a]		Recreational fishing[b]		Scuba-diving[b]	
	Added value[c]	Jobs[d]	Added value[c]	Jobs[d]	Added value[c]	Jobs[d]
Banyuls					973	22.9
Bonifacio					948	22.3
Cabo de Palos					868	20.4
Columbretes	1573	50.4			211	5.0
Côte Bleue			52	1.8	632	14.9
La Graciosa	482	50.0	35	1.1		
La Restinga	306	31.4	55	1.7	616	14.5
Medes	48	4.2			1099	25.9
Monte da Guia			211	5.0	241	5.7
Sinis	1140	133.9			16	0.4
Tabarca					16	0.4
Tuscany					446	10.5
Mean	**710**	**54.0**	**88**	**2.1**	**551**	**13.0**
Standard deviation	**563**	**43.4**	**71**	**1.7**	**374**	**8.8**

Data source: EMPAFISH field survey 2005–2006.
[a]Added value and jobs due to fishing within MPA.
[b]Added value and jobs related to expenditures of non-resident recreational users of MPA.
[c]Unit: 1000 €.
[d]Yearly full-time equivalents.

Source: Roncin et al., 2008

In addition, the authors found a considerable "reserve effect" among the divers, i.e. a majority of them declared that the existence of an MPA influenced their choice of location for their recreational activities. This is confirmed by the opinion of scuba-diving operators, the majority of which declared that the designation of the MPA had an impact on their business (see Figure 1). This can be explained by the fact that scuba-divers tend to think that the designation of an MPA has a direct impact on the quality of ecosystems, including abundance, variety and behaviour of fish species, resulting in the protection of underwater scenery and spectacular or emblematic species, which are the main drivers for the choice of location for their activity.

Figure 1 Declaration of scuba-divers concerning the influence of the MPA on their choice of diving site, and of scuba-diving operators on the impact of the MPA on their business

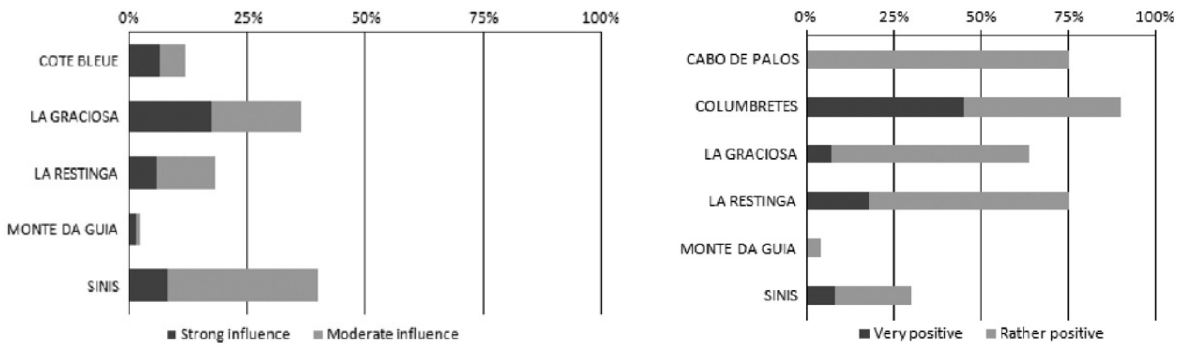


Source: Roncin et al., 2008

The views of recreational and professional fishermen were less clear (see Figure 2). In two of the five locations where this question was explored, more than 25% of recreational fishers declared that the MPA has a positive impact on their activities, whereas more than 50% of commercial fishers in four of the six analysed locations think the same. Roncin et al. (2008) speculate that this result may be explained by the increased fish abundance and size in the areas near the MPAs (see the discussion on the spillover effect in Chapter 2 of this report), which may in part compensate the reduced fishing opportunities due to the restrictions imposed by the MPA.

Figure 2 Opinion of recreational fishers on the influence of the MPA on their choice of a fishing site and of commercial fishers on the impact of the MPA on their business

Recreational fishers ***Commercial fishers***



Source: Roncin et al., 2008

3. CONCLUSIONS

Recreational activities like recreational fishing and scuba-diving generate a considerable amount of income and jobs in southern European MPAs. A study by Roncin et al. (2008) shows how they can be a major economic driver. Also, the evidence indicates that the income and job creation related to scuba-diving activities in the analysed MPAs were considerably higher than those attributable to recreational fishing. Finally, the revenues generated by MPAs are in most cases significantly higher than the management costs. These results show how the designation of an MPA can contribute to local economies through non-extractive uses of marine resources, thereby benefitting not only marine ecosystems but also local economies. In order to maintain the sustainability of this double benefit in the long term, it is important to ensure that the impact of tourism on marine species and habitats is kept as low as possible, through sustainable tourism policies and careful monitoring.

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Leisure and recreation benefits at Lyme Bay

Devon and Dorset (North Sea / the UK)

Based on Rees et al. (2010) and (2015), summarised by Marianne Kettunen and Monika Kotulak

KEY MESSAGE

The designation of a marine reserve, such as Lyme Bay in the UK, can result in increased opportunities for recreational activities for divers and sea anglers, thereby creating economic benefits for the tourism sector.

SHORT SUMMARY

Reefs in the northern part of Lyme Bay, located in southwest England, have been identified as a marine biodiversity hotspot (Hiscock et. al., 2007) and declared a reserve in 2008 to protect the reefs in the area, which were under threat from scallop dredging. In 2011, Lyme Bay was adopted by the European Commission as a Site of Community Importance (the UK Government then had six years from adoption to formally designate it as a Special Area of Conservation). The area provides leisure and recreation activities like diving, sea angling and wildlife watching, resulting in economic opportunities for diving businesses (offering services such as equipment and training) and the charter boat industry, bringing sea anglers and/or divers to their sites of interest. These leisure and recreation activities provide an income for tourism operators estimated at more than £18 million per year (Rees et al. 2010).

1. THE LYME BAY FISHERIES AND CONSERVATION RESERVE

Lyme Bay is situated in the English Channel in southwest England off the coast of Devon and Dorset. The area stretches 2,460 km^2 consisting of a variety of habitats such as sandy seabed, gravels, cobbles and rocky reefs. The area is home to over 1,300 species of marine fauna and flora, including several species of conservation interest at national level such as pink sea fan (*Eunicella verrucosa*), sponge (*Adreus fascicularis*) and sunset coral (*Leptopsammia pruvoti*) (Anon, 2015). The Lyme Bay habitats are also essential for commercial fish and shellfish species such as Sole (*Solea solea*), Bass (*Dicentrarchus labrax*), Brown Crab (*Cancer pagurus*), Lobster (*Homarus gammarus*), Scallops (*Pectin maximus*), and Cuttlefish (*Sepia officinalis*) (Anon, 2015). Reef habitats form the key conservation interest in the area, in addition to which maerl beds (*Lithothamnion corallioides*) and Eelgrass (*Zostera marina*) beds are also of high importance[32]. The ship wrecks in the bay help to support marine biodiversity as their structure creates a habitat which enables the settlement of reef associated species and provides shelter for fish (Rees et al. 2010).

The reefs in Lyme Bay have been under threat from scallop dredging. Consequently, in 2008 Lyme Bay was closed to towed demersal fishing gear (scallop dredging and bottom trawling) and Lyme Bay Fisheries and Conservation Reserve was established to protect the reef habitats. Fishermen using static gear and recreational users (e.g. divers and anglers) are still permitted in the closed area (Rees et al. 2010).

[32] Different habitats are listed for conservation under several policy instruments the EU Habitats Directive (92/43/EEC), UK BAP, IUCN Red List, Bern Convention,

2. SOCIO-ECONOMIC BENEFITS PROVIDED BY THE AREA

2.1 Tourism and recreation

Diving, sea angling and wildlife watching are key components of the leisure and recreation activities undertaken in Lyme Bay, all of which build on the enjoyment and use of biodiversity and biodiversity resources in the area (Rees et al. 2010 and 2015). Diving and angling activities in the Bay are supported by dive businesses, which offer services to divers including gear and training, and the charter boat industry whose skippers take sea anglers and/or divers who are not using their own boats to suitable sites (Rees et al. 2010). Charter boat operators also take people out on wildlife watching trips throughout the Bay to observe species such as bottlenose dolphins (*Tursiops truncatus*) and guillemots (*Uria aalge*) (Rees et al. 2010).

Whole of Lyme Bay: The above recreation activities occur across the whole of Lyme Bay and they are highly dependent on the quality and functioning of marine ecosystems. A study by Rees et al. (2010) assessed the spending created by different leisure and recreation industry sectors, thereby exploring the socio-economic importance of tourism and recreation ecosystem services. According to the study, sea anglers spend the most in the bay (£13,687,992 per year). The estimated expenditure by divers – estimated through trips made with dive clubs in Lyme Bay – is £1,048,956 per year. The boat charter and dive businesses in the Bay have a combined turnover of £3,542,919 per year. This gives a total value of recreation activities of £18,279,867 per year. In comparison, landings from scallop dredging within Lyme Bay were valued as £1,848,577 (in 2007).

Lyme Bay reserve: The Lyme Bay reserve protects a part of the turnover and expenditure generated by the marine leisure and recreation industry in the area. Rees et al. (2010) estimated that local dive and charter boat businesses generate a turnover of £676,734 per year through their use of the reserve in particular. Sea anglers and divers spend £3,266,999 per year visiting sites in the closed area. This gives a total turnover value for recreation activities in the closed area of £3,943,733 per year. The most valuable site within the closed area (and in Lyme Bay as a whole) is the wreck of the Baygitano with recreation groups generating £414,311 expenditure/turnover per year visiting the site. The most valuable reef site in the closed area – and also in the whole of Lyme Bay – is the West Tennants reef with recreation groups generating £427,056 of expenditure/turnover per year visiting the site.

A follow up study of Rees et al. (2015) presents results of a survey from 2008-2011 looking at the possible influence of Lyme Bay Reserve on recreation and leisure stakeholder groups over the years, most notably divers and anglers. According to the study, diving activity has increased both inside and outside the reserve with divers reporting that they prefer to dive within the reserve (as protection is associated with better quality diving sites) (Rees, Pers. Com., 2015). Dive businesses have increased their frequency of activity both inside and outside the reserve (by 35% within and 89% outside) and report an increase in turnover. However, the business sector perceives little or no effect of the reserve on business; mainly because the most of businesses are located further away from the reserve and do not explicitly depend on high quality dive sites for their activities (Rees Pers. Com., 2015). Charter boat operators have seen an overall decline of 33% in the frequency of activity outside the reserve and an increase of 19% inside the reserve, and they perceive that the reserve has increasingly had a positive effect on their business. Based on the responses from sea anglers, angling activity seems to have declined at sites outside the reserve and increased at sites within the reserve. This is because anglers prefer not to conflict with other users and are convinced that fishing is better in the reserve (Rees Pers. Com., 2015).

Overall, the above results indicate that Lyme Bay reserve is synergetic with continued revenue generation and can play an active role in attracting leisure and recreation expenditure and associated turnover to the area.

2.2. Other benefits

Fishing continues to be of importance within Lyme Bay and there are several commercially targeted species within the Lyme Bay reserve (Rees et al. 2010). The volume of catch ranges from the highest at 600 tonnes per year down to less than a single tonne, depending on the fish species. A dedicated initiative called the 'Reserve Seafood' brand has been established to help fishermen achieve top pricing for their catch. The charity Blue Marine Foundation together with its partner Direct Seafoods launched a new scheme where leading fish merchants collect the day's catch of fish, label it as 'Reserve Seafood' brand and sell to London's restaurants, which pay higher prices for fully traceable fish. 'Reserve Seafood' aims to help keep traditional fishing villages alive and sustain profits for the future.[33]

Law concerning fishing in Lyme Bay reserve prohibits bottom trawling (Lyme Bay Designated Area (Fishing Restrictions) Order 2008[34]). There is also a Voluntary Code of Conduct introduced by the Blue Marine Foundation for fishermen who agree to a stringent conservation code which sets limits on the numbers of nets and pots that may be used and requires every boat to use the mobile phone-based inshore vessel monitoring system (iVMS), which records the position and catches of 45 boats.[35]

2.3 Management of benefits

Information on both monetary and non-monetary valuation is considered to be of high importance for marine spatial planning/integrated coastal management (Rees et al. 2010). Supporting a monetary valuation with spatial data and frequency counts provides a means to value individual sites (Rees et al. 2010). These data could be used to support compensation claims by members of the recreation and leisure industry if a site they consider valuable has been damaged or destroyed by human activities (Rees et al. 2010).

The UK Marine and Coastal Access Act includes provisions for compensation for breaches to marine licensing conditions which damage the marine environment (Defra. 2008). Application of the precautionary principle also requires those who cause damage to be held responsible (Defra. 2006). Fishermen also feel that they should be financially compensated if excluded from fishing grounds under plans for Marine Conservation Zones (Jones. 2009). Determining the proportional value of a site can provide an evidence base for conserving particular marine sites, in this case the Lyme Bay reefs. A strong economic case for protection could also be made for other recreation hotspots in Lyme Bay and this would need to be considered for future marine spatial planning/integrated coastal management scenarios. This level of detail in the valuation can also enable the monetary value of recreation to be included and compared to sectors of the fishing industry in a long-term cost benefit analysis of the Lyme Bay closed area policy, taking into account mutual exclusivity of all activities (Rees et al. 2010).

A short term study based on perception of fishermen from Lyme Bay (preliminary results) indicates that there have been no significant changes in the gears used, value of landings and fishing duration.

[33] http://www.lymebayreserve.co.uk/reserve-seafood/
[34] https://www.gov.uk/government/publications/lyme-bay-designated-area
[35] http://blueandgreentomorrow.com/features/conservation-is-catch-of-the-day/

This implies that costs (including both costs of equipment and opportunity costs) have not increased since the closure. Costs incurred by the recreation industry in Lyme Bay following the closure were investigated for charter boat operators, dive businesses, divers, sea anglers and local hotels. Findings showed that no costs have been incurred by these recreational groups as a result of the closure (Mangi et.al. 2009). As regards future marine spatial planning/integrated coastal management, both monetary and non-monetary (spatial) valuations have a role to play. Non-monetary values represented spatially provide a baseline by which to plan with multiple stakeholder groups (Rees et al. 2010). Proportional monetary values of different sites can provide a baseline against which the costs and benefits of reserves can be measured to determine future marine spatial planning scenarios (Rees et al. 2010). A valuation of the marine leisure and recreation industry can support conservation objectives as the economics can justify and enable policy makers to designate areas for conservation when it may be to the short term detriment of other economic interests (Rees et al. 2010). However, recreation use needs to be sustainable in relation to the conservation objectives of the marine protected area. Dive tourism can, for example, have adverse effects on benthic features (Luna et. al. 2009; Hasler et al. 2008).

3. CONCLUSIONS

Estimates of the economic income generated by the recreation sector like the one carried out by Rees et al. (2010 and 2015) show that the establishment of reserves can be synergetic with and/or contribute positively to socio-economic opportunities and can therefore help argue in favour of protecting valuable ecosystems, such as the Lyme Bay reefs. The study shows the possible benefits provided by the designation and management of reserves, and can show how the economic income generated by reserves in general can, in principle, compensate the economic losses of specific stakeholders like fishermen.

It is to be noted, however, that while the increasing leisure and recreation activities in Lyme Bay bring in more money and therefore local stakeholders' acceptance, their environmental impact (including impacts on (non-)Natura 2000 species and habitats) could be further monitored in the future.

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Waterdunen, reconstruction for biodiversity and people

Province Zeeland (North Sea / The Netherlands)

Based on Bloom et. al. (2012), summarised by Monika Kotulak and Marianne Kettunen

KEY MESSAGE

Reconstruction of the coastal zone and creating the Waterdunen nature reserve in Zeeland Province (The Netherlands) has been estimated to be beneficial both for the environment and the economic development of the region. When the planned reconstruction and establishment of the nature reserve is completed it is foreseen that further evidence will be provided on the socio-economic benefits associated with MPAs.

SHORT SUMMARY

The coastal area in the Province of Zeeland, in the southwestern Netherlands, is struggling with depopulation caused by degradation of agricultural land. The local authorities, together with small businesses from the region, are trying to restore the coastal area, drawing inspiration from socio-economic studies assessing the benefits of environmental restoration in the area. The Waterdunen project – ongoing since 2012 – will create new habitats by connecting the currently cut off coastal area to Westerschelde, the estuary of the Scheldt river. Moreover, the project hopes to attract tourism which will help the local economy. The overall estimated costs of reconstruction will be around €200 million and overall monetised socio-economic benefits are estimated at €95.5 million per year and €46 million as one-off.

Source: http://www.waterdunen.com

1. WATERDUNEN

Waterdunen is a project initiated in 2012 by the owner of the Camping Napoleonhoeve and the Foundation Het Zeeuwse Landschap (HZL) in a rural area of the southwestern Netherlands. The project is carried out as a partnership between the province of Zeeland, town of Sluis, Zeeuwse Landschap Molecaten group and Scheldestromen water board. Previously, the project area was a large agriculture area with a camping site. The future vision is to create a large nature reserve and a recreational site. While doing so, the Waterdunen project focuses on improving the recreational value of the area, while simultaneously supporting the ecological restoration of the Westerschelde estuary.

Construction of a tidal culvert is planned to connect the Waterdunnen reserve to the Westerschelde estuary. The project will allow controlled tides in the area, creating a new tidal nature reserve of 250 ha near an existing Natura 2000 and Ramsar site (Westerschelde & Saeftinghe). This will generate a habitat for breeding and a foraging place for migrating birds, as well as salty meadows, mudflats and salt marshes (Bloom et. al. 2012).

The project will also build facilities for 400 recreational overnight stays across 40 ha of land, including a visitors centre, restaurants, retail stores, a pool, sports/wellness facilities, together with hiking and bike riding trails. Building infrastructure is foreseen to attract more visitors to the area, in order to boost the local economy. This is hoped to help with the ongoing depopulation of the region due to declining agricultural, fishing and tourism activities (Bloom et. al. 2012).

The project is planned to be finalised in 2016. A tidal culvert is scheduled to be opened in the near future, letting the water flow in and out of the area through three tubes at high and low tide. A camping site is already in place in the area which can host up to 300 people. Walking routes through the area will soon be organised. The coastal reinforcement work is almost complete. Recreational sites and holiday houses are planned to be built soon (Province of Zeeland, 2015).

The area of Waterdunen is a habitat for some protected and endangered species (Bureau Waardenburg, 2006, cited in Oranjewund, 2006). It is a nesting area for birds such as Redshank, Skylark, Green Woodpecker and Little Owl. Typical plants of the coastal strip are sea holly, sea spurge and celery, which are found in the salty grasslands.

The planned restoration works and increased number of visitors are foreseen to result in some disturbance to the biodiversity in the area. However, species associated with the dune ecosystems will benefit from the project in the long term. Further research is planned into the disturbance to birds (such as the little owl), which will then be appropriately addressed and minimised.

2. SOCIO-ECONOMIC BENEFITS PROVIDED BY THE AREA

Before the project implementation, a study by Bloom et. al. (2012) analysed the foreseeable outcomes of the planned intervention, as well as its costs and benefits. This study was based on two previous assessments (in Dutch only): the Environmental Impact Assessment (Oranjewoud, 2006) and an expert assessment by Ms. Dekker (Zeeland, 2010). According to Bloom et al. (2012), the identified benefits of the reconstruction were improved flood security, strengthening the coastal line, and increasing the ecological quality and economic strength of the area. Based on these calculations the Waterdunen project was initiated (Province of Zeeland, 2015).

The estimated foreseen benefits of the nature reserve were evaluated using a qualitative and quantitative approach (the latter only for some of the benefits), as shown in Table 1. As the table shows, the project was foreseen to make a positive contribution to the area’s landscape values, creating new nature areas, increasing flood safety and enhancing tourism, with benefits to the local economy.

Table 1. Estimated socio-economic benefits of the Waterdunen project

Ecosystem service	Estimated benefits	Qualitative indicators	Quantitative indicators	Methodology/sources
Provisioning ecosystem services	Saline cultivation (e.g. samphire, sea lavender, mussels and oysters)		€90,000 per year	Based on feasibility study (Roeleveld, 2008) which determines which crops are most likely in the project area, also giving potential harvest (€ / ha / year), multiplied by its market value at 5% profit. The plans include, for example, small scale saline cultivation for holidaymakers.
Regulation ecosystem services	Water	neutral	Not assessed in quantitative terms	
	Protection against flooding*	++	€36.2 million (avoided costs in terms of human life) €21.8 million (estimated economic damage avoided)	Avoided costs of possible future damage to dike.
Supporting ecosystem services	New/restored nature	++	€6-7.4 million	Willingness to pay (WTP)
	Biodiversity		Not assessed in quantitative terms	
	Landscape	++	Not assessed in quantitative terms	
	Soil	natural/+	Not assessed in quantitative terms	
Cultural ecosystem services	Tourism	+++	285,000 tourists/ 100,000 day-trippers	The number of potential visitors to the site was calculated based on information about estimated occupancy rates during different seasons.
	Recreation		€20 million (entrance fees, permits, recreational fees, parking/demurrage for cars and boats)	Calculated as €12 per person per day, which is seen as the average spending of a day tourist in Zeeland (source: Tourist Trend Report 2008- 2009).
	Enjoyment	+	€2.9 million	Calculated on the basis of the increase in the WOZ tax (Waardering Onroerende Zaken, Valuation of Immovable Property), whose value is estimated on the basis of the investment cost for the construction of new houses and hotels
	Employment related to tourism		€7.1 million (collaboration with local businesses and organisations)	The indirect impact on employment was determined based on average salaries for full time jobs in the region

* These protection benefits only occur if the dike is re-enforced more widely than just in the Waterdunen project area. For this reason, they cannot be attributed to the interventions at Waterdunen alone.

Source: own elaboration, based on Province of Zeeland (2010), Oranjewoud (2006) and Bloom et al. (2012)

Some negative impacts of the restoration activities were expected in terms of decreased area available for agriculture, due to the fact that the introduction of tidal waters in the area will cause a loss of part of the farmland. The corresponding loss of revenue is estimated at €700,000 per year. However, it is assumed that this will be compensated by gains in the tourism sector. Another negative impact due to the development of Waterdunen is the increased traffic. However, since the traffic intensity is in general low in the area, the impact on air quality and noise is predicted to be negligible (Oranjewoud, 2006).

In addition to the assessment by Oranjewoud (2006), the Zeeland Province has also calculated regional economic benefits to be expected from the Waterdunen project (2010). According to this study, the spending by visitors is calculated to result in additional revenue of €20.2 million per year to the area. The revenue associated with related business sectors is calculated to be €45 million during the construction phase. Additionally, the authors calculate that the project will create 121 new permanent jobs, plus 300 temporary jobs during the construction phase. The purchasing power effect[36] is estimated at €210,000 per year. Finally, the study calculates that additional revenues from building permits will be €1 million and additional income tax and property tax €420,000 per year.

The costs of planned interventions are estimated at €200 million, which will be mostly funded by government (Bloom et al. 2012). The most important costs include: construction of recreational facilities, works related to raising the ground level, building the tidal culvert and developing the nature reserve. The costs are estimated to total a minimum of €65-70 million. Secondly, the development of residential housing, hotels and other tourism facilities are estimated to cost €50-80 million and will be covered by Molecaten[37], a private tourism investor. The coastal reinforcement (€45 million) will be completely funded by the Flood Protection Programme of the Netherlands Government.

It was also estimated that the consequences of inaction (i.e. not implementing the project) would be negative for the region, e.g. continued depopulation and declining employment. To avoid that, and strengthen the social, economic and environmental features of the region, a nature-based development plan (Natuur Vilat) was established (Bloom et.al. 2012). The Waterdunen reconstruction project plays an important role in this plan.

3. CONCLUSIONS

The study of Bloom (2012), based on previous studies (Oranjewound, 2006; Provincie Zeeland, 2010), shows the positive impact of the creation of a new coastal nature reserve on the local economy. Losses in the agricultural sector are foreseen to be compensated by increased revenues for the local tourism sector.

This is important because the increased income due to a restoration project can contribute to a change of attitude of local stakeholders towards biodiversity conservation.

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