Habitat-forming macroalgae / corals in the western Mediterranean Sea

Storyline 29

NBS 2
EFFECTIVE CONSERVATION

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Future MARES

Introduction to FutureMARES

The EU Horizon project FutureMARES (2020-2024) was designed to develop science-based advice on viable actions and strategies to safeguard biodiversity and ecosystem functions to maximise natural capital and its delivery of services from marine and transitional ecosystems in a future climate. The program investigates effective habitat restoration, conservation strategies and sustainable harvesting at locations across a broad range of European and other marine and transitional systems. The restoration of habitat-forming species (plants or animals) and habitat conservation (e.g. marine protected areas, MPAs) represent two nature-based solutions (NBS) defined by the EU as "resource efficient actions inspired or supported by nature to simultaneously provide environmental, social and economic benefits that help to build resilience to change". A third action that will interact with these two NBS and have positive effects on marine biodiversity is nature-inclusive harvesting (NIH) such as the sustainable farming of plants and animals at the base of marine food webs and ecosystem-based management practices for traditional (artisanal) and commercial fisheries.

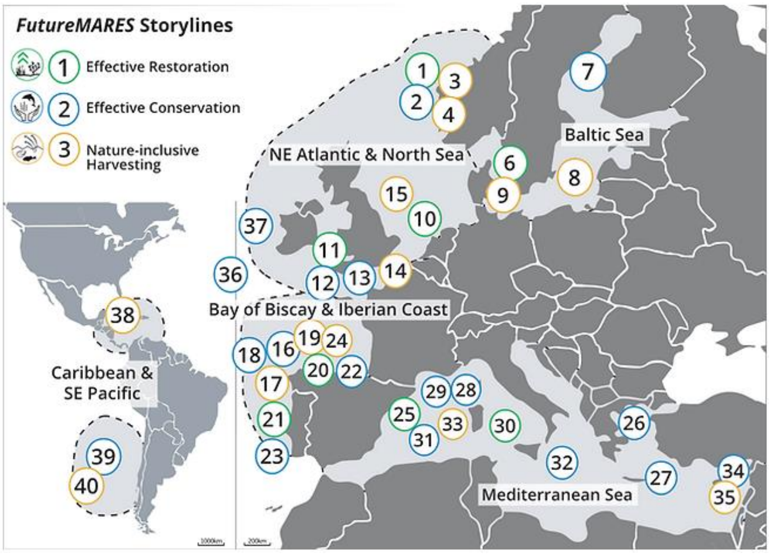

***Figure 1**: Overview of FutureMARES Storylines*

FutureMARES was designed to:

- advance the state-of-the-art forecasting capability for species of high conservation value,
- explore new and less carbon intensive aquaculture production methods,
- perform modelling analyses geared towards informing the development of climate-smart marine spatial planning approaches, and
- provide an assessment of ecosystem services based on scenarios of climate change and the implementation of NBS and NIH.

This document provides a summary of activities conducted in FutureMARES in a specific area on specific NBS and/or NIH. The activities are multi-disciplinary and include marine ecology (analyses of historical time series and experiments performed in the field and laboratory), climate change projection modelling (future physical, biogeochemical and ecological changes), economic analyses and social-ecological risk assessments. Many of these components and analyses were co-developed with local and regional stakeholders through regular engagement activities. The work presented in this Storyline document represent activities conducted by a large number of FutureMARES project partners. Broader comparisons and syntheses (across regions and/or topics) are provided in the FutureMARES deliverable reports submitted to the European Commission (www.futuremares.eu).

Regional Storyline Context

This Storyline will focus on the subnetwork of marine protected areas (MPAs) located in the northern Catalan coast, located in the NE of the Iberian Peninsula (NW-Mediterranean region). This subnetwork is composed of three protected areas; the Natural Parks of the Cap de Creus and the Montgrí, les Illes Medes i el Baix Ter and the Natura 2000 site Litoral Baix Empordà. Together, the three areas span over a geographical scale of 60 km and cover more than 65 km^2 of marine coastal waters. The area is protected to different extents from the reinforced protection no-take no-use zones (e.g., in Illes Medes and Cap de Creus), no-take zones (e.g. Illes Medes) to partial protection areas (some specific regulations for fishing modalities and recreational uses) up to similar regulation as in non-protected zones. This protection heterogeneity is the result of different processes adopted for the declaration of the MPAs, as well as the specific socio-ecological context of the area, in which fisheries and multiple tourist interests exist.

From an ecological perspective, the three MPAs contains a great diversity of coastal benthic habitats, including the coralligenous assemblages and the macroalgal forests dominated by *Ericaria crinita*. The macroalgal forests dominated by *E. crinita* are also recognised as a hotspot of diversity and a source of food and habitat to diversified assemblages of understory species. They also enhance coastal primary productivity. These macroalgal forests are distributed throughout the entire Mediterranean Sea (as *Cystoseira crinita*; Ribera et al. 1992, Sales et al. 2012) where they are mainly restricted to the upper sublittoral zone in relatively wave-sheltered and well-illuminated environments (Molinier 1960, Sales and Ballesteros 2009, 2010, 2012). Unfortunately, these marine forests are also threatened by multiple stressors, including urbanisation, eutrophication and increasing sediment loads in coastal areas, as well as climate change.

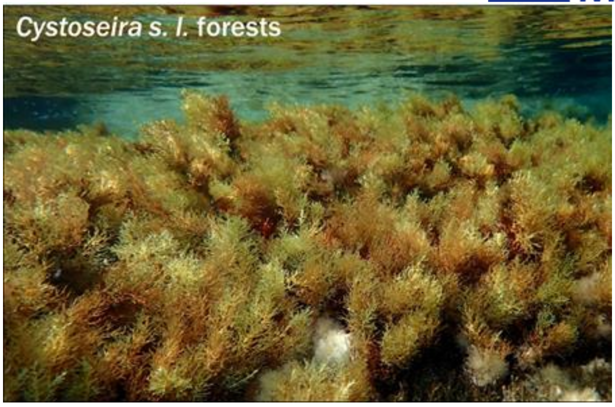

Figure 2: Typical shallow 0-3m macroalgal forest dominated by Cystoseira sensulato species in the study area. Photo by Enric Ballesteros

Figure 3: Typical deep (20-50 m depth) coralligenous formation dominated by the red gorgonian Paramuricea clavata in the study area. Photo by Josep Clotas

The coralligenous assemblages are hard-bottom habitats of biogenic origin that are mainly produced by the accumulation of calcareous encrusting algae growing at low irradiance levels (15-120m depth). Coralligenous habitats are highly biodiverse (hosting around 10% of Mediterranean species) (Ballesteros et al. 2006). They tend to be dominated by long-lived algae and sessile invertebrates such as sponges, corals, bryozoans and tunicates (Ballesteros 2006). However, because most of the structural species of the coralligenous are long-lived and exhibit slow population dynamics (Caragnano and Basso 2009, Garrabou and Ballesteros 2000, Garrabou and Harmelin 2002, Linares et al. 2007, Teixidó et al. 2011), they are also very sensitive any disturbance that increases adult mortality rate. As a consequence, coralligenous assemblages are currently threatened by several pressures such as nutrient enrichment, invasive species, increased sedimentation, mechanical impacts such as damage from fishing activity, and climate change (Ballesteros 2006, Balata et al. 2007, Garrabou et al. 2009 & 2021, Piazzi et al. 2012, Verdura et al. 2019, Gómez-Gras et al. 2021).

Coralligenous assemblages and *E. crinita*-dominated macroalgal forests both provide important ecosystem services to human societies (e.g., fishing, tourism, active compounds, carbon sequestration). Due to these services and the current threats to these habitats, the subnetwork of three MPAs represents an ideal study area for exploring scenarios of how NBSs (e.g., better designing the MPA network to increase climate resilience) could sustain the functioning and services provided by these habitats in different climate futures.

The information in this document should help inform key stakeholders such as the Generalitat de Catalunya (regional government).

Projected impacts of climate change

The Mediterranean Sea is considered a hotspot of climate change that is warming faster than the average surface of the world's oceans (Pisano et al. 2020). In particular, the western basin is warming at a rate of 0.03ºC per year, which is almost three times faster than the global oceans (average 0.012ºC per year; Pisano et al. 2020). Moreover, the frequency of extreme events has doubled in recent decades, with marine heatwaves becoming longer, more frequent and intense (Darmaraki et al. 2019).

FutureMARES has made projections of physical and biogeochemical impacts of climate change in the region including three IPCC scenarios (SSP126, SSP 245 and SSP 585 (for background see Deliverable Report 2.2). Since the Mediterranean is also a biodiversity hotspot (Bianchi and Morr, 2000), the convergence between rapid warming trends and exceptional biodiversity has resulted in widespread evidence of climate change impacts on Mediterranean biota at all levels of biological organization (Lejeusne et al. 2010, Marbà et al. 2015). In particular, extreme warming events such as marine heatwaves (MHWs) are triggering devastating mass mortality events (MMEs) that are impacting Mediterranean benthic communities across hundreds to thousands of kilometres of coast (Cerrano et al. 2000, Garrabou et al. 2009 & 2019, Linares et al. 2005). During these events, thousands of organisms from a great variety of species and phyla are experiencing temperatures that exceed their thermotolerance limits, suffering extensive tissue necrosis (partial and total mortality) and subsequent population declines. There is evidence of these species impacts are cascading to the community and ecosystem levels in some cases, causing structural and compositional changes, as well as changes in the ecosystem functioning (Verdura et al. 2019, Gómez-Gras et al. 2021). However, there is also evidence that local-scale climatic refugia exist that, if clearly identified, could be protected to safeguard the persistence of Mediterranean benthic communities (Verdura et al. 2021).

High-resolution projections (10- to 20-km spatial and daily temporal scales) using IPCC RCP scenarios 2.6, 4.5 and 8.5 revealed a sustained increase in the frequency and intensity of MHWs over the next century in the NW Mediterranean Sea (Garrabou et al. 2021). Specifically, the number of MHW days will probably reach levels far above what occurred in 2003, an exceptional year, during the next decade in all RCP scenarios. By 2050, and under RCPs 2.6 and 4.5, MHWs are expected to last for ca. 60% of the period (3.5 months) vs. 73-85% (4.5 to 5 months) under the worst-case RCP 8.5 scenario. In addition, MHW frequency is projected to further increase during the second half of the century, up to 80-100% of the period from June to November, except under RCP 2.6 where a decreasing trend occurred after 2070. In addition, MHWs are expected to increase their maximum intensity by two to three-fold during the second half of the 21st century depending on scenarios.

Overall, these projected warming trends suggest an increased number of winner and loser species, a loss of habitat complexity due to the loss of habitat-forming species, and the potential occurrence of changes in ecosystem structure, composition and functioning (Ben Rais Lasram and Mouillot 2009, Ben Rais Lasram et al. 2010, Sala et al. 2011, Verges et al. 2014, Azzurro et al. 2019, Montero-Serra et al. 2019 Gómez-Gras et al. 2019 & 2021). It is, therefore, urgent to identify and preserve the mechanisms of ecosystem stability that maintain essential functions and services in NW Mediterranean benthic ecosystems. In this sense, NBSs such as the conservation and/or restoration of key habitat-forming species will be critical.

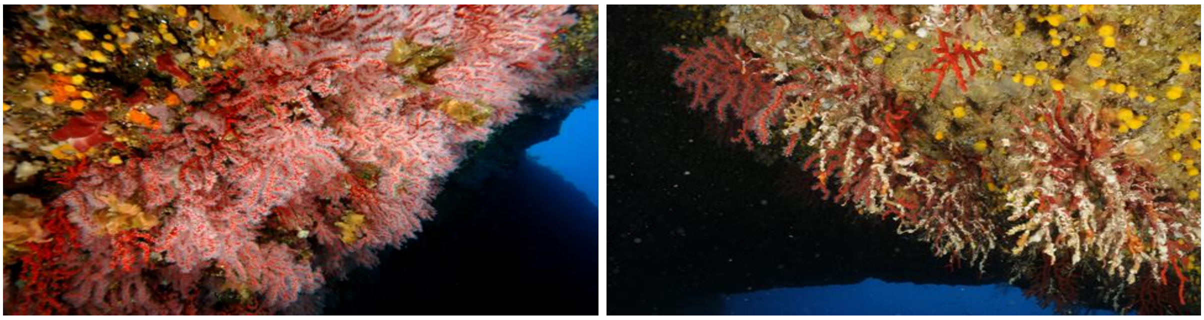

***Figure 4**: A healthy population of red coral Corallium rubrum (above) and affected by amass mortality event (below). Photos by Joaquim Garrabou*

Scenarios describing future society and economy

FutureMARES developed three policy-relevant scenarios for NBS and NIH based on commonly used IPCC frameworks (for more details see hyperlink). These scenarios were regionalised based on stakeholder perspectives to guide activities such as model simulations and risk assessments.

(GS) Global Sustainability (SSP126) - Low challenges to mitigation and adaptation

The world shifts gradually but pervasively to a more sustainable path, emphasising inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, investments in educational and health accelerate lower birth and death rates, and the emphasis on economic growth shifts to an emphasis on human well-being.

(NE) National Enterprise (SSP385) - High challenges to mitigation and adaptation

A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to focus on domestic or regional issues. Policies shift over time to be oriented more on national and regional security. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development.

(WM) World Markets (SSP585) - High challenges to mitigation, low challenges to adaptation
The world increasingly believes in competitive markets, innovation and participatory societies to produce rapid technological progress and train and educate people for sustainable development. The push for economic and social development is coupled with exploiting abundant fossil fuel resources and adopting resource and energy intensive lifestyles around the world.

***Figure 5:** The three, broad scenarios that were regionalised to guide activities in FutureMARES.*
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At the present time, there are three Natura 2000 sites with different levels of protection: two also designated as Natural Parks, reinforced protection no-take no-use zones (e.g., in Illes Medes and Cap de Creus), no-take zones (e.g. Illes Medes) to partial protection areas (specific fishing regulations and recreational use) up to similar regulation as in non-protected zones. Main marine uses are nautical activities, fisheries, and uses by the tourist sector. The implementation of NBS2 including no-use no-take zones is likely to lead to conflicts with these activities.

In the future, the GS scenario the Natura 2000 areas will be better managed, with effective management plans, the areas with no-take zones that will be enlarged and the three MPAs are better connected. Even though more strictly regulated, the activities outside MPAs benefit from better ecological status of habitats. In the NE scenario, there is ineffective management of areas by government, with few regulations, similar to unprotected areas. Increasing pressures such as CC, OA, fishing, recreational activities, etc. lead to long-term, unsustainable use of resources and harm a number of activities. Lastly, in the WM scenario, there probably are some well managed areas, but worst-case CC (SSP5-8.5) causes intense ecological impacts. Management is directed towards preserving climate refugia for these species. The urge for economic development leads to conflicts with certain stakeholders but, at the same time, other sectors benefit from this like Eco-tourism or sustainable traditional fisheries.

FutureMARES research needs

The main research questions that need to be address focus on understanding the processes and mechanisms enhancing the resilience of targeted rocky benthic habitats in the face of climate change.

Key research needs include:

1) Improve our understanding the factors and processes that shape intra-specific and inter-specific sensitivity to warming in benthic species to improve our ability to assess climate change risks. Field and experiments (in and ex situ) are required along with next generation genomic approaches.

2) Better support and coordination is needed in coastal observatories to track climate change effects in Mediterranean coastal areas. Sustained coastal observation networks are essentially lacking and the implementation of harmonised monitoring protocols is needed across the three MPAs. This will better inform MPA managers on ongoing climate impacts in their specific areas.

3) Newly availability technologies in data acquisition and analysis need to be implemented to better study and characterise benthic communities in structurally complex rocky benthic habitats. These new techniques can help quantify patterns across relevant spatial and temporal scales. Such advances are a crucial step forward to enhance our understanding in the relationship between the structure and functioning of benthic communities.

4) There needs to be a better implementation of marine citizen science activities in the MPAs. Community engagement strategies are being developed to take full advantage of this emerging activity and platforms (e.g. Observadores del Mar www.observadoresdelmar.es coordinated by CSIC) to improve the conservation status of marine ecosystems.

5) Climate adaptation strategies need to be developed to enhance the role of MPAs as Ocean Based Solutions to climate change. The lessons learnt in the development of operational climate adaptation strategies for the managers of the 3 MPAs will help establish tailored action plans to confront climate change in other MPAs.

FutureMARES research (T = Task – see program structure at futuremares.eu)

- **T1.1** Analysis and supporting long-term monitoring series including calculation of Community Thermal Index;
- **T1.2** Collect species traits for macroalgal and coralligenous habitats needed to examine climate risk;
- **T2.1** Provide the T-MEDNet high-resolution temperature series to explore agreement with ensemble model hindcasts with potential bias correction for near shore environments;
- **T2.3** Spatial and temporal analysis of physical and biogeochemical model runs bias corrected with T-MedNet measurements to identify climatic hotspots and refugia;

- **T3.1** Perform field measurements on macroalgal habitats to understand their role in biogeochemical cycling and potential carbon budgets;
- **T3.3** Analyse population genetic datasets and analysis of octocorals and potentially other key members of the MPA habitats;

- **T4.1** Perform spatial distribution projection modelling under different scenarios of climate and MPA network management;
- **T5.1** Provide input to estimate ecological climate risk to thee habitats (thermotolerance data available);
- **T6.1** Create spatial maps identifying options for implementing climate-ready conservation (NBS2) within the NW Mediterranean given multiple users, sectors and services (particularly fisheries);
- **T7.1-8.1** Engage local MPA managers to co-develop project activities and present FutureMARES activities to broader, MPA network through other, ongoing programs.

2. Research conducted

2.1 Ecological Knowledge

Storyline 29 contributed directly to WP3 with two experiments, one contributed to T.3.1: "Current and future ecosystem functions of shallow benthic communities"; and the other one to T.3.2: "Local adaptation potential of key coastal species through within-population physiological plasticity".

- <u>T.3.1. Macro algae forest restoration.</u>

Marine macrophytes, like seaweeds and seagrasses, drive primary production in coastal areas, forming marine forests vital for ecosystems and human societies. Human impacts lead to widespread loss and degradation of these forests, altering ecosystem functions. Restoration efforts aim to reverse this damage. This study assessed the recovery of primary production and respiration after restoring a marine forest. In situ benthic incubations compared a restored site with degraded and healthy forests. Metabolic rates were estimated using oxygen and carbon fluxes, aiming to understand the effectiveness of marine restoration in restoring ecosystem functions and services.

Our results show that, at all sites, gross community primary production (GPP) was higher than community respiration (CR), meaning that these sites accumulated organic matter in excess and, thereby acted as sinks of inorganic nutrients and CO2 from the surrounding water.

The evaluation of the functioning of these important habitats, their potential productivity and the recovery of the oxygen and carbon cycles will result in a more holistic understanding of the restoration success and provide a long-term perspective. The results from the restored forest suggest that community net primary production has likely increased after 10 years from the restoration action since its production values are similar to those found in healthy and well-established forests dominated by the same structural species. The net gain of primary production after restoration is expected to be transferred to higher trophic levels, thus benefiting other associated invertebrate and fish species.

- T.3.2. Temporal variability in the response to thermal stress in the red gorgonian, *P. clavata*: insights from common garden experiments.

This study aims to analyze the differential response to thermal stress between individuals and populations of *Paramuricea clavata* across three consecutive years.

We conducted the characterization of the spatial and temporal variability in the responses to thermal stress between individuals and populations of the red gorgonian *P. clavata*. We considered a local scale within 1 km^2 with three populations, while the temporal scale accounts for three consecutive years. We demonstrate a high variability in the percentage of tissue necrosis among the same individuals from the same population for a given year. This result is also in line with previous studies with *P. clavata* where necrosis values was variable across populations (Crisci et al., 2017) and individuals (Gómez-Gras D. et al., 2022) at different geographic scales.

We demonstrate a strong temporal variability in the response to thermal stress for all three populations. We found that the survival probability of colonies was strongly reduced in the 2017 experiment. Two non-exclusive hypotheses may potentially explain this result: i) impact of past thermal conditions (*i.e.* years before the experiment); ii) impact of recent thermal conditions (*i.e.* summer before the experiment). Preliminary results comparing 2017 with 2015 and 2016 thermal conditions at the depth where the populations dwell (15-20m), point toward a stronger and longer thermal disturbance (>23°C) observed during June to September of 2017 in comparison with 2015 and 2016 supporting the high impact of recent thermal conditions on the response to thermal stress.

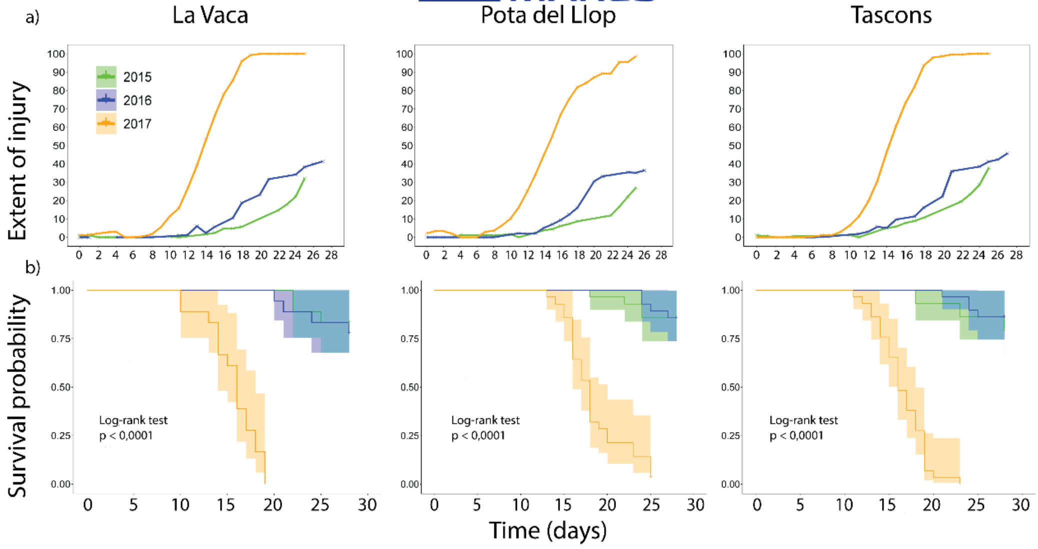

***Figure 6**. a) Average tissue necrosis in common garden experiments in La Vaca, Pota del Llop and Tascons from 2015 to 2017. b) Differences in survival probability (i.e. mortality) across years in P. clavata when exposed to thermal stress Kaplan-Meier survival curve (p<0,0001).*

This study indicates that determining the thermal response of populations and individuals to marine heat waves may not be straightforward. Despite this, we also found some potential sensitivity/resistance patterns that may support climate adaptation conservation measures. Further studies focused on transcriptomic responses are needed to understand the potential adaptation of *P. clavata* populations in the Mediterranean Sea.

2.2 Projections of future biological effects

Even though we did not work directly in WP4, the projections made in T.4.1 are applicable to this storyline, as it provides projections of the impact of climate change on seagrasses, including *Posidonia oceanica*.

Figure 7 shows mapped changes in *P. oceanica* biomass between the present day (1995-2014) and mid-century (2040-59). All models show clear agreement that there will be a widespread decline in *P. oceanica* biomass this century, with the projected decline increasingly dramatic in higher emissions scenarios.

Spreads within the model ensemble are large, with the magnitude of decline varying by a factor of 2 or 3 across regions in SSP 245.

A dramatic decline in the SSP 585 scenario is possible, and functional extinction is projected in some regions in some ensemble members. However, these dramatic declines are much more likely within the “hot” members of the ensemble, which have climate sensitivity above the IPCC’s credible range. Despite this uncertainty, a decline in Mediterranean wide biomass of over 70% is projected across the ensemble for SSP 585.

A number of the ensemble members within SSP 126 show increasing *P. oceanica* biomass in the second half of the century. This reflects the positive effects of reducing atmospheric carbon dioxide levels that occur after 2060 in this scenario. The scenarios were not extended beyond 2100. However, it is notably that individual ensemble members are trending towards a reversal of climate impacts in the early 2100s.

The changes within the ensemble are notably larger if you do not exclude the "hot" models (Figure 8), and there is a clear relationship between impacts on *P. oceanica* and the overall equilibrium climate sensitivity of the global model used in the projections.

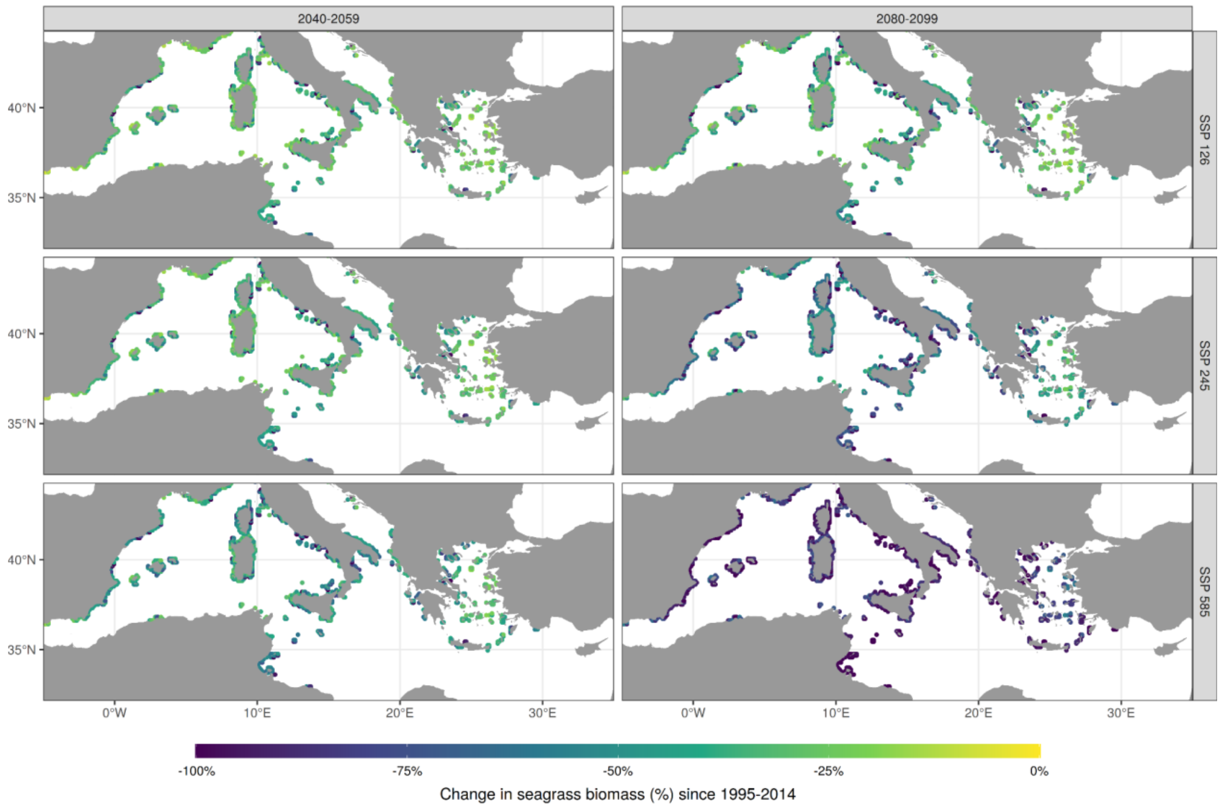

Figure 7*: Median modelled projected changes in surface Posidonia oceanica biomass between early 2000's (1995-2014) and mid-2100 Century (2040-59, left panels) and end-2100 Century (2080-99, right panels) under three different GHG-emission scenarios (top, mid, and lower panels). Projections are based on a large climate model ensemble and a mechanistic seagrass population model.*

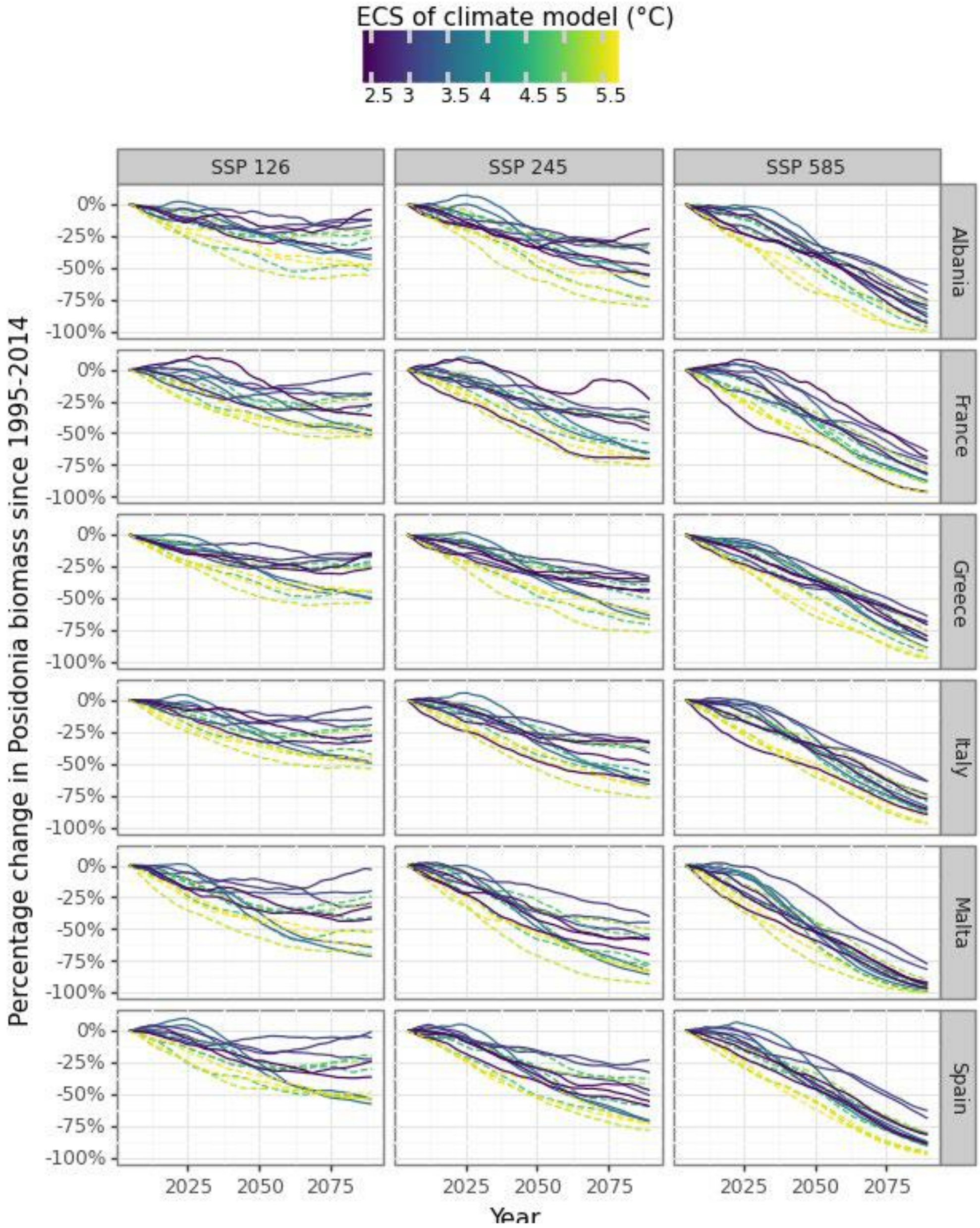

Figure 8: *Projected changes in EEZ-wide Posidonia biomass using a seagrass population model and a large ensemble of climate models. Each line represents the outcome when driven by a specific global climate model. Line colour represents the equilibrium climate sensitivity (ECS). Global models with ECS outside the IPCC's assessed credible range (1.5-4.5) have dashed lines. Each column represents a different climate change scenario.*

3.1 Social-ecological vulnerability

Climate risk assessments were made at the level of species (task 5.1), ecosystem services (task 5.2), and social groups (task 5.3), while considering the effect of one nature-based solutions (NBS) (conservation) in the case of our Storyline.

T.5.1 Climate Risk Assessment at the Species level.

The Climate Risk Assessment (CRA) approach posits that the climate-related Risk of a given system results from the combination of three dimensions: Hazard, Exposure and Vulnerability (Sensitivity – Adaptive Capacity). The logic behind the method is that the climate risk of the system is evaluated before/after or inside/outside the application of the Nature Based Solution "Effective Conservation" and in three different scenarios and time slices.

In the case of our Storyline, SL29, we addressed the effect of NBS2 conservation of macroalgae and corals and a subset of their associated communities against five hazards (3 climate & 2 human) in the Western Mediterranean (Table 1).We did not consider the assessment at habitat level.

Table 1. Summary of the parameters of the CRA performed within SL29.

SL No	SL title		NBS/NIH	No Taxa	Location
29	Habitat-forming macroalgae / corals in the western Mediterranean Sea		NBS2	6	Western mediterranean
Hazard category	Hazard	Taxa group	Taxa		
Climate (50%)	Temperature increase	Seagrass	*Posidonia oceanica*		
Climate (40%)	Heat waves	Algae	*Cystoseira* spp		
Climate (10%)	Storms	Algae	*Corallina*		
Human (60%)	Fisheries	Crustacea	*Palinurus elephas*		
Human (40%)	Boat anchoring	Fish	*Epinephelus marginatus*		
		Coral	Gorgonians		

The Climate Risk Assessment carried out for SL29 shows that with the Nature-based solution **ON**, under the Global Sustainability Scenario , the six taxa evaluated are at moderate risk during both time slices (Figure 9). In National Enterprise and World Markets, *Epinephelus marginatus* and Coralline algae increase their risk to high in 2040 and 2080, while Cystoseira and the Gorgonians only increase to high risk during 2080. *Posidonia oceanica* estimated risk is moderate in all scenarios and time slices except for NE2080, when it rises to high.

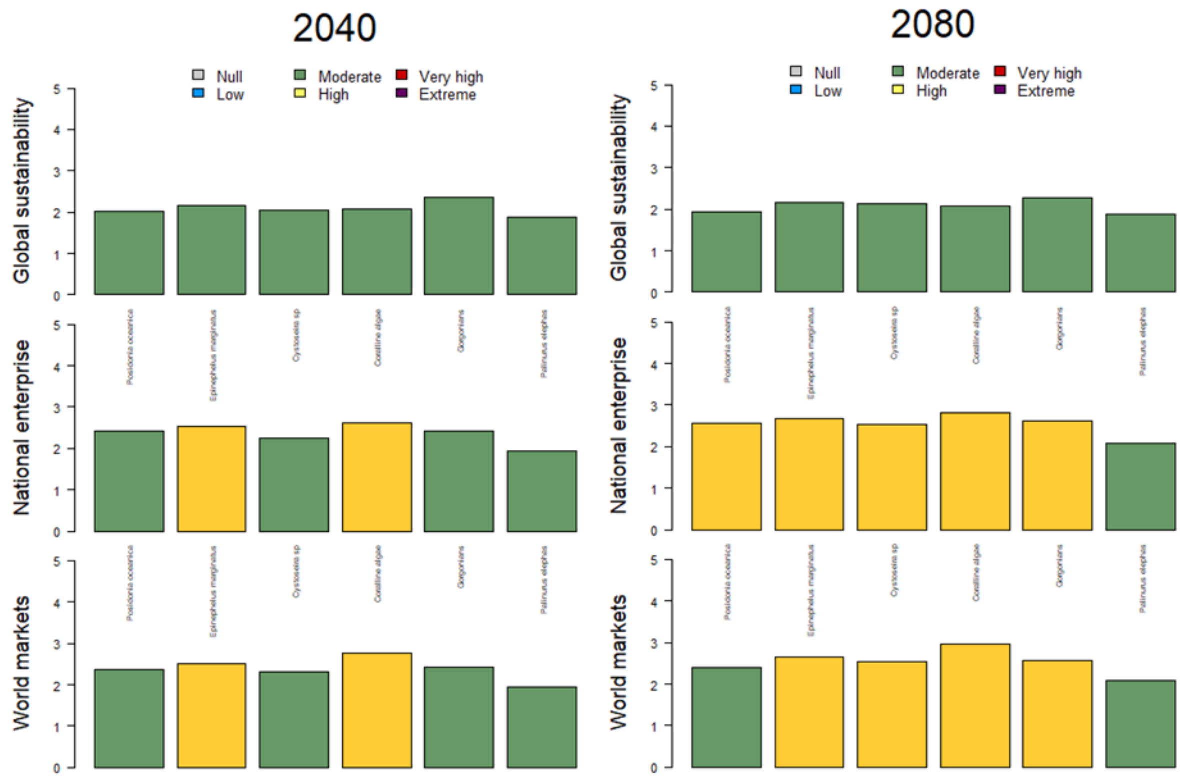

Figure 9. *Overall climate risk (NBS ON) assessed for the six taxa of SL 29 under the 3 scenarios and 2 time slices.*

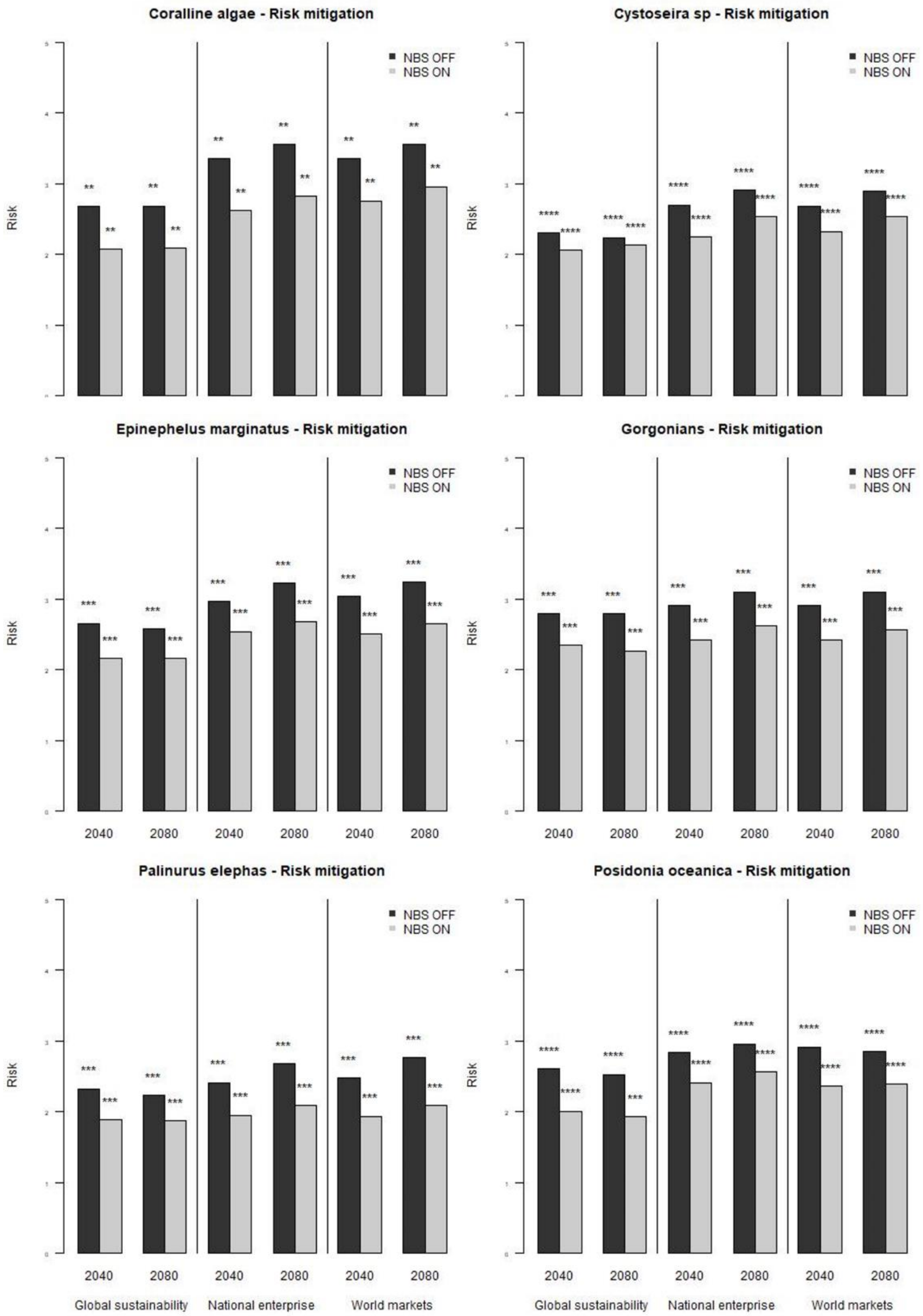

Figure 10. *Overall climate risk assessed for Corallina (top left), Cystoseira sp (top right), Epinephelus marginatus (middle left), Gorgonians (middle right), Palinurus elephas (bottom left) and Posidonia oceanica (bottom right) for story for SL 29 and the 3 scenarios, 2 time slices and 2 NBS states.*

As we observe in Figure 10, the NBS2 conservation of habitat-forming macroalgae and corals community has only positive (decrease) effects on the overall risks for all taxa and all scenarios and time-slices, therefore mitigating the risks under the different scenarios for all the species of study. All taxa show similar level of risk but slightly lower for Cystoseira and *P. elephas*. NBS have generally pronounced effects for each taxa and each scenarios but the lowest effects are shown for Cystoseira mostly because of the combined effects of NBS on Sensitivity and Adaptive Capacity.

T.5.2. Ecosystem Services Climate Risk Assessments

Task 5.2 is focused on the risk of specific ecosystem services (ES). We addressed the effect of NBS2 conservation of macroalgae and corals and a subset of their associated communities against five hazards (3 climate & 2 human) in the Western Mediterranean on three ES, one provisioning service, one regulating and one cultural. Specifically, SL29 focused on the provision of wild animals used for the production of food, the regulation of the chemical composition of the atmosphere and the oceans and on active interactions with the environment such as diving. A total of 8 experts participated in the ES CRA.

NBS2 conservation of habitat-forming macroalgae and corals community has only positive (decrease) effects on the overall risks for Ecosystem Services dependent from them for all scenarios and time-slices (Figure 11). All ES show similar levels of risk with the implementation of the NBS but they are slightly lower for the production of wild animals for food consumption. The magnitude of the mitigation of risk is greater for the provision of opportunities for active interactions with the environment.

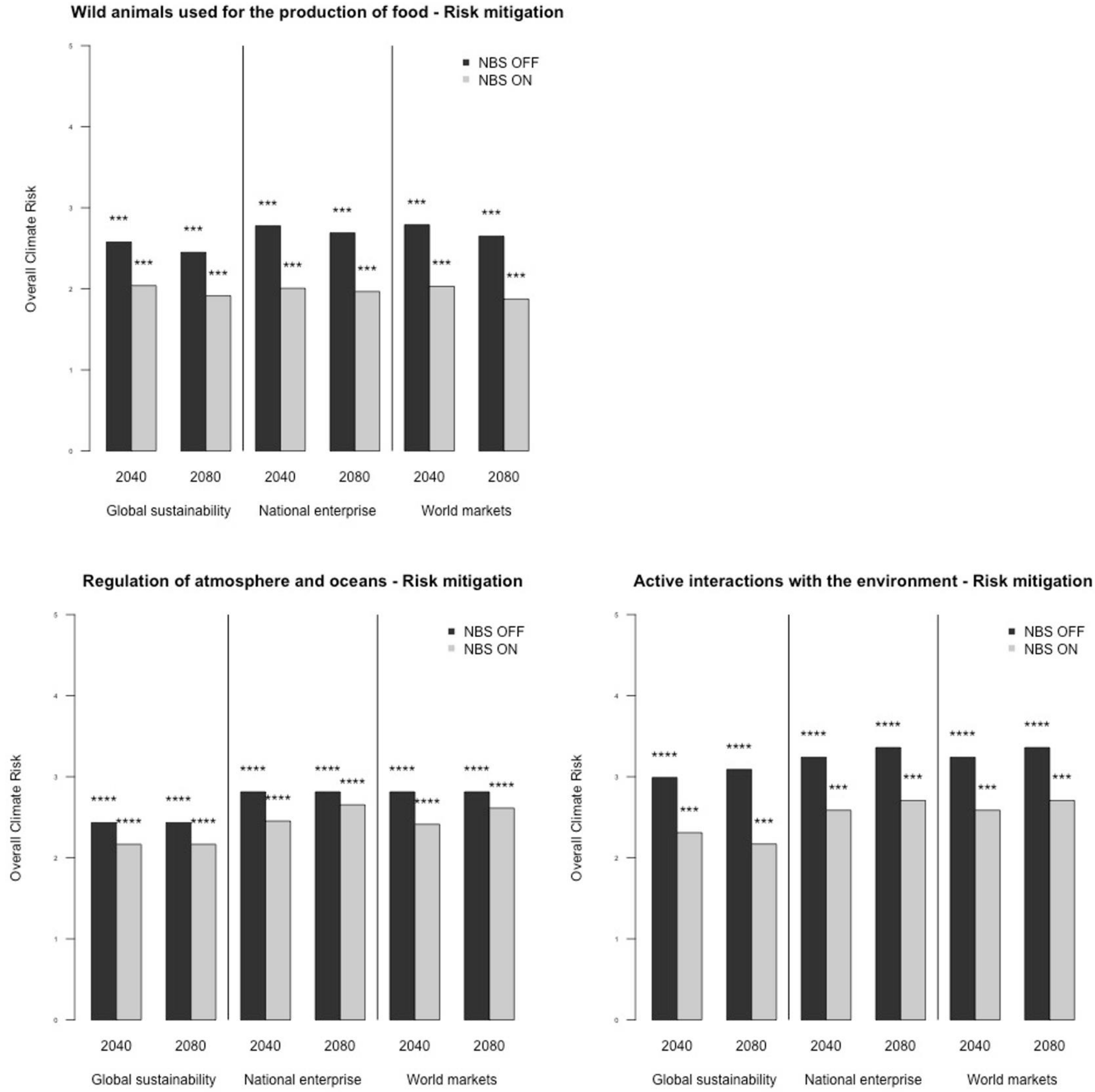

***Figure 11**. Overall climate risk assessed for the use of Wild animals in the production of food (top left), Regulation of the chemical composition of the atmosphere and the oceans (bottom left) and Active interactions with the environment (bottom right) for story for SL 29 and the 3 scenarios, 2 time slices and 2 NBS states.*

T.5.3. Social-Ecological Climate Risk Assessment

We identified several social groups of our storyline but unfortunately, we did not get responses on time from them, so our storyline finally did not contribute to this part.

T.7.1 report provides project participants with the knowledge they require to a) put the work of FutureMARES in a wider policy context; b) identify entry points to embed the work of FutureMARES in the most relevant stages of International Policy (e.g., policy formation, implementation and monitoring and evaluation).

One of the contributions of FutureMARES research has been providing the knowledge on the ability of marine ecosystems to contribute to climate change mitigation and adaptation. In SL29 we focused in the role of MPAs as nature based solutions to contribute to climate change adaptation and mitigation. In this topic we generate new knowledge to better evaluate the vulnerability of MPAs in the Catalan coast to climate change focusing on macroalgal and coralligenous habitats. From these evidences we support the development of adaptation action plans in the Catalan coast. We established regular contacts with the regional and national administrations in view to include some of the recommendations and activities to promote MPAs as effective tools to face climate change. In fact, some of the proposed recommendations have been adopted in the management plan of the Parc Natrual del Cap de Creus and there is a proposal to establish a network to monitor climate change indicators in all protected areas under the responsibility of the regional government of Catalonia Generalitat de Catalunya. Likewise, the lessons learnt from experience have been shared to wider group of stakeholders mainly at Mediterranean level such UN Mediterranean Action Plan, Union for the Mediterranean and Medpan network of Mediterranean MPA managers. For instance in 2021 we organized a MPAs and Climate Change session at the Mediterranean MPA Forum held every 4 years dedicated to establish the roadmap for the Mediterranean MPA networks, in the same line in 2022 we participated in two sessions within the UN Climate COP27 in the Mediterranean Pavilion.

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