DEVELOPMENT OF INDICATORS TO EVALUATE AND MONITOR CLIMATE CHANGE IMPACTS ON SOCIO-ECONOMIC TRENDS LINKED TO BIODIVERSITY AND NATURAL RESOURCES IN SPECIALLY PROTECTED AREAS OF MEDITERRANEAN IMPORTANCE (SPAMIS)

Final report, October 2020

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Review of the report by Antoine Lafitte, Programme Officer, Plan Bleu and Daniel Cebrian, SAP BIO Coordinator, SPA/RAC.

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Executive Summary

Context and purpose of the report

In addition to being considered a biodiversity hotspot, the Mediterranean region is often referred to as a hotspot for climate change. Recognition that climate change represents a significant threat to marine biodiversity and to vitality of marine ecosystems has had a strong impact on the Barcelona Convention policy framework and the support provided to national policies and plans.

The Barcelona Convention system is supporting efforts to develop and implement a coordinated basin-wide monitoring of climate change impacts in Specially Protected Areas of Mediterranean Importance (SPAMIs) and other marine protected areas (MPAs). At the same time, climate change monitoring in MPAs is receiving increased attention by the EU, IUCN, WWF, the MedPAN and other actors, and is a subject addressed through various projects and data sharing efforts.

Plan Bleu is one of the Regional Activity Centres in charge of the Mediterranean Action Plan implementation. Among others, it plays the role of the Mediterranean Observatory on environment and sustainable development promoting science-policy interface to support decision making process at regional level. It develops and informs a series of indicators and factsheets for the follow-up of the Mediterranean Strategy for Sustainable Development (MSSD) 2016-2021.

Five priority indicators to evaluate climate change impacts on marine ecosystems across SPAMIs have been identified by SPA/RAC in 2017 and recommended to managers and countries for implementation. These indicators are: sea surface temperature and thermal stratification; mortality and bleaching events; range shift of alien/ temperature-sensitive species; reproduction and breeding date of selected species, including flowering of *Posidonia oceanica;* and episodic species outbreaks.

Improved knowledge on socio-economic trends related to MPAs in a changing climate has been called for (directly or indirectly) in a number of Barcelona Convention policies and strategic documents – from Marrakesh Declaration through the Regional Climate Change Adaptation Framework to the MSSD – and is likely to remain in focus as climate change impacts on marine ecosystems are expected to accelerate.

Nevertheless, the existing monitoring of climate change impacts on physical/ natural characteristics and biodiversity in the Mediterranean MPAs and SPAMIs is not comprehensive and systematic, while monitoring of potential impacts on socio-economic systems that benefit from MPA natural resources is almost non-existent.

The present report is meant to support decision making process through technical advices for MPA managers and countries based on scientific evidence and on the ground experiences in three selected SPAMIs. The report was developed to meet the following objectives:

- analyse how socio-economic values related to protected areas' biodiversity and natural resources are impacted by climate change, and how MPAs could help limit such impacts and/ or adapt to them;
- select and develop at least 4 socio-economic indicators to evaluate and monitor impact of climate change on biodiversity and natural resources in SPAMIs (2 indicators related to costs induced by climate change and 2 indicators to measures benefits for climate change mitigation and adaptation).

Main findings

Experiences of three SPAMIs were used in the preparation of the report to inform and guide selection of socio-economic indicators for climate change impacts monitoring. These SPAMIs were Portofino and Torre Guaceto (Italy) and Karaburun-Sazan (Albania). In selecting the SPAMIs, criteria such as interest in and/ or experience with climate change monitoring, evidence of climate change impacts, diverse socio-economic conditions and physical locations (across various sub-regions of the Mediterranean, as delineated under the Barcelona Convention Ecosystem Approach) were taken into account.

Based on extensive literature review and analysis of the situation in selected SPAMIs, potential socio-economic indicators were identified, whereas four indicators were selected as the most suitable ones (at present) to monitor and evaluate climate change impacts. The four selected indicators are considered as a first step in setting up a

comprehensive monitoring of socio-economic trends linked to biodiversity and natural resources in MPAs/ SPAMIs. Moreover, four optional/ alternative indicators were proposed to allow for more flexibility.

The four recommended indicators are:

1. **Fisheries - Revenue per unit effort**: revenue of artisanal fishermen from fishing inside and outside the MPA, derived based on the amount of fish caught by different types of fishing gear and fish prices;
2. **Climate change mitigation - Carbon stored in *Posidonia* meadows and salt marshes linked to the MPA**: estimate of the total amount of carbon stored in *Posidonia* and salt marshes habitats (within the MPA and in the neighbouring waters/ coastal areas) based on their surfaces and condition, and per hectare storage rates;
3. **Climate change adaptation/coastal security - Damages to coastal and MPA infrastructure due to extreme weather events**: *ad hoc* and/ or annual estimations of damages caused by extreme weather events to infrastructure within the MPA and in the surrounding coastal areas; and
4. **Climate change adaptation/coastal security - Investments in coastal protection including remediation of coastal erosion impacts**: total investments into coastal protection measures and remediation of coastal erosion for the observed period.

Optional indicators are:

- Invasive species - Damages to artisanal fishing from invasive species presence;
- Recreational activities - Seasonality of tourist visits/ seasonality of diving
- Ecosystem services (regulation) - Value of blue carbon (carbon stored in protected marine ecosystems); and
- Loss of natural capital due to extreme weather events.

These indicators need to be re-visited over time and changed/ improved as more information and knowledge will become available. SPAMIs are well-positioned to lead this work, fulfilling at the same time their potential to act as 'laboratories' for the marine science and policy in relation to climate change. Commitment of countries and MPA managers is needed, as is cooperation and coordination (also with other projects and data sharing platforms) among all actors involved in monitoring. Use of local environmental knowledge is necessary as well to ensure adequate and cost-effective monitoring.

Technical advices for MPA/ SPAMI managers and policy makers

Based on the findings of this report, the following technical advices for managers and policy makers are put together:

- Address gaps in current climate change monitoring, including socio-economic aspects;
- Carry out climate change vulnerability assessment;
- Identify habitats and species that act as blue carbon sinks and define actions to conserve them in the long term;
- Strengthen cooperation through networking (such as capacity building and trainings allowing the transfer of knowledge and practices) within and between actors in MPAs/ SPAMIs in the frame of the Mediterranean Ecosystem Approach (EcAp);
- Consider effectively managed Mediterranean MPAs/ SPAMIs as 'laboratories' promoting socio-ecological resilience to climate change.

1 Background and purpose of the report

In addition to being considered a biodiversity hotspot, Mediterranean region is often referred to as a hotspot for climate change. Recognition that climate change represents a significant threat to marine biodiversity and to vitality of marine ecosystems has had a strong impact on the Barcelona Convention policy framework and has resulted in a number of initiatives aimed at better understanding and mitigating the impact of climate change on natural and socio-economic systems in the region.

In 2008 – 2009, a process to integrate climate change considerations into SAP BIO[1] was carried out, analysing situation at national and sub-regional levels, and aggregating the findings at the regional/ Mediterranean level. Pre-identification of habitats vulnerable to climate change showed the following were expected to be significantly affected by climate change: coastal lagoons, saline wetlands and ponds; estuaries, salt marshes and tidal mudflats; sandy low-lying beaches; submarine and coastal karst habitats; nursery sites; coralligenous assemblages; vermetid platforms; *Posidonia* meadows; and sites with endemic, endangered and rare species (UNEP/ MAP – SPA/RAC, 2009).

Through the adoption of the 2009 Marrakesh Declaration, Contracting Parties to the Barcelona Convention noted it was necessary to continue research on the extent of environmental and socio-economic impacts of climate change in the Mediterranean. The countries committed to 'promote Mediterranean cooperation to combat the effects of climate change' as well as to ensure 'integration of climate change issues into development policies' and 'sharing of experience in the field of surveillance (early-warning systems) and the development and implementation of adaptation and risk-management strategies' (UNEP(DEPI)/MED IG.19/8).

'Understanding of the vulnerability of natural and socio-economic systems and sectors and of possible impacts' (of climate change) is one of the strategic directions[2] of the Regional Climate Change Adaptation Framework for the Mediterranean Marine and Coastal Areas (Decision IG. 22/6 adopted by the Barcelona Convention Contracting Parties in 2016) whereas environmental and socio-economic vulnerability of MPAs has been highlighted as one of priorities for consideration (UNEP/ MAP, 2017).

Importance of improved understanding of climate change impacts is also emphasised in the Mediterranean Strategy for Sustainable Development (Decision IG. 22/2), where Flagship Initiative under Objective 4 (Climate Change) aims at building regional science-policy interface mechanism to enable preparation of consolidated regional scientific assessments and guidance on climate change trends, impacts, and adaptation and mitigation options.

Considering these strategic orientations, SPA/RAC has undertaken to contribute to the development and implementation of a coordinated basin-wide monitoring of climate change impacts in SPAMIs (Specially Protected Areas of Mediterranean Importance) and other MPAs (Marine Protected Areas). Pertinent work focused on effectively managed SPAMIs and MPAs due to their recognised ability to increase adaptive capacity and protect from negative impacts of climate change. These areas are also considered 'sentinel sites' to detect and study the effects of climate change since they are less affected by the other drivers of change due to their protection status.

The SPA/RAC efforts resulted with identification of five priority indicators: 1) Sea surface temperature (SST) and thermal stratification; 2) Mortality and bleaching events; 3) Range shift of alien/ temperature-sensitive species; 4) Reproduction and breeding date of selected species, including flowering of *Posidonia oceanica;* and 5) Episodic species outbreaks (blooms). Implementation of the five indicators based on common protocols has been recommended to MPA managers and countries (UNEP/ MAP – SPA/RAC, 2017).

[1] SAP BIO – Strategic Action Programme for the Conservation of Biological Diversity in the Mediterranean Region – provides principles, measures and concrete and coordinated actions for the conservation of the Mediterranean marine and coastal biodiversity.

[2] Under Strategic Objective 4 - Better informed decision-making through research and scientific cooperation and availability and use of reliable data, information and tools.

Climate change monitoring in MPAs is receiving increased attention with involvement of many actors active in the Mediterranean such as the EU, IUCN, WWF, MedPAN and others, and is a subject addressed through various projects and data sharing efforts, recent ones including the MPA-Adapt[3] and AMAre[4] projects, and the T-MEDNet initiative[5].

Taking into account deliberations of the Marrakesh Declaration, Regional Climate Change Adaptation Framework and of the MSSD, as well as other policy frameworks and related initiatives, and following up on the results of the 2017 SPA/RAC study, it was deemed necessary to expand the work within the Barcelona Convention system to address socio-economic aspects in monitoring how climate change affects MPAs/ SPAMIs.

The present report with the underlying analysis is a first step in this direction, implemented by Plan Bleu. The rationale for the Plan Bleu's work is a recognition that SPAMIs may play a crucial role to understand climate change influence on economic and social systems related to marine environment in the context of the Mediterranean Sea warming and related impacts, and that this potential needs to be measured to allow for formulation of adequate responses – for biodiversity conservation as well as for climate change mitigation and adaptation.

Within the same context and in parallel to the preparation of this report, a SPA/RAC supported initiative was launched to prepare a cost-effectiveness analysis for the implementation of a monitoring network for climate change impacts on biodiversity in SPAMIs.

General objectives for the preparation of the present report were to:

- analyse how socio-economic values related to protected areas' biodiversity and natural resources are impacted by climate change, and how MPAs could help limit such impacts and/ or adapt to them;
- select and develop at least 4 socio-economic indicators to evaluate and monitor impact of climate change on biodiversity and natural resources in SPAMIs.

Specific objectives were to:

- identify the main issues regarding socio-economic trends related to the effects of climate change on biodiversity and natural resources in at least three SPAMIs dealing with climate change, located in at least three of the four different ecosystem approach (EcAp) process subregions of the Mediterranean (Adriatic; West, Central and East Mediterranean)[6];
- Select and develop at least 2 indicators to estimate costs induced by climate change in SPAMIs and 2 indicators to estimate some benefits of protected areas in terms of climate change mitigation and adaptation;
- Assess feasibility of measuring selected indicators;
- Analyse availability of data in SPAMIs or surrounding areas and whether it already allows to document changes for all or some of the selected indicators.

[3] https://mpa-adapt.interreg-med.eu/
[4] https://amare.interreg-med.eu/
[5] http://www.t-mednet.org/
[6] According to Decision **IG.20/4** on *Implementing MAP ecosystem approach roadmap: Mediterranean Ecological and Operational Objectives, Indicators and Timetable for implementing the ecosystem approach roadmap*

2 Methodological approach

To address the set objectives, a sequence of five interrelated steps was implemented, as described below. The main questions addressed in the process were the following:

- What evidence (actual data and/ or estimates) is available on the socio-economic benefits provided by MPAs in general?
- How Mediterranean MPAs/ SPAMIs are likely to be affected by climate change? What will these impacts mean for the benefits MPAs generate for the economy and local communities?
- Why is it important to monitor climate change impacts on socio-economic trends linked to biodiversity and natural resources in MPAs/ SPAMIs?
- How to capture changes in socio-economic variables that are/ will be affected by climate change i.e. what indicators should be monitored at the level of MPAs/ SPAMIs and what role for other stakeholders (e.g. national statistics, other actors in marine monitoring programmes, local environmental knowledge)?

Step 1: Selection of SPAMIs

In consultation with Plan Bleu and SPA/RAC, the following sites were identified as potential pilots for the present report (Figure 1):

	SPAMI	EcAp subregion
1	Mar Menor, Spain	West Med
2	Portofino, Italy	West Med
3	Torre Guaceto, Italy	Adriatic
4	Lara – Toxeftra turtle reserve, Cyprus	East Med

The following criteria were considered for the initial identification of potential sites:

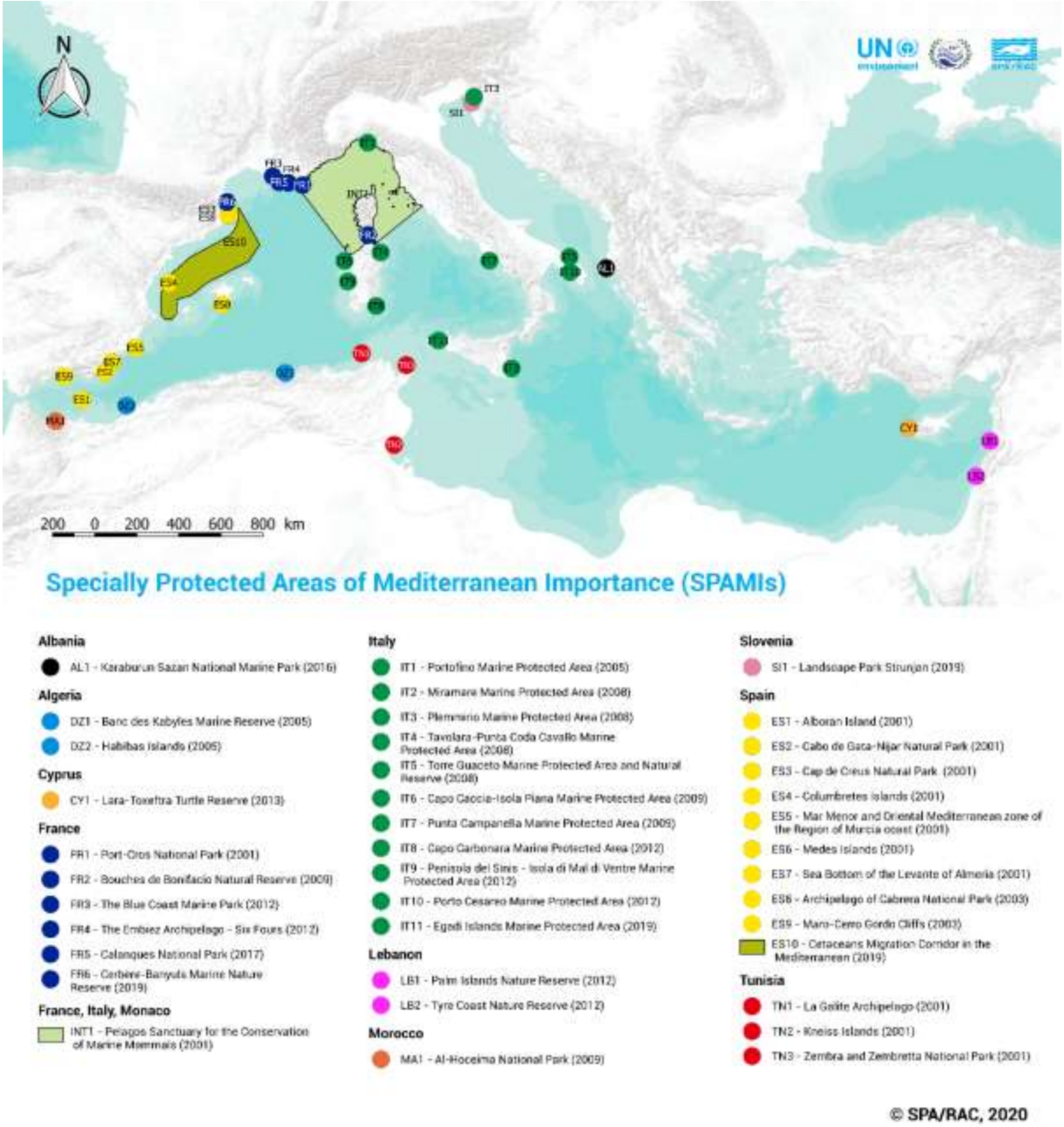
- Evidence of strong impacts of climate change in these SPAMIs exists;
- SPAMIs belong to three EcAp process subregions;
- Well established MPAs with proactive managers;
- Previous experience and active collaboration in the development of climate change indicators (in particular for the 2017 SPA/RAC study);
- Diverse natural and socio-economic characteristics (including how climate change affects them) to ensure selected indicators and findings will be relevant for the entire region;
- Ongoing work on socio-economic issues.

In the period November – December 2019, detailed interviews were conducted with Portofino and Torre Guaceto MPAs/ SPAMIs (questions serving as a basis for these interviews provided in Annex 2). Due to busy schedules and other project obligations, Mar Menor and Lara Toxeftra managers were not able to take part in this exercise. To expand the analytical basis and to test preliminary findings, Karaburun-Sazan MPA/ SPAMI (Albania), located in the border area of Adriatic and Ioannina Seas (Adriatic/ Central Mediterranean EcAp subregions), was also included in the analysis.

Step 2: Literature review and identification of potential indicators

Comprehensive review of available literature (including proceedings of relevant events and project reports) was conducted in order to identify socio-economic benefits provided by MPAs/ SPAMIs, how are these affected/ likely to be affected by climate change and to determine potential (long) list of indicators. In identifying the long list of indicators, key economic activities, key stakeholders and key habitats (in terms of expected impacts, climate change mitigation and adaptation potential) were kept in focus. As a result, an interim report on socio-economic trends related to the effects of climate change on biodiversity and natural resources in MPAs/ SPAMIs was prepared including a list of potential indicators to evaluate and monitor climate change impacts on these trends.

Figure 1. SPAMIs identified as potential pilots for the report from the ones listed up to 2019



Source of the map: http://www.rac-spa.org/spami

Step 3: Interviews with SPAMI managers

Interviews were held on 28 November 2019 in Santa Margherita Ligure, Italy, (Portofino SPAMI) and on 4 December 2019 in Carovigno, Italy (Torre Guaceto SPAMI). Moreover, an online interview was organised with representatives of the agency responsible for Karaburun-Sazan SPAMI management on 24 January 2020.

The aim of the interviews was to:

- consult managers on:

- the main issues regarding socio-economic trends related to effects of climate change on biodiversity and natural resources,
- identification/ selection of the most suitable indicators to measure and monitor socio-economic gains or losses that are arising/ will arise from climate change impacts on biodiversity and natural resources;

- test applicability of selected indicators;
- collect information needed to prepare the final report/ publication on socio-economic indicators and SPAMIs covered.

Step 4: Selection of indicators

Based on conducted consultations, 4 socio-economic indicators were selected from the list of potential indicators as the most suitable ones (at present) to evaluate and monitor climate change impact on SPAMI values. In selecting these indicators, a pragmatic approach was employed in order not to overburden MPAs with comprehensive data collection and analysis requirements. Indicators that can capture changes related to climate change impacts and are at the same time linked to existing data collection and monitoring efforts at the level of MPA or surrounding area (local or national statistics, other actors in marine monitoring) were prioritised and recommended.

Step 5: Analysis and presentation of results

Collected information and analysis results were summarised and presented in this report, and technical advices for MPA/ SPAMI managers and policy makers formulated.

Coordination with the SPA/RAC activities on the preparation of cost-effectiveness analysis was ensured throughout the process.

3 Socio-economic benefits provided by MPAs/ SPAMIs

Ocean-related activities in the Mediterranean Sea have been assessed to generate an annual economic value of 450 billion US$ (Randone et al., 2017) while most of the traditional sectors of the Mediterranean maritime economy (such as tourism, shipping, aquaculture and offshore oil and gas) are expected to keep growing in the period until 2030. International tourist arrivals in the Mediterranean, for example, are expected to increase by 60% between 2015 and 2030 to reach 500 million arrivals in 2030 (Piante and Ody, 2015). The professional fishing sector in the Mediterranean generated 3 billion US$ in 2016 and provided 360,000 jobs (direct and indirect employment) (Vertigo Lab, 2019).

SPA/RAC study from 2006 found out the main benefits of marine protection were related to: enhancement of fisheries; development opportunities in tourism and recreation; species/ habitats conservation and improved resilience; protection against storms and coastal erosion (and other ecosystem services); biochemical prospecting; and education and research (Becker and Choresh, 2006). A more recent review (by Pascual et al., 2016) of 208 published studies on socio-economic impacts of MPAs in the Mediterranean and Black Seas identified a total of 22 marine uses that could potentially be impacted by the establishment of MPAs. Most of the reviewed studies explored how fishing, tourism, and recreational activities have been affected by the establishment of MPAs. Assessments for the remaining uses were scarce or absent. Overall evidence from the examined studies suggested that artisanal, land and boat-based recreational fishing, tourism and beach access, scuba diving, and other recreational activities can be generally benefited by the establishment of MPAs.

Nowadays, it is widely accepted that in addition to positive impacts on biodiversity, effectively managed MPAs support generation of a range of socio-economic benefits and contribute to preservation of services provided by marine ecosystems. Some examples (at European level, globally) of the scale of benefits provided by MPAs are provided below:

- Setting up the Columbretes Islands Marine Reserve in Spain increased catches in surrounding fisheries by about 10% a year (EC, 2015).
- The designation of a British network of MPAs was estimated to generate a monetary value of 8.2 billion £ for gas and climate regulation and 1.3 billion £ for nutrient cycling (EC, 2015).
- A rough assessment of the value of benefits delivered by the marine Natura 2000 network (equivalent to 4.7% of the EU's marine area at the time of the assessment) indicated these areas generated annual benefits of 1.4 - 1.5 billion €. If 10% of the European seas were protected, it was assessed the annual benefits would increase up to 3.0 - 3.2 billion € per year. The higher figures apply to stronger protection measures (EC, 2013).
- Australian Great Barrier Coral Reef Marine Park – one of the largest MPAs in the world with a surface of around 344,000 km^2: national level contribution (value added) generated by tourism, recreation, commercial fishing and scientific research in the Marine Park's catchment area in 2012 was estimated at 5.7 billion US$; number of full time jobs was estimated at around 69,000. The figures are based on both direct and indirect contributions of the considered activities and are driven by just over 7 billion US$ of expenditure in the catchment area and around 1.8 million tourist visitor days (Great Barrier Reef Marine Park Authority, 2014).
- Calanques of Piana, the gulfs of Porto and Girolata, and the Scandola Nature Reserve (UNESCO World Heritage site with a total surface of 11,800 ha, of which 3,500 ha marine protected area) generated the following benefits:
    - 1.1 million visitors, representing 44% of the 2.85 million tourists who travel to Corsica between April and October;
    - 387 million € for the economy, or 22.5% of Corsica's tourism revenue in 2012;
    - the site accounts for 3,627 jobs (full-time equivalents);
    - the site's contribution to tax revenues amounts to 46 million €;
    - image benefits of 2 million € (UNESCO, 2013).

Despite the growing interest and a large number of research projects, assessments and data collection efforts, information on socio-economic benefits of MPAs remains limited. In the study led by MedPAN in 2015, it was concluded the economic contribution of MPAs was still both poorly documented and poorly understood and, therefore, under-valued by decision makers (Binet et al., 2015). The IEEP 2016 study on socio-economic benefits of the EU MPAs confirms this by finding that ecosystem services and related socio-economic benefits provided by the European marine environment (including MPAs) remain poorly understood and unappreciated (Russi et al., 2016).

The most relevant findings from selected publications on socio-economic benefits of MPAs are provided in Box 1. Case studies on economic aspects of MPAs, extracted by Nir Becker & Yael Choresh (2006), are presented in The three case studies below illustrate .

Box 1. MPAs and socio-economic benefits they provided: selected publications' findings

Plan Bleu Economic study of the impacts of marine and coastal protected areas in the Mediterranean (Mangos A., and Claudot M.-A., 2013)

The study was conducted with the aim to qualify and quantify the effects of protection on the socio-economic situation by observing changes in ecosystem services provided in five Mediterranean marine and coastal protected areas. Benefits provided by these sites for fishing (commercial and recreational), tourism, diving and carbon sequestration were examined and estimated under three protection scenarios – business as usual, increased protection and decreased protection. At the same time, costs of managing the protected areas were estimated and cost-benefit analysis conducted. The analysis showed protection of marine and coastal ecosystems generated significant socio-economic benefits for local communities which exceeded management costs, mainly due to long-term increase in services provided by protected ecosystems and their contribution to human wellbeing.

MedPAN Newsletter Science for MPA management Issue 6, Socio-economic benefits of MPAs: healthier seas, healthier people (Rodríguez-Rodríguez et al., 2017)

Proceedings of the MedPAN workshop Socio-economic benefits of protected areas and marine spaces in the Mediterranean held in June 2015 in Marseille, France

The workshop gathered 170 participants including decision-makers, researchers, MPA managers and other stakeholders from 11 Mediterranean countries. A range of socio-economic benefits generated by MPAs in the Mediterranean Sea was highlighted during the workshop discussions including maintenance of activity and jobs in the sectors of artisanal fishing, scuba diving and leisure, tourism and culture, but also indirect but vital benefits, such as natural hazard mitigation or carbon storage. In a broader sense, it was concluded MPAs contributed to many other relevant aspects, such as the attractiveness of territories, the quality of life of their inhabitants, their well-being, health and education.

Findings of the 2013 study by Sala et al.

The study assessed economic effects of a zoned MPA (covering 51 no-take ha and 460 multiple-use ha) off the Catalan coast of Spain on fishing and diving activities. According to the authors, there were some short-term losses to fishers after the designation of the MPA that were offset by increased catches due to spill-over effect few years after proclamation. Tourism revenues from diving fees, catering and accommodation businesses rose constantly after the MPA designation and were estimated at a minimum of 10 million € annually (plus 200 fulltime jobs).

EC Study on economic benefits of MPAs (EC, 2018)

Although robust ex-post evaluation evidence that clearly attributes socio-economic changes to an MPA is limited, the study concludes that parts of fisheries and tourism sectors are most often found to benefit from MPAs.

The fisheries sector usually obtains economic benefits as a result of changes in biodiversity/ environmental quality. Where improvements occur in fish stocks, MPAs can support increased catch per unit effort, thus improving fishing revenue, profits and employment opportunities. It was also demonstrated there were economic benefits from MPA product branding and eco-certification.

MPAs can directly and indirectly influence the quantity and quality of tourism including:

- increased visitor numbers and hence business opportunities and revenue;
- increased length of visitor stay, and hence the ability to capture increased tourism expenditure;
- extension of the season/ increased activity outside of the peak season, which helps to combat the perennial problem of seasonality in tourism (particularly coastal tourism) dependent economies;

- eco-tourism and other forms of specialised tourism can allow for a shift towards higher value tourism – both higher spend per visitor, but also greater benefits per spend resulting from a higher local retention of revenues.

The three case studies below illustrate economic aspects of Marine Protected Areas (MPAs) from Nir Becker & Yael Choresh (2006).

Box 2. Case study 1: Economic Values for Montego Bay Marine Park, Jamaica

Ruitenbeek et al. (1999) made an assessment of Total Economic Value of Montego Bay Marine Park in Jamaica (Table 1). In the first numeric column (under Benefits), the table shows the aggregate total values of the range of associated values in Montego Bay using the Net Present Value (NPV). In the second numeric column, the marginal benefits/ costs of a percentage change in the abundance of the resource (e.g. quality of coral reef) are estimated. Finally, in the last column, the marginal benefit of an additional hectare (or costs of the loss of a hectare) of the resource, under current reef conditions, is estimated. This demonstrates the importance of identifying the range of associated values in the MPA. The information can be used as an educational tool to assist policy makers, as well as a planning tool in the formulation of policies (such as investment in the protected area).

Source: Benchley, P. (2002). Cuba Reefs. National Geographic Magazine 201: 44-67

Table 1. Benefits at Montego Bay Marine Park

	Benefit	Marginal Benefits*	
	NPV (MM$)	MM$/%	MM$/ha
Tourism/Recreation	315.00	7.33	17.18
Artisanal Fishery	1.31	0.03	0.07
Coastal Protection	65.00	1.51	3.54
Local Non-use	6.00	0.24	0.56
Visitor Non-use	13.60	.54	1.28
Subtotal	400.91	9.65	22.63
Pharmaceutical Bioprospecting (Global)	70.09	0.23	0.53
Total (Global)	471.00	9.88	23.16
Pharmaceutical Bioprospecting (Jamaica)	7.01	0.02	0.05
Total (Jamaica)	407.92	9.67	22.68

* Marginal Benefits shown at typical current reef conditions

Source: Ruitenbeek,HJ, M Ridgley, S Dolar and R Huber (1999).Optimization of economic policies and investment projects using a fuzzy logic based cost-effectiveness model of coral reef quality: empirical results for Montego Bay, Jamaica. Coral Reefs 18:381-392

Box 3. Case study 2: Revenue for MPA Entrance Fees Charged by the Galápagos National Park

Galápagos National Park (GNP), a marine reserve off the shores of Ecuador, earns over US$ 5 million per year through user fees of various sorts. This is of high value to the government of Ecuador, and previously 30% of this revenue was reverted to the mainland. However, since 1998, the Special Law for the Galápagos has required 90% of this revenue to remain in the islands. Currently, 40% of the revenues are reinvested into the management of GNP, 5% to the quarantine and control system, 5% to the Galápagos National Trust, 20% to the Galápagos municipalities, 20% to provincial local governments, 5% to the Department of Environment and 5% to the National Navy. In order to achieve this high level of revenue, Galápagos National Park charges a high fee, particularly from foreign tourists. This fee reflects the high willingness to pay for entry to the park (**Erreur ! Référence non valide pour un signet.**).

Source: Benchley, P. (2002). Cuba Reefs. National Geographic Magazine 201: 44-67

Table 2. Galápagos National Park's Fee System in US$

Type of Visitor	Entrance Fee (US$)
Foreign Tourist	100
Foreign Tourist under 12 years	50
Foreign Tourist from the Andean Community or Mercosur	50
Foreign Tourist from the Andean Community or Mercosur under 12 years	25
Citizen/resident of Ecuador	6
Citizen/resident of Ecuador under 12 years	3
Foreign tourist non-resident attending national academic institute	5
Tourist under 2 years	0

Source: http://www.galapagosonline.com/nathistory/nationalpark/nationalpark.htm

Box 4. Case study 3: Cost-Efficiency Options Sport Fishing Licenses Provide Large Incentives for Conservation in Cuba

About 50 miles off the southeast coast of Cuba, roughly a thousand square miles (about 26,000 km^2) of reefs, mangrove swamps, and islands, are known collectively as Jardines de la Reina (the Garden of the Queen).This area is closely guarded and accessed by only a few Cuban lobster boats, foreign divers and light-tackle fishers. Strictly enforced government laws against poaching protect the area, but this is not likely to be enough to ensure the pristine state of the area maintained. Some essential protection comes from a public-private joint venture between the Cuban government and an Italian company named Avalon. The government has granted Avalon a license to operate a substantial catch-and-release fishing camp. This area boasts the finest fly-fishing in the world for bonefish. As a by-product, the permit system makes it in the company's best interest to ensure that nobody affects the area (Benchley 2002).

Source: Benchley, P. (2002). Cuba Reefs. National Geographic Magazine 201: 44-67

4 Marine environment and MPAs in a changing climate

WWF[7] asserts the current increase in global temperature of 0.7°C since pre-industrial times is already disrupting life in the oceans. Having in mind the IPCC[8] predictions of a potential further rise of between 1.4°C and 5.8°C by the end of the century, climate change is perceived as a major threat that could harm (to the point of extinction) many species which are already under stress from overfishing and habitat loss.

IUCN recognizes the critical role of services provided by marine ecosystems in reducing climate related risks to human populations in vulnerable areas and the need to protect (and restore) natural infrastructure through MPAs and other measures. Climate change impacts are already affecting management objectives for MPAs and their very existence, as it is assessed that 60% of species which they have been created to protect could move or disappear by 2100. On the other hand, by reducing other ocean stressors, MPAs can also help to reduce risks and build resiliency, thus offering an effective way to cope with climate change (Simard et al., 2016*).* Moreover, MPAs and MPA networks are seen as laboratories to monitor the impacts of climate change.

According to Roberts et al., 2017, marine reserves help the oceans to mitigate and adapt to climate change by promoting intact and complex ecosystems with high diversity and abundance of species. Some of the key pathways by which MPAs can mitigate and promote adaptation to the effects of climate change in the oceans include the following:

- MPAs promote genetic diversity that provides raw material for adaptation to climate change;
- protecting coastal habitats maintains carbon sequestration and storage processes;
- MPAs prevent the release of carbon from disturbed sediments (due to habitat modifying fishing gear, infrastructure development, etc.);
- MPAs can provide stepping stones for dispersal and safe “landing zones” for climate migrants.

Roberts et al. conclude the existing and emerging evidence suggests that MPAs can serve as a powerful tool to help ameliorate some problems resulting from climate change, slow the development of others, and improve the outlook for continued ecosystem functioning and delivery of ecosystem services[9]. The study also emphasises that knowledge on the benefits, costs, and limits of MPA protection, as well as on complementary management measures and alternative strategies needed to minimize disruption to ecosystems and human societies from climate change, is limited.

4.1 FOCUS ON THE MEDITERRANEAN

In 2016, the 1,215 MPAs and OECMs[10] covered 6.81 % of the Mediterranean through a large variety of conservation designations, with national designations accounting for 1.27% and no-go, no-take or no-fishing zones for only 0.04% of the total protected area. Around 73% of the designated surfaces is located in the Western Mediterranean (MedPAN and SPA/RAC, 2019). Total surface of designations approached 9% in 2019, most of it referring to multiple-use MPAs (conclusions of the LabexMED workshop, Marseilles, France. 25-26 September 2019). In view of growing pressure to which marine environments are exposed that include overexploitation, pollution, climate change and their combined effects, MPAs are seen as tools that can play a critical role in protecting species and ecosystems, as well as in mitigating climate change and helping adapt to it.

The Barcelona Convention Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/ BD Protocol) provides criteria for the choice of protected marine and coastal areas that can be included in the List of SPAMIs in order to promote cooperation in the management and conservation of natural areas, as well as in the protection of threatened species and their habitats. In 2018, a total of 35 MPAs had been listed as SPAMIs.

[7] https://wwf.panda.org/our_work/oceans/problems/climate_change/
[8] Intergovernmental Panel on Climate Change
[9] The effectiveness of MPAs in supporting climate change mitigation and adaptation is believed to be partly contingent on the same characteristics as the ones producing the greatest conservation benefits (no-take; well-enforced; well established (≥10 y old); large (≥100 km^2); and isolated).
[10] Other Effective area-based Conservation Measures

The Barcelona Convention COP 21 held on 2 – 5 December 2019 in Naples, Italy, adopted a decision[11] to add four more areas to the list of SPAMIs and has called upon the Contracting Parties to *inter alia*:

- promote the role of MPAs as reference sites under the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast and Related Assessment Criteria;
- ensure further cooperation in the management and conservation of SPAMIs among countries and individual SPAMIs, mainly through technical, institutional and financial support, technology transfer, capacity building, best practices and experience sharing, twinning and other appropriate means.

According to IUCN[12], the Mediterranean will be strongly affected by climate change in the course of this century. The IPCC data indicate the temperature of the Mediterranean shallow waters has already increased by almost 1°C since 1980 and is expected to rise for another 2,5 degrees in the next 70 years. The salinity has been rising steadily and will continue to increase, particularly in the Adriatic and Aegean Seas. Acidification is also expected to accelerate in the coming years. The sea level has been raising by 1 – 3 mm per year and it seems to be accelerating.

The data of the E.U. Copernicus Marine Service Information show that the warming of the Mediterranean Sea occurring over the course of the past 35 years has an even more pronounced trend. Sea surface temperature increased by 1.4°C on (average across the basin) over the 1982-2017 period, whereas the highest warming was recorded for the Adriatic, Aegean and Levantine ecoregions (1.5 - 1.8°C average, locally >2°C) and lowest for the Alboran and Western ecoregions (1.1 - 1.2°C average, locally > 1.5°C). These warming trends are associated with amplification of conditions now perceived as extreme, exacerbating the potential heat stress with multiple effects on marine ecosystems (Garrabou et al., 2019).

Climate change is already taking a toll on the Mediterranean marine biodiversity. Some of the key impacts include changes in native species distribution; spread of alien species; mass mortalities of microbenthic communities; and population blooms (Otero et al., 2013). Acidification has the potential to affect species growth, reproduction and activity rates, while sea-level rise threatens some of the specific Mediterranean habitats (such as coastal marshes, sea caves and beaches) of crucial importance to many species. Mediterranean population and economies will certainly be affected by climate change manifestations and related impacts, but the extent and scale of socio-economic consequences are still not sufficiently examined and understood. Both natural and socio-economic systems are also expected to be affected by intensification of storms and decreased productivity and oxygen availability.

Box 5: Climate change and the role of MPAs in the Mediterranean

IUCN video on Mediterranean MPAs as nature- based solutions	LabexMED workshop, Marseilles, 25-26 September 2019
Mediterranean MPAs have an important role in providing ecosystem service, mitigating impacts and increasing ecological and socio-economic resilience of biodiversity and surrounding coastal communities. For example, MPAs habitats act as effective coastal defences. Salt marshes dissipate over 90% of incident wave energy and reduce the potential impacts of sea level rise. Coastal dunes nourish the beaches and near shore sandbars during storms enhancing physical barriers against the erosion. Vermetid reefs can help in the dispersal of wave energy. Sea grass meadows attenuate wave energy and underpin sediment and beach stability. Marshes and sea grass meadows are at the same time significant carbon sinks.	Well designed and well managed MPAs can: • Contribute to recovery of marine resources; • Sustain fisheries and aquaculture; • Improve local livelihoods; • Promote sustainable maritime and coastal tourism; • Help protect fragile and emblematic ecosystems, like *Posidonia* meadows and coralligenous habitats; • Create opportunities for ecological engineering (restoration of natural habitats, carbon sequestration capacity of the regenerated marine ecosystem); and • Reinforce resilience of islands.

Sources: https://www.youtube.com/watch?v=sB_cSdSlZ-A&t=3s; proceedings of LabexMED workshop

[11] Decision IG.24/6 on ***Identification and Conservation of Sites of Particular Ecological Interest in the Mediterranean, including Specially Protected Areas of Mediterranean Importance***
[12] https://www.youtube.com/watch?v=sB_cSdSlZ-A&t=3s

The role of Mediterranean MPAs in the context of climate change is very important; IUCN and the views expressed at the recently held LabexMED workshop in relation to this topic are presented in Box 5. It is widely accepted that effective management measures are needed to fully utilise potential of Mediterranean MPAs as natural tools for mitigation and adaptation to climate change, and that monitoring efforts need to be strengthened and expanded to enable formulation of appropriate polices and measures.

In terms of climate change mitigation, marine ecosystems play an important role by capturing and storing atmospheric carbon (so called blue carbon). MPAs are powerful tools to protect, conserve and restore blue carbon habitats (such as *Posidonia oceanica* and *Cymodocea nodosa* meadows or rhodolith beds), and, consequently, help climate change mitigation (Kersting and Webster, 2017). P*osidonia oceanica* meadows in the Mediterranean Sea store about 2 Tg (teragrams) of carbon per year. Due to infrastructure development and other human activities, these marine and coastal ecosystems are being degraded, which undermines their role as sinks and turns them into sources of carbon dioxide emissions (Russi et al., 2016).

Phytoplankton is also considered an important blue carbon sink (CEC, 2012). The contribution made by phytoplankton to carbon sequestration, however, did not merit inclusion of these organisms in climate change mitigation policies so far (Thompson et al., 2017). While it is still not certain how warming, acidification or sea storms affect phytoplankton, changes in its abundance and diversity could have significant repercussions for services provided by protected areas/ marine ecosystems to economy and society, primarily with a view to phytoplankton's fundamental role in the marine food web. Consequently, more research and increased attention to phytoplankton monitoring in protected areas would be welcome in the near future.

Seagrass beds, mudflats, saltmarshes and biogenic reefs[13] 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. Hypothetical costs of the destruction of all *Posidonia oceanica* meadows in southern Spain (i.e. costs of building alternative coastal protection infrastructure) were, for example, estimated at 96 million €. The avoided costs of replacing natural protective barriers formed by UK coastal ecosystems with man-made coastal defence structures were assessed at between 21 and 42 billion £. 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 that improve coastal security and help adapt to climate change (Russi et al., 2016).

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

5 The need to monitor socio-economic impacts of climate change

In the EU, it has been recognised that MPAs have potential to contribute to the development of a sustainable blue-green economy, thus ensuring the long-term sustainability of marine ecosystems, as well as the associated livelihood opportunities and wellbeing of different stakeholders. Moreover, the MPAs are seen as a tool to aid the achievement of various EU policy objectives, most notably the Marine Strategy Framework Directive, but also those related to marine spatial planning and integrated coastal management (Russi et al., 2016). In such a context, the need for a more comprehensive and systematic monitoring of socio-economic variables linked to MPAs is apparent.

In the Barcelona Convention framework, as already mentioned, improved knowledge on socio-economic trends related to MPAs in a changing climate has been called for (directly or indirectly) in a number of policies and strategic documents – from Marrakesh Declaration through the Regional Climate Change Adaptation Framework to MSSD – and is likely to remain in focus as climate change impacts on marine ecosystems are expected to accelerate.

Some early signs of the effects of climate change on marine environment and MPAs in the Mediterranean are already visible and have been documented (UNEP/MAP-RAC/SPA 2009). Nevertheless, there are large gaps in our knowledge and a significant degree of uncertainty about the overall impacts of climate change – current and future. The knowledge on how climate change will affect socio-economic systems that depend on the benefits provided by marine environment and MPAs is even more scarce.

A study by Rodríguez-Rodríguez et al., 2015, found out (based on a survey of stakeholders' opinions) that climate change was perceived as one of the top three most concerning pressures to MPAs in terms of the extent and intensity. The other two were fishing and pollution from maritime transport. Climate change impacts on the MPAs habitats and species as well as on related economic activities and communities are likely to vary between different Mediterranean regions and between individual MPAs within each region.

According to MedPAN, long-term, sound and consistent MPA socio-economic monitoring is rarely found in practice. An exception mentioned in the MedPAN Science for MPA Management series is monitoring programme conducted in the US for the Californian Channel Islands since the MPA establishment in 2004. Four categories of human activities were monitored and the results of the first five years of monitoring showed certain variations in the ways MPA resources were used over time (Rodríguez-Rodríguez et al., 2017). Only one example of socio-economic indicators being recommended for evaluation and monitoring of climate change in protected areas (López and Pardo, 2018) was found through the search and review of literature conducted in the preparation of the present report, relating to a terrestrial protected area.

The need for better understanding of how climate change will affect not only the natural conditions and biodiversity in MPAs/ SPAMIs but also the socio-economics benefits related to them was highlighted during representative recent meetings/ events.

A regional experience exchange workshop[14] of the MedPAN network for example, looked at economic and ecological impact of invasive species to artisanal fishing. During the workshop, it was reported that 329 sightings of *Caulerpa cylindracea* and 343 sightings of other invasive species from the black list have been recorded in 2017 in more than 184 Mediterranean MPAs from 19 countries. Moreover, it was stated that invasive species were strongly affecting artisanal fisheries within and around MPAs (due to clogging of nets, damaging fishing gears and causing injuries and deaths to fishermen and other sea-goers), and concluded that further work on socio-economic implications of invasive species in MPAs is needed across the region (MedPAN network workshop, 2018, presentation by Mar Otero, IUCN).

[14] Titled *Mediterranean challenges for MPAs and small-scale fisheries*, held in November 2018 in Palma de Mallorca, Spain.

The 2019 LabexMed workshop – session on climate change indicators and monitoring in the Mediterranean – concluded (as presented in the workshop proceedings) the following:

- There is a need to find a common strategy to achieve a better sharing of information on climate change impacts and ensure compatibility.
- The challenge in working with indicators is to simplify a complex issue. For a proper monitoring of climate change at sea a long-term engagement of countries is key. Need for a real engagement of practitioners in MPA and their governments to engage.
- Regular monitoring in the Mediterranean is needed in a detailed way. The issue is that monitoring is costly. Citizen science could be a complementary support for countries to ensure a frequent monitoring at low cost.
- Indicators can be also populated thanks to collaboration with other initiatives, projects and observatories in the Mediterranean, in addition to citizen science.
- Climate change monitoring indicators have to be operational: easy to measure, cost affordable and not too complex for managers to populate them along years or decades.
- The development of climate change monitoring indicators should be taken into consideration within the UNEP/MAP IMAP, as transversal issue touching ecological priorities in the Mediterranean.
- Cost of monitoring climate change for national budgets should be calibrated by countries vs. cost of doing nothing.

6 Identification of indicators to monitor climate change impacts on socio-economic trends linked to biodiversity and natural resources in SPAMIs

The analysis presented in the previous sections of the report showed the main perceived socio-economic benefits of MPAs were generated for the fisheries and tourism sector. At the same time, benefits provided by MPAs to these sectors are the most studied ones in the Mediterranean. The two sectors strongly rely on the ecosystems, natural habitats and species protected by MPAs (Vertigo Lab, 2019) and are likely to be impacted by climate change, whereas both losses and gains are possible.

These findings were corroborated by the results of vulnerability assessments (details in Box 6) conducted for the five pilot MPAs in the framework the MPA-Adapt project[15], as well as through the interviews with SPAMI managers. Consequently, identification of potential socio-economic indicators to monitor climate change impacts in MPAs focused on fisheries and tourism. Other socio-economic/ blue economy activities contingent on MPAs biodiversity and natural resources were also considered in the process of identification of potential indicators, together with aspects such as attractiveness of the area and quality of life of its inhabitants.

Similar approach was employed in determining ecosystem services to which the Mediterranean MPAs contribute and are of interest for monitoring of climate change impacts. As a result, it was concluded that identification of indicators should focus on carbon sequestration (for climate change mitigation), and costal protection (from extreme weather events, flooding, erosion) and increased resilience of species and ecosystems (for adaptation).

Box 6. MPA-Adapt: main findings of the vulnerability assessments conducted at five pilot MPAs

From an ecological perspective, the assessment focused on five key habitats: coralligenous, *Posidonia* meadows, rocky habitats, infra-mesolitoral, soft bottom habitats, and pelagic environment. The main common stressors identified were increasing water temperature, storms, precipitations, algae blooms and coastal erosion.

Regarding the socio-economic perspective, from the three sectors selected (fisheries, divers and tourism), small-scale fisheries and coastal tourism emerged as the most vulnerable activities with an overall medium vulnerability score. Water temperature increase and extreme storm events are the stressors that pose the main risks to these activities in the MPAs while others such as the increase of air temperatures or mucilaginous algal blooms are also mentioned. In some specific cases, mucilaginous algal blooms have been identified as an extreme risk to tourism as well as for recreational underwater activities.

Overall results indicated that climate change poses a medium risk to the ecological and socio-economic aspects related to MPAs.

Source: Garrabou et al., 2019

Identification of potential indicators was therefore focused on the five categories corresponding with the key economic sectors/ groups of socio-economic activities likely to be affected by climate change and related to MPAs, as well as with climate change mitigation and adaptation potential of MPAs. These five categories are:

1. Fisheries,

[15] The pilot sites were: Port Cros National Park; Reserve Naturelle de Bouches de Bonifacio; Portofino AMP; Isole Pelagie AMP; and Brijuni National Park. The effects of climate change at these sites have been monitored based on a set of harmonised protocols, and biodiversity and socio-economic vulnerability assessments to climate change have been conducted.

2. Tourism and recreation,
3. Other blue economy activities[16],
4. Climate change mitigation, and
5. Climate change adaptation – coastal security.

Measuring socio-economic benefits of MPAs is a complex process in itself. Summarising the findings of pertinent studies on the applicability of indicators systems in MPAs, Rodríguez-Rodríguez et al., 2014, conclude that some of the main limitations include: the difficulty of attributing effects; data collection and availability; understandability by and salience to end-users; and the difficulty of producing a synthetic MPA evaluation. Another layer of complexity is added when climate change impacts are factored in.

Some of the challenges for monitoring climate change impacts on socio-economic trends linked to MPAs that were identified through the preparation of this report are:

- Climate change and its consequences (e.g. increases in air and sea temperatures, species migrations) can have both positive and negative impacts on the socio-economic systems: attractiveness for tourism and the number of visitors may grow or decline due to temperature increases, total catches and fisheries profits may go into both directions as native species are substituted with new ones.
- Lack of continuous and systematic monitoring of socio-economic variables means a lack of baseline data. Establishing a baseline is difficult as multiple factors are at work whereas attributing specific benefits to MPAs is not a straightforward task; adding climate change impacts to the equation represents further complication.
- Socio-economic benefits of MPAs include direct ones, but also indirect (including multiplicative effects) and induced benefits; all of them need to be considered.
- Spatial and temporal distribution of benefits represents another challenge for developing adequate indicators as MPA benefits can arise at the level of MPA, at the level of local community, economic sectors, national economy or even wider – regional and/ or global economy, and at different points in time.
- Each MPA/ SPAMI has its own specificities that need to be taken into account, yet there is a need for comparable data across the region to allow for robust evaluations and conclusions on how will climate change affect provision of goods and services by MPAs that benefit population and economies in the Mediterranean.

Despite complexities, MPAs and SPAMIs in particular need to collect a set of basic socio-economic data that will allow further development and refinement of indicators as more knowledge and information becomes available, and to allow for deriving complex indicators. Other stakeholders – especially national statistical offices and other entities involved in marine monitoring programmes – should contribute in a more comprehensive manner to the ways of measuring gains and losses that may arise for local economies/ communities due to climate change.

6.1 LIST OF POTENTIAL INDICATORS

The list of potential indicators (provided in Table 3) was compiled by applying the logic used in the MPA-Adapt climate change vulnerability assessments[17], for each pre-determined category (fisheries, tourism and recreation, other blue economy activities, climate change mitigation, and climate change adaptation/ coastal security). The intent was to identify indicators that could be used to evaluate changes in socio-economic variables linked to key habitats and species likely to be affected by climate change and/or contributing to climate change mitigation and adaptation.

In identifying potential indicators, recommendations of the 2018 MedPAN network and the 2019 LabexMED workshops were taken into account, and a pragmatic approach applied aiming to ensure that:

- indicators should be reasonably easy to measure, not too complex;
- monitoring should start with simple indicators and basic data collection, with a possibility to move to more complex procedures in the future;
- monitoring should be periodically adapted, as the new data and knowledge become available;

[16] The term ‘blue economy’ refers to all the economic activities that depend on the sea and ecosystem services it provides. In addition to fisheries and tourism, other traditional blue economy sectors include aquaculture, maritime transport, shipbuilding, ports and warehousing, and exploitation of hydrocarbons and other minerals. Moreover, renewable energy, desalination and others are emerging as ‘new’ blue economy sectors. Besides major economic sectors, blue economy is also understood to comprise activities that are directly linked to protected areas (e.g. MPA management, research, etc.).

[17] Where identification of key habitats and species likely to be affected by climate change is followed with an assessment of the key socio-economic activities and benefits linked to them, and an analysis of how the main stressors/ climate change manifestations can affect such activities and benefits.

- indicators should help monitor climate change driven changes to ecosystem services provided by MPAs where both gains and losses are possible;
- monitoring should not incur high additional costs to MPAs and all possibilities should be utilised to combine monitoring efforts/ synergise with other potential sources, including local environmental knowledge.

Table 3. List of potential indicators to monitor climate change impact on socio-economic trends linked to MPA/ SPAMI biodiversity and natural resources

Category	Indicator	Level and frequency of monitoring	
		MPA	Wider/ national statistics
Fisheries	Significance of small-scale fishing (measured by the number of fishermen), size of fishing fleet/ number of vessels)	Annual	
	Income of local fishermen		Annual
	Profit of artisanal vessels		Annual
	Catch per unit effort	Annual	
	Weight and size of individual species in experimental catches		Periodic (when experimental catches are done)
	Number, size and species measured by visual census	Representative months	
	Total value of landings (from within the MPAs and outside)	Annual	Annual
	Product branding: MPA labels, fishermen eco-certifications	Annual	
	Sightings of black list invasive species (number)	Annual	
	Damages to small-scale fishery due to invasive species (number of incidents reported, estimate of damages to fishers active in/ around MPA)	Annual	
	Number of recreational fishers	Annual	
	Expenditure per recreational boat fisher and/ or per recreational shore fishermen		Annual
Tourism and recreation	Number of MPA visitors (divers, beach goers, boating, others)	Annual	
	Number of beach goers/ divers correlated to algal blooms	Periodic/ annual	
	Revenues from tourism (share of MPA revenues)	Annual	
	Revenues from tourism for the local communities around the MPA		Annual
	Seasonality of visits	Annual	
	Length of stay	Annual	
	Visitor expenditures		Annual
	Number of ecotourism enterprises	Annual	
	Number of businesses associated with tourism and recreation services (diving, wildlife watching, charter boats)	Annual	
Other blue economy activities	Number of local residents working for MPA	Annual	
	Number of scientists/ research teams visiting the MPA and conducting research	Annual	
	Local population income per capita		Annual
	Life expectancy of local population		Annual
	Surface of coastal built-up area		Annual

	House prices		Annual
	Total MPA revenues and share of revenues from the use of natural resources	Annual	
	Compensation for the provision of ecosystem service (if existing)	Annual	
Climate change mitigation	Surface of blue carbon sinks MPA is protecting/ contributing to	Periodic (3 - 5 years)	
	Carbon budget for the habitats with carbon sequestration potential within MPA and in surrounding area	Periodic (3 - 5 years)	
	Value of blue carbon		Periodic (3 - 5 years)
	Release of carbon avoided from protected habitats within MPA	Periodic (3 - 5 years)	
Climate change adaptation/ coastal security	Population exposed to extreme weather events (area surrounding the MPA)	Periodic (3- 5 years)	
	Investments in coastal protection measures		Periodic (3- 5 years)
	Damages to coastal infrastructure due to climate change impacts		Ad hoc, annual
	Costs of coastal erosion		Periodic (3- 5 years)

7 Monitoring socio-economic impacts of climate change in pilot SPAMIs

As already mentioned, monitoring of climate change impacts on socio-economic variables related to MPA resources is scarce: there are hardly any examples (in the literature and practice alike) of indicators used to evaluate and monitor these impacts. Monitoring of climate change impacts on natural/ physical characteristics and biodiversity is more developed and can be, together with available socio-economic data, used as a starting point for development and application of socio-economic indicators. Key characteristics of the three SPAMIs from the Western Mediterranean, Adriatic, and Adriatic/ Central Mediterranean EcAp subregions – Portofino, Torre Guaceto and Karaburun-Sazan – and their experiences with assessing and understanding the climate change impacts are presented below with the aim to guide the final selection of indicators for recommended application across all the Mediterranean MPAs/ SPAMIs.

7.1 PORTOFINO

7.1.1 Key features of the MPA

The Portofino MPA[18] is located in the province of Genoa, Ligurian region of Italy, covering the sea area around Portofino Promontory. Due to exquisite landscapes and environmental quality it is a renowned tourist destination. The MPA was established in 1999 and is managed by the consortium comprising the Metropolitan City of Genoa, the Municipalities of Camogli, Portofino and Santa Margherita Ligure, and the University of Genoa. Since 2005, the site has a SPAMI status. The MPA has a total surface of 346 ha, whereas no entry no take zone (zone A) spreads over some 10 ha (3.7% of the total protected area). In the general reserve zone (zone B), swimming, scuba diving, yachting and fishing activities are allowed based on specific MPA regulations. In the partial reserve (zone C) there are no restrictions for swimming and scuba diving while yachting and fishing activities are allowed but monitored (have to be performed in line with MPA regulations).

Portofino MPA has one of the most abundant red coral populations (the most important shallow-water coral population of the Ligurian Sea) in the entire Mediterranean, and is in general characterised by thriving coralligenous communities. In terms of species richness, particularly for gorgonian populations, Portofino is among the top MPAs in Italy. Small meadows of Posidonia oceanica are found along the eastern and western coastlines, but are rare along the southern coast. Distribution of the main habitats is shown in Figure 2.

Portofino hosts a rich fish population: using visual methods, about 80 species were recorded in recent years. Many economically important fish species such as *Dentex dentex, Seriola dumerili, Sphyraena sphyraena, Epinephelus marginatus* and others are found in the MPA.

[18] Data, maps and photos used in this section come from the interview with MPA staff, MAP-Adapt project results (Deliverable 3.9.2 by Cappanera V. and Merotto L, 2017 and Deliverable 3.9.6 by Merotto L. and Cappanera V., 2019), and presentation by Chiara Paoli et al.

Figure 2. Distribution of habitats in Portofino MPA

Note: Coralligenous in red and *Posidonia* meadows in green
Source: Merotto L. and Cappanera V., 2019

7.1.2 Socio-economic activities

Natural capital assessment for Portofino MPA (produced through a project funded by the Italian environment ministry, covering all the MPAs in the country) came to an average value of 2.81 € per square metre of protected area, while the annual net benefits produced by the MPA were assessed at around 11.5 million €.

The main socio-economic activities include fisheries (artisanal and recreational) and tourism. Number of tourists visiting the wider region of Portofino during the past decades was around 1.3 million. Number of tourists visiting the MPA is estimated at 85,000, with average spending of 28 euros per person (total spending of around 2.4 million € at the MPA territory). Boating is monitored since 2006 showing that on average, 17,472 boats (close to 69,000 people) stop within Portofino MPA annually, generating a revenue of around 3.25 million €. Figures for the period 2000 – 2016 show that on average, 6,000 diving trips are made within the MPA with some 25,000 divers annually. The value of diving activities is estimated at over 1.7 million €.

Artisanal fishery is an important activity – socio-culturally and economically. In 2018, a total of 39 boats from the municipalities of Camogli, Santa Margherita Ligure and Portofino were permitted to fish within the MPA. The most frequently used fishing gears are gill nets, followed by surrounding net, boat seine and longlines. Tuna trap (Tonnarella) is also an important traditional way of fishing in Portofino area (exercised since the 17th century at the same point in front of Punta Chiappa, now in the MPA zone C). The number of active fishermen (those that carry out more than 50 fishing trips annually) is around 20. The average age of fishermen is high and for many of them revenue from fishing is a secondary income source (additional to pensions and/ or earnings from real estates they own, which usually have a high commercial value).

7.1.3 Observed climate change impacts and their repercussions for natural and socio-economic systems

Mass mortalities of gorgonians were observed in 1999, 2003 and 2006. The cover of the red gorgonian (*Paramuricea clavata),* for example, was reduced to one third from spring to fall 2003. Other events like mucilage blooms and tissue necrosis with mortalities of madrepores, such as *Cladocora caespitosa,* occurred during these years too.

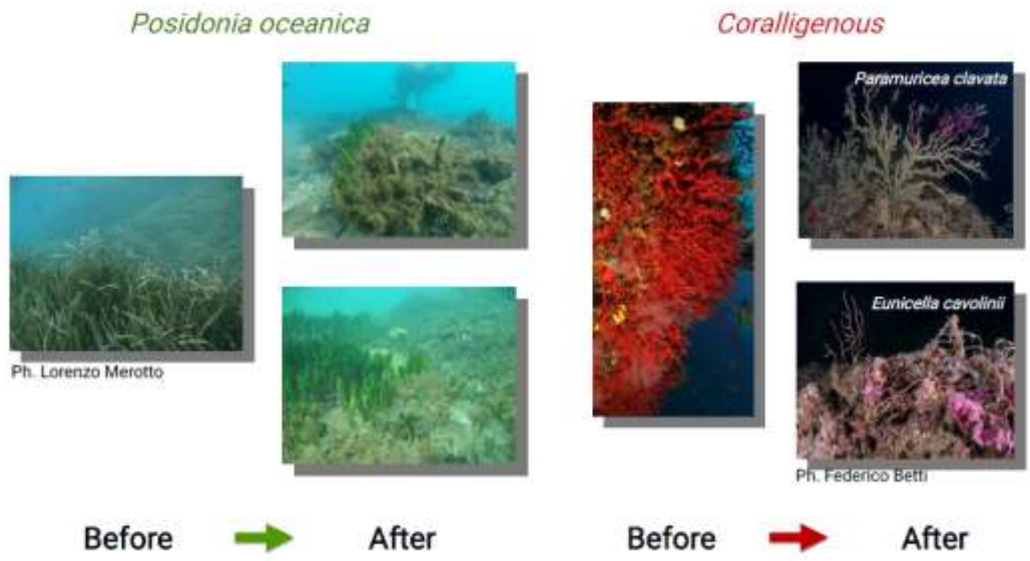
Changes in species distribution and composition were also recorded. Homogenization of the benthic communities along the bathymetric gradient, for example, which was noticed in 2003, became particularly evident in 2013 with a shift of deep community assemblages. As regards the spread of non-native species, the alien toxic dinoflagellates *Ostreopsis ovata* appeared for the first time in the Ligurian Sea in 1998; a bloom of this species causing health problems was recorded in 2005.

An increase in the abundance of warm-water fish species such as the amberjack (*Seriola dumerili*), dolphinfish (*Coryphaena hippurus*) and Yellowmouth barracuda (*Sphyraena viridensis*) has been recorded in recent years, in parallel to a decrease in boreal species. Observations during the past decade indicate that the fishing season has been altered and that there are changes in the life cycle of many species.

Fishermen can be affected by climate change in different ways: the arrival of new species can change the structure of their catch and affect (in both positive and negative ways) their revenues, storm events can damage their boats and reduce the number of useful fishing days. Mass mortality of organisms like gorgonians or calcareous algae can reduce attractiveness of underwater landscape for divers. Episodic outbreaks/ blooms of species such as jellyfish and algae can cause a decrease in the number of tourists that usually come for recreation and swimming. Storms can cause massive damages to both natural and man-made systems. The storm that hit Ligurian coast in October 2018, for example, caused damages to *Posidonia* meadows and coralligenous habitats (shown in Figure 3), resulting in an estimated loss of natural capital of 90,000 € in an area of just 2% of the MPA. Human activities and infrastructure in the Ligurian region were severely affected, with estimated damages in the range of hundreds of millions of euros.

The main climate related stressors in the Portofino MPA (as identified in the Vulnerability Assessment prepared under the MPA-Adapt project) include: temperature increase; storms/ waves; altered precipitation patterns; microplankton blooms; harmful algae blooms; and erosion/ sedimentation/ turbidity. These stressors were further elaborated and considered in relation to the main habitats and socio-economic activities, assessing at the same time possible effects and their likelihoods, as well as potential consequences. Adaptive capacities were also considered together with sensitivity and exposure to come up with the final evaluation of vulnerabilities.

Figure 3. Natural capital depletion due to extreme meteorological events (October 2018 sea storm)



Source: Presentation by Chiara Paoli et al. (University of Genoa and CoNISMa), for the Interreg maritime project *Integrated Management of Ecological Networks through Parks and Marine Areas* (GIREPAM project) conference on the valuation of ecosystem services held on 27 November 2019 in Santa Margherita Ligure, Italy

Among the socio-economic activities performed in Portofino MPA, consequences[19] of the identified climate stressors were assessed to be the gravest for the fishing activity, with a high negative score of 2.25 (on a scale 0 – 3). Temperature increase/ stratification was identified as a factor with the most significant negative effect due to the facts that fish (with temperature increase) tend to move to areas not accessible by many fishing gears and that clear waters make the nets more visible, as well as due to disappearance or decrease of native species. This negative effect is partially offset by a spread of thermophilic species which, in principle, replace local ones and have a lower

[19] For the next 10 years, which was the time frame for the Vulnerability Assessment.

commercial value, but in some cases, increase in species with high commercial value is possible. Consequences of alien species spread, mucilage, and storms/ waves for fishing were assessed as negative but much less significant (compared to temperature increase). For diving and beach tourism, the overall consequences of climate stressors were evaluated as moderate negative, with respective overall scores of - 1.25 and - 0.5.

7.1.4 Socio-economic indicators to monitor climate change impacts

Based on the data and knowledge acquired through the existing monitoring efforts and climate change vulnerability assessment, indicators presented in Table 4. were identified as the most promising ones in terms of their potential to capture the effects of climate change on socio-economic benefits linked to Portofino biodiversity and natural resources. In selecting suitable indicators, it was recognised that development of socio-economic protocols was less simple compared to biological ones, as a multitude of issues is at play. Variations in the number of divers and their interest for Portofino could be, for example, attributed to a number of reasons that have nothing to do with climate change impacts on the site's gorgonian populations, such as political instability at other diving locations, pricing and others.

For most of the proposed indicators, basic data is already available through systematic or *ad hoc* monitoring efforts and surveys – at the level of MPA or through the regional administrative and statistical offices. For some of the proposed indicators – mainly for the ones related to fishing, already available data is sufficient to document changes that have happened over the time.

Table 4. Portofino MPA: proposed socio-economic indicators

<table>
<tr><th>Proposed indicators</th><th>Remarks (on data availability, links with ongoing monitoring efforts)</th></tr>
<tr><td>Total catch/ structure of the catch</td><td rowspan="3">Data series on the catch/ specific species exist (since 1970s), possible to understand how catch varies over time
Monitoring protocols for fishing (catch, fishing effort) developed under the FishMPABlue 2 project, data collected can be used to derive socio-economic indicators
Good cooperation with fishermen established (use of Local Environmental Knowledge, fishermen involved in monitoring)</td></tr>
<tr><td>Catch per unit effort</td></tr>
<tr><td>Income of artisanal fishermen</td></tr>
<tr><td>Seasonality of diving</td><td>Cooperation with diving centres established, ongoing efforts to involve divers in monitoring</td></tr>
<tr><td>Carbon sequestration potential of Posidonia meadows</td><td rowspan="2">Posidonia meadows within the MPA monitored (extent, density) once in 3 years (by the MPA manager); in 2018/ 2019 two monitoring campaigns conducted due to storms
Posidonia meadows outside the MPA monitored by University of Genoa</td></tr>
<tr><td>Carbon released due to damages/ reductions in Posidonia habitats</td></tr>
<tr><td>Loss of natural capital due to storms/ catastrophic events</td><td>Monitoring of impacts of big storms/ catastrophic events done in cooperation with University of Genoa</td></tr>
<tr><td>Damages to MPA and coastal infrastructure due to storms/ catastrophic events</td><td>Data collected and published by the regional administration and MPA management</td></tr>
<tr><td>Damages from coastal erosion</td><td>Estimates for the Ligurian coast available</td></tr>
</table>

7.2 TORRE GUACETO

7.2.1 Key features of the MPA

The Torre Guaceto MPA[20] is located in the Apulia region on the Adriatic coast of Italy. Marine Protected Area was designated in 1991, covering 2,227 ha that extend into the sea along 8,405 m long coastline. The terrestrial part is protected since 2000 and it covers 1,100 ha. Torre Guaceto is also a Natura 2000 area comprising a Site of Community Importance (SCI) under the EU Habitats Directive and a Special Protection Area (SPA) under the Birds Directive. The SCI site has a surface of 7,978 ha (95% marine), and in addition to Torre Guaceto, it covers the neighbouring area Macchia S. Giovanni (Figure 4, upper pane).

The terrestrial reserve includes a wetland area of national importance, recognised under the Ramsar Convention. The MPA is on the SPAMI list since 2008. Torre Guaceto's management body (since 2000) is a consortium formed by the municipalities of Brindisi and Carovigno, and WWF Italy.

The MPA is divided into three zones (Figure 4, lower pane). Zone A (179 ha) is a no-take and no access area, which is open only for scientific research and guided tours. Zone B (163 ha) is used for bathing, research activities and guided tours. In addition to the mentioned activities, zone C (with the largest surface of 1,885 ha) is used for artisanal and recreational fishing and for the transit of sailing ships (whereas berthing is prohibited).

The MPA comprises the coastal sea out to a depth of 50 m. Rocky and sandy bottoms alternate with *Posidonia oceanica* beds at about 12-20 m depth. *Posidonia* beds provide optimal environmental conditions for numerous species, including crustaceans and fish that often have high commercial value. Coralligenous formations can be found at the depths of 25 to 35-40 m, while sandy–muddy bottoms are found at deeper locations (EC, 2018a). Some of the precoralligenous formations, mostly localized in front of the Tower of Guaceto, at 15-17 m depth, are characterized by patches of high-density gorgonians species *Eunicella cavolini* and *E. singularis*. *Cladocora caespitosa*, an important hard coral of the Mediterranean Sea, is well represented in the area (UNEP/MAP – RAC/SPA, 2017).

7.2.2 Socio-economic activities

The total economic value of the natural capital in Torre Guaceto was estimated at around 36 million €. Among the individual habitats, the highest value (around 17 million €) was assessed for *Posidonia* beds.

Fishing is the main economic activity in Torre Guaceto. In the first five years after management was introduced in the MPA (in the period 2000 – 2005), fishing was prohibited to allow for regeneration of stock. Nowadays, artisanal fishery is well regulated. Local fishermen have exclusive access rights inside the MPA. They can only fish once a week in the zone C, using large mesh nets[21] to avoid capturing juveniles. The MPA staff (and researchers) are authorized to check the catches (species, number, size and total weight for the species), the length and the mesh size of the nets. Fishermen

are also involved in monitoring. Protocols to monitor catches and fishing effort have been developed under the FishMPABlue 2 project (Calò et al., 2019). In autumn 2019, only 5 fishermen from Carovigno municipality were permitted to fish in the MPA. Total number of artisanal fishermen in the two municipalities of Torre Guaceto – Brindisi and Carovigno – is around 15.

The MPA provides significant economic benefits for the fishery sector. The average CPUE (catch per unit effort) is found to be 1.8 times higher within the MPA compared to neighbouring waters (12.1 vs. 6.5 kg per 1,000 m of trammel net), while the income generated within the MPA is twice as much the income earned for fishing in the MPA surroundings (eFrame, WWF Oasi and Università degli Studi di Udine, 2018). The fish caught within the MPA is usually larger than those caught outside, and thus have higher economic value. Another factor that increases the market value of the fish caught within the MPA is higher demand for the food products associated with protected areas.

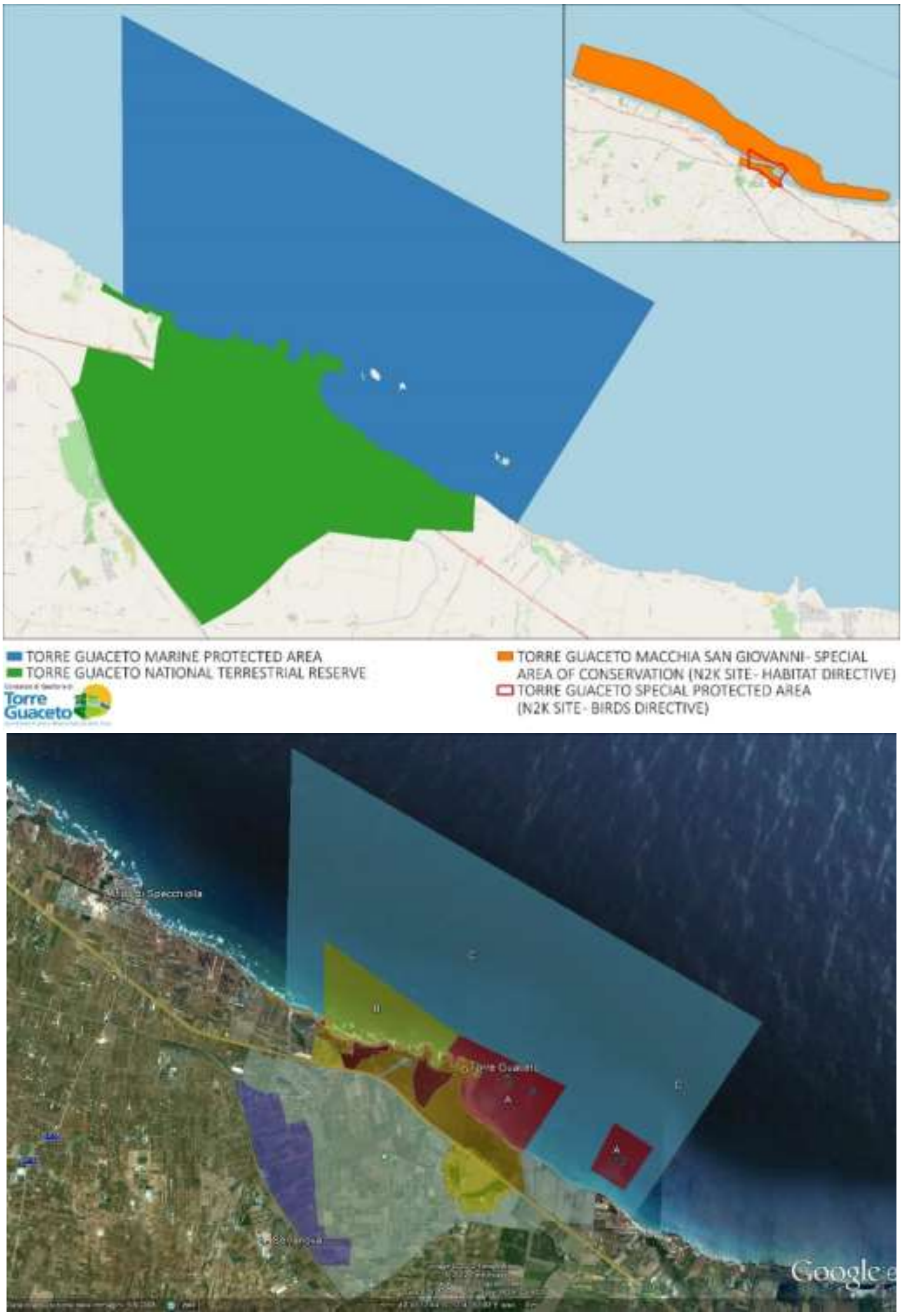
Tourism is another important activity. The area around the MPA receives around 100,000 tourists during the summer months, mainly beach goers. Diving is not a significant activity in Torre Guaceto, but snorkelling is a common part of tourism offer, with fish being the main attraction. The number of visitors to the MPA is around 1,000; on top of this number, some 5,000 students visit the MPA through regular outdoor educational programmes. Efforts were made during past years to shift from high-volume low-value to low-volume high-value tourism (including, for example,

[20] Data and maps used in this section come from the interview with the MPA manager and collected materials/ presentations, as well as from: EC, 2018a; UNEP/MAP – PAP RAC, 2017; and eFrame, WWF Oasi and Università degli Studi di Udine, 2018.

[21] The only allowed net is the trammel (post nets), max 1,200 m with mesh over 10 (3 cm) and 11 (2.6 cm).

sustainable tourism certification), to improve economic opportunities for residents while reducing environmental impact.

Figure 4. Torre Guaceto: extent of the protected area and zoning



Source: Tore Guaceto management body

7.2.3 Observed climate change impacts and their repercussions for natural and socio-economic systems

In the experience of the Torre Guaceto management body, evaluation of climate change effects is not a straightforward task for the MPA managers and more data is needed from other actors involved in marine monitoring to ensure better understanding and more appropriate management actions. The MPA manager emphasised that other pressures (such as pollution, marine litter) are currently more important for daily management than climate change impacts.

Nevertheless, some changes in the fishing activities have been observed but it is not clear to which extent are they attributable to climate change. For example, a decrease in catches is obvious in the course of the past years but the reasons cannot be easily identified and more information from outside the MPA is needed. During the past 7 – 8 years, significant increase in the numbers of non-indigenous or indigenous thermophilic species, such as for example the Bluefish *Pomatomus saltatrix* and *Caulerpa cylindracea,* has been observed. Bluefish are predators that have an impact on other fish species population levels, and their market value is low. That is why local fishermen perceive these species as significant threat to their livelihoods.

Weather affects both fisheries and tourism and change in the number and distribution of useful days (days on which fishing/ touristic activities can be performed) has been observed.

The invasive species *Caulerpa cylindracea* is very common, but algal blooms and jellyfish are very rare in Torre Guaceto.

While it is not certain to what extent is coastal erosion aggravated by climate change, erosion of clay cliffs at the southern part of the MPA represents a problem for the MPA management due to sedimentation, whereas *Posidonia* habitats are particularly affected. Beach erosion is also an issue as during the past decade, more than 200,000 € has been spent/ allocated for reconstruction of beaches.

7.2.4 Socio-economic indicators to monitor climate change impacts

The so far monitoring efforts in Torre Guaceto focused on fish and benthic habitats. Monitoring of different sea uses/ human activities related to the sea is a responsibility of regional authorities in line with the relevant EU Directives, and there is usually a delay of 2 – 3 years before relevant data is made available to MPA managers.

In the experience of the MPA management body, the key indicator to monitor impacts of climate change on socio-economic variables is fishermen's income (derived based on total catch and market value of different species). A very good system developed to monitor fishing in cooperation with local fishermen is already in place, linked to issuance of permits for fishing within the MPA, and can be used as a starting point. Changes in the structure of the catch have been already observed and documented, and are affecting revenues from fishing in a negative way as new species have lower market prices. Torre Guaceto MPA has very good data series on fishing.

Another suitable indicator could be the number of useful days (for fishing, possibly also for beach goers/ tourist visiting the MPA). Useful days for fishing are currently being electronically recorded as a part of permitting procedure (fishing permits are issued every week), and a similar tool is being developed for tourism.

Regarding indicators to monitor benefits of MPAs for climate change mitigation and adaptation, the key issues for Torre Guaceto include the status of *Posidonia* and coralligenous habitats, and beach erosion.

Benthic map was produced in 2013/ 2014. *Posidonia* mapping for the Natura 2000 site is underway, and a small-scale evaluation of the condition of *Posidonia* beds was carried out in 2018. Preparation of benthic maps once in 5 years and biennial evaluation of the status of benthic habitats is aimed for. For the natural capital assessment study (eFrame, WWF Oasi and Università degli Studi di Udine, 2018), carbon sequestration rate of 1.82 t C ha^{-1} $year^{-1}$ was used. In Torre Guaceto, terrestrial part of the protected area (wetland) also provides climate regulation services.

Coastal erosion is not systematically monitored but due to natural conditions (composition of cliffs, position of beaches and prevailing currents/ wind direction) it represents an issue for the MPA management. Indicators such as the costs of remedial actions, rate of beach erosion and similar should be considered.

7.3 KARABURUN-SAZAN

7.3.1 Key features of the MPA

Marine area around Karaburuni Peninsula and Sazani Island has been proclaimed a national marine park in 2010[22]. The MPA is located in the Bay of Vlora (southern part of Albanian coast), in the area between Adriatic and Ionian Seas. Total surface of the MPA is around 12,571 ha (some 9,849 ha around Karaburuni Penninsula and 2,722 ha around Sazani Island). The MPA location and extent/ zoning are shown on the map in Figure 5.

Specific natural values for which the area was protected and designated as a SPAMI (since 2016) include: *Posidonia* meadows, coralligenous communities and other vulnerable marine habitats; fish species; characteristic geological formations and landscape diversity; and presence of endangered and protected species (including emblematic species such as cetaceans, monk seal, sea turtles).

Karaburun-Sazan MPA is managed by the Regional Administration for Protected Areas (RAPA – part of the National Agency for Protected Areas in Albania). Four management zones are determined within the MPA: core zone (accounting for 6% of the protected area); effective management zone (69%); recreational zone (16%); and sustainable development zone (9%). Research, monitoring and regulated visitation are the only activities allowed in the core zone. In addition to these activities, diving, wildlife watching, boating (excursions), mooring and water sports (including sailing, kayaking) are allowed in the effective management zone, based on the permits issued by the PA manager. According to the 2014 management plan, swimming and fishing were only allowed in the recreational and sustainable development zones. Since two and a half years ago, fishing has been prohibited in the entire MPA (except for monitoring purposes).

The Karaburun-Sazan coastline is mainly rocky with, in some places, important calcareous limestone cliffs covered by typical Mediterranean vegetation (maquis) and some pocket beaches. The coastal wetlands and dunes host halophytes, psamophytes and other brackish and freshwater associations. The rocky coast has exceptional scenic quality. The underwater landscape is also of exceptional quality with cliffs, submarine caves and associated fauna and flora, as well as with some archaeological remains.

[22] Data and maps used in this section come from the interview with MPA staff, 2014 MPA management plan, economic valuation of the Karaburun-Sazan protected area carried out in 2016, and results of the MedPAN small project implemented in 2015 – 2016.

Figure 5. Karaburun-Sazan MPA

Source: Management Plan for National Marine Park Karaburun-Sazan (2014)

The most important and sensitive species and biocenosis in the MPA are:

- Red coral (Corallium rubrum),
- Date mussel (Lithophaga lithophaga),

- Dusky grouper (Epinephelus marginatus),
- Starfish (Ophidiaster ophidianus),
- Coralligenous biocenosis,
- Biocenosis of Posidonia oceanica meadows,
- Biocenosis dominated by Lithophyllum byssoides (Lithophyllum byssoides rims),
- Biocenosis of infralittoral algae – Cystoseira communities.
- Monk seal (Monachus monachus),
- Short-beaked common dolphin (Delphinus delphis), and
- Loggerhead turtle (Caretta caretta).

Karaburun-Sazan habitat mapping (last conducted in 2016) showed that *Posidonia* and coralligenous habitats cover surfaces of around 194 and 276 ha respectively.

Fish fauna is quite diverse and relatively abundant, especially on the western side of Karaburuni peninsula and around Sazani island. Noteworthy fish species (included in the Annex III of Barcelona Convention) are the dusky grouper (*Epinephellus marginatus*), the Atlantic bluefin tuna (*Thunnus thynnus*) and the swordfish (*Xiphias gladius*). Some important crustaceans like lobster (*Homarus gammarus*), the crawfish (*Palinurus elephas*), the greater locust lobster (*Scyllarides latus*), and the spiny spider crab (*Maja squinado*) are found in the area.

7.3.2 Socio-economic activities

A study carried out in 2016 estimated economic value of ecosystem services provided by Karaburun-Sazan MPA at EUR 12.2 million (ALL 1.68 billion) annually. The key contributors were regulating services (sea water quality, carbon storage, protection against natural hazards) providing for some 95% of the total value, and provisioning (artisanal fisheries) and cultural services (excursions, aesthetic values, diving, swimming/ beaches, etc.) with equal shares of 2.5% of the total.

The main socio-economic activities linked to Karaburun-Sazan natural resources are fishing (artisanal, sports fishing) and tourism (boat excursions, swimming/ sunbathing, some diving). Around 65 licensed artisanal fishers operate in the region (plus some non-registered small-scale fishing), together with around 20 professional fishing boats (trawlers). Trawling is not allowed in the Bay of Vlora. Artisanal fishing was originally allowed in some 20% of the MPA but is now banned in the entire park, except for monitoring purposes[23].

During the high season, the fisheries management centre located in Orikum municipality sells around 1.5 tons of fish/ crustaceans per day from artisanal fishing in the area (2016 data). Estimated income per boat is around USD 6,000. The main species sold are shrimps, red mullet, sea bream, sea bass, hake, sardinella and Altantic horse mackerel. Fisheries landing survey (conducted from November 2015 – May 2016 within the MedPAN small project) monitored catches at Radhime and Treport (Vlora) fishing ports and calculated average CPUE for the Bay of Vlora at 14.8 kg per 1,000 m of trammel net.

Tourism is seen as one of the key economic development opportunities in the Vlora county. A survey showed the predominant reasons for the tourist visits to the region were swimming/ sunbathing (for 31% of respondents), rest and relaxation (26%) and nature (18%). Rapid urbanisation and development of tourist facilities and services over the past two decades is apparent. Organisation of boat excursions in and around the MPA is an activity where a particularly quick expansion has been recorded, whereas number of boats providing such services rose from two to around 60 within a timespan of few years. The annual number of tourists using excursion boats was estimated at 22,000. Diving is not well developed, with an estimated number of 300 – 500 divers annually. Inside the Karaburun-Sazan MPA, there are five small tourist points offering food and beverages. One of them (also renting beach equipment) records the number of visitors, which ranged from 4,500 to 5,000 per season in 2015/ 2016.

Posidonia meadows have a very important role in climate regulation due to their ecological function of carbon sequestration. In addition to 194 ha of *Posidonia* meadows within the Karaburun-Sazan MPA, beaches along the Bay of Vlora are protected with large areas (around 1,658 ha) of *Posidonia*. The value of carbon stored in the *Posidonia* habitats within the MPA has been estimated at EUR 11.64 million.

[23] During the past two years, around 50 fishing trips have been allowed within the MPA area for monitoring purposes; protocols developed under the FishMPABlue 2 project have been used.

7.3.3 Observed climate change impacts and their repercussions for natural and socio-economic systems

Since it assumed responsibilities as the Karaburun-Sazan manager in 2015, RAPA's focus was on the priority management issues. Some monitoring activities in and around the MPA have been conducted in cooperation with local fishermen, non-governmental organisations, University of Vlore and University of Tirana. As regards climate change, the work was mainly dedicated to educational activities. The 2014 management plant for the Karaburun-Sazan MPA recognised climate change as a threat to *Posidonia* meadows and coralligenous communities but did not elaborate necessary management and/ or monitoring actions to address the threat.

Even though systematic monitoring of climate change impacts has not been conducted so far, some information on how climate change is affecting the park can be derived from other activities of the MPA manager and involved stakeholders. Through a good cooperation established with the main fishing cooperative as well as based on the results of specific projects, evidence that confirms changes in the composition of catch has already been collected. Increased presence of non-native and/ or temperature sensitive species (blue crab, rays, sharks) has also been confirmed. Moreover, divers testify of climate change related changes in marine ecosystem. A mass growth of the invasive algae *Caulerpa racemose* along the coast of the Bay of Vlora has been recorded, in parallel to regression of *Posidonia oceanica* beds. The algae were first recorded in Albanian waters in 2002.

The impacts of sea level rise and storms are not particularly pronounced in the MPA and surrounding area, mainly due to the fact that the Bay of Vlora is naturally sheltered. Nevertheless, it is evident that sea storms cause some damages to local infrastructure (ports, roads).

Climate change monitoring is going to be significantly strengthened in the coming period, with Karaburun-Sazan being a part of the MPA Engage project[24]. The project will be implemented over the course of two years (2020 – 2022), aiming primarily to support MPA managers to adapt to and mitigate the ongoing climate change effects in the Mediterranean.

7.3.4 Socio-economic indicators to monitor climate change impacts

While systematic work on the development of climate change indicators in the MPA is expected to take place in the coming years, the existing knowledge and experiences of the park's manager and local stakeholders confirm conclusions of the assessment conducted for Portofino and Torre Guaceto SPAMIs. Socio-economic indicators should be developed in a way to capture effects of climate change on the key economic activities linked to Karaburun-Sazan natural resources and/ or key ecosystem services, thus focusing on:

- Fishing effort and revenue of local fishermen active in the areas neighbouring the MPA;
- Invasive species;
- *Posidonia* meadows and their carbon sequestration potential.

[2424] Full title of the project is *MPA Engage: Engaging Mediterranean key actors in Ecosystem Approach to manage Marine Protected Areas to face Climate Change*. It is funded by the Interreg MED programme.

8 Selected indicators and related factsheets

Based on the review of available literature and the list of identified/ potential indicators (section 6.1), analysis of the situation in pilot SPAMIs and related consultations, four indicators were selected as feasible and useful choices to start a coordinated monitoring of socio-economic trends linked to biodiversity and natural resources in MPAs/ SPAMIs. In the final selection of indicators, care was taken to include those that refer to costs induced by climate change as well as those that refer to benefits MPAs/ SPAMIs provide in terms of climate change mitigation and adaptation. Moreover, four optional/ alternative indicators are proposed in order to allow more flexibility to protected areas in selecting indicators suited to their specific conditions.

The selected (recommended) indicators are:

1. Fisheries: Revenue per unit effort (to measure costs/ losses expected to be incurred by climate change);
2. Climate change mitigation: Carbon stored in *Posidonia* meadows and salt marshes linked to the MPA (to measure benefits provided by MPA/ marine natural resources);
3. Climate change adaptation/ coastal security: Damages to coastal and MPA infrastructure due to extreme weather events (costs/ losses);
4. Climate change adaptation/ coastal security: Investments in coastal protection including remediation of coastal erosion impacts (benefits i.e. avoided costs).

Optional indicators:

- Invasive species: Damages to artisanal fishing generated from invasive species presence;
- Recreational activities: possibility 1: seasonality of visits; possibility 2: seasonality of diving
- Climate change mitigation: Value of blue carbon (carbon stored in protected marine ecosystems);
- Climate change adaptation/ coastal security: Loss of natural capital due to extreme weather events.

For the recommended indicators, factsheets were developed as presented below.

Name of the indicator	**Revenue per unit effort (RPUE)**
Group of indicators	Fisheries
Definition	Revenue of artisanal fishermen from fishing inside and outside the MPA, derived based on the amount of fish caught by different types of fishing gear and fish prices.
Objective	To monitor how fishermen's income change over time and to evaluate if such changes are correlated with temperature increases/ other climate stressors; to analyse differences in the effects of fishing effort in the MPA and in the neighbouring waters.
Justification	Changes in the composition of catches/ revenues have been already observed and believed to be caused by a range shift in temperature sensitive fish species; new thermophilic (and/ or invasive) species are perceived as a threat to fishermen income.
Unit of measurement	Currency per unit effort i.e. per length of the fishing gear deployed, expressed in metres
Reference area	MPA and area outside the MPA
Timing	Monthly, annually
Information needs	Data on catches, fishing effort and ex-vessel prices of each species caught
Sources of data	MPA monitoring records, fishermen logbooks, fish markets
Responsible institution	MPA managers
Related indicators	Catch per unit effort, total catch/ composition of catch

Name of the indicator	**Carbon stored in *Posidonia* meadows and salt marshes linked to the MPA**
Group of indicators	Climate change mitigation
Definition	Estimate of the total amount of carbon stored in *Posidonia* and salt marshes habitats (within the MPA and in the neighbouring waters/ coastal areas) based on their surfaces and condition, and storage rates (per ha).
Objective	To illustrate scale of benefits provided by habitats with carbon sequestering potential the MPAs are protecting (directly or indirectly).
Justification	Seagrass and salt marshes are marine/ coastal habitats with high carbon sequestering potential; quantification of the amount of carbon stored in these habitats can illustrate the scale of socio-economic benefits provided and make a powerful argument for conservation.
Unit of measurement	Tonnes (of carbon)
Reference area	MPA and neighbouring waters/ coastal areas
Timing	Periodical, aligned with the timing of *Posidonia* monitoring campaigns
Information needs	Surface of relevant habitats/ their condition; carbon sequestration rates for the considered habitats
Sources of data	Habitats monitoring; research and other studies on carbon sequestration[25]
Responsible institution	MPA managers, other actors involved in marine monitoring
Related indicators	Value of blue carbon, Surface of blue carbon sinks MPA is protecting

Name of the indicator	**Damages to coastal and MPA infrastructure due to extreme weather events**
Group of indicators	Climate change adaptation/ coastal security
Definition	Periodic (ad hoc) and/ or annual estimations of damages caused by extreme weather events to infrastructure within the MPA and in the surrounding coastal areas.
Objective	To estimate and record costs incurred to economy and society from damages to coastal and infrastructure developed by MPAs, and to analyse trends over time.
Justification	Extreme weather events are causing significant damages to coastal infrastructure in and outside the MPAs.
Unit of measurement	Currency
Reference area	Coastal municipalities/ regions where MPA is located
Timing	Ad hoc (following the extreme weather events), annual
Information needs	Type and scale of damages and their monetisation
Sources of data	Municipal/ regional administrations and statistical offices; MPA
Responsible institution	MPA managers based on own and data gathered from other sources
Related indicators	Incidence of and population exposed to extreme weather events

Name of the indicator	**Investments in coastal protection including remediation of coastal erosion impacts**
Group of indicators	Climate change adaptation/ coastal security
Definition	Total investments into coastal protection measures and remediation of coastal erosion for the observed period.
Objective	To estimate and record level of investments that can be, partially or fully, offset by the benefits provided by MPAs.

[25] Russi et al., 2016, for example, quote the rates of 0.18 – 17.3 tonnes of carbon for salt marshes and 0.56 – 1.82 tonnes for seagrasses, based on Nellemann C., Corcoran E., Duarte C. M., Valdés L., De Young C., Fonseca L., and Grimsditch G., (Eds), 2009, *Blue Carbon: A Rapid Response Assessment,* United Nations Environment Programme, GRID-Arendal.

Justification	Marine / MPA habitats dissipate/ attenuate wave energy, nourish the beaches and protect from erosion i.e. they act as nature-based solutions that can replace the need for protective infrastructure and curative measures.
Unit of measurement	Currency
Reference area	Coastal municipalities/ regions where MPA is located
Timing	Periodic (3 – 5 years)
Information needs	Coastal protection and erosion remediation investments made in the observed coastal area
Sources of data	Municipal/ regional administrations and statistical offices; MPA
Responsible institution	MPA managers, based on own and data gathered from statistical offices and other marine monitoring stakeholders
Related indicators	Costs of coastal erosion

9 Conclusions and technical advices

It is beyond doubt that climate change manifestations affecting biodiversity and the key physical characteristics of the marine environment and MPAs will have a profound impact on related socio-economic variables, but our understanding of potential scales, timing and trends of such impacts is rather limited. Current monitoring of climate change impacts on physical/ natural characteristics and biodiversity in the Mediterranean MPAs and SPAMIs is not comprehensive and systematic, while monitoring of potential impacts on socio-economic systems that benefit from MPA/ SPAMI natural resources is almost non-existent.

That is why it is important to further expand efforts to collect data that will, over time, help evaluate and monitor climate change impacts on socio-economic trends linked to protected marine biodiversity and natural resources. Effectively managed SPAMIs are well-positioned to lead this work and to fulfil the potential to act as 'laboratories' for the marine science and policy in relation to climate change.

Selection of indictors that could help measure and evaluate socio-economic impacts of climate change across the Mediterranean is not an easy task due to several reasons:

- Knowledge on socio-economic benefits of MPAs is limited;
- Complexity of marine environment and variety of its uses in individual MPAs;
- Changes in socio-economic variables may be affected by a range of factors and it is difficult to discern climate change effects;
- Climate change adaptation potential of MPAs is dependent on local conditions that may vary significantly from one site to another.

Despite these difficulties, it is important that MPAs and SPAMIs in particular start collecting a set of socio-economic data that can help monitor impacts of climate change in a coordinated manner, using compatible approaches and procedures.

Commitment of countries and MPA managers is needed, as is cooperation and coordination (also with other projects and data sharing platforms) among all actors involved in monitoring. Use of local environmental knowledge is also necessary to ensure adequate and cost-effective monitoring.

The four indicators selected in this report represent a first attempt at development of a systematic approach to monitoring of climate change impacts on SPAMI natural resources and related socio-economic costs and benefits. They need to be re-visited over time and changed/ improved as more information and knowledge will become available.

Prime responsibility for monitoring rests with the MPA/ SPAMI managers. Indicators recommended in this report should not create a significant additional burden for the managers since care was taken to propose those that can be derived from the ongoing monitoring efforts at the level of MPAs as well as from information collected by other actors in marine monitoring programmes, research and statistical institutes.

In view of recently adopted Barcelona Convention Decision (IG.24/6) where marine protected areas are seen as reference sites for IMAP and Contracting Parties are encouraged to ensure further cooperation in the management and conservation of SPAMIs, the Barcelona Convention system should, by building up on the existing achievements, provide support to SPAMIs in monitoring impacts of climate change on natural and socio-economic systems through capacity development, cooperation and data sharing.

Based on the above considerations, the following technical advices are formulated for MPA/SPAMI managers and policy makers:

- **Address gaps in current climate change monitoring, including socio-economic aspects**
  Monitoring should be further developed to ensure climate change effects, including on socio-economic systems that depend on marine biodiversity and natural resources, are better understood, and formulation of adequate responses is enabled both for biodiversity conservation and for climate change mitigation and adaptation. To this end, strengthened cooperation among countries and individual sites is needed, whereas SPAMIs are well-

positioned to lead the work and the Barcelona Convention system to provide support through (*inter alia*) development of regional/ sub-regional approaches, capacity building and best practices/ experience sharing.

- **Carry out climate change vulnerability assessments**
  MPA/SPAMI managers should assess protected areas' ecological and socio-economic vulnerability to climate change to identify key habitats/ species likely to be affected by climate stressors together with likelihood and scale of impacts on related socio-economic activities. Findings of vulnerability assessments could be used to develop and fine-tune monitoring efforts in the future.
- **Identify habitats and species that act as blue carbon sinks**
  Habitats and species with carbon sequestering potential that are benefiting from protected areas management regimes should be identified and mapped, and carbon budget models should be developed for them. Such information should be used to ensure long-term protection of mechanisms by which carbon is absorbed, cycled and stored within marine environment, whereas protected areas networks would not only maximise protection of biodiversity but also provide strategic opportunities for climate change mitigation.
- **Strengthen coordination and cooperation among all actors in MPAs (including SPAMIs) and marine environment monitoring, and provide necessary resources**
  Financial and other necessary means should be provided to ensure adequate monitoring of climate change impacts on protected areas resources, as insufficient knowledge and lack of appropriate responses could generate much higher costs in the future (in view of amplified/ accelerated climate change impacts on marine ecosystems and related socio-economic losses). On the other hand, every effort should be made to ensure cost-effective monitoring, including through coordination and cooperation in data collection, joining of analytical capacities and usage of local environmental knowledge/ citizens science to complement monitoring.
- **Consider Mediterranean MPAs (including SPAMIs) as a network to enhance resilience to climate change and minimise disruptions for socio-economic systems**
  While there are still many uncertainties on how (when, where, at what rate) will climate change affect marine ecosystems, the so far experiences and research show the impacts are/ will be wide ranging. At the same time, potential of protected areas to contribute to climate change mitigation and adaptation has been well demonstrated. To utilise this potential of MPAs and SPAMIs on a regional level, it is important they are integrated, mutually supportive and focused on sustaining key ecological functions, services and resources. By protecting stability and integrity of ecosystems, resilience of socio-economic systems that depend on them will be also enhanced. To this end, it is very important that integrated approaches are applied and results of climate change monitoring are taken into account in planning, designation and management of protected areas.

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Annex 2: Questions for the interviews with SPAMI managers

Objectives of the interview: Analyse how socio-economic values related to biodiversity and natural resources are impacted in MPAs by climate change, and how MPAs could help limit such impacts and/ or adapt to them; propose/ develop indicators to monitor socio-economic implications of climate change in MPAs.

Questions:

1. What are the key socio-economic values of your SPAMI?
2. What are the main economic activities linked to the SPAMI's natural and cultural resources? Is data available on the size/ significance of such activities and from which sources (e.g. size of fishing fleet, number of fishermen, total catch, number of businesses providing services to non-resident visitors/ number of jobs, total revenues from tourism/ additional revenues linked to the SPAMI values and resources, and similar)?
3. What are the main services biodiversity and natural resources the SPAMI protects are providing to local population and economy in terms of climate change mitigation and adaptation (e.g. carbon sequestration, flood/ erosion protection)? Are these services significant on a wider (than local) scale?
4. How would you describe the main issues related to effects of climate change on biodiversity and natural resources at your SPAMI?
5. The key characteristics of the local community/ ies in the area surrounding the SPAMI (population, type of settlements, economic activities).
6. The main socio-economic stakeholders of the SPAMI; who benefits/ bears costs from protection measures in the SPAMIs?
7. Structure of the SPAMI revenues; what is the share of self-generated revenues and how are they earned? Any specific financing mechanisms in place?
8. What socio-economic data is collected at the level of the SPAMI, if any? What other sources keep data pertinent to socio-economic trends in the SPAMI and surrounding area?
9. Is there already evidence that climate change is affecting biodiversity and natural resources the SPAMI is protecting? Any evidence of the impact on socio-economic values of the SPAMI?
10. Based on the recorded trends and available projections, what gains or losses do you think will arise for local economy due to climate change? How local communities will be affected? (Loss of/ increase in economic opportunities, employment, income? Greater exposure to natural disasters? Improved resilience? Damages to infrastructure? Higher business and/ or private costs to adapt to CC?). What socio-economic impacts can be expected on a wider scale (national, regional)?
11. What indicators do you find the most suitable to monitor: a) the costs induced by climate change in MPAs; and b) benefits MPAs are providing for climate change mitigation and adaptation?
12. Is data needed to derive such indicators already available at your SPAMI/ from other sources? If not, what needs to be done? What is feasible at the SPAMI level, what role for other stakeholders?
13. Do you think our understanding of socio-economic role of MPAs/ marine environment in the context of climate change is sufficient and adequately integrated in the decision-making processes? What are priorities for improvements? Any recommendations for various stakeholders (MPA managers, local communities, scientific community, national statistics…)?