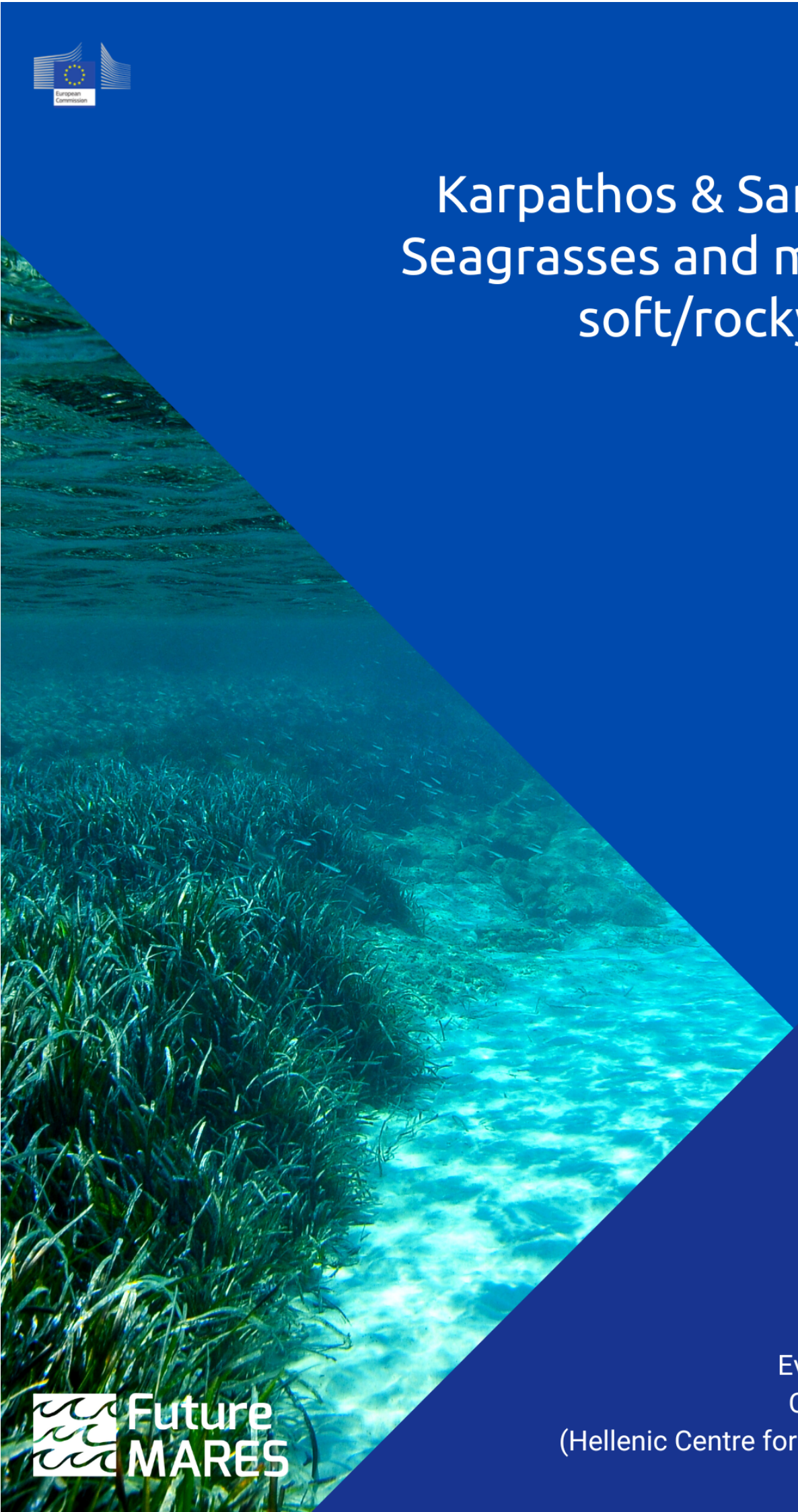
Karpathos & Saria MPAs: Seagrasses and meadows, soft/rocky bottom

Storyline 27



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Introduction

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. FutureMARES will 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 multi-disciplinary summary of activities conducted in FutureMARES in a specific area on specific NBS and/or NIH. The activities include work across various disciplines including 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, social-ecological risk assessments. Many of these components and analyses, including NBS / NIH scenarios tested, were co-developed with local and regional stakeholders through regular engagement activities. The work presented in these Storylines 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 (www.futuremares.eu) submitted to the European Commission.

NBS regional context

The Northern Karpathos and Saria MPA is located in the Dodecanese islands (Greece), Eastern Mediterranean Sea, and covers an area of about 154 km^2. Saria is a small island separated from Karpathos by a narrow sea strait less than 100 m wide. The MPA is included in the list of Natura2000 sites (GR4210003) and hosts a rich biodiversity and many endemic species (flora and fauna, including birds). Populations of several charismatic marine species such as the Mediterranean monk seal (*Monachusmonachus*), the dolphin *Tursiops truncatus*and the marine turtles *Caretta caretta* and *Chelonia mydas* are present in the MPA. Tristomo Bay is an enclosed highly productive fishing area in the MPA with extensive *Posidonia oceanica* and *Cymodocea nodosa* meadows surrounded by hard substrate. The bay hosts thriving populations of the bivalves *Arca noae*and *Pinna nobilis*. The area has a significant archaeological value due to the 7th-10th century AC settlements that are present, while the Ephorate of Underwater Antiquities performs field research as there are remains which are yet to be studied. The Management Agency of Dodecanese Protected Areas (formerly Management Agency of Karpathos-Saria) was established in 2002, and its primary objective is the management, protection and conservation of the species and habitats of the MPA.

P. oceanica is spread around the coasts of Karpathos and Saria. The meadows are healthy, existing for about a decade, hosting rich populations of invertebrates. Although the number of non-native species, such as *Caulerpa taxifolia* and *Halophila stipulacea,* are increasing in the area, *P. oceanica* has been proven so far, a good competitor maintaining the ecosystem balance. These habitats provide a range of services, such as: a) provisioning services (i.e. dead leaves can be used in industry and agriculture); b) regulation and maintaining services (i.e. seawater is purified by filtration, the leaves reduce water turbidity, offer shelter and nursing habitat, protect the seabed from erosion and support nutrient cycling and oxygenation; and c) cultural services (preservation of the underwater cultural heritage, diving tourism, marine environmental education).

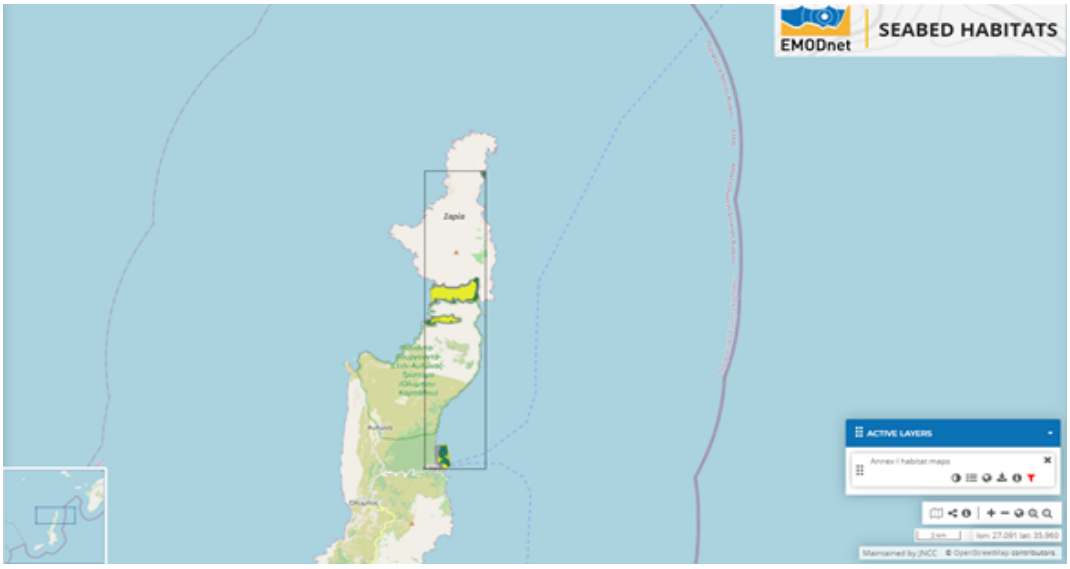


Figure 1: Map of the northern Karpathos and Saria MPA (Greece).
Credit: EMODnet Seabed Habitats Map Viewer (map GR789365)

Figure 2: *Posidonia oceanica* and *Cymodocea nodosa* meadows in northern Karpathos and Saria MPA (Greece).
Credit: Georgios Chatzigeorgiou - Hellenic Centre for Marine Research (HCMR), IMBBC

Figure 3: The critically endangered bivalve *Pinna nobilis* in northern Karpathos and Saria MPA (Greece). Credit: Georgios Chatzigeorgiou - Hellenic Centre for Marine Research (HCMR), IMBBC

Projected impacts of climate change

Climate change may impact in different ways the seagrass meadows of the *Posidonia oceanica* and the associated benthic assemblages at the MPA of northern Karpathos and Saria.

Firstly, the region is close to the Suez Canal, which is the main point of entrance for invasive alien species (IAS) in the Mediterranean [1]. Thus, the islands of Karpathos and Saria are characterized by the high prevalence of marine IAS, which form dense populations. Examples of such IAS are the seaweed *Halophila stipulacea*, the lionfish (*Pterois miles*) and the invasive long-spined sea urchin (*Diademasetosum*). *H. stipulacea* does not seem to compete with *P. oceanica* since the two species are ecologically very different; however, the temperature increase poses a potential threat at the naturally occurring meadows of *P. oceanica* which, in turn, could be substituted by *H. stipulacea*, one of the “100 Worst Invasive Alien Species in the Mediterranean” [2]. Despite the capability of *P. oceanica* plants to acclimate to temperature changes, it has been predicted that even under a relatively mild greenhouse-gas emissions scenario, this species might face functional extinction by the middle of this century [3].

In addition, changes in the sea currents imposed by climate change may impact the gene flow and connectivity of the *P. oceanica* meadows with other meadows in the Eastern Mediterranean, since population connectivity is strongly influenced by environmental factors such as oceanic currents, depth profiles, changing water flows and gyres [4].

Furthermore, Tristomo gulf is a naturally occurring semi-enclosed gulf in the region, protected by sea waves, that may act as a climate refugium in terms of warming for several species; it is considered as the most important marine site in Karpathos [5]. There is also very limited anthropogenic activity in Tristomo gulf, therefore it can act as a hotspot for preservation and conservation of several marine species, from schools of fish to the critically endangered noble pen shell (*Pinna nobilis*) and the Noah's Ark shell (*Arca noae*).

Figure 4: Thriving populations of the invasive lionfish (*Pterois miles*) in northern Karpathos and Saria MPA.
Credit: Georgios Chatzigeorgiou - Hellenic Centre for Marine Research (HCMR), IMBBC

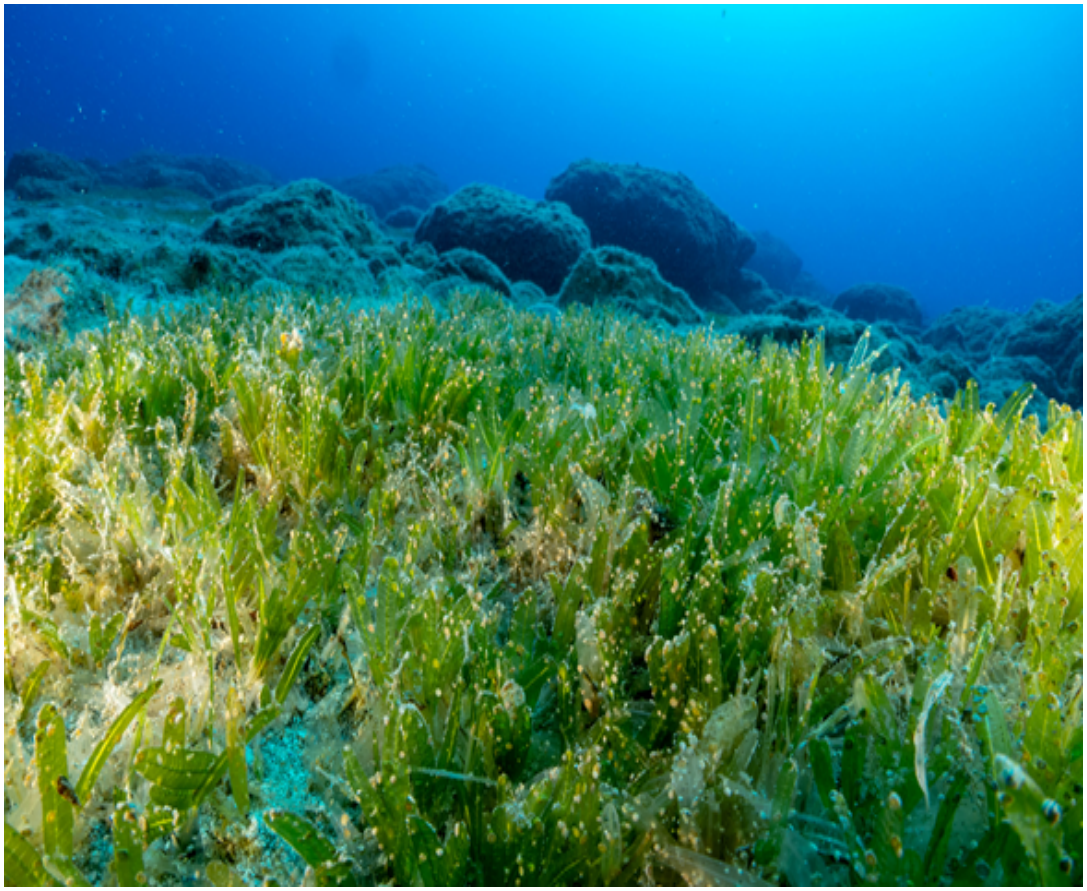
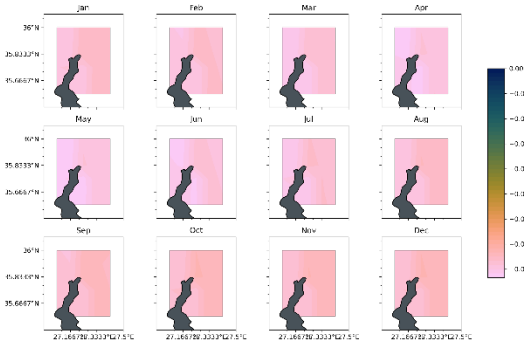
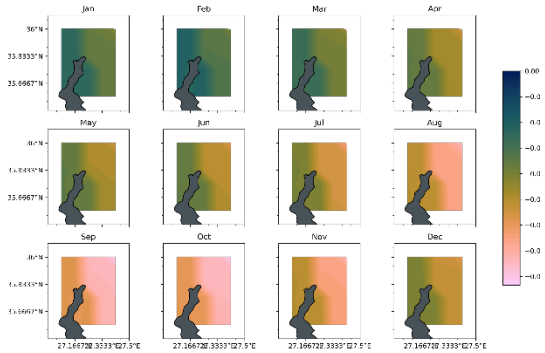


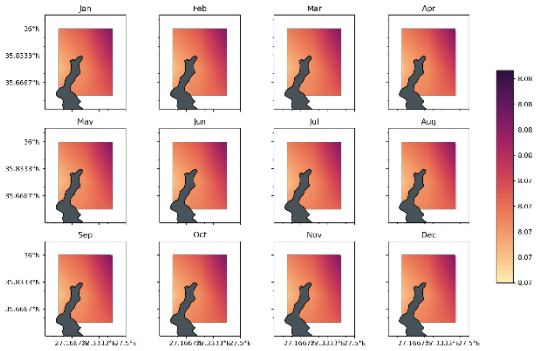
Figure 5: Meadows of the invasive *Halophila stipulacea*in northern Karpathos and Saria MPA.
Credit: Georgios Chatzigeorgiou - Hellenic Centre for Marine Research (HCMR), IMBBC



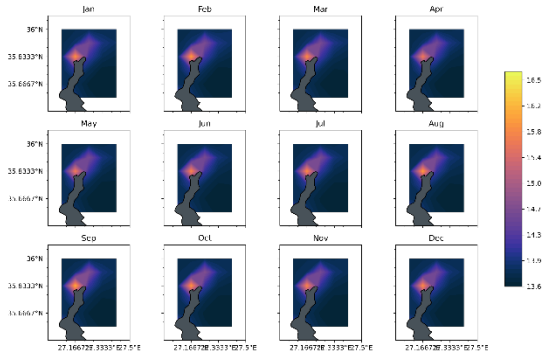
pH changes in the near future at seafloor under scenario SSP5-8.5



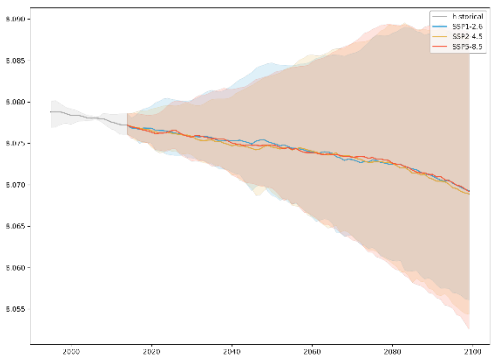
Potential Temperature (in degrees C) changes in the near future at seafloor under scenario SSP5-8.5



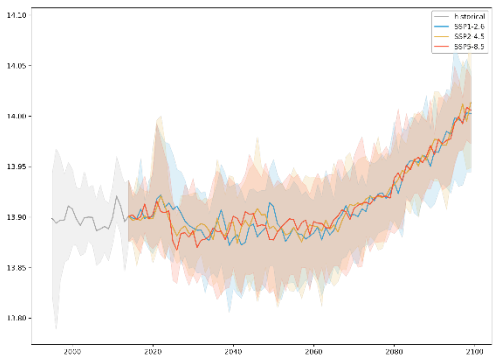
pH at seafloor under present day conditions



Potential Temperature (in degrees C) at seafloor under present day conditions



pH [1] at seafloor



Potential Temperature (in degrees C) at seafloor

Figure 6: Climate projections for the northern Karpathos and Saria MPA. The figures were produced using trend preserving statistical downscaling (Lange, 2019) of a multi-model ensemble Earth System Model historical simulations and future projections from the CMIP6 archive trained on reanalysis datasets from the Copernicus Marine Environment Monitoring Service.

Geographical Maps were extracted from the full dataset by averaging over the following periods, consistent with the periods considered in the IPCC AR6 WG1 report:

- present day: 1995-2014
- near future: 2021-2040
- mid future: 2041-2060
- far future: 2080-2099

Time-series plots were produced averaging over the area of interest for each storyline and show the ensemble mean in the full lines and the range of model responses in the shaded areas as represented by the 2.5 and 97.5 percentiles of the ensemble. Credit: Momme Butenschön, Euro-Mediterranean Center on Climate Change.

Scenarios describing future society and economy

FutureMARES will develop policy-relevant scenarios with stakeholders across the world. These scenarios are based on commonly used IPCC frameworks including SSPs and RCPs.

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. Societies increasingly commit to achieving development goals and this reduces inequality across and within countries. Consumption is oriented toward lower material growth, resource and energy intensity.

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. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialised countries and high in developing ones. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.

Figure 7: Representation of three, broad scenarios to be regionalised to guide activities such as model simulations in FutureMARES project. Credit: FutureMARES

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. Global markets become more integrated and strong investments in health, education, and institutions are made to enhance human and social capital. 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. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary.

FutureMARES research needs

Research needs to continue to understand the magnitude and interaction between various threats facing the Dodecanese (eastern Greece) to better plan how management goals and actions for the Marine Protected Area. Critical threats are those from climate change and marine invasive species (this area is an entry point for the latter). Specific environmental pressures include temperature increase, acidification, local heavy rainfalls, sea level rise and turbidity increase.

A better understanding of the role of the area in connectivity of protected species is also needed. Several key habitats and protected species, such as *Posidonia oceanica* meadows and *Pinna nobilis* populations, which are important for genetic connectivity between areas and for the provision of ecosystem services, are present in this Eastern Mediterranean area.

At the same time, needs and conflicts between different users in the area (i.e. fishing, tourism, conservation) need to be understood and taken into consideration before implementing any management plan. The NBS2 approach (Effective Conservation) could benefit the parallel implementation of conservation and economic activities (i.e. fishing and eco-tourism) that need to be combined in a sustainable way. The Risk Assessment can be used for planning concrete adaptation measures at local level focusing on the restoration and conservation of the Storyline area.

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

- **T1.1** Biodiversity data for macrobenthos, macroalgae and macrophytes for Karpathos area (#27), as well as environmental data, are available for 2018;
- **T1.2** Biological traits data for macrobenthos, macroalgae and macrophytes species are available (or under preparation in some cases);
- **T1.3** Collect ecosystem indicators for the MPA;
- T1.4 Engage stakeholders to regionalise narratives for the PESTLE scenarios;
- Tasks 2.1, 2.2 and 2.3: Provide physical and biogeochemical projections of the effects of climate change including uncertainty and the potential locations of climate hot spots or refugia;
- **T3.1** In situ experiments will be implemented outside the Storyline area but in similar habitats (barren vs vegetated) with different gradients of CC impacts (e.g. local temperature, invasive species populations);

- **T3.3** Genetic connectivity data on *Posidonia oceanica* micro-satellites are available. Sea urchin samples from Greece will be provided for additional genetic analysis. Information on currents and bathymetry will be contributed for the larval dispersion model;
- **T4.1/4.4** Data on *P. oceanica*(presence/absence, density, growth) are available. Also, data on rock presence/absence are available from habitat mapping;
- **T5.1**: A Climate Risk Assessment (CRA) will be implemented. A Risk Implementation Plan has been already provided.
- **T6.1, 6.2 and 6.3** data will be provided as requested.
- **T7.1** Direct engagement with MPA managers for exploitation of FutureMARES knowledge and products;
- **T8.1** Identification of involved stakeholders has been provided and their engagement will be performed during the project.

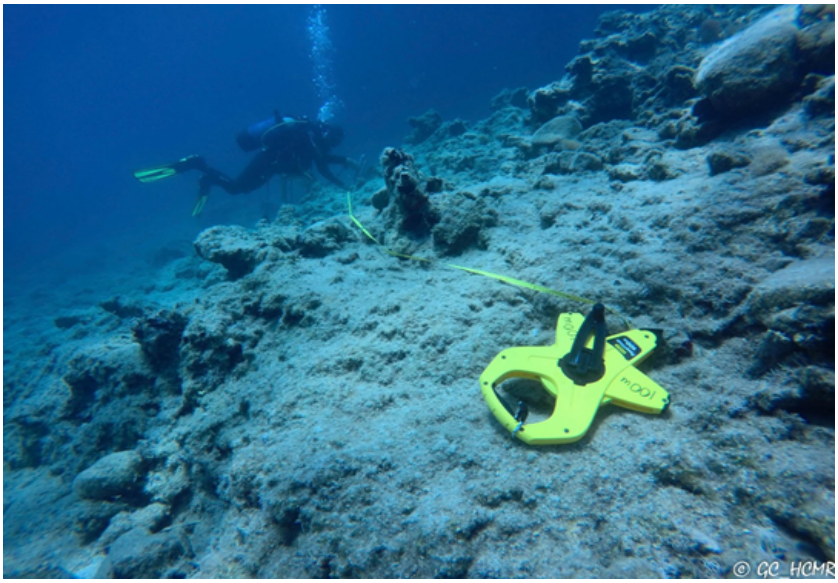


Figure 8: Scientific diving in action in the northern Karpathos and Saria MPA.
Credit: Georgios Chatzigeorgiou - Hellenic Centre for Marine Research (HCMR), IMBBC

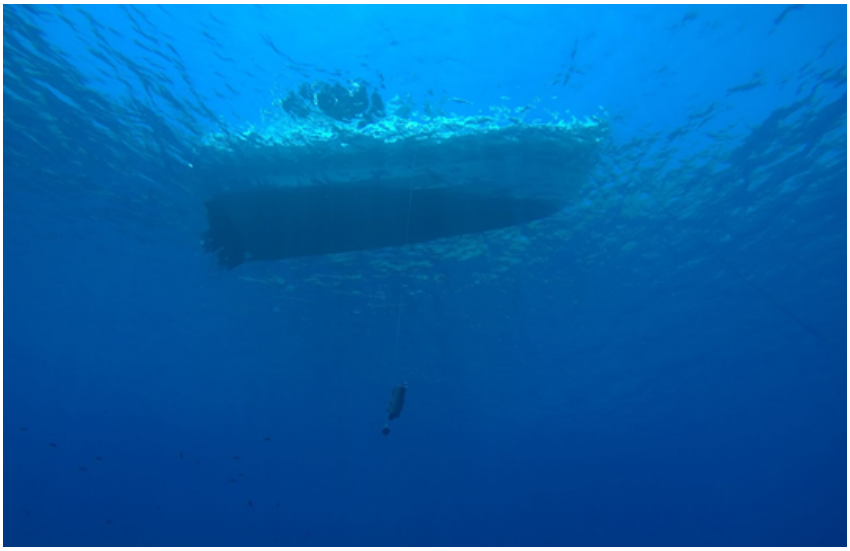


Figure 9: A Niskin bottle is used to collect seawater samples for measuring nutrients.
Credit: Georgios Chatzigeorgiou - Hellenic Centre for Marine Research (HCMR), IMBBC

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References

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