Interreg Mediterranean

MPA Engage

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# Joint Plan for Climate Change Adaptation in Mediterranean MPAs: **methodological approach & priority actions**

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# IDENTIFICATION

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|---|---|---|---|
| **Project Number** | 5MED18_3.2_M23_007 | **Acronym** | MPA Engage |
| **Full title** | MPA Engage: Engaging Mediterranean key actors in Ecosystem Approach to manage Marine Protected Areas to face Climate change | | |
| **Axis** | 3.2: To maintain biodiversity and natural ecosystems through strengthening the management and networking of protected areas | | |
| **Partner Responsible** | MIO-ECSDE | | |
| **Contact Person** | Thomais Vlachogianni | | |

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| **Deliverable** | 3.7.8 | **Title** | Joint Plan for Climate Change Adaptation in Mediterranean MPAs: methodological approach & priority actions |
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| **Description of the deliverable** | This document is a synthesis report of the results and outcomes of the participatory 5-phase decision-making process run by 7 pilot Mediterranean MPAs with the aim to identify and adopt priority climate change adaptation measures. The report features the climate change adaptation options endorsed or shortlisted by the pilot MPAs and defines the common priority actions that should implemented by all Mediterranean MPAs in response to the lurking effects of climate change. |
| **Key words** | Quintuple helix, decision-making process, public participation, climate change adaptation, joint plan |

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# INDEX


# EXECUTIVE SUMMARY

**Climate change is dramatically affecting** the Mediterranean Sea, which is warming at a rate three times faster (0.41°C per decade) than the world's average (0.13°C per decade). Marine Protected Areas (MPAs), despite the nature-based solution they offer to support efforts towards climate change adaptation and mitigation, also experience the effects of climate change. In fact, several Mediterranean MPAs are already facing major biodiversity and functional alterations due to climate change, whereas others will likely face them within the next few decades. There is, therefore, an urgency to mitigate these risks and to consider adaptation options, in partnership with local communities, decision-makers, civil society organizations, research bodies, and other socio-economic actors at local, national and regional level.

**MPA Engage** is an Interreg Med funded project that seeks to support Mediterranean MPAs to adapt to and mitigate the ongoing climate change effects in the Mediterranean. Within a period of three years, MPA Engage has provided essential support to managers of marine protected areas to fast-track actions against climate change. During this time, MPA managers and climate change experts from 14 entities and 6 different countries, namely Albania, Croatia, France, Greece, Italy and Spain, have been brought together and have evolved into a taskforce with a joint mission to promote MPAs as nature-based solutions for climate change adaptation.

**Participatory approaches** are at the heart of the MPA Engage project; through a participatory approach, MPA Engage monitored in a harmonized way the climate change impacts, elaborated vulnerability assessments and developed climate change adaptation and mitigation action plans in the pilot MPAs.

**At an early stage** of the project, detailed guidelines were developed by MIO-ECSDE (Task Leader) aiming to guide the MPA Engage public participation processes that are key for all the phases of the elaboration of the climate change adaptation and mitigation action plans. These guidelines featured all those elements needed for designing and implementing participatory processes and addressed all key aspects, from selecting the appropriate participation tools to ensuring that all key actors are effectively engaged in the decision-making process. The guidelines deploy the quintuple helix approach that promotes the engagement of MPA managers, scientists, public authorities, socio-economic actors and citizens in the development of MPA climate change adaptation and mitigation action plans. In addition to the guidelines, a related capacity building webinar was organized and the managers of the pilot MPAs were technically supported by MIO-ECSDE at every step of the participatory process.

**The 7 pilot MPAs** of the project that tested the aforementioned guidelines were the following: Brijuni National Park (Croatia), Portofino MPA (Italy), Calanques National Park (France), Zakynthos MPA (Greece), Cap de Creus MPA (Spain), Litoral del Baix Empordà MPA (Spain) and Tavolara MPA (Italy).

**This document** is a synthesis report of the results, outcomes and lessons learned of the quintuple helix participatory approach implemented in the 7 pilot Mediterranean MPAs, with the aim to identify and adopt priority climate change adaptation and mitigation measures. The report features the experiences gained by deploying the MPA Engage “Guidelines for applying a Quintuple Helix Participatory Approach” and features the essential elements for success for any participatory process plan implemented in Mediterranean MPAs. The collective experience of the pilot MPAs sets the foundations for a joint participatory approach in Mediterranean MPAs to deal with the rapidly increasing challenge of climate change. This approach, along with its strategic elements, is captured in the present document which aims to assist other MPA managers in the region to achieve their conservation goals.

**Participation** means many things to many people. It carries potential benefits, but only if all those involved have a common understanding and set of expectations. Plans, methods, tools and techniques do not guarantee participation. The showcases of the MPA Engage quintuple helix participatory process, illustrate that public participation is a context-driven process, where the full understanding of the political, cultural and institutional context at local, national, regional and global level is needed. The experiences described in this document highlight some of the various challenges posed by the complex and multidimensional local and national contexts in which the participatory process was introduced. Factors affecting the successful outcome of the participatory process were identified at different levels: individual, community, organizational, political, economic, etc. It should be highlighted that these factors are intertwined and affect each other in very complex ways.

**All pilot MPAs** that operationalized the MPA Engage participatory process plan reported that the overall process was comprehensive, well-articulated and educative, concretely enabling them to put together the different components of the MPA Engage pilot actions, namely the monitoring results, the vulnerability assessments, the citizen science actions, and the actions to elaborate climate change adaptation and mitigation plans. Despite challenges that had to be dealt with, the experience strengthened the capacities of all those involved in the participatory processes, generated commitment to promote MPAs as natured-based solutions to tackle climate change, established and/or strengthened alliances among key stakeholders, and emphasized the potential of the participatory process as a powerful tool to generate constructive discussion among communities related to climate change. The MPA Engage showcases demonstrate that supporting the implementation of participatory processes can successfully lead to effective decision-making for climate change adaptation and mitigation in Mediterranean MPAs.

# 1. SETTING THE SCENE

Climate change is dramatically affecting the Mediterranean Sea, which is warming three times faster (0.41°C per decade) than the world's average rate (0.13°C per decade).

## 1.1 Climate Change in Marine Protected Areas

**Climate change** is dramatically affecting the Mediterranean Sea, which is warming three times faster (0.41°C per decade) than the world's average rate (0.13°C per decade) (IPCC, 2019, Pisano et al., 2020). Climate change is amplifying the effects of existing threats to marine ecosystems and is reshaping their biophysical and chemical characteristics, from increased water temperature, sea-level rise, and extreme events, to ocean acidification, with serious consequences for natural systems (Cramer et al. 2018, Grorud-Colvert et al., 2021). The Mediterranean marine ecosystems are experiencing the following macroscopic and measurable impacts: (i) the shift towards more thermophilic biota; (ii) an increased vulnerability to tropical invaders; (iii) the increased occurrence of phenological shifts; (iv) the occurrence of unprecedented large-scale mass mortality events (Cramer et al., 2018; Garrabou et al., 2019; D'Amen, M., & Azzurro, E., 2020; MedECC, 2020).

**This rapid transformation** of the Mediterranean biota, is producing a novel scenario in which multiple and combined pressures are increasingly eroding the functioning and health of marine and coastal ecosystems, impacting the multiplicity of ecosystem services that the Mediterranean society relies on such as food production, flood and erosion control, carbon storage, sequestration and water quality (Figure 1-1).

**By only covering** 0.82% of the ocean surface, the Mediterranean Sea supports a high level of biodiversity, including about 18% of all known marine species and its rapid warming, in synergy with other climate and non-climate related drivers, threatens some key ecosystems that have high vulnerability to such pressures (e.g., coralligenous, Posidonia habitats, marine caves, infralittoral habitats) (Coll et al., 2010, MedECC, 2020). Despite the designation of Marine Protected Areas (MPAs) to effectively protect such ecosystems and the nature-based solution they offer to support efforts towards climate change adaptation

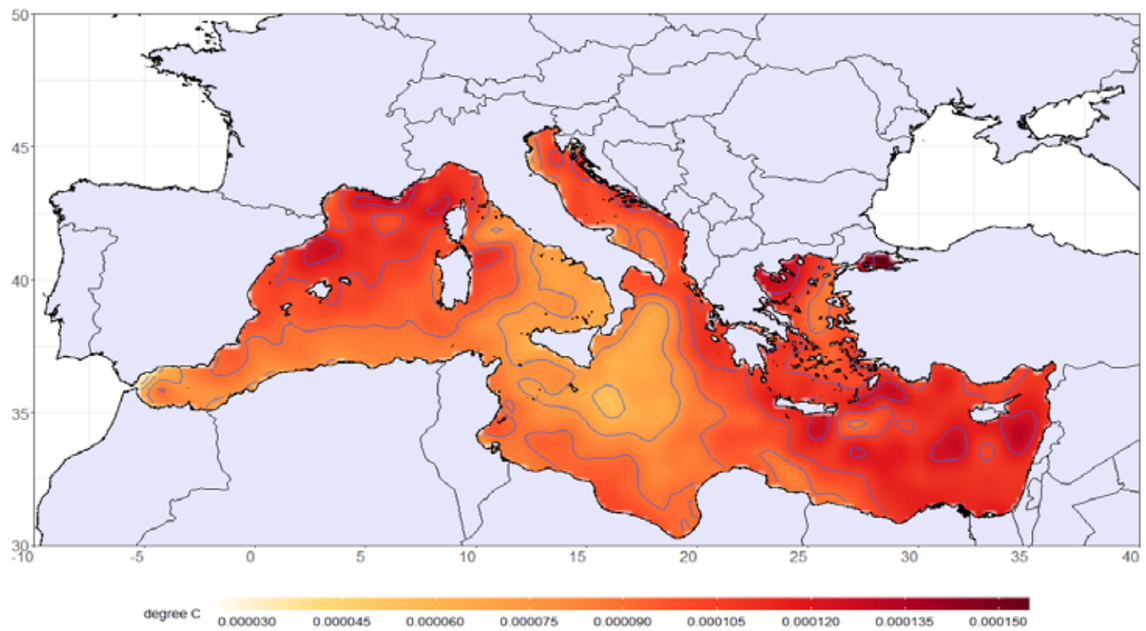



***Figure 1-1.***
*Daily warming trend in the Mediterranean basin from 1982 to 2019. Each contour denotes a change of 1.5×10−5 °C/day. (Pastor et al., 2020).*


and mitigation, they also experience the widespread and pervasive effects of climate change that may challenge their effectiveness to fully protect biodiversity. In fact, several Mediterranean MPAs are already facing major biodiversity and functional alterations due to climate change, whereas others will likely directly face them in the next few decades (Gomez-Gras et al., 2021).

**Even though** it is difficult to foresee with precision to what extent the current climatic trends will affect the effectiveness of Mediterranean MPAs and their ability to meet their biodiversity and conservation goals now and in the future, most recent studies indicate the increased risk of extinction of endemic fauna, loss of habitat complexity and changes in ecosystem configurations, while the socioeconomic effects are not well-studied yet. Consequently, climate change requires a more concerted effort by Mediterranean conservation strategies and management to restore, preserve, and protect the ecological integrity and resilience so MPAs can adapt to environmental changes and withstand the additional stress of climate change.

**There is an overwhelming** scientific consensus that supporting marine conservation under climate change is one of the grand challenges for the coming decade (Borja et al., 2020). The Mediterranean MPAs face an urgent need to pursue evidence-based solutions to the biodiversity decline and the unprecedented pressures from climate change in the region. There is, therefore, an imperativeness to mitigate these risks and to consider adaptation options in partnership with local communities, decision-makers, civil society organizations, research bodies, and other socio-economic actors at local, national and regional level.

## 1.2 The role of marine protected areas in the face of climate change

**MPAs are recognised** as one of the strongest and effective tools for protecting marine life and the livelihoods of coastal communities (Sala et al., 2021). While the effectiveness of MPAs to halt global climate change impacts such as ocean acidification has been questioned (Bruno et al., 2018), there is growing evidence for their role as important areas for enhancing the resilience and adaptive capacity of ecosystems (Tittensor et al., 2019). The long-term, place-based nature of MPAs provides an advantage in addressing the impacts of climate change by providing a focal area for management and science to reduce stressors, to monitor conditions and trends, and engage with the public. MPAs and related networks that work together to meet objectives beyond those of a single area by protecting areas from degradation and allowing the recovery of ecosystems can contribute to addressing climate change through a number of different routes:

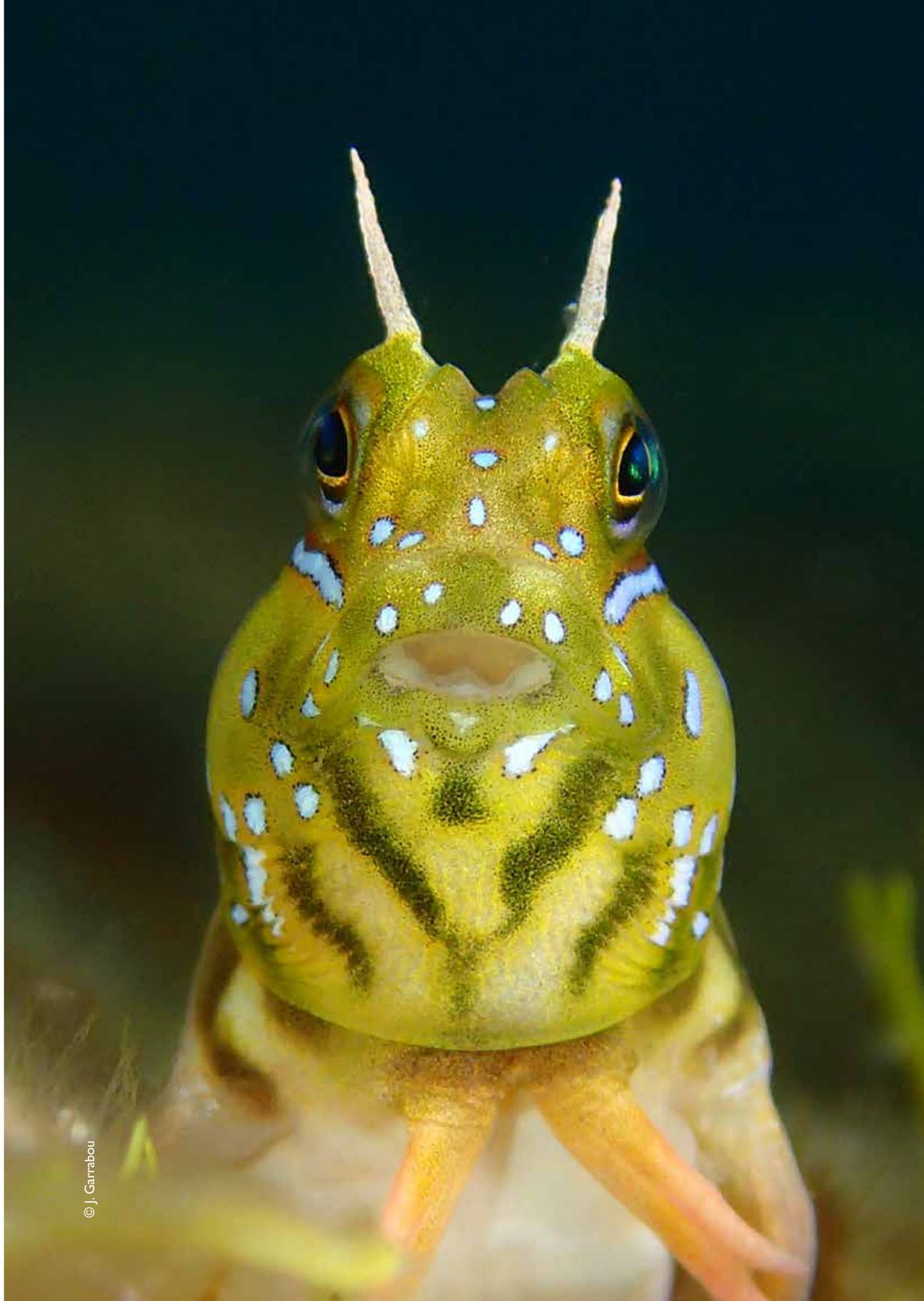
- **Reduce** other non-climate ocean stressors
- **Function** as important carbon sinks
- **Provide** ecologically connected corridors for shifting species
- **Provide** refuge and replenishment zones
- **Reduce** risk and promote resilience
- **Serve** as sentinel (research) sites to monitor climate change effects
- **Raise** awareness and educate local communities
- **Provide** numerous ecosystem services

**MPA management** and planning that ignore potential climate change impacts or that are based on unrealistic

generalizations, might result in conservation targets or indicators that are unlikely to be achieved (Katsanevakis et al., 2020). However, despite recognition of the importance of integrating climate change as a core consideration for MPA planning and implementation, and the development of conceptual approaches and decision support tools for over a decade, the uptake of these measures into management and policy appears limited and/or uncoordinated (Tittensor et al., 2019). The latest Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment indicates that there are “few protected areas whose objectives and management take climate change into account” while only limited studies exist on this issue, with no comprehensive synthesis (Rilov et al., 2020; IPBES, 2019).

**As MPAs** need to anticipate and prepare for the socioecological effects of climate change, they require adaptive management to enable them to tackle problems, while they are still manageable. In order to be effective and to better understand the transboundary impacts of climate change, monitoring programmes targeting multiple indicators for ecological and social effectiveness in MPAs are essential. Long-term monitoring is necessary to fill in the data gaps, in particular in terms of distinguishing natural variability and climate change impacts on biodiversity at multiple levels. Such data will shape future adaptation and mitigation scenarios, but given the threats from climate change and the need to act urgently, actions should be undertaken on the basis of available information, while also advancing, strengthening and deepening the associated knowledge base (Simard et al., 2016).

**Participatory** engagement of local communities in all steps of this anticipatory process is perhaps the most important component to ensure increased support and long-term sustainability. It is essential to provide and encourage climate-smart management around the principles of inclusiveness and capacity transfer, to enable cross-sectoral sharing of successful experiences and best management practices, while promoting regional cooperation for the management of climate change resilient MPAs.



## 1.3 The MPA Engage project in a nutshell

**In order to address** some of the aforementioned challenges, the MPA Engage project kick-started in 2019. MPA Engage is an Interreg Med funded project seeking to support Mediterranean MPAs to adapt to and mitigate the ongoing climate change effects in the Mediterranean Sea. Within a period of three years, MPA Engage has provided essential support to managers of marine protected areas to fast-track actions against climate change. During this time, MPA managers and climate change experts from 14 entities and 6 different countries, namely Albania, Croatia, France, Greece, Italy and Spain have been brought together and have evolved into a taskforce with the joint mission to promote MPAs as nature-based solutions for climate change adaptation.

**The MPA Engage project** entailed testing, transferring and capitalization activities that were coordinated by CSIC. The ultimate goal of the MPA Engage project was to support managers of the pilot MPAs in managing the cumulative impacts of climate change on their areas via the definition of an effective societal response. To this end, harmonized and novel tools were provided to the pilot MPAs to facilitate the implementation of 5-fold pilot actions, which focused on:

- **Harmonized** monitoring of the climate change effects and impacts in MPAs (Led by SZN);
- **Assessment** of the ecological and socio-economic vulnerability of MPAs to climate change (Led by UVIGO);
- **Engagement** of local communities in citizen science activities to monitor the climate change effects and impacts in MPAs (Led by UNIVPM);
- **Engagement** and mobilization of all key actors of the quintuple helix participatory framework (Led by MIO-ECSDE);
- **Elaboration** of climate change adaptation plans (Led by MIO-ECSDE).

**The 7 pilot MPAs** of the project that implemented the aforementioned activities were the following: Brijuni National Park (Croatia), Portofino MPA (Italy), Calanques National Park (France), Zakynthos MPA (Greece), Cap de Creus MPA (Spain), Litoral del Baix Empordà MPA (Spain) and Tavolara Punta Coda Cavallo MPA (Italy).

**It should be noted** that in the early stages of the project, an additional pilot MPA, the Karaburun - Sazan Marine Park (Albania) was involved in the aforementioned activities. However, due to administrative difficulties it was not possible to complete the respective pilot.

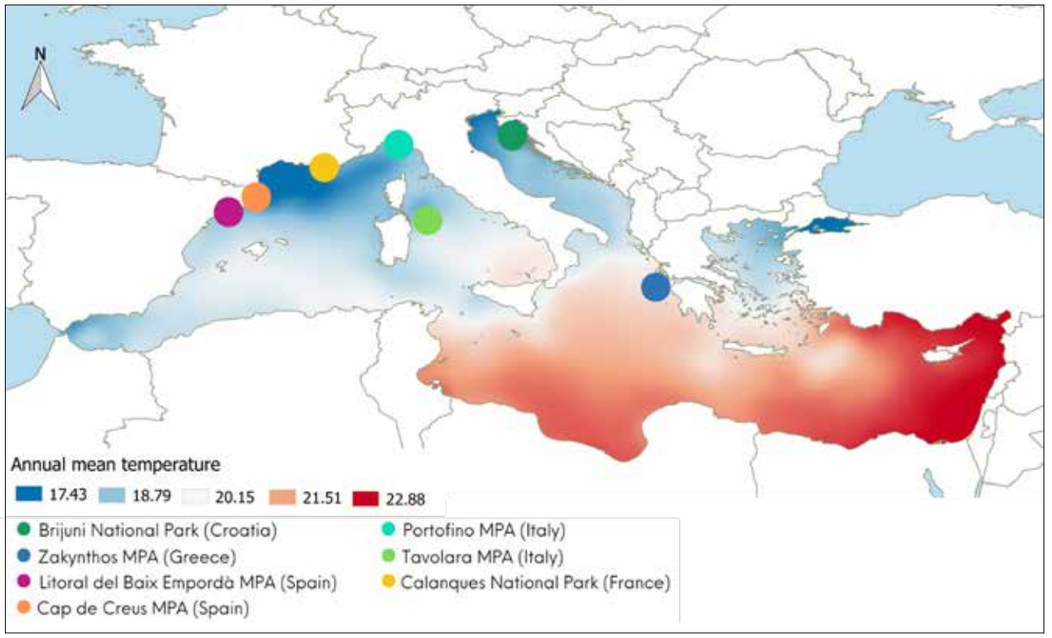



***Figure 1-2.***
*Map of the Mediterranean Sea, with the mean annual surface temperature and the location of the 7 pilot MPAs. The temperature data are extracted from Assis et al., 2017.*

# 1.4 About this document

This document is a synthesis report of the results, outcomes and lessons learned of the quintuple helix participatory approach implemented in the 7 pilot Mediterranean MPAs with the aim to identify and adopt priority climate change adaptation and mitigation measures. The report features the experiences obtained by deploying the MPA Engage “Guidelines for applying a Quintuple Helix Participatory Approach” and features the essential elements for success for any participatory process plan implemented in Mediterranean MPAs. The collective experience of the pilot MPAs sets the foundations for a joint participatory approach in Mediterranean MPAs to deal with the rapidly increasing challenge of climate change. This approach, along with its strategic elements, is captured in the present document, which aims to assist other MPA managers in the region to put Mediterranean MPAs at the frontline of adaptation and mitigation to climate change.

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# 2. THE MPA ENGAGE PILOT ACTIONS: CONCEPTUAL DESIGN & SUMMARY OF RESULTS

## 2.1 The conceptual design of the MPA Engage pilot actions

**The figure below** depicts the conceptual design of the MPA Engage pilot actions and how the different components fit together. Participatory approaches are at the heart of the MPA Engage project; through a participatory approach, MPA Engage monitored in a harmonizedwaytheclimatechangeimpactsviacitizens science action, elaborated vulnerability assessments and developed climate change adaptation action plans in the pilot MPAs. A summary of the results and outcomes achieved by each component is presented within this chapter; however, a more comprehensive description of the component related to the climate change adaptation action plans is provided in the next chapters.

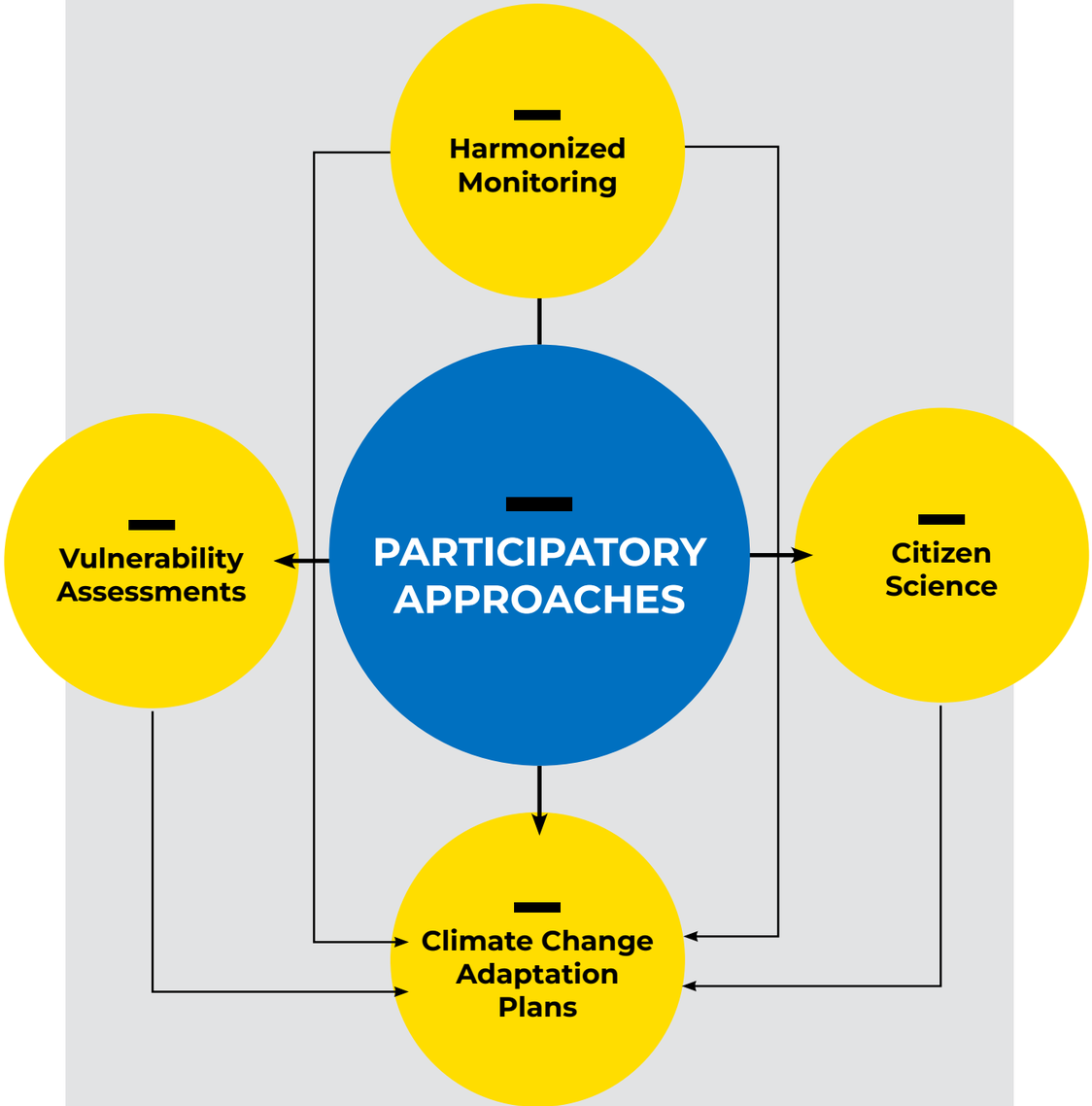



***Figure 2-1.***
*The components of the MPA Engage pilot actions.*

# 2.2 Harmonized monitoring of the climate change effects and impacts in MPAs

**Documenting climate-driven changes** is a key task to support Integrated Coastal Zone Management (ICZM) and to inform maritime spatial planning (MSP). Nevertheless, the complexity of ecological transformation coupled by inadequate human and financial resources hampers down observation capabilities. Capitalizing on previous results of the Interreg Med programme (Garrabou et al., 2018) and scanning for new effective monitoring experiences, the MPA Engage project has developed a harmonized monitoring strategy to track climate change effects across Mediterranean MPAs and beyond. An important merit of this effort is the development of a series of comprehensive protocols, which are provided in the form of complete toolkits, ready to be used and transferred. These toolkits are complemented by learning materials such as presentations, video-tutorials and tools to assist the process of data collection and analysis. All together, these materials provide a system to support the entire process, from the data collection (monitoring), to the analysis and interpretation of data, up to the final assessment of climate change impacts.

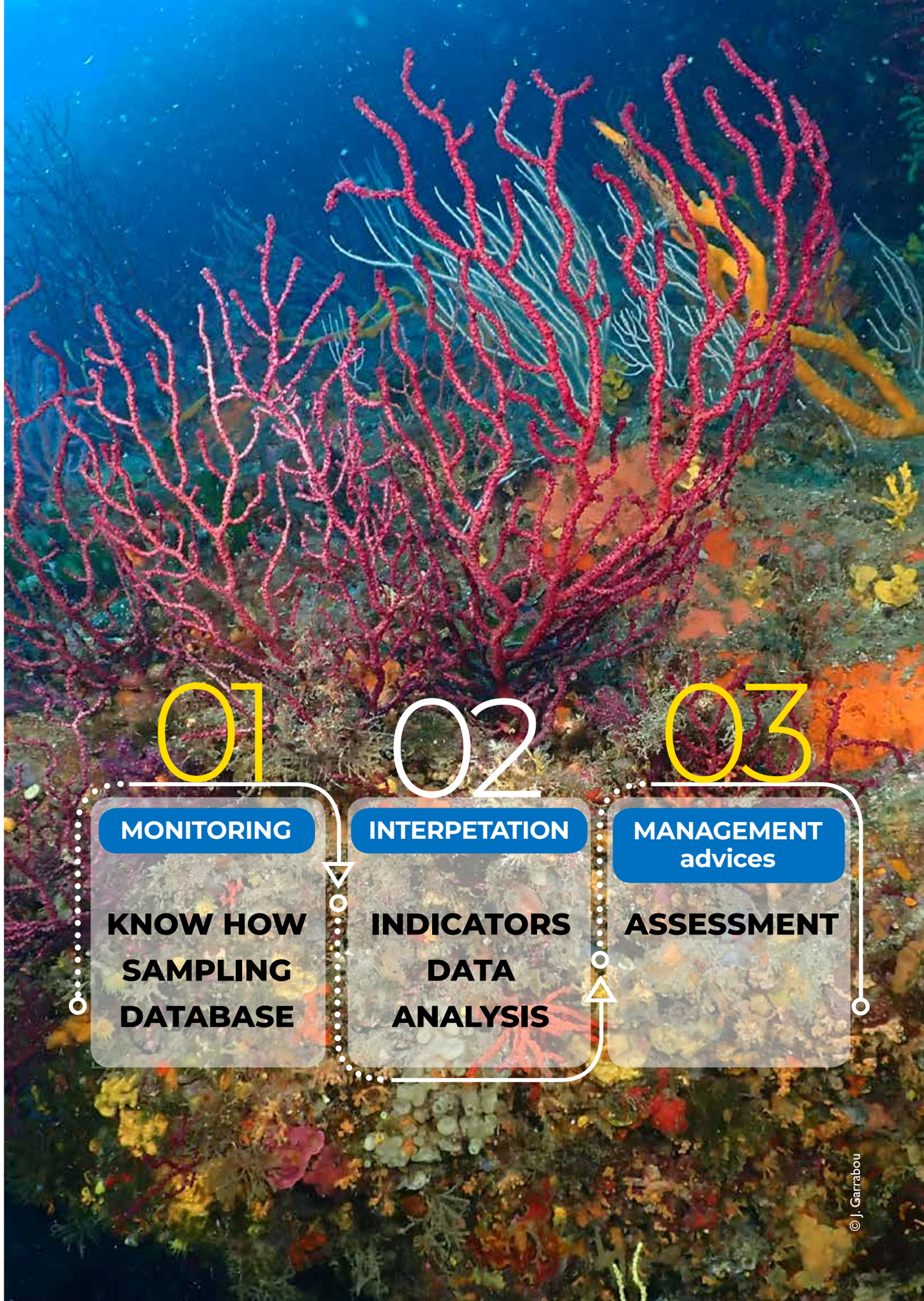



***Figure 2-2.***
*Conceptual scheme of the MPA Engage monitoring strategy.*

**The MPA Engage monitoring strategy** has been designed explicitly for Mediterranean MPAs; MPAs are the best observatory (at local, sub-regional or regional scale) for tracking the effects of climate change. The aim of the MPA Engage project was to support Mediterranean MPAs to take up their role as primary sentinel sites and assess climate change effects on coastal marine ecosystems. The MPA Engage project enabled the updating and fine-tuning of a first set of 5 monitoring protocols developed within the Interreg Med MPA Adapt project (Garrabou et al., 2018) and the delivery of a complete guide of 11 monitoring protocols on climate change indicators. These tools and associated indicators are fully in line with the Barcelona Convention Ecosystem Approach and EU Marine Strategy Framework Directive (MSFD; Directive 2008/56/EC), aiming at reaching good environmental status in marine waters through informed management decisions.

**The indicators associated** to the different protocols fall in four categories of priority interest that have been indicated by regional scientists to track climate change effects in the Mediterranean area:

- **Physical-chemical** conditions
- **Episodic** events
- **Shifts** in alien and native temperature sensitive species distribution patterns
- **Changes** in the reproduction dates

**The testing of the monitoring** protocols in the 7 pilot MPAs characterized by different contexts has provided actionable insight into the overall feasibility and effectiveness of each protocol paving the for efficient implement of climate change monitoring activities in Mediterranean MPAs (Azzurro et al., 2021).

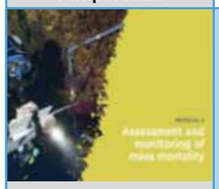
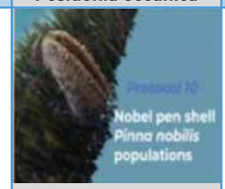
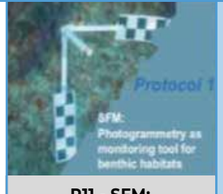
| PROTOCOL | OBJECTIVES | INDICATORS | PROTOCOL | OBJECTIVES | INDICATORS |
|---|---|---|---|---|---|
|  **P1: Temperature** | Water temperature along the depth gradient | High-resolution data on temperature conditions along the depth gradient |  **P6 - LEK3: Mass mortalities** | Detection and historical reconstruction of mass mortalities | Incidence; % mortality |
|  **P2: Mass mortality** | Conservation status of benthic species | Incidence; % mortality |  **P7 - POFA: Posidonia oceanica** | Conservation status of posidonia oceanica | Density |
|  **P3 - LEK1: Historical changes** | Historical changes in the abundance and distribution of coastal species | Thermophilic and temperate species |  **P8 - FAP: Pinna nobilis** | Density and conservation status *of Pinna nobilis* | Incidence; % mortality |
|  **P4 - LEK2: Periodical monitoring** | Periodical monitoring of abundance and distribution of target species | Thermophilic and temperate species |  **P9 - URCH: Sea urchins** | Conservation status of sea urchins | Abundance and population structure |
|  **P5: Fish Underwat er Visual Census** | Periodical monitoring of abundance and distribution of coastal fishes | Native temperate and thermofilic species; tropical invaders |  **P10 - BARD: Benthic species** | Benthic species | Abundance and occurrence |
| *The protocols above (P1-P5) were capitalized from the previous interreg Med project MPA-Adapt* | | |  **P11 - SFM: Photogrammerty** | Benthic habitats | Tridimensional structure |

***Figure 2-3.***
*The 11 monitoring protocols implemented within the MPA Engage project.*

# 2.3 Assessment of the ecological and socio-economic vulnerability of MPAs to climate change

**A socio-ecological vulnerability assessment** to the impacts of climate change has been implemented within the framework of MPA Engage. Vulnerability to climate change refers to the propensity or predisposition to be adversely affected by climate change impacts, defining how severe the effects can be in a given system. Vulnerability comprises the exposure of the system to the changing climate along with the degree to which the system could be affected but it also involves the capacity of the system to reduce its disruption by taking actions that enhance resilience. Considering the MPA as a socio-ecological system, where the ecological domain interacts with the social domain, an indicator-based approach has been applied to calculate the vulnerability of the system (Figure 2-4 shows the vulnerability framework deployed).

The approach developed assesses the MPAs vulnerability by calculating a multidimensional socio-ecological index that combines the vulnerability scores of habitat, species and users of the MPA. The approach enables to differentiate vulnerability at different levels, obtaining vulnerability scores per species, habitat and user groups, and a total vulnerability score at the MPA-level. It also provides results for two different emission scenarios (mild-RCP2.5 and high emissions-RCP8.5); and, for 2050 and 2100. The calculation of a multidimensional vulnerability index allows for a detailed understanding of the MPA vulnerability and consequently support information to design and implement targeted adaptation strategies to face the impacts of climate change.

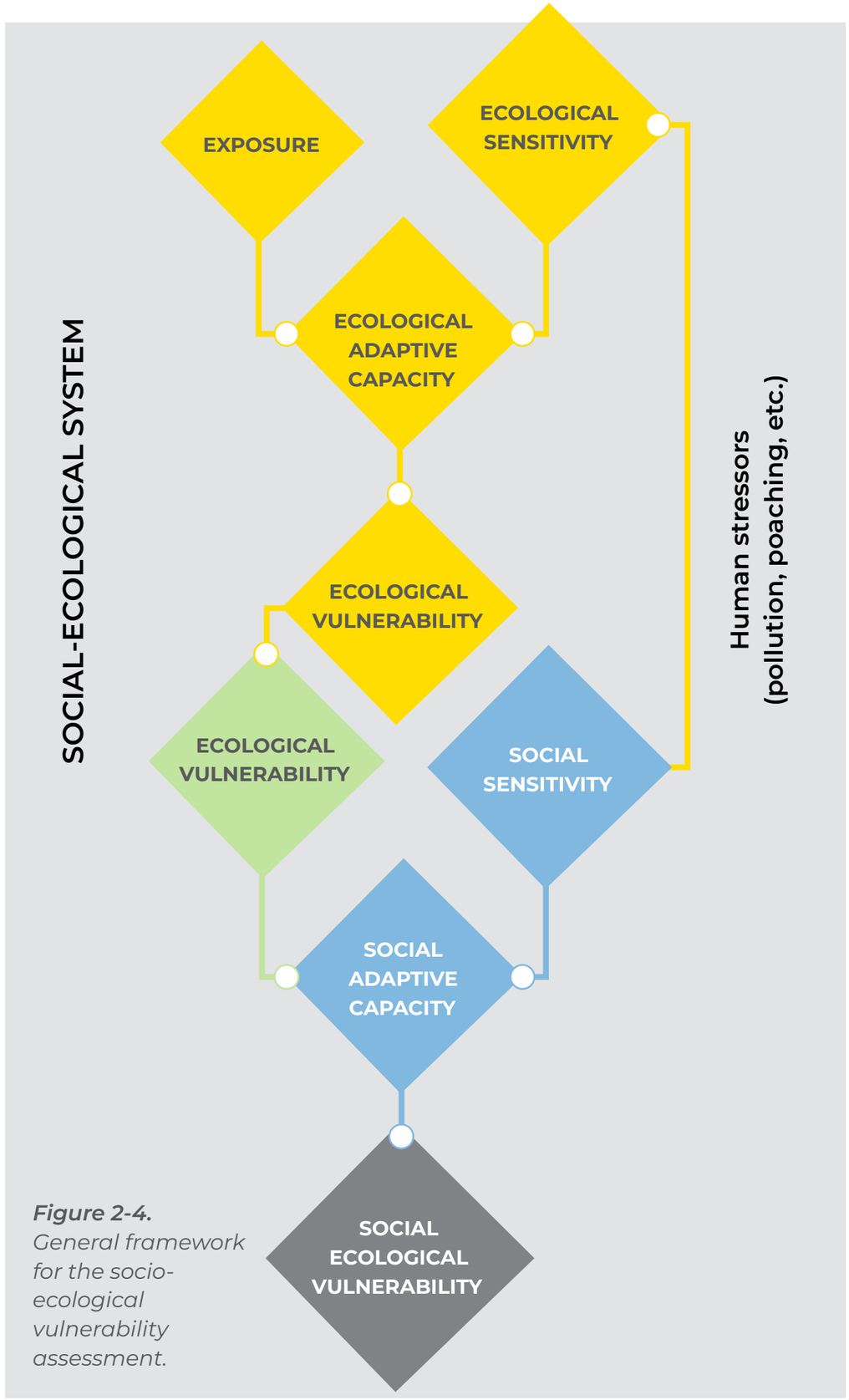



***Figure 2-4.*** *General framework for the socio-ecological vulnerability assessment.*

**All seven pilot MPAs** successfully developed the vulnerability assessment. Final results show that the Calanques National Park exhibits the lowest vulnerability index value, while Brijuni National Park was predicted to be the most vulnerable MPA to the impacts of climate change. However, the MPAs data coverage was not complete specially for social-ecological indicators showing a need for further data collection to provide a higher quality of the information carried by the assessment.

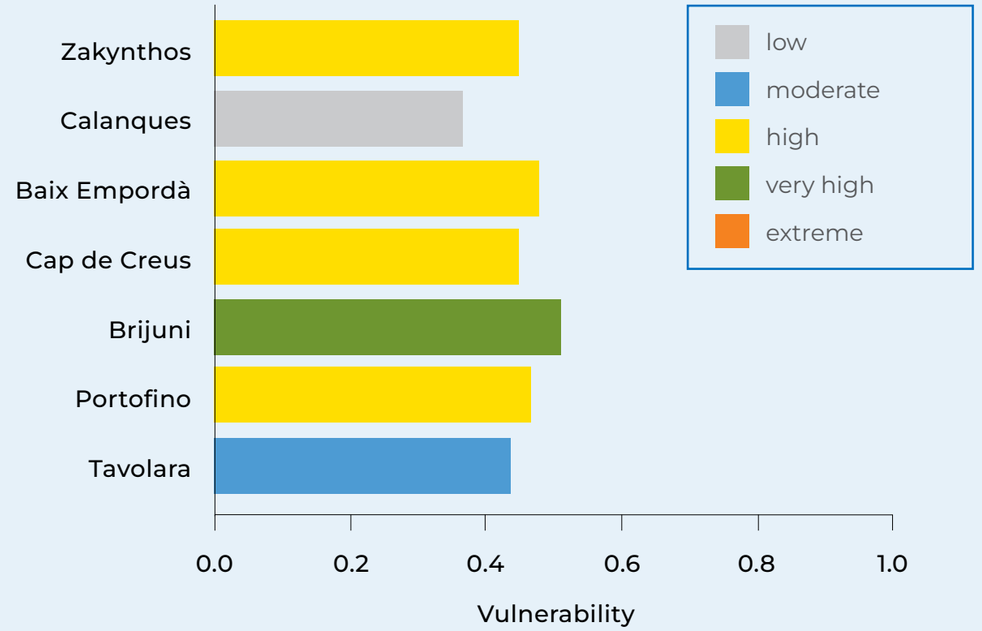
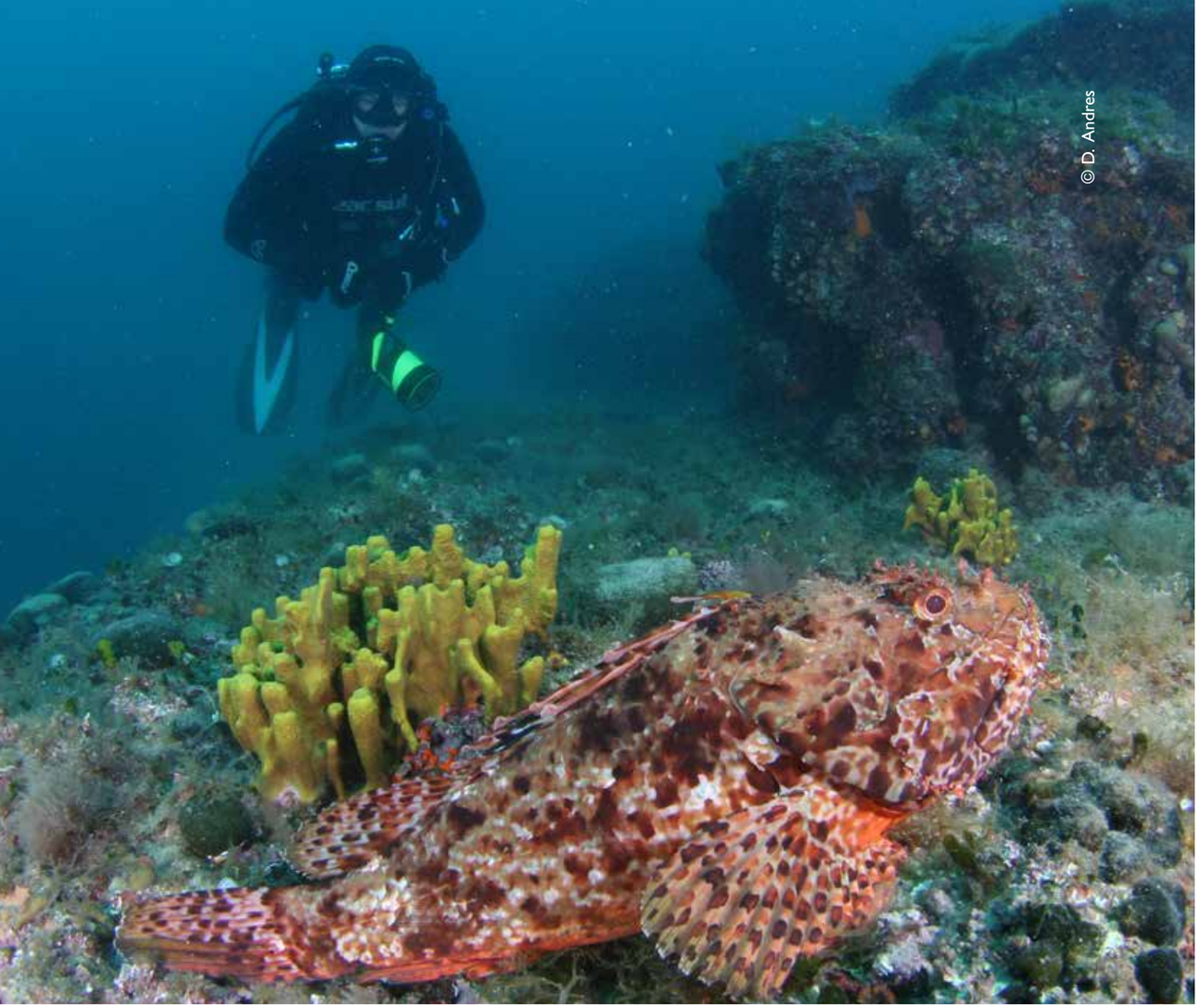




***Figure 2-5.***
*Results of the MPA socio-ecological vulnerability index for RCPs 2.6 and 8.5 2100.*




As expected, species and habitats that are already in bad condition or endangered are the ones that are going to experience the highest vulnerability levels, while invasive species such as *Caulerpa cylindracea* and *Fistularia commersonii* are the species that are going to experience the lowest vulnerability levels. The macroinvertebrates *Pinna nobilis, Paramuricea clavata, Corallium rubrum, Eunicella cavolini, Cladocora caespitosa and Savaglia savaglia* are the species presenting the highest vulnerability levels. *Posidonia oceanica* and coralligenous habitats are particularly sensitive habitats that the increasing temperature will put at risk along with the services that they provide. In the user sectors, diving and nautical activities represent the users that are going to experience the highest vulnerability inside the MPAs boundaries.

| | |
|---|---|
| **TAVOLARA** | |
| **- Poaching**<br>**- Invasive species status**<br>**- Shape of the MPA**<br>**- Habitat extension**<br>**- MPA Zoning**<br>**- Water column monitoring**<br>**- Level of climate scientific advice** | - Available fishing area - Number of companies<br>- Activity area - Users number<br>- Ports access - Ports mooring fees<br>- Species catch dependence - Fishing days<br>- Professional fishers engagement in citizen science<br>- Professional fishers financial resources |
| **BRIJUNI** | |
| **- Deoxygenation**<br>**- Salinity**<br>**- Habitat sensitivity to SST and MHW**<br>**- Invasive species status**<br>**- Level of climate scientific advice**<br>**- Habitat extension**<br>**- Habitat restoration** | - Number of companies - Activity area<br>- User number - Recreational fishers' species catch dependence - Ports mooring fees Working days<br>- Financial resources of recreational activities<br>- Recreational activities users engagement in citizen science - Number of targeted species for recreational fishers - Gear diversity for recreational fishers |
| **PORTOFINO** | |
| **- Deoxygenation - Salinity**<br>**- Habitat sensitivity to SST and MHW**<br>**- Invasive species status**<br>**- Level of climate scientific advice**<br>**- Habitat extension**<br>**- Habitat restoration** | - Available fishing area - Species dependency<br>- Fishing days - Fishers density<br>- Local income dependence on fishing<br>- Number of companies - Activity area<br>- Ports access - Ports mooring fees<br>- Professional fishers financial resources |
| **CATALONIA** | |
| **- Ghost nets (C) - MME (C) - Fishing pressure (C, B) - Habitat extension (C, B)**<br>**- Water column monitoring (C, B)**<br>**- MPA shape (C, B) - Fully protected area (C, B) - MPA Zoning (B)**<br>**- Habitat sensitivity to SST and MHW (B)**<br>**- Level of climate scientific advice (B)**<br>**- Species monitoring (B)** | - Fishing days (C) - Species catch dependence (B)<br>- Attachment to occupation (B, C)<br>- Local income dependence on fishing (B, C)<br>- Recreational activities number of companies (B, C)<br>- Users number (B, C) - Ports access (B, C)<br>- Activity area (B) - Engagement in citizen science (B, C)<br>- Recreational activities financial resources (B, C)<br>- Professional fishers' livelihood diversity (C) |
| **ZAKYNTHOS** | |
| **- Fishing pressure**<br>**- Habitat sensitivity to SST and MHW**<br>**- MPA shape**<br>**- Fully protected area**<br>**- Habitat extension**<br>**- Level of climate scientific advice**<br>**- Species monitoring** | - Available fishing area - Species dependence<br>- Fishing days - Users number<br>- Ports access - Fishers income<br>- Recreational activities days<br>- Recreational activities users engagement in citizen science<br>- Users financial resources |
| **CALANQUES** | |
| **- Deoxygenation**<br>**- Water ecological status**<br>**- Salinity**<br>**- Coastal population density**<br>**- MPA shape - Habitat extension**<br>**- Water column monitoring**<br>**- Level of climate scientific advice** | - Local income dependence on fishing<br>- Ports mooring fees - Activity area - Working days<br>- Available fishing area - Attachment to occupation<br>- Species catch dependence<br>- Professional fishers livelihood diversity<br>- Recreational activities target species<br>- Recreational fishers gear diversity |

***Figure 2-6.***
*Social and ecological indicators contributing the most to the MPAs vulnerability. The blue cells correspond to the ecological indicators while the green cells to the social indicators. For Catalonia, two MPAs were assessed; Cap de Creus (C) and Baix Emporda (B).*

Figure 2-6 provides an overview of the ecological and social indicators that have been found to contribute the most to the socio-ecological vulnerability in the 7 MPAs analysed. These indicators carry important information in terms of decreasing the local vulnerability of the MPAs. In fact, this information can be of relevant importance when developing specific actions and measures for the adaptation plans of each MPA in order to increase their resilience and decrease their local vulnerability.

**Results** highlight indicators that are specific to the water conditions where monitoring activities are crucial and management can have a positive impact in vulnerability. Other indicators are more difficult to address, such as coastal population pressure or habitat sensitivity. In several MPAs, fishing and poaching are important threats that can be addressed with enforcement. In almost all MPAs, the level of climate scientific advice is important to reduce vulnerability. From the social indicators, many indicators that increase user's vulnerability are related to the fishing restrictions, which illustrate the trade-off between conservation and artisanal fishing. Regulating access and zoning via a public participation process as a follow up of the social information collection can help MPAs to decrease social vulnerability. Other indicators across MPAs that can be improved are the financial support for some of the activities, access to ports outside the MPA and other related facilities. So, regulations, financing and infrastructure are the main issues to reduce social vulnerability.

**The lessons learned** from the pilot MPAs during the development of the activity highlight the relevant and essential pillars for the effective implementation of the socio-ecological vulnerability assessment. These elements are summarized below:

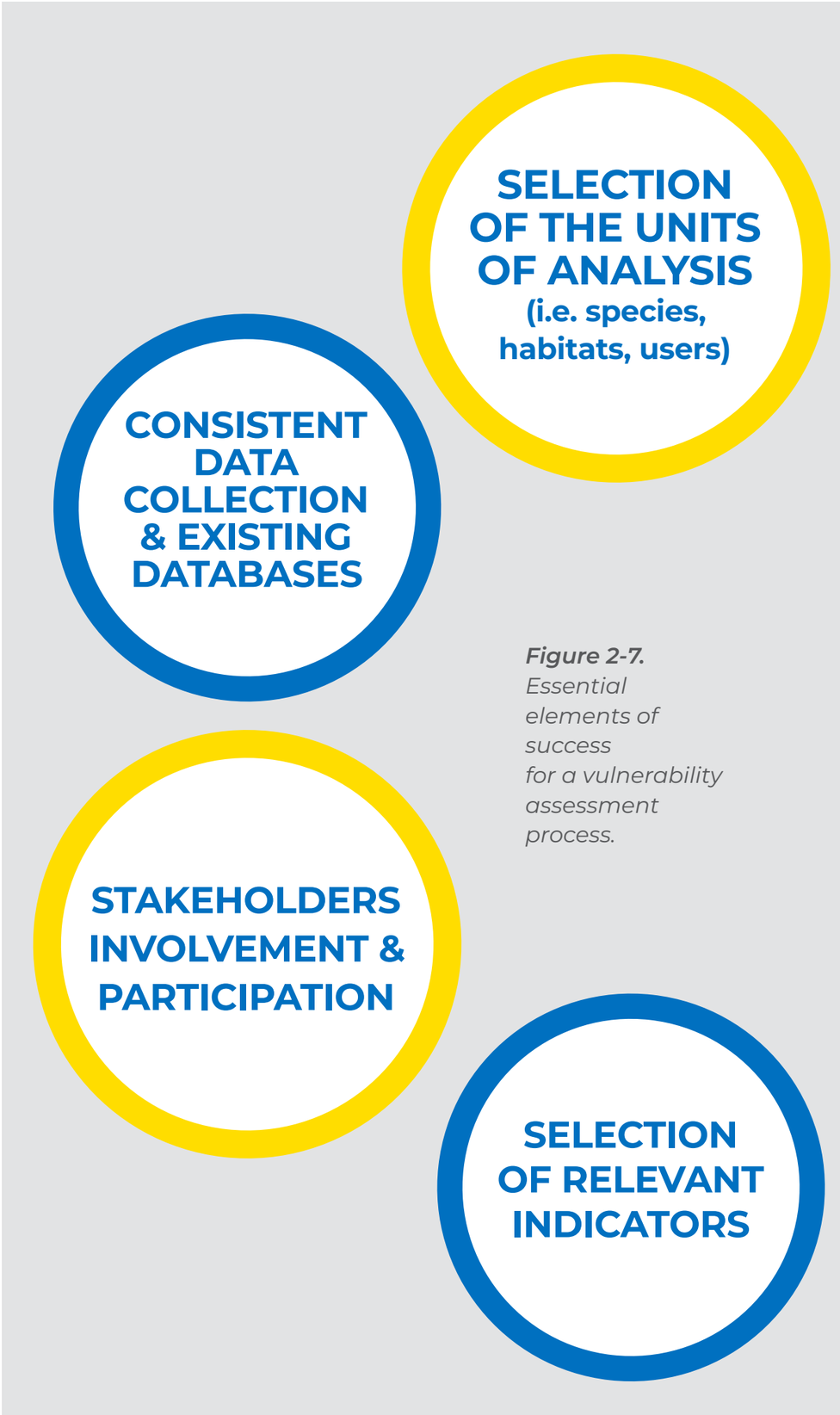



***Figure 2-7.*** *Essential elements of success for a vulnerability assessment process.*


**All things considered,** the information provided by the socio-ecological vulnerability assessment such as the most vulnerable species, habitats and sectors and the indicators that contribute the most to the local vulnerability represent important baselines to consider for the elaboration of specific climate change adaptation plans. All partner MPAs involved in the project have perceived the Vulnerability Assessment as a useful tool that can provide managers with relevant and important information to support the management of the marine protected area. Despite the challenges and difficulties encountered along the project, the activity process was positive and successful. In fact, the activity has helped to understand their starting point acknowledging which data are missing and where they should focus their attention and resources to establish and improve a monitoring system in order to get more data and cover an increased number of indicators.

## 2.4 Citizen science activities to monitor the climate change effects in MPAs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**Environmental agencies** have nowadays massive data requirements; national research funds are drying up while emerging technologies are constantly advancing. These three factors are driving citizen science to boom around the world. Among the different disciplines of citizen science, environmental science and in particular marine science attracts the majority of initiatives and the most dedicated volunteers. Citizen science is a method of undertaking scientific research whereby community groups and science professionals work together in a meaningful way on locally-relevant scientific research projects. Participants/ volunteers gain new skills and a deeper understanding of the scientific work at hand during the activity

**Marine citizen science** has a key role to play in comprehensive data collection and monitoring of the ocean health to dynamically fill in the knowledge gaps on the impacts of climate change, overfishing, pollution, habitat loss and the introduction of invasive alien species to marine systems (Garcia-Soto et al. 2017). It also promotes non-formal and informal education of the general public regarding ocean literacy and the ocean related challenges, develops a sense of responsibility and cultivates positive behavioural change towards more sustainable actions.

**Within this context,** the MPA Engage project aimed at developing a strategy for the engagement of local communities to acquire a deeper understanding of the impacts of climate change to marine ecosystems and provide participants with the right tools, skills and methodologies to measure these impacts within MPAs. MPAs are outdoor laboratories where significant concepts such as climate adaptation can become accessible through direct experience. MPAs can act as sentinel sites where researchers together with the involvement of citizens can study and monitor the cumulative effects of climate change, while MPA managers through a participatory approach can collectively elaborate climate change adaptation plans. In other worlds, create a space to link citizen science with adaptive management.

**To achieve one** of its major objectives, namely to promote harmonized monitoring of climate change effects and impacts in MPAs, MPA Engage has developed 11 monitoring protocols; three of which have been selected to be deployed in the citizen science activities. These protocols are depicted in the Figure 2-8.

**The data obtained** from the implementation of the three protocols by citizen scientists were collected in the marine citizen science platform Observadores del Mar (www.observadoresdelmar.es). This platform was the main repository where the collected data could be uploaded, valorised, further elaborated and shared with the MPAs in order to provide input for the elaboration of the climate change adaptation plans.

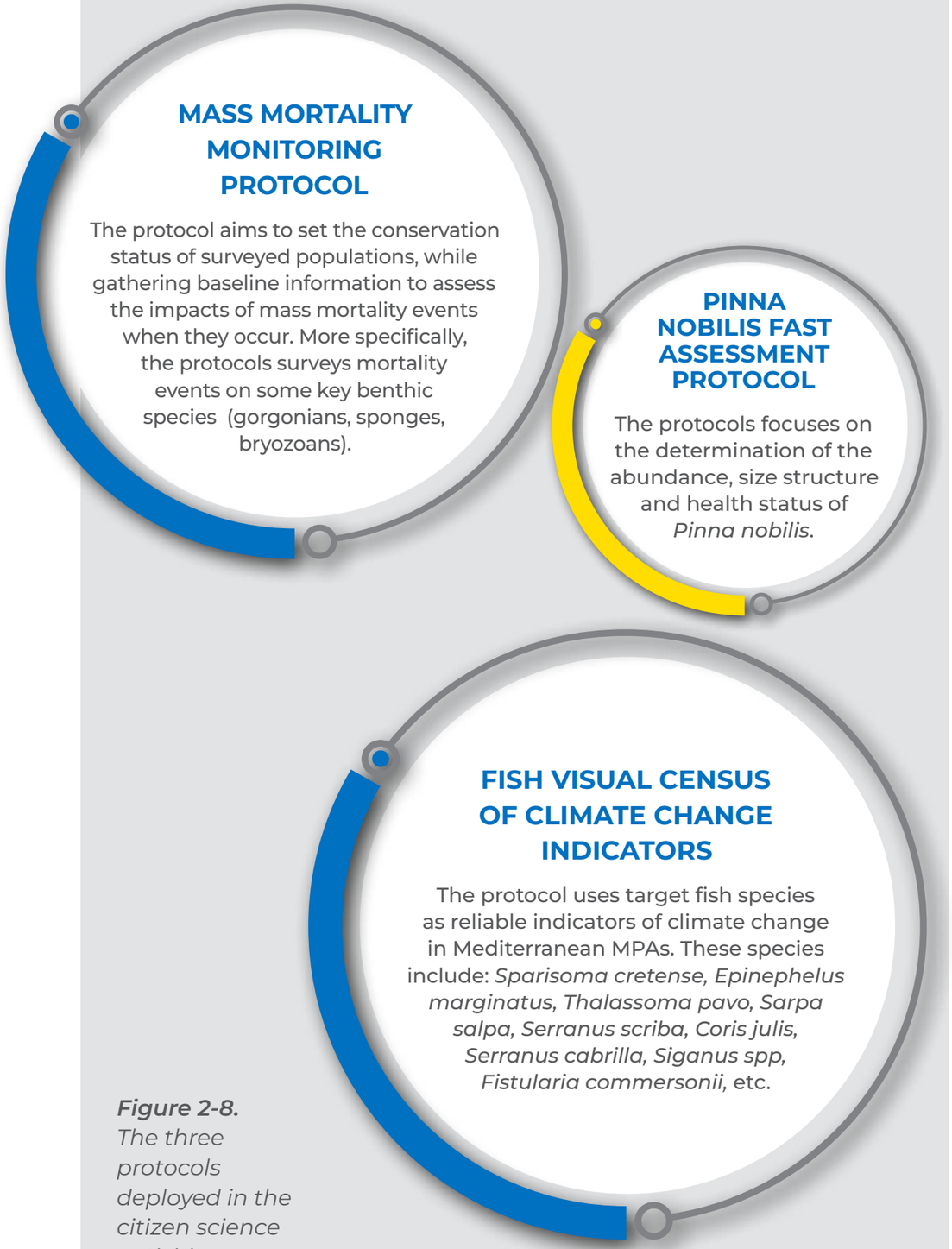



***Figure 2-8.*** *The three protocols deployed in the citizen science activities.*

**It should be highlighted** that within the MPA Engage citizen science activities the main target group were divers, diving instructors, diving associations, diving centres, etc. The citizen science activities were facilitated by training activities which firstly familiarized the diving instructors with the protocols and then educated the recreational divers on how to apply these protocols in order to collect harmonized data and successfully monitor any potential climate change effects in the surveyed MPAs. In fact, within the scope of the project, a dedicated training program entitled “Basic Research Operator (BRO)” was designed by PADI and DAN with the support of UNIVPM. The training program was key to building the capacities and skills of the diving centers instructors on how to setup and implement specific citizen science actions. One of the key achievements of the “BRO” programme was that it created new business opportunities for the diving centers and their instructors.

**The approach followed** for the development, organization and implementation of the three protocols comprised of the following phases:

**Phase 1:** Define a research question

**Phase 2:** Design the protocols

**Phase 3:** Train the volunteers and partner MPAs

**Phase 4:** Collect data

**Phase 5:** Data analysis

**Phase 6:** Share results

**Overall,** the main results achieved so far regarding the citizen science activities to monitor the effects of climate change within MPAs are very promising. The large number of volunteers -439 volunteers have been engaged in the pilot MPAs- and the high level of interest expressed by the pilot MPAs towards citizen science manifest the success of the activities. The pilot MPAs have profited by a useful tool to involve the diving centres and their recreational divers and creating a taskforce for data collection in line with the protocols developed by the project.


**Throughout** the process the diving industry has acquired new skills and knowledge on the effects of climate change in Mediterranean MPAs and how to monitor them and a relationship of mutual respect and common interest has been created among the MPA managers, the local diving centres and/or fishermen. One of the lessons learned from this experience was that MPA Engage can provide an opportunity for the diving centres and relevant stakeholders to create a real business model. This is confirmed by the immense efforts made by PADI and DAN during the summer period when the citizen science activities took place. The recently established association of the Portofino MPA entitled “Reef Alert Network” greatly demonstrates that the incorporation of citizen science activities in the MPAs management planning is win-win for all actors involved. The realization of citizen science activities within the MPA Engage project has established the first foundations for the development of a Mediterranean network marine citizen scientists committed to monitoring the effects of climate change and biodiversity conservation.

**Number of volunteers engaged in the implementation of the three citizen science protocols in the pilot MPAs.**

| Pilot MPA | Protocol 1 | Protocol 2 | Protocol 3 | **TOTAL** |
|---|---|---|---|---|
| Brijuni National Park (Croatia) | 0 | 8 | 8 | **16** |
| Portofino MPA (Italy) | 118 | 118 | 0 | **236** |
| Calanques National Park (France) | 20 | 35 | 0 | **55** |
| Zakynthos MPA (Greece) | 0 | 0 | 38 | **38** |
| Cap de Creus & Litoral del Baix Empordà MPA (Spain) | 10 | 10 | 0 | **20** |
| Tavolara MPA (Italy) | 21 | 34 | 19 | **74** |
| **TOTAL** | **169** | **205** | **65** | **439** |

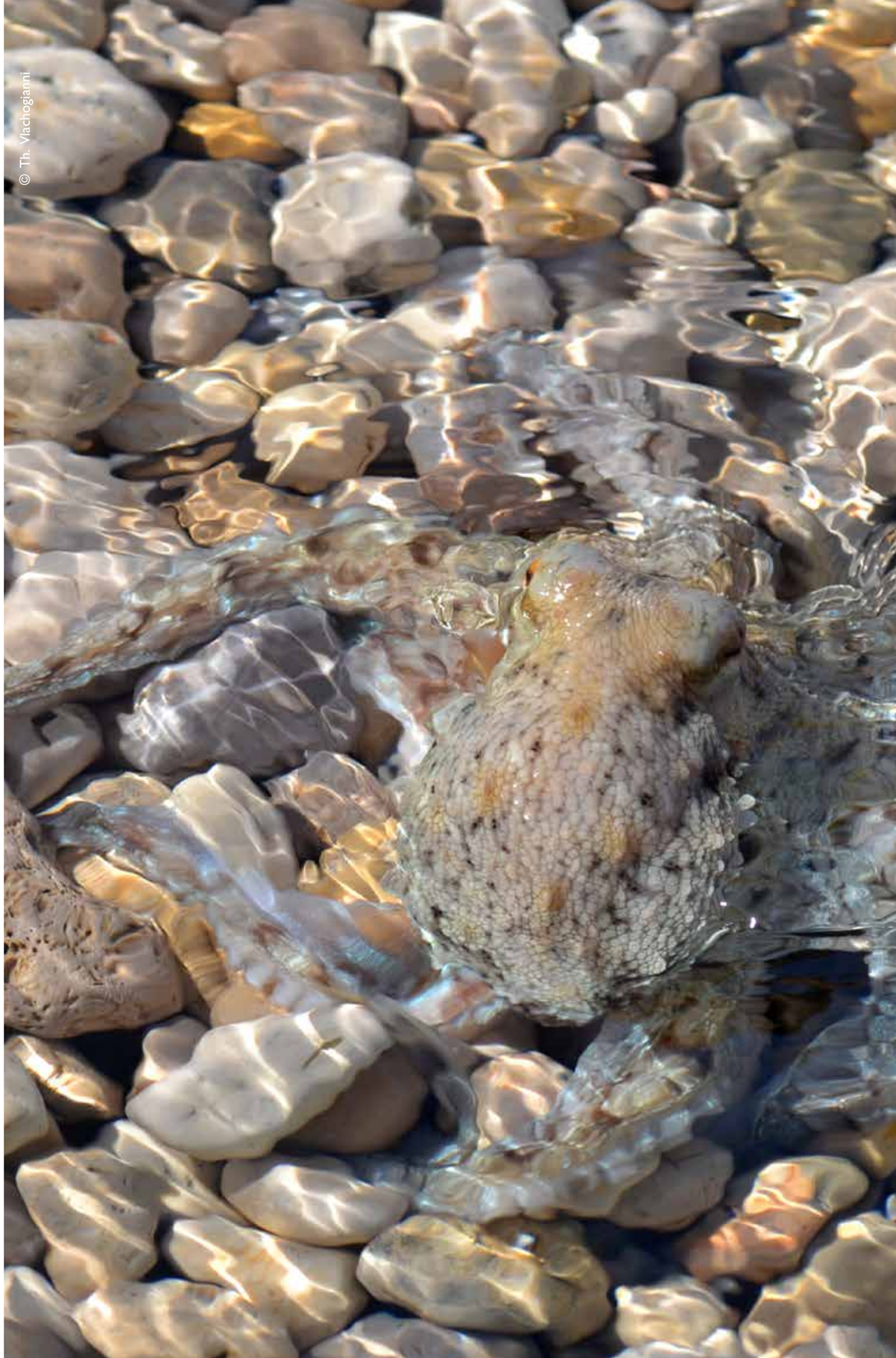
*Table 2-1.*

## 2.5 The quintuple helix participatory approaches

**Within the MPA Engage** project we deployed the quintuple helix participatory approach for the elaboration process (planning process) of the local climate change adaptation plans; this approach ensured the engagement of the following groups:

- **MPA-managers:** MPA managers are in charge of incorporating climate change adaption and mitigation measures into the MPA management plans through a participatory approach, supported by monitoring and vulnerability assessments.
- **Socio-economic actors:** Local socio-economic stakeholders include associations, cooperatives, civil society organizations, non-governmental organizations, foundations, and businesses.
- **Scientists:** These include members of the research and academic community, including those that provide science advice via established routes at local, national or European level.
- **Public authorities:** These include public authorities at national, regional and local levels.
- **Citizens:** Citizens are people in society that do not primarily belong in the four groups above. These may include educators, journalists, individuals, etc.





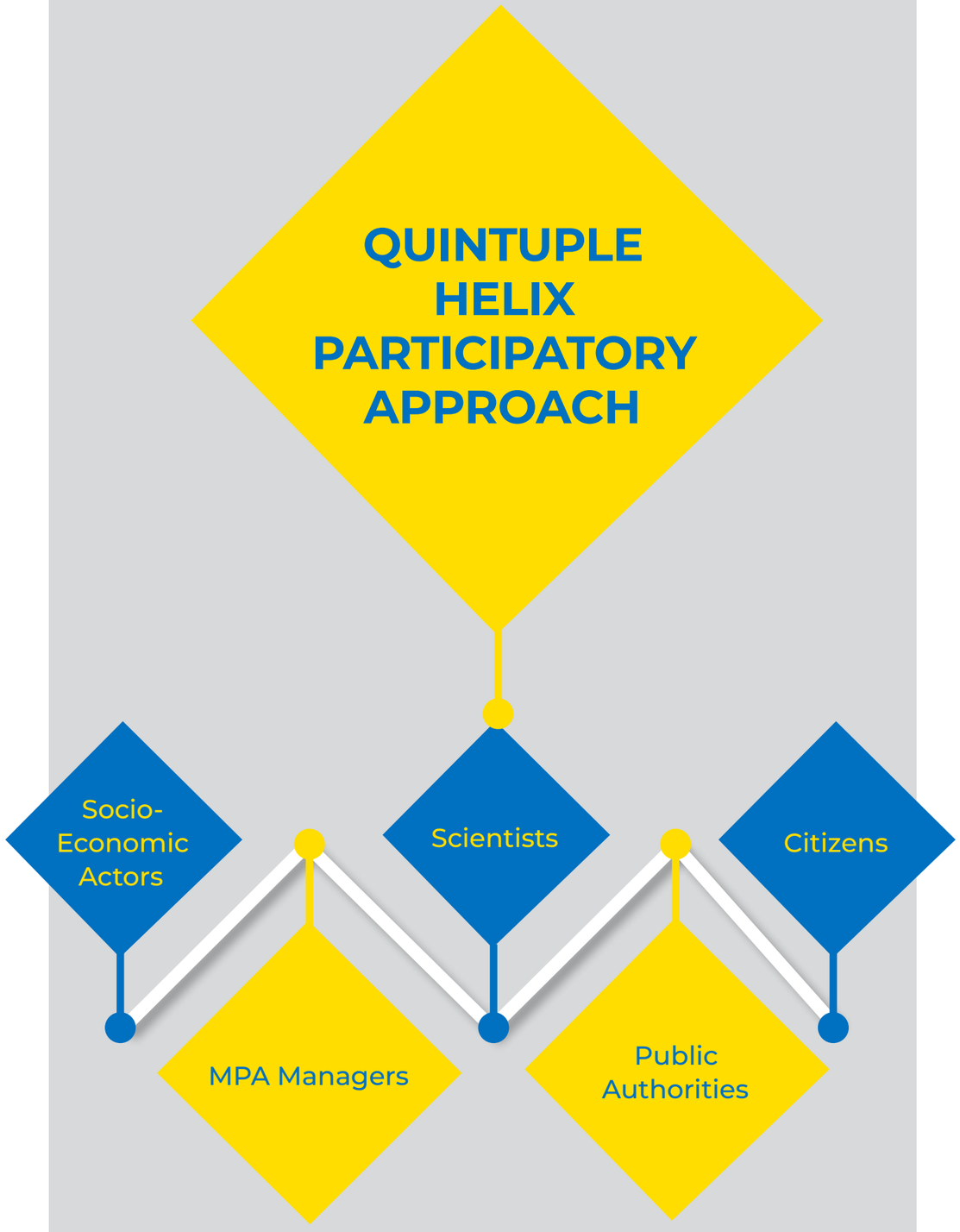



***Figure 2-9.***
*The Quintuple Helix Approach.*

Overall the pilot MPAs engaged 300 stakeholders (see table below), with half of them (51%) being socio-economic actors. The main socio-economic actors were: professional and recreational fishermen, divers, boaters, tourism professionals and environmental NGOs. Regarding public authorities (11% of all stakeholders involved), these mainly consisted of municipalities and local or regional authorities, while in some cases representatives of national authorities partook in the process.

**Number of stakeholders engaged in the quintuple helix participatory process to elaborate climate change adaptation plans in the pilot MPAs.**

| Pilot MPA | Number of socio-economic actors | Number of scientists | Number of MPA managers | Number of public authorities | Number of citizens | **TOTAL** |
|---|---|---|---|---|---|---|
| Brijuni National Park | 6 | 0 | 28 | 2 | 0 | **36** |
| Portofino MPA | 50 | 6 | 4 | 0 | 0 | **60** |
| Calanques National Park | 18 | 6 | 5 | 0 | 0 | **29** |
| Zakynthos MPA | 6 | 12 | 8 | 5 | 21 | **52** |
| Cap de Creus MPA | 21 | 3 | 4 | 11 | 0 | **39** |
| Litoral del Baix Em-pordà MPA | 41 | 13 | 2 | 14 | 0 | **70** |
| Tavolara MPA | 9 | 2 | 1 | 1 | 1 | **14** |
| **TOTAL** | **151** | **42** | **52** | **33** | **22** | **300** |

***Table 2-2.***

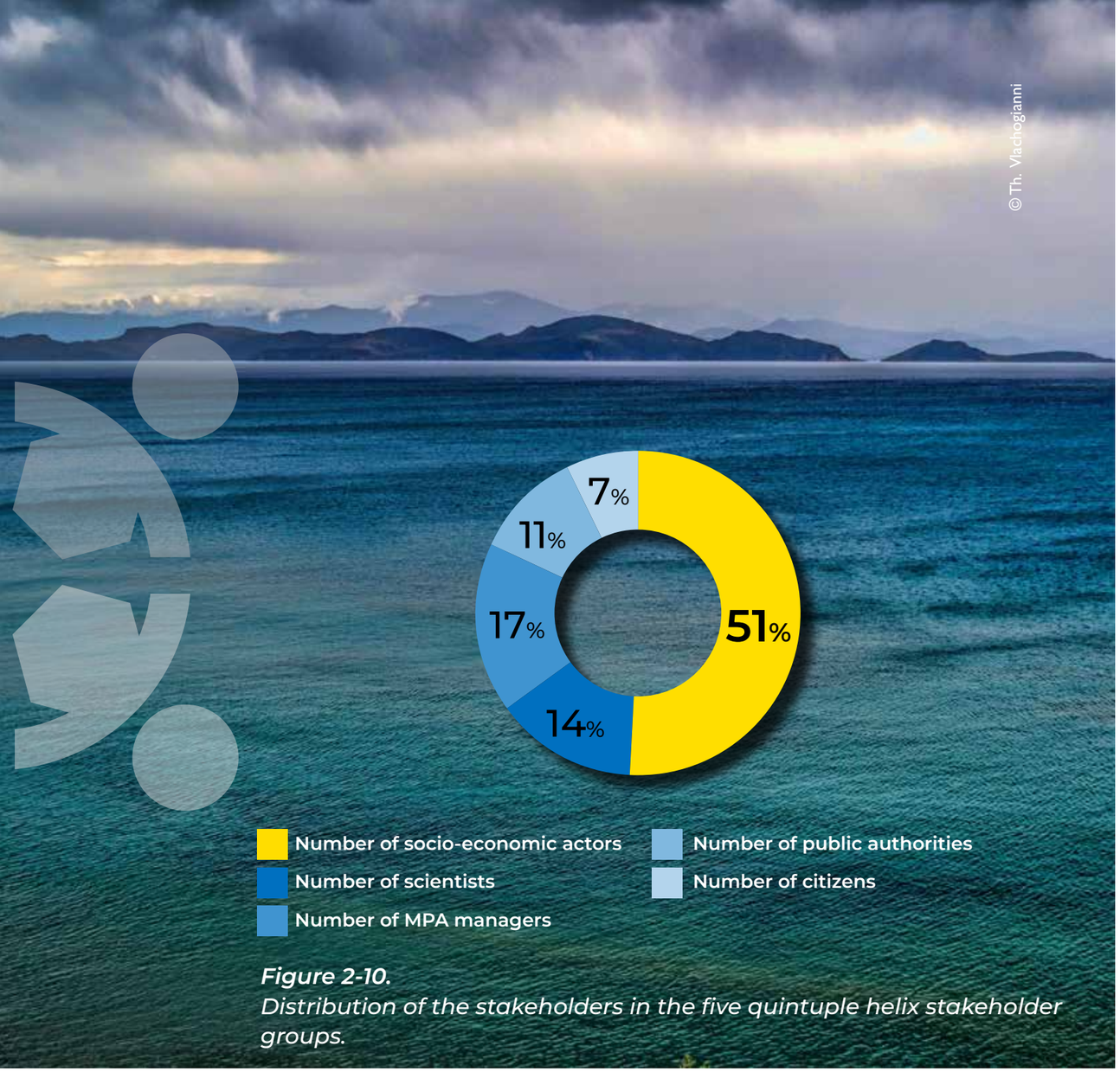



*Figure 2-10.*
*Distribution of the stakeholders in the five quintuple helix stakeholder groups.*

**In order** to concretely facilitate the MPA Engage partner MPAs in setting up and implementing a participatory process for the elaboration of the climate change adaptation plans, a draft participatory process plan was elaborated. This plan provided a solid basis - the minimum minimorum- for harmonized actions when it comes to organizing a participatory process within the scope of the project; however, it should be noted that the plan was enriched and/or modified to meet the needs of the pilot MPAs in order to carry out more effective participatory processes.

**The participatory process** plan built upon the MPA-Engage participation matrix which aimed to provide conceptual clarity when designing and implementing a participatory process. The dimensions of the matrix included: level of participation, stakeholders involved in the participation process, the climate change adaption planning process phases, namely the initiative/decision to act (how the adaptation process begins); development of potential adaptation options (by those involved in the process); decision-making (what measures will be implemented), and finally implementation.

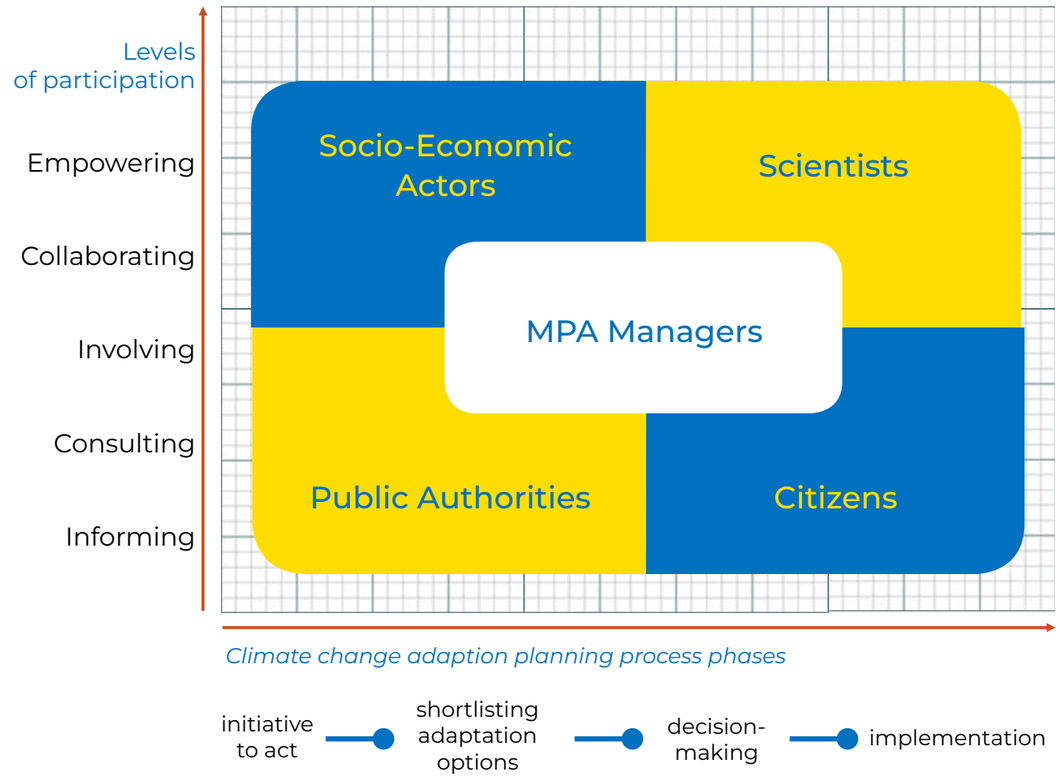



*Figure 2-11.*
*The MPA Engage participation matrix.*


**Participation** means many things to many people. It carries potential benefits, but only if all those involved have a common understanding and set of expectations. Plans, methods, tools and techniques do not guarantee participation. The showcases of the MPA Engage quintuple helix participatory process illustrate that public participation is a context-driven process, where the full understanding of the political, cultural and institutional context at local, national, regional and global level is needed.

**The experiences** gained by the showcases highlight some of the various challenges posed by the complex and multidimensional local and national contexts in which the participatory process was introduced. Factors affecting the successful outcome of the participatory process were identified at different levels such as at individual, community, organizational, political, economic, etc., levels. It should be highlighted that these factors are intertwined and affect each other in very complex ways.

**Capitalizing** on the experiences and lessons learned of the project's pilot MPAs, which tested the MPA Engage quintuple helix participatory approach, we have identified and/or reinforced the following essential elements for success towards achieving stakeholder consensus throughout the planning process. These elements are summarized in the figure below:


***Figure 2-12.***
*Overview of the essential factors of success of a participatory process.*

**All pilot MPAs** that operationalized the MPA Engage participatory process plan reported that the overall process was comprehensive, well-articulated and educative, concretely enabling them to put together the different components of the MPA Engage pilot actions, namely the monitoring results, the vulnerability assessments, the citizen science actions. In spite of the challenges that had to be dealt with, the experience strengthened the capacities of all those involved in the participatory processes, generated commitment to promote MPAs as natured-based solutions to tackle climate change, established and/or strengthened alliances among key stakeholders, and emphasized the potential of the participatory process as a powerful tool to generate constructive discussion among communities related to climate change. The MPA Engage showcases demonstrate that supporting the implementation of participatory processes can successfully lead to effective decision-making for climate change adaptation in Mediterranean MPAs.



# 3. METHODOLOGICAL FRAMEWORK FOR DEVELOPING A LOCAL CLIMATE CHANGE ADAPTATION PLAN

There is no one-size-fits-all approach for preparing a local climate change adaptation plan.

## 3.1 Introduction

**There is no one-size-fits-all** approach for preparing a local climate change adaptation plan. Local contexts vary depending on the nature and magnitude of existing and future threats, the condition of the ecological resources, past and ongoing management efforts, prevailing political and socioeconomic circumstances, etc. This section provides an overview of the methodological framework deployed for setting up the decision-making process for the elaboration of the climate change adaptation plans in the pilot MPAs via the quintuple helix participatory approach.

## 3.2 The DPSIR framework at the heart of the MPA engage planning process

**At the heart** of the MPA Engage planning process lay the DPSIR framework (**D**riving Forces-**P**ressures-**S**tate-**I**mpacts-**R**esponses).

- **Drivers** are the socio-economic and socio-cultural forces driving human activities, which increase or mitigate pressures on the environment.
- **Pressures** are the stresses that human activities place on the environment.
- **State**, or state of the environment, is the condition of the environment.
- **Impacts** are the effects of environmental degradation.
- **Responses** refer to the responses by society to the environmental situation.

**The DPSIR** framework illustrates the dynamic nature of planning and it presents a logical, stepwise chain of cause-effect-control events that describe the progression from the identification of an environmental problem to its management. The DPSIR approach is widely acknowledged as a valuable tool for analysing cause-effect-response links, determining management measures and communicating these aspects to wide-ranging stakeholders.

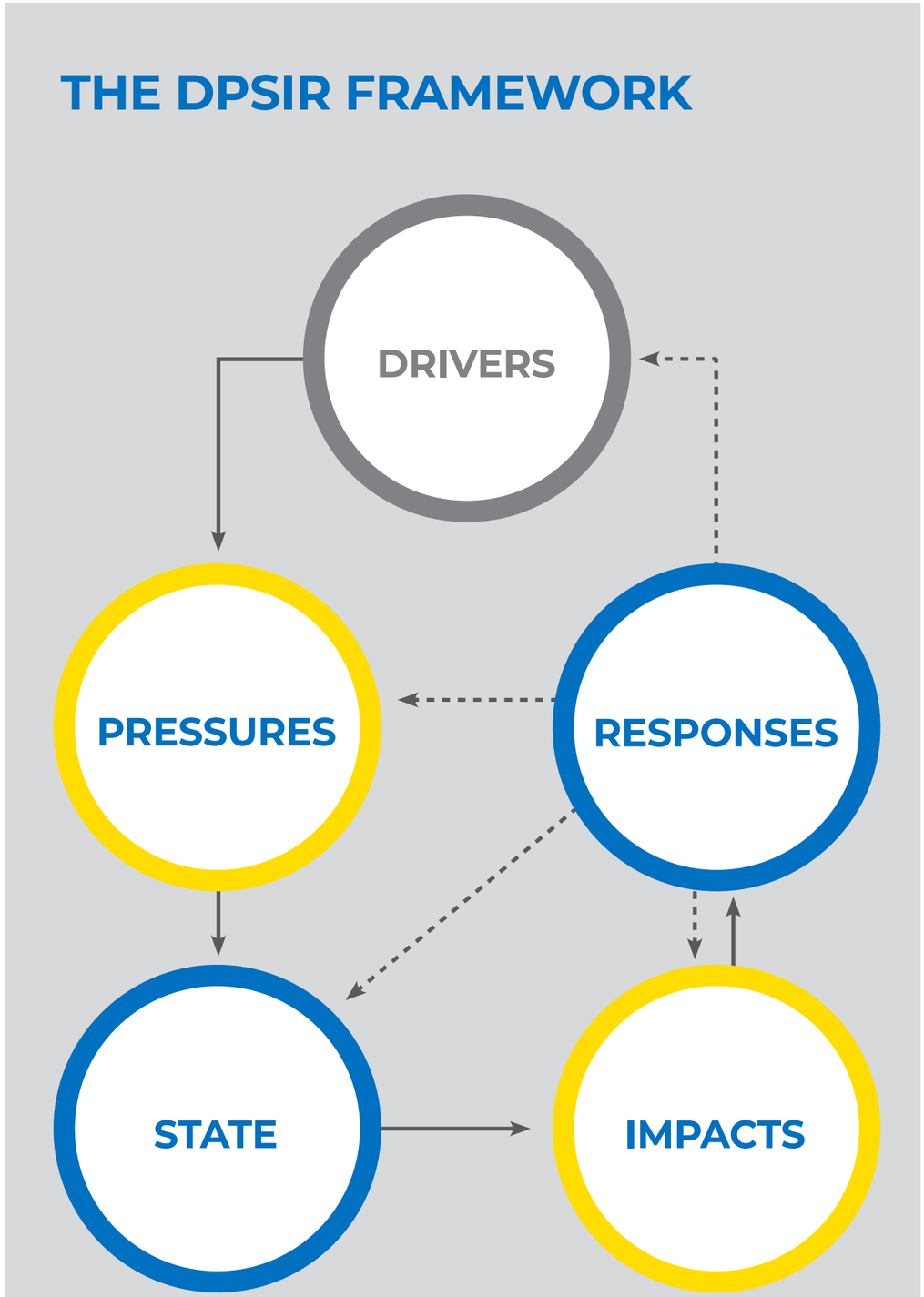



***Figure 3-1.***
*The DPSIR framework (**D**riving Forces-**P**ressures-**S**tate-**I**mpacts-**R**esponses)*

## 3.3 Overview of the five-phase process for crafting a local Climate Change Mitigation and Adaptation Plan

**Within the MPA Engage project** we adopted the five-phase process proposed by Scoullos et al., 2015. Each of the five phases includes a number of tasks and each task a series of steps, actions, deliverables and outputs. It should be highlighted that the various phases of the planning process should not be seen necessarily as distinct steps but as parts of a continuum.

**Phase 1 – Establishment:** The overall aim of the establishment phase is to make known the intention for drafting the plan and identify the convening body responsible for the overall coordination of the planning. All parties that should be involved were identified and a core group/team with the mandate to prepare and implement the plan was established. At this early stage, effort was directed to identify the stakeholders and design the stakeholders' engagement and participatory process, in line with the MPA Engage quintuple helix approach.

**Phase 2 – Analysis and Scenarios:** The aim of the analysis phase is to establish the foundation on which the preparation of the plan and its implementation will be based. Any available information on the climate change issue impacts and vulnerabilities was collected, including information on pre-existing relevant plans. In parallel, within this stage the engagement of stakeholders in line with the MPA Engage participatory process plan was initiated.

**Phase 3 – Setting the Vision:** The aim of this stage is to achieve the engagement and consensus building with the stakeholders and the wider community on the action plan based on the findings from the phases 1 and 2. Within this stage stakeholders were engaged in the identification of the key problems and issues for the plan to deal with and will set the course for the eventual 'shape' of the plan and its implementation by reviewing the proposed scenario (from Phase 2).

**Phase 4 – Designing the Future:** The aim of this stage is the actual drafting and finalization of the local climate change mitigation and adaptation plan, which will contribute in shaping the future of the MPA. The local plans indicatively included: the goals and objectives of the plan, a preamble explaining the scope and process followed for its production and approval, the context derived from the analysis, the governance structure, the institutional framework for implementation, the priority climate change adaptation and mitigation measures agreed upon by the different stakeholders along with a roadmap for their implementation. Within this stage stakeholders were engaged in the finalization and final adoption of the local plan.

**Phase 5 – Realizing the Vision:** The aim of this final phase is to operationalise the adopted climate change mitigation and adaptation plan and provide for its constant improvement. Within this stage the necessary actions will be undertaken for the operationalization of the action plan, including getting access to funds and monitoring and reviewing the implementation of the action plan.

**It should be highlighted** that the completion of the first four phases (Phase 1-4) were achieved within the scope of the MPA Engage project, while the actual implementation of the action plan (Phase 5) will be dealt with through follow-up projects and/or initiatives.

*Figure 3-2.*
*Overview of the five-phase planning process and associated tasks.*

## REALIZING THE VISION

- Implementing the plan
- Monitoring the effectiveness of the plan
- Reviewing the plan

## SETTING THE VISION

- Building consensus and selecting the adaptation options
- Identifying key problems and issues to be addressed
- Setting the course of the plan

## DESIGNING THE FUTURE

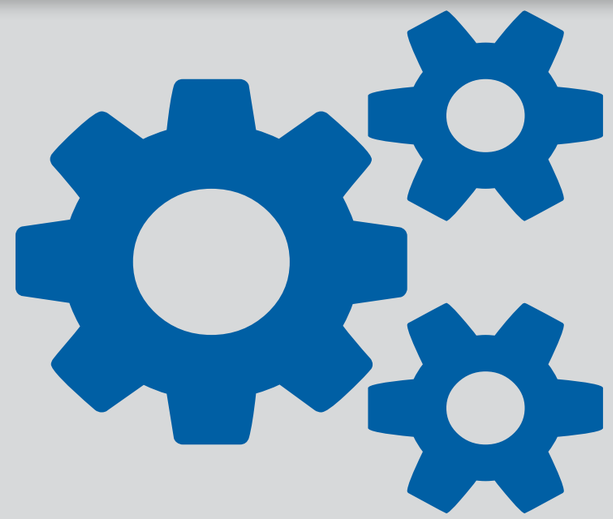
- Formulating the plan
- Adopting the plan
- Establishing the management structure

## ESTABLISHMENT

- Defining planning purpose and scope
- Establishing coordination mechanisms
- Designing the stakeholders engagement process

## ANALYSIS & SCENARIOS

- Building the evidence
- Identifying possible mitigation and adaptation options
- Screening feasibility and implications of proposed mitigation and adaptation approaches



**Based on the overall** experience of the MPA Engage participatory process, the following lessons learned were identified by the managers of the Park:

- **Adequate** amount of time is needed in order to implement a full-blown participatory process, allowing for each step of the process to unfold smoothly and effectively.
- **A participatory** decision-making process takes patience and commitment on everyone's part. Everyone has to maintain the commitment over time, remain civil while discussing issues that may induce strong feelings, and be willing to compromise; to that end outsourcing to external consultants the organization of the process might prove helpful. However, it should be noted that finding individuals that are appropriately skilled in participatory approaches and are familiar with the Brijuni and the climate change context was very challenging.
- **During a participatory** process there can be different levels of involvement of the participants, ranging from informing them, to consulting them, to involving them and to collaborating them. The final step related to empowering them, the step that places the final decision-making in their hands is step that requires a very high level of trust and very strong working relations.
- **Deciding** who should be involved in a participatory process is very important and deserves its own chapter. Knowing the people, you have on board, enables you to better address the problems but also prevent the conflicts in advance. The approach of the Brijuni National Park when it comes to that, was to sometimes point out some potential conflicts in advance and address them before they become an issue.
- **Education** and awareness raising activities are catalytical when engaging with stakeholders; they keep them informed of and make them part of the process from the very beginning, ensuring their collaboration and commitment. Long-standing collaboration with the stakeholders is crucial for their trust which closely correlates to the amount and the quality of their inputs.



# 3.4 The five-phase planning Matrix

**Within this section** the list of tasks implemented within the MPA Engage project under each of the five phases of the planning process described above is depicted.

## Phase 1 – Establishment

- **Each pilot MPA** set up a team tasked to elaborate the climate change adaptation plan.
- **Each MPA team** defined the initial territorial scope of the plan by identifying the boundaries of the specific plan area and the ecosystems involved.
- **Each MPA team** defined the governance context, in the form of the steering group or committee, including its objectives, tasks, terms of reference, etc.
- **Each MPA team** identified the related policy context (international, regional, national, local).
- **Each MPA team** carried out the stakeholders mapping, in line with the MPA Engage "Guidelines for applying a Quintuple Helix Participatory Approach".
- **Each MPA team** designed a stakeholders' engagement and participatory process, in line with the MPA Engage "Guidelines for applying a Quintuple Helix Participatory Approach".
- **Each MPA team** defined and proposes an initial planning purpose and scope (the vision).
- **Each MPA team** put in motion the MPA Engage participatory process.

## Phase 2 – Analysis and Scenarios

- **Each MPA team** built the evidence related to the climate change induced problem in their MPA. This entailed the assessment of the climate change impacts via harmonized monitoring activities and the assessment of the vulnerabilities of the MPA's habitats and species, and socio-economic activities. The citizen science data were also considered as part of the evidence.
- **Each MPA team** collected information on pre-existing relevant plans.
- **Each MPA team** identified possible climate change adaptation options (scenarios).
- **The MPA team** engaged with the stakeholders in line with the MPA Engage participatory process.

## Phase 3 - Setting the vision

- **Each MPA team** engaged with the stakeholders. Consensus on the key problems, issues and priorities for the plan were identified and agreed. Furthermore, agreement on the priority measures to feed into the first draft of the local climate change adaptation plan was sought and achieved.
- **Each MPA team** prepared the vision statement (setting the direction) – observing the priorities and the consistency of the objectives of the plan.
- **Each MPA team** selected a set of necessary indicators to measure the success of the planning process and its outcomes.

## Phase 4 - Designing the future/the plan

- **Each MPA team** drafted the local climate change adaptation action plan.
- **Each MPA team** engaged stakeholders in the validation of the action plan and its final adoption.

## Phase 5 – Realizing the future

- **The plan core group** ensures the implementation of the action plan.
- **The plan core group** coordinates supporting actions related to awareness-raising, partnerships, financing and investment.
- **The plan core group** monitors and reviews the implementation of the plan and provides regular feedback into the review process of the plan.

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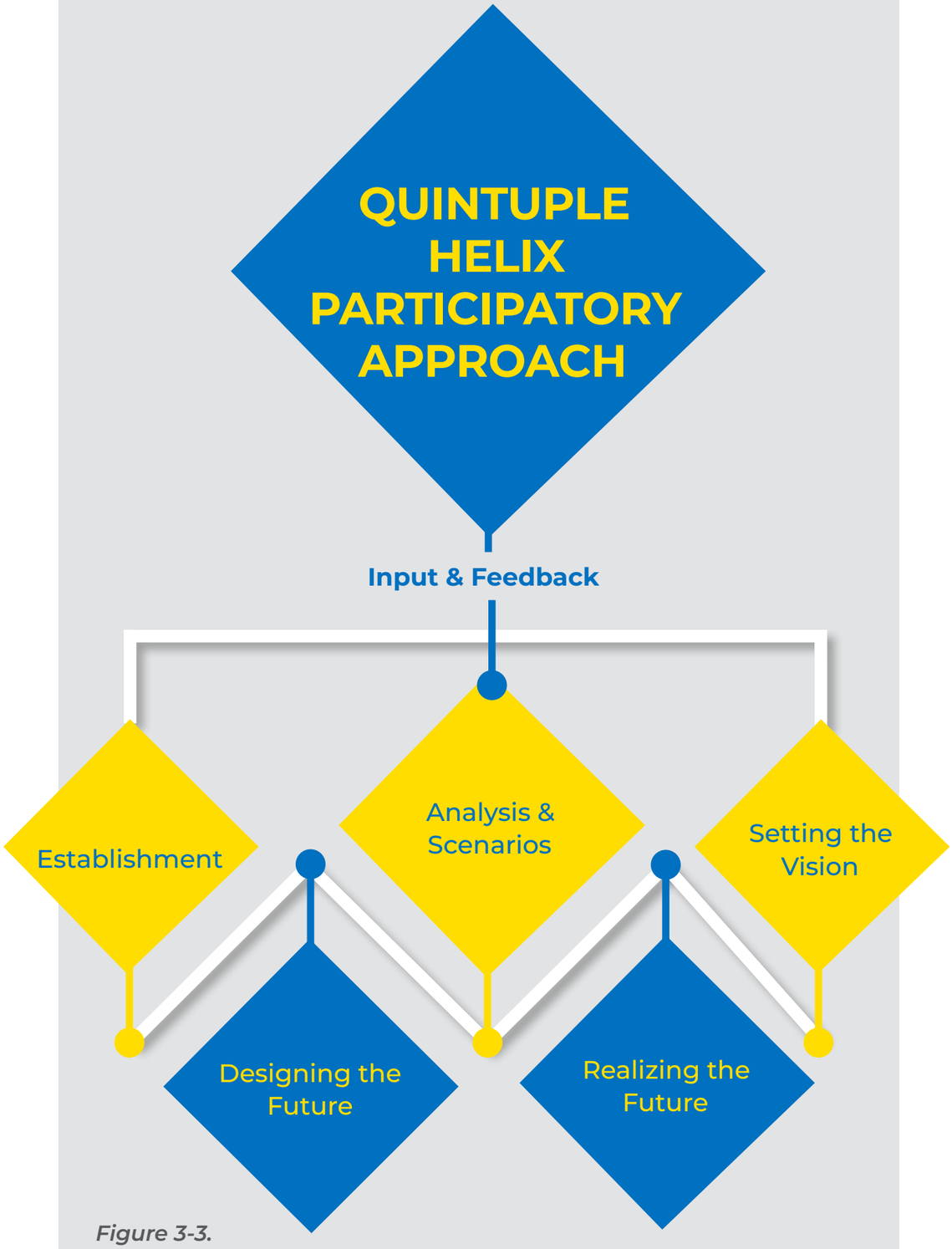


***Figure 3-3.***
*The quintuple helix participatory approach and its connection with the five-phase planning process for the elaboration of the climate change adaptation.*

# 4. OPTIONS FOR CLIMATE CHANGE ADAPTATION IN MEDITERRANEAN MPAS: OVERALL EXPERIENCE & PRIORITY ACTIONS FOR A JOINT PLAN

## 4.1 Types of climate change adaptation measures

Generally speaking, from the perspective of adaptation based on ecosystems, adaptation measures should aim for maintaining the favourable conservation status and maximum resilience of ecosystems (Shoo et al., 2013). Adaptation measures can be further determined according to the environment or ecosystem type, the foreseeable effects of climate change and the available options for intervention (Atauri Mezquida, et al., 2020). Within the scope of the MPA Engage project the climate change adaptation options were classified as shown in the table below:


***Table 4-1.*** *Proposed typology of adaptation measures deployed within the MPA Engage project.*


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# 4.2 Options for climate change adaptation considered by the MPA Engage pilot MPAs

**The pilot MPAs** worked on the Interreg MPA Adapt long-list of adaptation options (Garrabou et al., 2019) -enriching it, modifying it and critically assessing it- with the ultimate goal to identify, shortlist and adopt priority adaptation measures for their corresponding action plans. The tables below provide the full list of measures that were considered during the planning processes of the MPA Engage project. It should be noted that this list of somewhat 30 measures is not exhaustive and by no means does represent the overall diversity of measures that can be deployed by MPAs.



**Options for climate change adaptation in MPAs per *social vulnerability* area.**

| Response category | Response type | Response description |
|---|---|---|
| **Diving sector** | | |
| Capacity Building & Awareness Raising | Increase adaptive capacity | Sensitize divers about the effects of climate change on marine ecosystems. |
| Regulation & Governance | Reduce consequence | Close and/or change diving paths in damaged sites with coralligenous or limit the presence of divers in affected sites. |
| Research & Monitoring | Increase adaptive capacity | Engage divers in participatory monitoring to amplify and support the MPA capabilities to detect and quantify the ongoing ecological changes (e.g. invasive species, mass mortalities, population declines). |
| **Coastal tourism sector** | | |
| Capacity Building & Awareness Raising | Increase adaptive capacity | Develop awareness raising activities targeting MPA visitors on climate change effects and best practice responses at MPA level. |
| Regulation & Governance | Reduce consequence | Prevent fire risks by reinforcing surveillance, updating fire programmes and evacuation measures. |
| Research & Monitoring | Increase adaptive capacity | Monitor and assess the impact of tourist frequentation (the practice of visiting often) and disturbance (e.g. trampling) on sensitive species. |
| Technological | Increase adaptive capacity | Optimize water consumption and improve availability. |
| **Professional & recreational fishing** | | |
| Capacity Building & Awareness Raising | Increase adaptive capacity<br><br>Reduce consequence | Develop educational activities to enhance ocean literacy of professional and recreational fishers towards ocean-informed actions and the adoption of good practices for sustainable fishing activities. |
| Capacity Building & Awareness Raising | Increase adaptive capacity | Carry out public awareness raising activities on the importance of sustainable fishing activities and the added value of opting for sustainable fisheries products. |
| Regulation & Governance | Reduce consequence | Phase out or reduce the use of disposable plastics by fishers and setup derelict fishing gear management schemes. |
| Regulation & Governance | Reduce consequence | Apply restrictions for professional and recreational fishing in order to avoid or decrease damages on coralligenous habitats from fishing operation (including damages induced by the loss of fishing nets and lines). |

*Table 4-2.*

| Response category | Response type | Response description |
|---|---|---|
| Research & Monitoring | Increase adaptive capacity | Access the knowledge of local fishermen (professionals and recreational) to detect signals of ecological change and engage them in regular monitoring activities. |
| Research & Monitoring | Increase adaptive capacity | Evaluate the abundance and distribution of cold and warm water species to guide future adaptation measures. |
| Research & Monitoring | Increase adaptive capacity | Develop targeted research actions aiming to fill in the information gaps related to key species targeted by professional fishers. |
| Economic | Reduce consequence | Promote the consumption and commercialization of warm-water species of either native or exotic origin (e.g. *Pomatomus saltatrix*, *Callinectes sapidus*). |
| Regulation & Governance | Increase adaptive capacity | Reinforce the partnership with fisheries associations for implementing adaptive management measures, with a special focus on the use of natural resources. |
| **Navigation Sector** | | |
| Research & Monitoring | Increase adaptive capacity | Improve or launch monitoring and record keeping on location-specific overtopping-related metrics, including area affected of extreme rainfall events, storm surges or flooding due to sea level rise. |
| Research & Monitoring | Increase adaptive capacity | Develop data-sharing procedures with MPA-managers regarding changes in vegetation growth rates (algal blooms or seagrass die-off events). |
| Economic | Reduce consequence | Engage navigators to switch from diesel to low-sulfur fuels such as methane, natural gas or LNG fuels to reduce GHG emissions. |
| Regulation & Governance | Reduce consequence | Identify, secure and coordinate alternative navigation routes or modes for avoidance of affected or vulnerable areas. |
| Regulation & Governance | Increase adaptive capacity | Develop or update emergency response plans to address potential greater frequency of extreme weather events. |
| Capacity Building & Awareness Raising | Increase adaptive capacity | Develop and implement public awareness activities on the role of Posidonia oceanica meadows and coralligenous habitats for natural protection of ports from storms and prevention of coastal erosion. |
| Capacity Building & Awareness Raising | Increase adaptive capacity | Improve awareness of the port authorities, shipowners and managers, trade associations and others about the implications of climate change for ship movements and how operational practices and supporting infrastructure may need to adapt to these demands. |

## Options for climate change adaptation in MPAs per *habitat type*.

| Response category | Response type | Response description |
|---|---|---|
| **Posidonia habitat** | | |
| Protection & Restoration | Increase adaptive capacity | Implement restoration activities targeting protected, endangered and rare species. |
| Protection & Restoration | Reduce consequence | Preserve coastal forests to prevent and reduce coastal erosion. |
| Regulation & Governance | Reduce consequence | Reinforce the implementation of existing regulations on anchoring and/or prohibit anchoring activities on Posidonia meadows to reduce seagrass fragmentation. |
| Research & Monitoring | Increase adaptive capacity | Monitor the status of *Posidonia oceanica* meadows, including depth limit and flowering events. |
| **Coralligenous habitats & communities** | | |
| Protection & Restoration | Increase adaptive capacity | Implement restoration activities targeting protected and endangered species. |
| Research & Monitoring | Increase adaptive capacity | Monitor the status of coralligenous communities and impacts. |
| **Rocky, soft & other infralittoral habitats** | | |
| Protection & Restoration | Increase adaptive capacity | Implement restoration activities targeting protected, endangered and rare species. |
| Research & Monitoring | Increase adaptive capacity | Establish a monitoring programme for *Lithophyllum byssoides* to sea level rise. |
| Technological | Increase adaptive capacity | Identify locations that are critical for coastal habitats expansion, including locations that have roads or other types of infrastructure that reduce habitat connectivity; redesign them. |

*Table 4-3.*

**Options for climate change adaptation in MPAs addressing *horizontal* issues.**

| Response category | Response type | Response description |
|---|---|---|
| Regulation & Governance | Increase adaptive capacity | Upgrade the existing health management plan of the MPA in collaboration with other organisations. |
| Technological | Increase adaptive capacity | Develop pilot actions for reducing energy consumption and increasing the use of renewable energy. |
| Capacity Building & Awareness Raising | Increase adaptive capacity | Implement regular educational activities on climate change issues. |
| Research & Monitoring | Increase adaptive capacity | Deploy salinity and pH sensors on the MPA territory; set up weather stations and develop terrestrial monitoring protocols, especially on specific parameters such as droughts. |
| Research & Monitoring | Increase adaptive capacity | Establish a baseline and monitor beaches and cliffs to prepare future adaptation measures. |

*Table 4-4.*

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# 4.3 Overview of the climate change adaptation measures identified and/or adopted by the pilot MPAs

**The 7 pilot MPAs** applied the proposed five-phase planning process and the quintuple helix participatory approach towards the identification, elaboration, shortlisting and adoption of climate change adaptation measures. Four out of the seven MPAs managed to successfully elaborate a full-blown climate change adaptation plan with priority measures agreed to be undertaken by the MPA; each adopted measure is featured with a description, the target group, the expected results, the lead organization(s) and those who should be involved in the implementation, a timeframe and performance indicators (used to measure achievement of outputs or outcomes). The MPAs that successfully completed the forth phase of the planning process (Designing the Future) and formulated and adopted the climate change adaptation plan are the following: Brijuni National Park (adopted 14 measures), Portofino MPA (adopted 10 measures), Cap de Creus MPA (adopted 13 measures) and Litoral del Baix Empordà MPA (adopted 25 measures) (see Tables 4.6-4.9). The remaining three pilot MPAs (see Tables 4.10-4.12), namely the Calanques National Park, the Zakynthos MPA and the Tavolara MPA made significant progress in implementing the planning process and are currently in the second phase (Setting the Vision); possible climate change adaptation options have been identified and are either being screened in terms of their feasibility and implications or are under consultation towards building consensus and selecting the adaptation options to be included in the plan.


**Overview the progress achieved by the pilot MPAs, in terms of shortlisting and/or adopting climate change adaptation measures.**

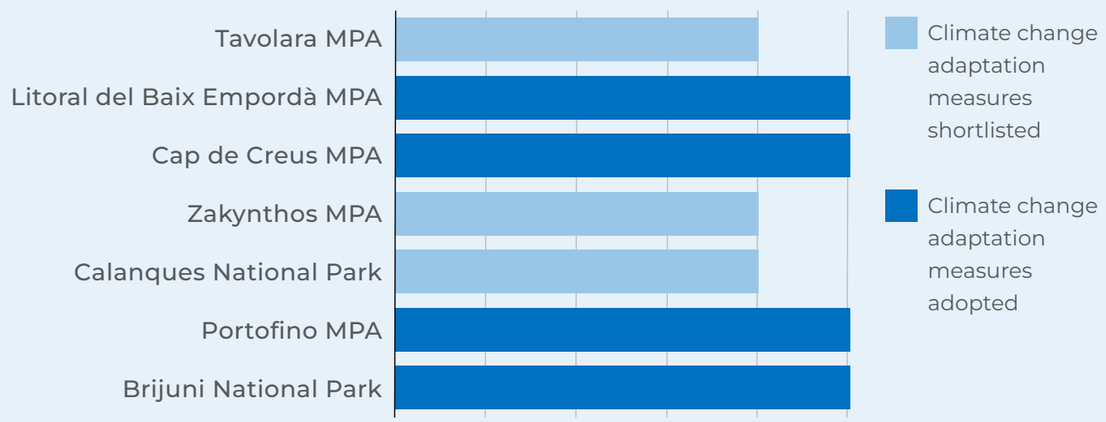



*Table 4-5.*

**Climate change adaptation measures adopted by *Brijuni National Park* (Vukadin et al., 2021).**

| Response category | *Response description* |
|---|---|
| Research & Monitoring | Monitor the conservation status of key marine habitats, such as Posidonia meadows and the coralligenous communities. |
| Research & Monitoring | Establish targeted research and monitoring of key marine species relevant for monitoring of the impact of climate change. |
| Research & Monitoring | Establish targeted research and monitoring of marine invasive species relevant for monitoring of the impact of climate change. |
| Research & Monitoring | Set up weather stations and develop monitoring protocols for extreme weather conditions, especially on specific parameters such as droughts. |
| Research & Monitoring | Establish and implement monitoring of physico-chemical parameters in the sea relevant for monitoring changes caused by climate change. |
| Capacity Building & Awareness Raising | Develop communication tools and materials about climate change and opportunities for adaptation to climate change, for the general public and visitors of the Brijuni National Park to raise their awareness on the topic. |
| Research & Monitoring | Develop and implement programs for involvement of citizens in monitoring biodiversity and ecosystems and collect their knowledge and observations on changes in the marine environment, including in relation to the impacts of climate change. |
| Capacity Building & Awareness Raising | Develop and implement Brijuni National Park certificates for concessionaires (e.g., “friends of Brijuni”) that operate in accordance with the objectives of preserving the value of the Brijuni National Park and implementing measures to adapt to climate change. |
| Capacity Building & Awareness Raising | Collaborate with fishers on development and implementation of sustainable fishing activities and the promotion of added value of sustainable fisheries products. |
| Capacity Building & Awareness Raising | Collaborate with divers on development and implementation of sustainable tourist activities of the Brijuni National Park and the promotion of added value of such activities. |
| Regulation & Governance | Collaborate with other users of the Brijuni National Park (Ministry of Defence, State Real Estate, concessionaires) on the development and implementation of climate change adaptation measures. |
| Regulation & Governance | Advocate the establishment of a buffer zone around the Brijuni National Park with special regulations for commercial fishing. |
| Technological | Optimize consumption of water in the Brijuni National Park and modernize the water supply and wastewater management infrastructure. |
| Technological | Establish efficient waste management in the Brijuni National Park, including the reduction of waste. |

*Table 4-6.*

## Climate change adaptation measures adopted by *Portofino MPA* (Merotto, 2021).

| Response category | *Response description* |
|---|---|
| Regulation & Governance | Introduce restrictions for fishermen and divers to preserve coralligenous habitats. |
| Regulation & Governance | Reduce impacts on Posidonia meadows by reinforcing the implementation of existing regulations on anchoring and/or prohibiting anchoring activities on Posidonia meadows to reduce seagrass fragmentation. |
| Capacity Building & Awareness Raising | Carry out climate change related awareness raising campaigns that are based on sound-scientific evidence and/or improve existing awareness. |
| Research & Monitoring | Implement continuous monitoring of the climate change effects and improve knowledge on the state of habitats and species. |
| Capacity Building & Awareness Raising | Implement capacity building activities targeted to professionals, such as divers and fishermen to reduce impacts on habitats and species. |
| Research & Monitoring | Carry out citizen science activities to collect data on climate change effects. |
| Protection & Restoration | Implement restoration activities targeting protected, endangered and rare habitats and species. |
| Economic | Develop new business models within existing economic sectors (i.e. diving, fishing). |
| Economic | Promote the consumption and commercialization of warm-water species of either native or exotic origin (e.g. Pomatomus saltatrix, Callinectes sapidus) |
| Regulation & Governance | Draft emergency plans to manage disasters (storms, floods, spills). |

***Table 4-7.***

## Climate change adaptation measures adopted by *Cap de Creus MPA* (Carbonell & Fábregas, 2021).

| Response category | *Response description* |
|---|---|
| Regulation & Governance | Integrate the climate change dimension in the Master Plan for the use and management of the marine environment of the Park. |
| Capacity Building & Awareness Raising | Implement awareness and outreach activities related to climate change. |
| Capacity Building & Awareness Raising | Develop educational activities related to climate change. |
| Research & Monitoring | Promoting citizen science programs. |
| Research & Monitoring | Monitoring programs with professional fishermen. |
| Research & Monitoring | Monitoring programs with recreational fishermen. |
| Research & Monitoring | Establish oceanographic stations. |
| Research & Monitoring | Monitoring and systematization of socio-economic data. |
| Regulation & Governance | Precautionary limitation of activities for different socio-economic sectors. |
| Protection & Restoration | Implement restoration projects for certain species, habitats or communities, such as gorgonians, cystoseira, bryozoans, phanerogams, etc. |
| Capacity Building & Awareness Raising | Perform awareness campaigns aimed at motorized vessels. |
| Research & Monitoring | Promote new surveillance mechanisms. |
| Research & Monitoring | Evaluate the implementation of a communication and awareness channel. |

***Table 4-8.***

**Climate change adaptation measures adopted by *Litoral del Baix Empordà MPA* (Carbonell & Fábregas, 2021b).**

| Response category | *Response description* |
|---|---|
| Regulation & Governance | Strengthening the management of the maritime area to increase its protection and resilience to climate change. |
| Capacity Building & Awareness Raising | Develop educational activities (seminars and trainings) related to climate change |
| Capacity Building & Awareness Raising | Implement awareness and outreach activities related to climate change. |
| Capacity Building & Awareness Raising | Raise awareness on the importance of marine phanerogams to deal with climate change. |
| Capacity Building & Awareness Raising | Organize eco-briefings in the nautical sector. |
| Capacity Building & Awareness Raising | Organize eco-briefing talks on diving activities. |
| Capacity Building & Awareness Raising | Promote good practices for recreational fishing. |
| Research & Monitoring | Promoting citizen science programs. |
| Research & Monitoring | Implement monitoring programs with professional fishermen. |
| Research & Monitoring | Implement monitoring programs with recreational fishermen. |
| Research & Monitoring | Monitor and systematize the collection of socio-economic data. |
| Research & Monitoring | Establish one oceanographic station for environmental and physicochemical variables. |
| Research & Monitoring | Implement, on a stable and long-term basis, monitoring programs to assess the status and impacts on key habitats and species. |
| Protection & Restoration | Implement restoration projects for certain species, habitats or communities, such as gorgonians, cystoseira, bryozoans, phanerogams, etc. |
| Protection & Restoration | Implement restoration of coastal habitats. |
| Regulation & Governance | Reduce pollution at sea via carrying out a comprehensive study on the different sources of pollution of the MPA and developing a strategy and action plan to minimize the sources of pollution detected. |
| Regulation & Governance | Improving the management of the marine reserve of Ses Negres. |
| Regulation & Governance | Implement precautionary limitation of activities. |
| Regulation & Governance | Introduce speed limitations for vessels navigating close to the coast with the aim of reducing the associated multiple impacts. |
| Regulation & Governance | Develop a zoning map with the suitable areas for anchoring. |
| Regulation & Governance | Promote new surveillance mechanisms. |
| Capacity Building & Awareness Raising | Establish a dedicated communication channel that facilitates an agile transfer of information between the users and the MPA. |
| Capacity Building & Awareness Raising | Raise awareness of the nautical sector on climate change effects. |
| Regulation & Governance | Introduce environmental and climatic criteria in the use plans to be drafted in the future. |
| Capacity Building & Awareness Raising | Establish an awareness program for ports related activities to climate change. |

*Table 4-9.*

**Climate change adaptation measures shortlisted by *Calanques National Park* (Vouriot, 2021).**

| Response category | *Response description* |
|---|---|
| Research & Monitoring | Develop partnerships with researchers with the aim of deepening knowledge on the resilience and adaptation of species/habitats, refuge areas. |
| Research & Monitoring | Maintain the sea temperature observatory run by OSU Pythéas. |
| Research & Monitoring | Monitor the abundance and distribution of cold and warm water species (native or invasive). |
| Research & Monitoring | Implement sea urchins monitoring. |
| Research & Monitoring | Establish a monitoring programme for *Lithophyllum byssoides* to sea level rise. |
| Research & Monitoring | Monitor the status of benthic invasive alien species. |
| Research & Monitoring | Monitor the status of coralligenous communities and impacts. |
| Research & Monitoring | Monitor the status of *Posidonia oceanica* meadows, including depth limit and flowering events. |
| Research & Monitoring | Monitor the *Pinna nobilis* resettlement. |
| Regulation & Governance | Reinforce the implementation of existing regulations on anchoring and/or prohibit anchoring activities on Posidonia meadows to reduce seagrass fragmentation. |
| Protection & Restoration | Strengthen efforts to reduce human pressures on habitats and species most vulnerable to climate change. |
| Capacity Building & Awareness Raising | Sensitize divers about the effects of climate change on marine ecosystems. |
| Research & Monitoring | Engage divers in participatory monitoring of the impacts of climate change. |
| Regulation & Governance | Improve knowledge of the diving activities (number of divers, location of diving sites) in the Calanques National Park. |
| Regulation & Governance | Avoid congestion on the most emblematic dive sites and regulate the number of divers |
| Research & Monitoring | Promote environmental watch and reporting of ecological changes. |
| Research & Monitoring | Access the knowledge of local fishermen (professionals and recreational) to detect signals of ecological change and engage them in regular monitoring activities. |
| Research & Monitoring | Develop targeted research actions aiming to fill in the information gaps related to key species targeted by professional fishers. |
| Protection & Restoration | Remove the fishing ghost nets and lines in the Calanques National Park. |
| Economic | Promote the consumption and commercialization of warm-water species of either native or exotic origin. |
| Regulation & Governance | Reinforce the partnership with fisheries associations for implementing adaptive management measures. |
| Regulation & Governance | Apply regulations for professional and recreational fishing. |
| Regulation & Governance | Optimisation of the management capacities of the Calanques National Park. |
| Capacity Building & Awareness Raising | Raise awareness among the general public on climate change issues. |

***Table 4-10.***

**Climate change adaptation measures shortlisted by the *MPA of Zakynthos* *(Dimitriadis, Ch., 2021).***

| Response category | *Response description* |
|---|---|
| Capacity Building & Awareness Raising | Sensitize divers about the effects of climate change on marine ecosystems. |
| Research & Monitoring | Engage divers in participatory monitoring to amplify and support the MPA capabilities to detect and quantify the ongoing ecological changes (e.g. invasive species, mass mortalities, population declines). |
| Capacity Building & Awareness Raising | Develop awareness raising activities targeting MPA visitors on climate change effects and best practice responses at MPA level. |
| Research & Monitoring | Monitor and assess the impact of tourist frequentation (the practice of visiting often) and disturbance on sensitive species. |
| Capacity Building & Awareness Raising | Develop educational activities to enhance ocean literacy of professional and recreational fishers towards ocean-informed actions and the adoption of good practices for sustainable fishing activities. |
| Capacity Building & Awareness Raising | Carry out public awareness raising activities on the importance of sustainable fishing activities and the added value of opting for sustainable fisheries products. |
| Regulation & Governance | Phase out or reduce the use of disposable plastics by fishers and setup derelict fishing gear management schemes. |
| Research & Monitoring | Evaluate the abundance and distribution of cold and warm water species to guide future adaptation measures. |
| Economic | Promote the consumption and commercialization of warm-water species of either native or exotic origin. |
| Regulation & Governance | Reinforce the partnership with fisheries associations for implementing adaptive management measures, with a special focus on the use of natural resources. |
| Protection & Restoration | Implement restoration activities targeting protected, endangered and rare species. |
| Regulation & Governance | Reinforce the implementation of existing regulations on anchoring and/or prohibit anchoring activities on Posidonia meadows to reduce seagrass fragmentation. |
| Research & Monitoring | Monitor the status of *Posidonia oceanica* meadows, including depth limit and flowering events. |
| Protection & Restoration | Monitor the status of coralligenous communities and impacts. |
| Protection & Restoration | Implement restoration activities targeting protected, endangered and rare species. |
| Regulation & Governance | Upgrade the existing health management plan of the MPA in collaboration with other organisations. |
| Technological | Develop pilot actions for reducing energy consumption and increasing the use of renewable energy. |
| Research & Monitoring | Establish a baseline and monitor beaches and cliffs to prepare future adaptation measures. |

***Table 4-11.***

## Climate change adaptation measures shortlisted by the *MPA of Tavolara* (Cinti et al., 2021).

| Response category | *Response description* |
|---|---|
| Capacity Building & Awareness Raising | Raise awareness among divers on the effects of climate change on marine ecosystems. |
| Capacity Building & Awareness Raising | Implement continuous training of operators in diving centres, so that they can become "ambassadors" of positive messages to their users with respect to the advancement of climate change and the need for environmental conservation. |
| Research & Monitoring | Engage divers in participatory monitoring to amplify and support the MPA's ability to detect and quantify ongoing ecological changes. |
| Research & Monitoring | Enhance the MPA's mobile app for reporting climate change related effects, e.g., a list of organisms from another geographic region (whether alien or thermophilic). |
| Regulation & Governance | Identify new diving routes to not always impact the same sites and/or to increase monitoring of the new ones. |
| Capacity Building & Awareness Raising | Develop awareness activities aimed at visitors of the MPA on the effects of climate change but also on the effects caused by human activities (e.g. trampling on dunes). |
| Capacity Building & Awareness Raising | Implement continuous training of tourism operators in the beach concessions, so that they can become "ambassadors" of positive and environmental conscious messages to their users regarding the advancement of climate change and the need for environmental conservation. |
| Capacity Building & Awareness Raising | Develop sustainability signage (e.g., user guidance on water consumption through stickers in concession facilities) |
| Capacity Building & Awareness Raising | Implement a sustainability Decalogue to encourage the practice of visiting the MPA at a time of year other than then one which is most commonly visited or promote the exploration of other areas in the neighbouring territory during the vacation. |

| Response category | *Response description* |
|---|---|
| Capacity Building & Awareness Raising | Development of a Decalogue aimed at improving the knowledge of the sea (environments, resources, functioning) of recreational fishermen towards the adoption of good practices for sustainable fishing |
| Capacity Building & Awareness Raising | Carry out public awareness activities on the importance of sustainable fishing activities and the added value of choosing sustainable fishery products (e.g. mussels from local mussel farms). |
| Regulation & Governance | Establish a management scheme for abandoned fishing gear through the codification of a protocol. |
| Research & Monitoring | Access the knowledge of local fishermen (professional and recreational) to identify signs of ecological change (e.g. Did you catch unusual species? How deep did you set your nets to get a good catch? How far were you from the coast?). |
| Regulation & Governance | Strengthen partnership with fishing associations to implement adaptive management measures, with a focus on natural resource use (at least one annual meeting with de-materialized information materials) |
| Capacity Building & Awareness Raising | Strengthen the diffusion of the mobile application DONIA (navigation and help for anchoring outside of fragile environments, *Posidonia oceanica* for example) in the territory. |
| Capacity Building & Awareness Raising | Develop and implement public awareness activities on the role of Posidonia and coralligenous habitats for the natural protection of the littoral system |
| Capacity Building & Awareness Raising | Implement ongoing training for operators in the recreational boating sector so that they can become "ambassadors" of positive and knowledgeable messages to their users with respect to advancing climate change actions and environmental conservation. |

***Table 4-12.***

# 4.4 Priority adaptation actions for a Joint Plan

**In order to identify** and propose priority adaptation measures for a Joint Plan in Mediterranean MPAs, we have taken a closer look at the adaptation measures adopted and/or shortlisted by the MPA Engage pilot MPAs, with the aim to identify the most frequently encountered measures in the respective climate change adaptation plans or short lists of measures. As shown in the graph below, the main typologies of measures endorsed by the pilot MPAs are those related to capacity building & awareness raising, research & monitoring, regulation & governance. Measures related to technological solutions, protection & restoration, and economic instruments are the least favoured ones, most probably because they are more difficult to implement, are more resource-intensive, stir more conflicts and/or disagreements among and between the different stakeholders, etc.

**The measures** adopted and/or shortlisted by the pilot MPAs, differ in levels of sophistication, in levels of detail or in levels of comprehensiveness, depending also on the natural, political, organizational and institutional context of the MPAs. However, we have processed them all and we have identified a set of common no-regret priority measures that should be jointly adopted by Mediterranean MPAs. The list of measures that gives shape and form to a Joint Plan for action to face climate change in Mediterranean MPAs is depicted in Figure 4-1.

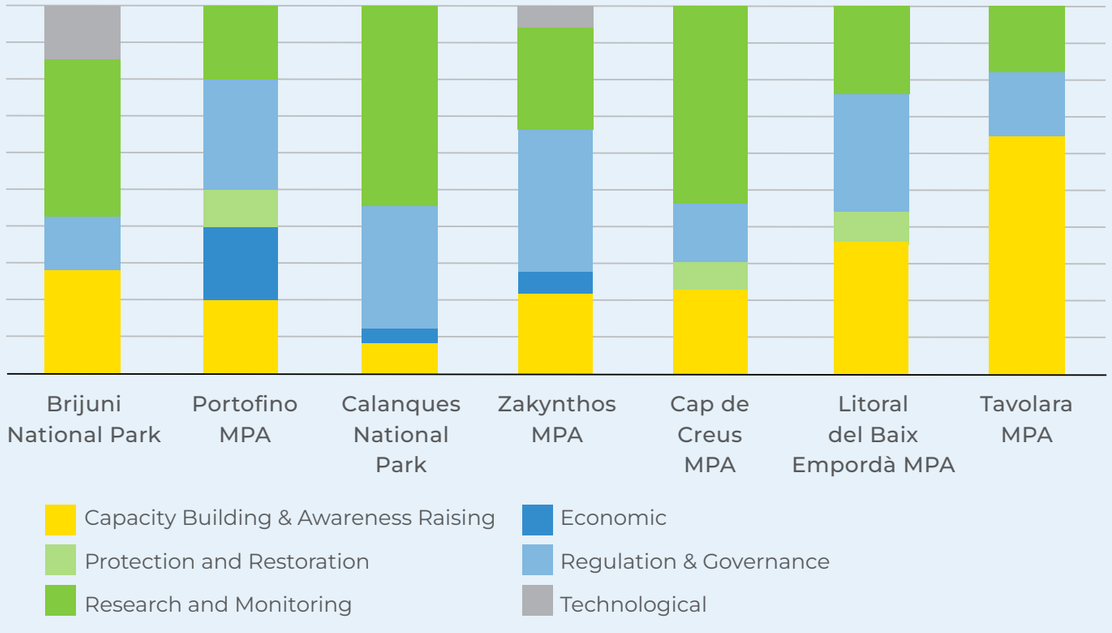




***Figure 4-1.***
*Summary graph with the typologies of adaptation options adopted and/or shortlisted by the pilot MPAs.*

Implement awareness raising campaigns on the climate change effects targeting key local stakeholders, such as artisanal and recreational fishermen, divers, boaters and others

Develop awareness raising activities targeting MPA visitors on climate change effects and best practice approaches and responses at MPA level

Carry out sector-specific capacity building to reduce and manage the impact of coastal and marine users' activities on MPAs and enhance ocean literacy towards ocean-informed actions and the adoption of good practices

Set up comprehensive monitoring schemes focused on climatic variables, species or habitats, extreme events, ecological and social processes

Carry out research on the effects of climate change, vulnerability and capacity for adaptation

Engage with wide-ranging volunteers in citizen science activities to monitor the effects of climate change on marine ecosystems

Apply and/or reinforce restrictions for professional and recreational users to avoid or decrease damages on marine ecosystems

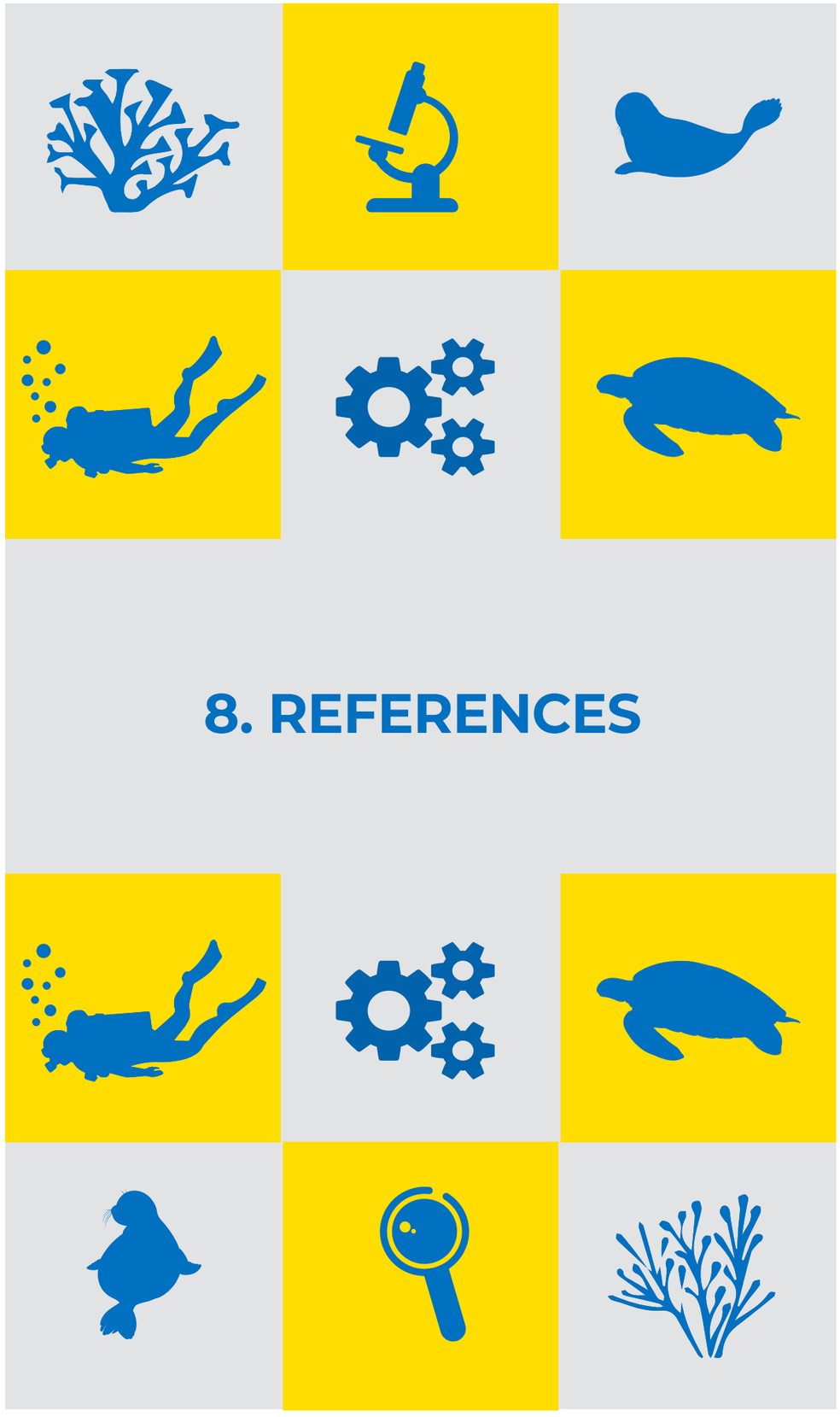
Develop or update emergency response plans to address potential greater frequency of extreme weather events

Promote the consumption and commercialization of warm-water species of either native or exotic origin

Implement restoration activities targeting protected, endangered and rare species

- Capacity Building & Awareness Raising
- Economic
- Protection and Restoration
- Regulation & Governance
- Research and Monitoring
- Technological

*Figure 4-2.*
*The list of measures that gives shape and form to a Joint Plan for action to face climate change in Mediterranean MPAs.*



# 8. REFERENCES


Assis, J., Berecibar, E., Claro, B., Alberto, F., Reed, D., Raimondi, P., & Serrão, E. A., 2017. Major shifts at the range edge of marine forests: The combined effects of climate changes and limited dispersal. Nature Publishing Group, 7(44348), 1– 10.

Azzurro, E., Ballerini, T., Garrabou, J., Di Franco, A., 2021. Joint Climate Change Monitoring Plan in MPAs. D. 3.4.8. Interreg Med MPA Engage.

Borja, A., Andersen, J. H., Arvanitidis, C. D., Basset, A., Buhl-Mortensen, L., Carvalho, S., et al., 2020. Past and future grand challenges in marine ecosystem ecology. Front. Mar. Sci., 7, 362. https://doi.org/10.3389/fmars.2020.00362

Bruno, J.F., Bates, A.E., Cacciapaglia, C. et al., 2018. Climate change threatens the world's marine protected areas. Nature Clim Change 8, 499–503. https://doi.org/10.1038/s41558-018-0149-2

Campos et al., 2018. The Diversity of Adaptation in a Multilevel Governance Setting. In: Adapting to Climate Change in Europe Exploring Sustainable Pathways - from Local Measures to Wider Policies, pp. 49-172.

Carbonell X., Fábregas, M., 2021a. Climate Change Adaptation Plan in Cap de Creus Natural Park. D.3.7.5. Interreg Med MPA Engage.

Carbonell X., Fábregas, M., 2021b. Climate Change Adaptation Plan in Litoral del Baix Empordà MPA. D.3.7.6. Interreg Med MPA Engage.

Cinti et al., 2021. Climate Change Adaptation Plan in Tavolara MPA. D.3.7.7. Interreg Med MPA Engage.

Claudet, J., Loiseau, C., Sostres, M., Zupan, M., 2020. Under-protected Marine Protected Areas in a Global Biodiversity Hotspot. One Earth. 2, 380-384. https://doi.org/10.1016/j.oneear.2020.03.008

Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Ben Rias Lasram, F., Aguzzi, J., Ballesteros, E., Bianchi, C.N., Corbera, J., Dailianis, T., et al., 2010. The biodiversity of the Mediterranean Sea: estimates, patterns, and threats. PloS One 5: e11842.

Cramer, W., Guiot, J., Fader, M., Garrabou, J., Gattuso, J. P., Iglesias, A., ... & Xoplaki, E., 2018. Climate change and interconnected risks to sustainable development in the Mediterranean. Nature Climate Change, 8(11), 972-980.

D'Amen, M., Azzurro, E., 2020. Lessepsian fish invasion in Mediterranean marine protected areas: a risk assessment under climate change scenarios. ICES Journal of Marine Science, 77(1), 388-397.

Dimitriadis, Ch., 2021. Climate Change Adaptation Plan in Zakynthos MPA. D.3.6.4. Interreg Med MPA Engage.

Garrabou J., Azzurro E, Bensoussan N., Sbragaglia V., Otero M., 2019. Joint Governance Plan. Developing adaptation plans to face climate change impacts in Mediterranean Marine Protected Areas. MPA-Adapt project.


Gómez-Gras et al., 2021 Climate change transforms the functional identity of Mediterranean coralligenous assemblages. Ecology Letters, 24, https://doi.org/1038–1051.10.1111/ele.1371

Grorud-Colvert, K., Sullivan-Stack, J., Roberts, C., Constant, V., Horta e Costa, B., Pike, E. P., Kingston, N., Laffoley, D., Sala, E., Claudet, J., & Friedlander, A. M., 2021. The MPA Guide: A framework to achieve global goals for the ocean. Science, 373(6560), eabf0861.

Hastrup Clemmensen, A., Haugvaldstad, A., Vizinho, A., Penha-Lopes G., 2015. Participation in Climate Change Adaptation. European Union's Seventh Framework Programme for research, technological development and demonstration under Grant Agreement No. 308337 (Project BASE).

IPBES 2019. Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.355357

IPCC, 2019. IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. et al. eds.)].

Katsanevakis et al., 2020. Twelve Recommendations for Advancing Marine Conservation in European and Contiguous Seas. Front. Mar. Sci. 7, 565968. https://doi.org/10.3389/fmars.2020.565968

Larsen, K., & Gunnarsson-Östling, U., 2009. Climate change scenarios and citizen-participation: mitigation and adaptation perspectives in constructing sustainable futures. Habitat International, 33 (3): 260-266.

MedECC, 2020. Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future. First Mediterranean Assessment Report (W. Cramer, J. Guiot, & K. Marini, eds.). Union for the Mediterranean, Plan Bleu, UNEP/MAP.

Merotto, L., 2021. Climate Change Adaptation Plan in Portofino MPA. D.3.6.2. Interreg Med MPA Engage.

Pastor, F., Valiente, G.A., Khodayar, S., 2020. A Warming Mediterranean: 38 Years of Increasing Sea Surface Temperature. Remote Sens. 12(17), 2687; https://doi.org/10.3390/rs12172687

Patrício, J., Elliott, M., Mazik, K., Papadopoulou, K.N., Smith, C.J., 2016. DPSIR—Two Decades of Trying to Develop a Unifying Framework for Marine Environmental Management? Front. Mar. Sci., 14 September, https://doi.org/10.3389/fmars.2016.00177

Pisano, A., Marullo, S., Artale, V., Falcini, F., Yang, C., Leonelli, F.E., Santoleri, R., Buongiorno Nardelli, B., 2020. New Evidence of Mediterranean Climate Change and Variability from Sea Surface Temperature Observations. Remote Sensing, 12, 132.

Reid, H., Alam, M., Berger, R., Cannon, T., Huq, S., & Milligan, A., 2009. Community-based adaptation to climate change: an overview. Participatory learning and action, 60(1), 11-33.

Rilov, G., Fraschetti, S., Gissi, E., Pipitone, C., Badalamenti, F., Tamburello, L., Menini, E., Goriup. P., Mazaris, D.A, Garrabou, J., Benedetti-Cecchi, L., Danovaro, R., Loiseau, C., Claudet, J., Katsanevakis, S., 2020. A fast-moving target: achieving marine conservation goals under shifting climate and policies. Ecological Applications. https://doi.org/10.1002/eap.2009

Sala, E., Mayorga, J., Bradley, D. et al., 2021. Protecting the global ocean for biodiversity, food and climate. Nature 592, 397–402. https://doi.org/10.1038/s41586-021-03371-z

Scoullos, M. (ed), 2015. An Integrative Methodological Framework (IMF) for coastal, river basin and aquifer management. UNEP/MAP-PAP/RAC, GWP-Med and UNESCO-IHP. MedPartnership, Split, Croatia.

Simard, F., Laffoley, D. and Baxter, J., M., 2016. Marine Protected Areas and Climate Change: Adaptation and Mitigation Synergies, Opportunities and Challenges. Gland, Switzerland: IUCN. 52 pp.

Stein, B.A., Glick, P., Edelson, N. Staudt, A. (eds.), 2014. Climate-Smart Conservation: Putting Adaptation Principles into Practice. National Wildlife Federation, Washington, D.C.

Tittensor et al., 2019. Integrating climate adaptation and biodiversity conservation in the global ocean. Sci. Adv; 5, eaay9969; https://doi.org/10.1126/sciadv.aay9969

Vlachogianni, Th., 2020. Guidelines on how to develop a local Climate Change Mitigation and Adaptation Plan. Deliverable 4.6.1. Interreg Med MPA Engage Project.

Vouriot, P., 2021. Climate Change Adaptation Plan in Calanques National Park. D.3.6.3. Interreg Med MPA Engage.

Vukadin, V., Blašković, A., Kukoleča, L., Kovačec, K., 2021. Climate Change Adaptation Plan in Brijuni National Park. D.3.6.1. Interreg Med MPA Engage.

West. J.M., Courtney, C.A., Hamilton, A.T., Parker, B.A., Julius, S.H., Hoffman, J., Koltes, K.H., MacGowan, P., 2017. Climate-Smart Design for Ecosystem Management: A Test Application for Coral Reefs. Environmental Management, 59, 102–117. https://doi.org/10.1007/s00267-016-0774-3



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