POSBEMED2

Governance and management of Posidonia beach-dune systems accross the Mediterranean

A review of lessons learnt

Project co-financed by the European Regional Development Fund

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*General Directorate of Protected Areas and Biodiversity of the Regional Government of the Balearic Islands is not funded by ERDF funds

Posidonia beach-dune systems

Coastal zones are among the most productive areas in the world, offering a wide variety of valuable habitats and ecosystems services that have always attracted humans and human activities. Due to their beauty and richness, coastal populations have grown as well as their popularity as tourist destinations, major commercial zones and transit points. Nonetheless, this high concentration of population and excessive exploitation of natural resources places enormous pressure on our coastal ecosystems leading to biodiversity loss, habitat destruction, pollution, as well as conflicts between potential uses and space congestion problems.

Coastal zones are home to relatively fragile ecosystems, and unplanned urbanization, infrastructure expansion, and unrestrained commercial, recreational, and agricultural activities can quickly degrade coastal habitats and resources. In numerous European nations, increasing strain on the coastal zone environment has led to a sharp reduction in open spaces and natural sites as well as a shortage of room to support coastal activities without significantly negative consequences. Coastal zones are also among the most vulnerable areas to natural hazards and climate change. Risks include flooding, erosion, sea level rise as well as extreme weather events. These effects are far reaching and are already changing the lives and livelihoods of coastal communities.

Coastal zones are among the most vulnerable areas to natural hazards and climate change.

The Mediterranean coastal regions are densely populated and environmentally vulnerable. The population in these coastal regions is about 150 million, which serves to show that one third of the population of the countries resides in 15 % of the area (European Environment Agency, 2014). At the same time, they are subject to increasing pressures from several sources, including industrial development, urban expansion, the exploitation of marine resources and tourism.

Tourism and recreation connected with "sea, sun and sand" are recognized as an integral part of industrialised and developing countries, as well as a significant contribution to economic growth. However, tourism has been shown to have an adverse pressure on the environment. During the summer tourist season, the population of many of the Mediterranean's largest resorts more than doubles, and local governments struggle to provide the necessary resources. Yet, tourism has a significant detrimental influence on the ecosystem. Unsustainable tourism may place a great deal of strain on a region and have negative effects including soil erosion, increased pollution, discharges into the sea, loss of natural habitat, greater pressure on endangered species, and increased susceptibility to forest fires.

Environmental deterioration and changes in coastal regions have a direct impact on their ability to offer environmental services such as acting as a buffer against erosion and storms, as well as providing outdoor recreation and food supplies. At the same time, tourism-dependent economies suffering from such environmental degradation and the resulting decline in tourism, causes losses in government revenues and income to local communities and businesses, gradually worsening conditions at the destination level.

There is thus an urgent need for an integrated approach that brings together the conflicting demands of society for products and services, taking into account both current and future interests. The aim is to generate economically, socially and ecologically acceptable policies for coastal and marine management.

The POSBEMED2 project, dealing with the aspect of the presence of *Posidonia oceanica* in Mediterranean coastal areas, aims to establish an appropriate and effective framework for the protection and sustainable management of the Posidonia littoral zone by taking into account scientifically based conservation objectives, the challenges and opportunities, the current state of international management regulations and practices, as well as stakeholder perceptions and expectations with the overarching goal of balancing environmental, economic, social, cultural and recreational objectives, all within the limits set by natural dynamics.

The Mediterranean endemic plant *Posidonia oceanica*, commonly known as Neptune grass, is a very selective species that requires transparent and clean waters, while at the same time, it is very sensitive to pollution and other pressures. It is a marine plant that forms remarkable underwater meadows, also known as beds or prairies, whose presence is an indicator of ecosystem health and water quality.
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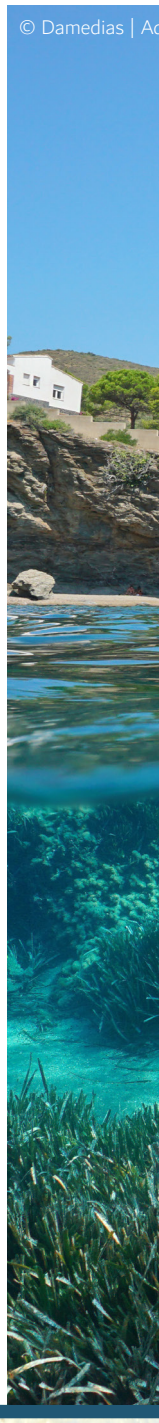
Posidonia meadows are one of the richest and most valuable ecosystems in the Mediterranean. Among others, they provide food and shelter to marine life, acting as a natural water filtration system that traps particles and pathogenic microorganisms. Posidonia meadows also reduce swell and wave strength, resulting in enhanced sand deposition, beach progradation, and hence protection of beaches from erosion. Because of their essential functions, but also of the threats they face, Posidonia meadows are designated as a priority habitat type for conservation under the EU Habitats Directive (92/43/EEC).

In addition, one of the most important features of this seagrass is that it forms in the lower part of the meadows, a structure called "matte", consisting of interlaced remnants of roots, rhizomes and entangled sediments. It has been reported that nearly 50% of the carbon buried in marine sediments around the world is stored inside the matte. Their ability to remove carbon dioxide (CO2) from the atmosphere means that "mattes" are considered to be excellent carbon sinks, and therefore their conservation represents a valid strategy to combat climate change.

As a flowering plant, *Posidonia oceanica* regularly sheds its leaves and other parts, some of which wash ashore with waves and currents.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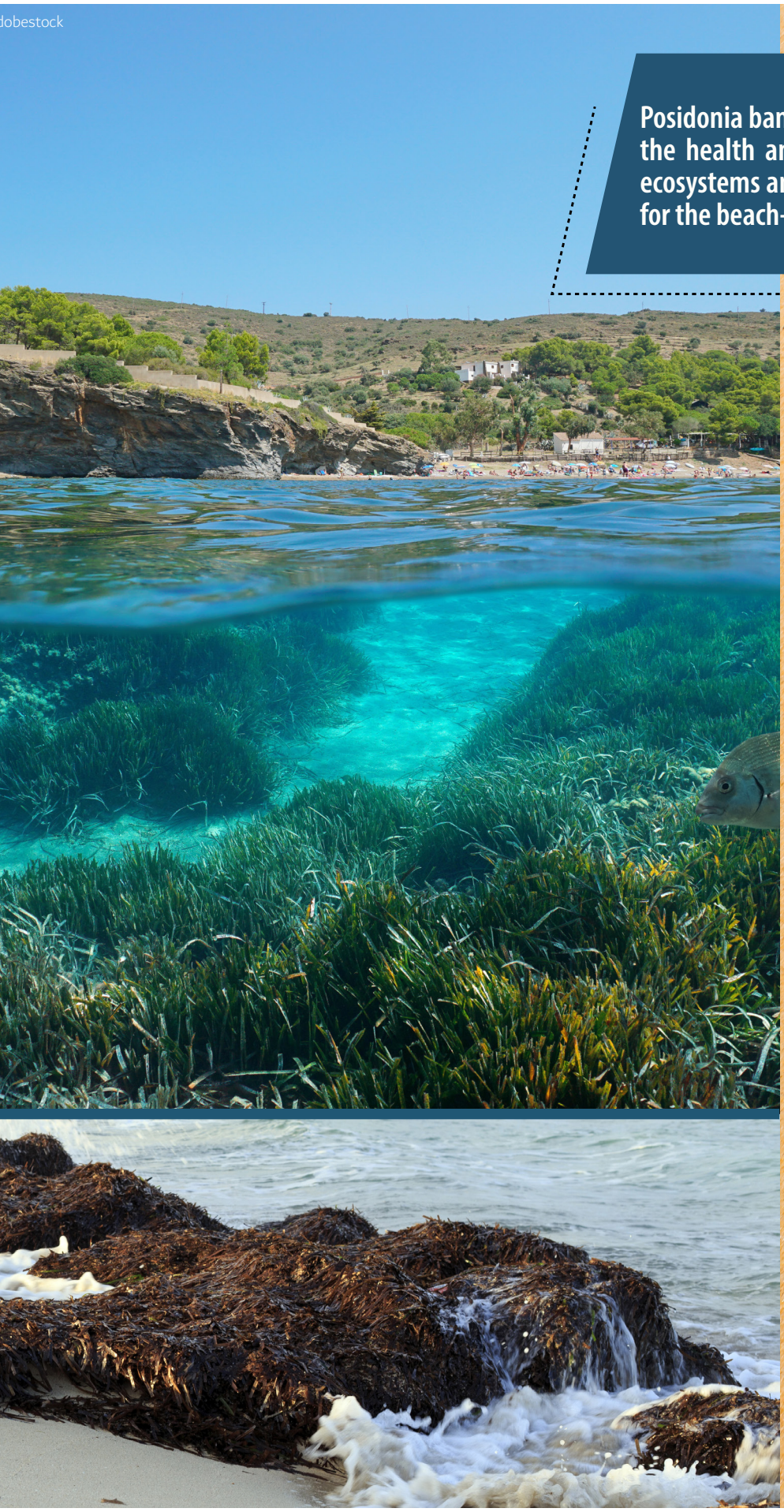

Posidonia banquettes contribute to the health and balance of coastal ecosystems and are a vital element for the beach-dune system.

The accumulated material on the beaches and coastal shoreline is mixed with sand, usually forming a strip that runs parallel to the water's edge. On sandy shores, these wrack deposits can vary from relatively thin and sparse sheets (seagrass beach-cast) to extensive piles several meters thick, forming wedge-shaped structures commonly known as "banquettes".

Posidonia banquettes contribute to the health and balance of coastal ecosystems and are a vital element for the beach-dune system, as they protect the coasts from erosion, form and stabilize beaches and dunes, fertilize and moisten the coastal and dune vegetation and create a unique habitat that supports biodiversity.

Dune habitats occur mainly in coastal areas and consist of sand dunes that host a wide variety of plant species and provide shelter for a number of organisms, many of which are of unique ecological importance. The dune vegetation, which retains the sand, stabilizes the coastline against the corrosive action of the sea and wind, and acts as a natural filter and flood barrier for salt water.

Posidonia meadows, sandy beaches and associated coastal dunes are valuable natural assets that have outstanding ecological, socioeconomic and cultural value, as well as important roles in providing a diversity of ecosystem services linked to the nutrient and energy exchange in the coastal landscape. The lack of awareness regarding the threats this species faces, as well as its vital role in supplying a variety of ecosystem services to the coastal landscape, causes substantial conservation concerns. Aside from direct anthropogenic impacts, global climate change is already affecting coastal systems and is likely to have severe, widespread and long-term implications.

While climate and other global impacts require international actions, regional management practices may help reduce local effects. Over the last decades, following increased coastal urbanisation and industrialisation, many Posidonia meadows have disappeared or have been altered. It is estimated that 46% of the underwater meadows in the Mediterranean have experienced some reduction in range, density and/or coverage, and 20% have severely regressed since the 1970s. Current main threats to the habitat are related to: (a) water and sediment enrichment (eutrophication), (b) the disruption of the sedimentation / erosion balance along the coast and direct destruction by human modifications of the coastline, (c) degradation by boat trawling and anchoring, (d) salinity increase in the vicinity of water desalination facilities and (e) the proliferation of invasive algal species.


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At the same time, surveys conducted in the context of the POSBEMED project (2016-2018) in Cyprus, Greece, Italy, France and Spain revealed that as much as 83% of coastal municipalities remove Posidonia banquettes and washed-up seagrass remnants on some, or all of the beaches where they are present. In most cases, removal operations involve heavy (44%) or light (40%) machinery, a practice that has been identified as a major factor behind the loss of sediment and which ultimately compromises the integrity of the coastal habitats. Coastal sand dune loss across the Mediterranean has also been significant, with nearly 80% of area loss in some Mediterranean countries during the last century.

The assemblage of near-shore Posidonia meadows, beaches with banquette formation and associated dunes, collectively referred to as the "Posidonia littoral zone", represents a significant, neglected, and threatened ecological system whose importance is, with rare exceptions, poorly appreciated.

Climate change is known to have adverse impacts on the beach-dune systems, including their increasing susceptibility to coastal erosion, shoreline retreat and withdrawal of the lower limit of Posidonia meadows in bays and saltwater intrusion. Human constructions have reduced natural wave buffering zones in many of these places and interfere with longshore sediment transport, making urban beaches particularly vulnerable.

Healthy and stable Posidonia littoral zones play a significant role in decreasing storm forces but are also influenced by all of these effects and stresses. Maintaining healthy meadows promotes the supply of cast material for beaches, which, along with well-vegetated dunes, provide the best protection and adaptation against rising sea levels, coastal erosion and storm surge occurrences, especially when coasts retreat in response to rising sea levels.

Clearly, we are at a tipping point, at which prioritization for the conservation of species and habitat types will only be effective if accompanied by specific actions.

Indeed, there is an increasing demand among many Mediterranean coastal municipalities and stakeholders, for more sustainable and economically viable solutions for the long-term management of Posidonia banquettes. Thus, the adoption of conservation policies and management strategies that seek better ways of managing the Mediterranean coastal landscape and decreasing impacts is essential.

Actions to protect, sustainably manage and restore the Posidonia littoral zone that are rooted in nature-based solutions, using nature and the natural functions of healthy ecosystems, will benefit not only the coastal environment but also provide many economic and social benefits.


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The recommended approach promotes soft interventions that support the natural processes of the Posidonia beach-dune system, increase the resilience of the coastline and contribute to climate change mitigation and adaptation.

Sustainable solutions for the long-term management of Posidonia banquettes

Since Posidonia banquettes trap large amounts of sand and absorb sea wave energy during storms and strong winds, cleaning operations and the consequent complete removal of Posidonia banquettes and remnants of washed-up seagrass, result in the extraction of sediment from the beaches and a deficit in the sedimentary budget of coastal system, which in turn trigger coastal erosion.

Such scenarios also affect biodiversity and sand dune vegetation, due to the fact Posidonia banquettes form structural habitats that enhance the abundance of beach and play an important role in the continuous formation of dunes and backshore vegetation.

On the other hand, the presence of Posidonia banquettes and washed-up seagrass remnants can contribute not only to the protection of the beach but also to the creation of new dunes. In addition, the vegetated, stable sand dunes can also contribute to the stability of the coastal systems.

Furthermore, Posidonia banquettes and washed-up seagrass remnants can contribute to the nitrogen nutrient requirements of dune vegetation and can be a considerable source of calcium carbonate to both the beach and its surrounding ecosystem. This is particularly important in Mediterranean regions without rivers or with low fluxes of particulate matter from land to the sea, where the supply of sedimentary particles on the shore is mostly of biogenic origin (animal skeletons, coral, foraminifera, calcareous remains of benthic algae and shell fragments) or as the result of coastal erosion.

The removal operations of local authorities employing heavy machinery such as bulldozers and excavators are carried out often to meet the demands of the tourism sector for pristine, sandy beaches. The subsequent sediment loss has an influence on littoral stability and may enable erosive processes on beaches subjected to high hydrodynamic pressure.

Building further on the principles and elements for integrated coastal management, the recommended approach promotes soft interventions that support the natural processes of the Posidonia beach-dune system, increase the resilience of the coastline and contribute to climate change mitigation and adaptation. Overall, the best option is that Posidonia banquettes and washed-up seagrass remnants are left in place in the coastal environment. Their presence on the beach has an important role in protecting and stabilizing the coastline and coastal dunes, boosting biodiversity and preventing sand erosion during the winter. In cases where the removal of banquettes is deemed truly necessary, the least disruptive removal methods available should always be used.

This includes avoiding the use of heavy machinery, limiting the pressure asserted on the beach and shoreline, as well as assuring the sufficient know-how of the entities responsible for carrying out the removal operations. It is also recommended that a protocol for removal operations as well as for the return of the material is established, in order to minimize the impact of operations, as a part of the beach management plan, following the local and national regulations. In addition, management approaches should take into account the factors that influence the natural dynamics of the entire Posidonia system, including dunes, as well as the presence of potentially sensitive areas nearby. Furthermore, it is important to consider the pressures caused by beach goers and leverage the opportunities to build capacity and raise awareness on the significance of this endemic species among the tourism sectors.

All in all, this kind of approach may contribute to the protection of the coastline against erosion processes and to the stability of substrates behind the fore-dunes, while at the same time can play a critical role in ensuring the stability, sustainability, and longevity of Mediterranean coastal livelihoods.

Lessons learnt from the governance and management of Posidonia beach-dune systems across the Mediterranean

The first phase of the project "Governance and management of Posidonia beach-dune systems across the Mediterranean" (POSBEMED) was carried from 2016 to 2018. The main objectives of project were (a) to identify and analyse the current management practices of Posidonia beach-dune systems as well as examine stakeholders' perception and expectations in Mediterranean countries and provide a socioeconomic evaluation synthesis of its ecosystem services, and (b) to propose a model of governance and a common strategy for the management of Posidonia beach-dune systems in the Mediterranean Natura 2000 sites and other coastal protected areas.

Beyond the findings regarding the percentage of coastal municipalities that remove Posidonia banquettes and washed-up seagrass remnants, POSBEMED project surveys also indicated that a large percentage of beach goers (44%) are unaware of the ecological role of banquettes in formation and maintenance of beaches as well as in preventing beach erosion. In addition, it was highlighted that the concept of a Posidonia-free beach corresponds more to stakeholders' and decision-makers' perceptions of what beach users would expect than to actual beach users' attitudes. Notably, 41% of the beach users would require the removal of banquettes, while the rest either have a positive attitude (26%) towards the presence of banquettes or are indifferent (33%). Despite a 41% unfavourable attitude among beachgoers, only 38% asked for total removal and disposal either during the summer (28%) or throughout the year (10%). At the same time, 88% of decision makers claim to plan beach operational procedures in response to visitor needs. When considering the above-mentioned findings and since local government administrations do not have a direct line of communication with tourists, it is reasonable to assume that their primary source of information about tourists' preferences and perceptions is based on tourism operators. Since the majority of tourism operators believe that the most significant disadvantage of onsite preservation of Posidonia banquettes is that it is unpleasant for tourists, 65% of them asked for permanent removal of the banquettes during the summer (46%) or throughout the year (19%). Finally, although the public seems to have a negative perception of banquettes on the beach and is unaware of their ecological importance, a great majority (74%) agreed that sufficient education and incentives might help changing attitudes and shifting mindsets.


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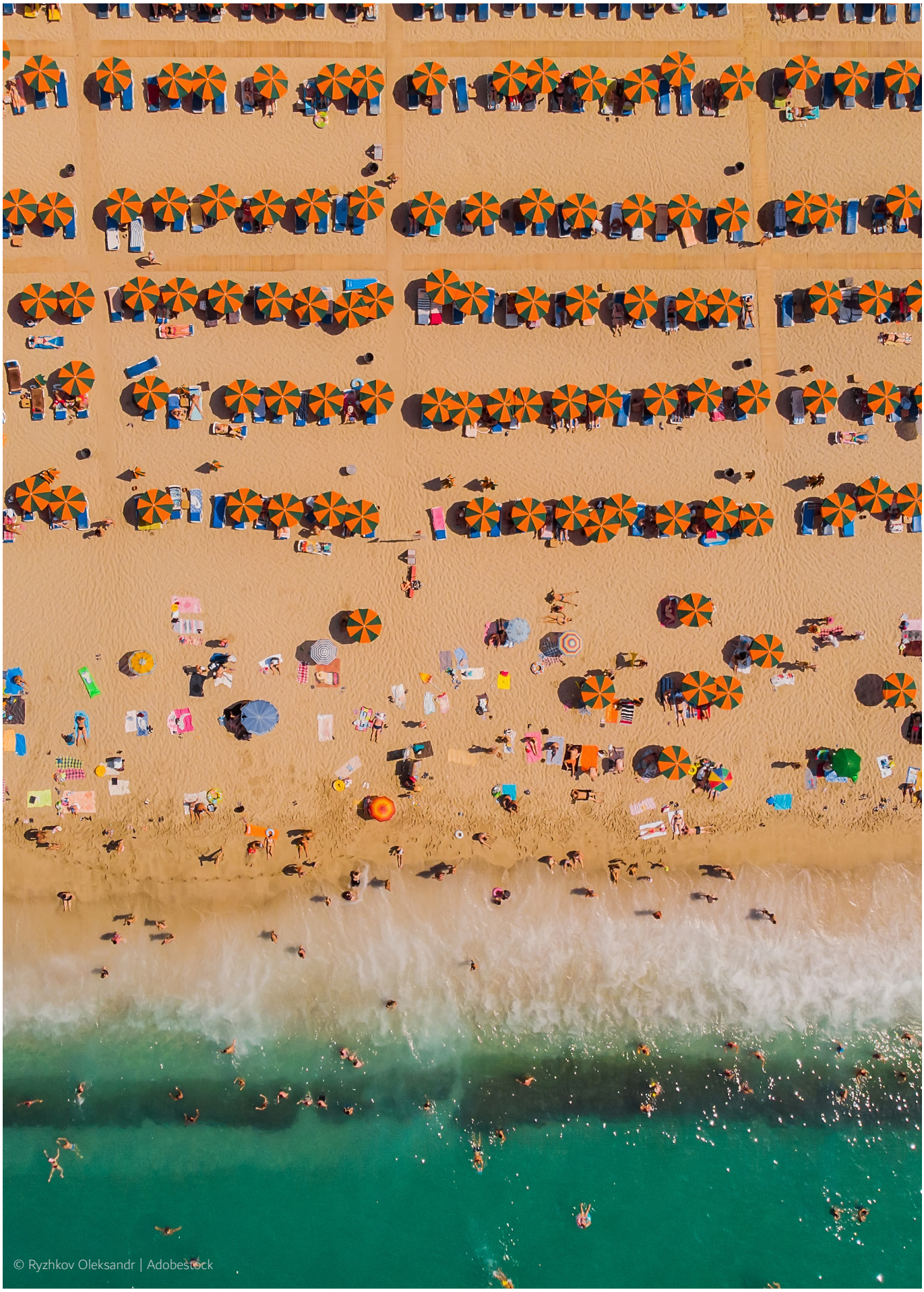

POSBEMED2 catalyses the results of the previous project in order to develop planning strategies that take into account the value of Posidonia beach-dune environments and to incorporate them into the overall Mediterranean coastal strategy, while also addressing concerns and educating stakeholders. It also fills in significant knowledge gaps by providing information that will help beach managers to make better decisions about adaptation, policy, planning and advocacy in Protected Areas. The project's primary goals are to raise awareness in order to garner support from stakeholders for more nature-oriented management strategies, and to develop better integration planning tools that can be incorporated into management planning and coastal regulations and policies.

The pilot actions in Spain, Italy, Croatia, Greece, and Cyprus were designed to evaluate the methodology and instruments for improving management plans and measures in Marine Protected Areas with *Posidonia oceanica*. The understanding gained through that process provides essential information for the protection and sustainable management of Posidonia beach-dune systems within a framework that takes into account scientifically based conservation objectives, the challenges and opportunities, the current state of international management regulations and practices, as well as stakeholder perceptions and expectations.

The pilot activities aimed at assessing the impact on the coastal environment and designing successful management strategies that take into account the overall beach-dune system as a whole. The pilot actions took into consideration the various steps of management planning, including the collection of information and data, planning (in its broadest sense), decision making, management and monitoring of implementation while focusing on the informed participation and cooperation of all stakeholders to assess the societal goals in each coastal area, and to take actions towards meeting these objectives.
The pilot actions were carried out at the following sites:

- Es Trenc-Salobrar de Campos Maritime-Terrestrial Natural Park, Balearic Islands, Spain.
- Spyros beach, Larnaka, Cyprus.
- Capo Carbonara Marine Protected Area, Sardinia, Italy.
- Sinis Mal di Ventre Marine Protected Area, Sardinia, Italy.
- Schinias – Marathon National Park, Attica, Greece.
- Potamos beach, Central Macedonia, Greece.
- Sakarun beach – island Dugi Otok, County of Zadar, Croatia.

Both the information gathered in these evaluations of the 7 pilot sites, as well as previous research, improved the knowledge regarding the spatial and temporal evolution of the dynamic procedures as well as the factors that determine how Posidonia banquettes are formed on the beaches. In addition, the analysis of the historical evolution of the coastline and dunes as well as the analysis of the scope and extension of seagrass meadows improved the level of understanding regarding of how different management interventions influence the coastal environment. Understanding how the entire sea-to-land systems evolved and how they currently function, enabled for the development of efficient management plans for each of the sites.


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The evaluation of the implementation sites revealed the main highlights regarding the function of Posidonia banquettes in minimizing the impacts of coastal erosion. Specifically, the management actions at Es Trenc-Salobrar de Campos Marine-Terrestrial Natural Park that until 2017, when the area was declared a natural park, included the yearly removal of Posidonia banquettes with the use of heavy machinery which resulted in a recession of 13.5 m on average throughout the park. However, some sections show larger erosion values than others, reaching up to 26 m in some areas. A nautical port was constructed in the late 1970s at the northern end of Es Trenc and it is in this area that an accumulation of banquettes and sand of 14.6 m has been registered, to the detriment of other areas that have experienced beach losses ranging from 15 to 26 m. The monitoring activities showed that the beach-dune system is highly dynamic and that the preservation of Posidonia banquettes on the beach plays an important role in creating net-positive sediment balances and decreasing the impacts of erosion on the coastline.

Similarly, the coastal front of Schinias – Marathon National Park presents an ongoing coastline setback from 1945 until recent years. The average change for the area where the largest changes were observed is a recession of 23.2 m, while the average change of the entire coastline is 15.3 m. Nonetheless, in the period 2018-2021, a rather remarkable shoreline accretion of 6-13 m has been observed, in sheer contrast to the generally high erosion rates characterizing this part of the coast. This coincided with regulations adopted in 2018 by the Management Authority, prohibiting the removal of Posidonia banquettes within the National Park boundaries. Thus, the shoreline accretion that was observed after the adoption of the non-removal strategy, underlined the important role of the beach casts in the conservation of the coastal area by demonstrating that removal compromises the integrity of the coastal habitats.

Despite the fact that both existing literature as well as management measures implemented in the rest of the sites demonstrate that onsite preservation of the banquettes plays a pivotal role in maintaining positive sediment balances, enhancing the positive balance associated with their sediment retention ability and mitigating coast erosion, engaging local stakeholders and beneficiaries in an alternative management approach may prove to be a challenging procedure.

At Sakarun beach, part of the process included a pilot implementation of seasonal removal of Posidonia banquettes from the central and most dynamic part of the beach. The displaced Posidonia banquettes were stored near the beach and returned at the beach after the swimming season to minimize the erosion caused by the storms. This was disapproved primarily by the owners of beach catering facilities (concessionaires) who sought complete removal. The local community had no objections to its temporary storage in a designated place near the beach, or to its return to the beach after the bathing season, as long as this involves the removal of Posidonia banquettes during the summer.

To that end, it will be necessary to further negotiate in order to come up with a compromising solution for stakeholders to accept partial rather than complete removal. Subsequently, in order to ensure sustainable development and the integrity of the Mediterranean coastal zones, their ecosystems and related services and landscapes, we need to emphasize the importance of knowledge, awareness raising and stakeholder involvement through a joint strategy for the sustainable management of beaches with Posidonia banquettes.

Opting for a participatory approach has the potential to reduce conflict, build trust, and facilitate learning among stakeholders, who are then more likely to support project goals and implement decisions in the long run. Furthermore, it is essential to maintain regular communication with the local communities on decisions that affect them and on the protection and use of the coastal area. Indeed, open dialogues with local communities allowed information, concerns and opinions on management approaches to be shared between beach managers

Nature-based Solutions used to manage the Posidonia beach-dune systems have a tremendous yet unexplored capacity to help address concerns such as biodiversity loss and coastal erosion.

and stakeholders. This facilitated the development of a common understanding, the enhancement of interaction, the identification and resolution of problems, and to a greater understanding and support for the protection schemes.

Furthermore, by gathering information and feedback, this mechanism can also be used for monitoring, gathering local perceptions, identifying sensitive issues and stakeholder conflicts, as well as positive experiences with the initiative.

All in all, the active involvement and participation of all major stakeholders (local authorities, decision makers, PA managers, the private sector and particularly the interested public) in the design and implementation of a more sustainable management approach, facilitates its long-term success.

Future considerations include further informative events and collaborative meetings with the local and national authorities, in order not only to ensure the sustainability and durability of these management approaches but also to promote the advantages of implementing management strategies based on nature.


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Indeed, Nature-based Solutions (NbS) used to manage the Posidonia beach-dune systems have a tremendous yet unexplored capacity to help address concerns such as biodiversity loss and coastal erosion.

Furthermore, it is essential that management systems and their implementation are regularly reviewed so that priorities, targets and methods are adjusted as necessary. In addition, strengthening of institutional capacities through training programmes enables institutions to keep in touch with the latest requirements, standards and regulations. Moreover, it is essential to improve knowledge and understanding of the local community, decision makers, stakeholders and the tourism sector in order to change their perceptions about banquettes and thus function as a catalyst for the development of sustainable tourism in local communities and tourist destinations.

In conclusion, by promoting soft interventions that support the natural processes of the Posidonia beach-dune systems, this integrated coastal management approach has a significant capacity to manage and protect the coastal environment as well as to mitigate impacts of climate change in a way that is economically, socially and ecologically beneficial.

Project information

Lead partner

Autonomous Region of Sardinia – Department of the Environment – Nature conservation and forestry policies Office. ITALY

Source of funding

POSBEMED2 is co-financed by the European Regional Development Fund in the frame of the Interreg Med Programme 2014 - 2020

Duration

November 2019 - June 2022

Project partners

- Institute for the Study of Anthropogenic Impact and Sustainability in the Marine Environment of the National Research Council. ITALY
- International Union for Conservation of Nature. SPAIN
- Region of Central Macedonia. GREECE
- Hellenic Society for the Protection of Nature. GREECE
- Enalia Physis Environmental Research Centre. CYPRUS
- Provence-Alpes-Côte d'Azur Region. FRANCE

Website

https://posbemed2.interreg-med.eu/

Keywords

Beach management, coastal tourism, Mediterranean, Natura 2000, seagrass, *Posidonia oceanica*, coastal erosion

Climate impacts

Flooding, Sea Level Rise

Elements

Adaptation measures and actions

Sectors

Coastal areas

Geographic characterization

Europe

Macro-Transnational region

Mediterranean

Biogeographical regions

Mediterranean