



GOVERNANCE AND MANAGEMENT OF **POSIDONIA BEACH-DUNE SYSTEMS**

PROJECT PARTNERS

GOVERNANCE AND
MANAGEMENT OF
**POSIDONIA
BEACH-DUNE
SYSTEMS**



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Context

The Mediterranean coastal areas are one of the most popular tourist destinations in the world. Hence, long-term management of the coast is an important and challenging task. Some of the problems faced today by coastal managers include the increasing marine and coastal tourism demand that is driving the expansion of economic development and growing human population near its coast. This demand is accompanied by the need to support recreational and commercial activities, as well as to develop infrastructure, while also balancing the necessity to maintain the natural character of the coastal landscape.

The coastal landscape is affected by the dynamic influence of the sea and the weather. As areas at the interface between marine and terrestrial ecosystems, they are naturally very complex. Much attention has been given to address management alongshore (separating the land from the sea) and less on a cross-shore axis (sea to land and vice versa). We know, however, that these separations of management practices disturb the connectivity between the environments and tend to limit the ability of coastal ecosystems to perform certain functions and deliver services (e.g. sand supply).

Understanding the extent, characteristics and dynamic nature of the coastal environment, including its marine environment, is important for managing the wide range of coastal development issues, activities and effects within the coastal zone.

The Mediterranean coastline covers approximately 46,000 km, with a large proportion occupied by beaches (more than 46%), along with other habitats such as cliffs and rocky shores (UNEP/MAP, 2012). In the nearshore marine environment, the endemic

seagrass *Posidonia oceanica* forms large meadows widely distributed along the Mediterranean coastline between the surface and 44 m depth in the clearest waters. Recent estimates suggest that its overall known distribution is about 12,247km² with more than 50% within EU territory (Telesca et al., 2015).

Posidonia loses its leaves regularly throughout the year, mostly autumn and winter, and the leaves and plants removed during this natural shedding are transported onshore by wave action and high water levels associated with storm surges and strong onshore winds. Consequently, large volumes of *Posidonia* wrack (leaves and rhizomes) are sometimes deposited onto beaches and along rocky shores. It has been estimated that on some Mediterranean beaches up to 7000 tons of seagrass deposits can be present during the winter (e.g. Spain or Italy, this work). Here, *Posidonia* wrack mixed with sand accumulates forming wedge structure deposits from a few centimetres to several metres thick, named banquettes (Boudouresque and Jeudy de Grissac, 1983).

Such accumulation of seagrass deposits on the beaches has become a major issue for some local authorities. Banquettes and disperse seagrass wrack are often removed as part of beach cleaning activities in many localities, often for aesthetic reasons (e.g. odour, visual appearance, reduced beach use) and then disposed of in landfills or biomass waste facilities. Removing the *Posidonia* beach wrack poses a range of challenges for the municipalities and other stakeholders, but also implies substantial economic costs and impacts on the ecosystem.

Over the last years, a variety of approaches that focus on these particular coastal environments have been developed, but few guidelines and regulations



Posidonia oceanica leaves drift on Mediterranean beaches. Photo taken in Grado beach, Coast Azzurra (Italy).
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address the specific role of banquettes and how to manage them in this diverse and dynamic context. Making decisions about how to maintain, manage or clean the coastline is complex and challenging, with ramifications that can have a drastic impact on the coastal ecosystem, including the seagrass meadows and beach associated coastal dunes.

With this in mind, the aim of this document is to bridge this gap on knowledge and its implications for management decisions to help local users and decision makers to make more informed and sound decisions. The document and the results presented have been produced as part of the **POSBEMED** project (Sustainable

management of the systems of *Posidonia*-beaches in the Mediterranean region), developed within the Interreg Med program with the aim of defining a joint strategy for the sustainable management of the beaches with seagrass banquettes.

The document is thus divided to first present an overview of the current knowledge on this particular coastal ecosystem, and the legislative and policy frameworks that exist where this ecosystem occurs. It is followed by an overview of the assessments carried out during the course of the project to examine the current local beach management practices, together with the perceptions and expectations of different stakeholder groups regarding the



Cliffs at Northwest coast Of Corfu Island (Greece) with Posidonia banquettes along the beach shoreline.

presence of banquettes (tourist operators, local managers, residents and beach tourists), collected in 5 European countries (Spain, France, Italy, Greece and Cyprus). By taking into account previous experiences, recommended practices and research findings, it provides guidance to stakeholders (including national and local governments and protected area managers) with respect to littoral environments where Posidonia occurs, in order to define the risks and benefits of management practices and identify preferred solutions. This aims to ensure sustainable tourism practices and avoid significant and valuable loss of coastal habitats and ecosystem services in the Mediterranean.

As such, the options and approaches presented here are not intended to give site-specific recommendations, as their correct implementation requires a priori detailed information on which to base management decisions. Rather, it presents a set of desirable approaches and the process to build a framework for taking management decisions and activities in each site.

Furthermore, this document aims to provide the elements of a common transnational strategy and action plan for the Mediterranean region for the coastal areas where Posidonia beaches and dunes develop.

Introduction

POSIDONIA MEADOWS, BEACHES AND COASTAL DUNES

The Mediterranean coast is varied and dynamic with a combination of different geological settings, oceanographic conditions, and regional and local climate conditions and factors that affects its diverse coastal environment. In addition, biotic factors derived from flora and fauna communities have a strong influence on the coast and the creation of environments such as sandy shores.

One of these communities is that of the seagrass meadow, particularly that of Posidonia oceanica, an endemic and dominant species of the Mediterranean shallow waters. Posidonia forms vast meadows, from the sea-surface down to over 40 m in depth in the clearest waters and it is found in the entire Mediterranean Basin, with the exception of the extreme south-east (from the Nile Delta to south-east Turkey), most of the

shores of Languedoc (France) and the vicinity of the Gibraltar Strait (Pergent et al., 2012).

During regular storms and heavy swells, mainly in late summer and early autumn, significant amounts of *Posidonia* seagrass break away. The drifting plant material (leaves, rhizomes and stems) is moved around by hydrodynamic forces (currents and waves) and eventually transported either to deeper waters offshore or accumulated in the surf zone, where it forms semi-submerged mats, some of which are washed ashore and deposited in banks on beaches and rocks.

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, making wedge-shaped structures commonly known as *banquettes* (Boudouresque and Meinesz, 1982; Jeudy de Grissac, 1984).

Whilst the majority of the wrack on Mediterranean beaches is made of *Posidonia* material, it can also include other seagrasses, macroalgae and other marine organisms.



- Different formations of *Posidonia* beach deposits:**
- a) seagrass beach cast**
 - b) *Posidonia* banquettes along a rocky shore**
 - c) *Posidonia* wrack buried in sand**
 - d) semi-submerged *Posidonia* mat and banquetette formation**

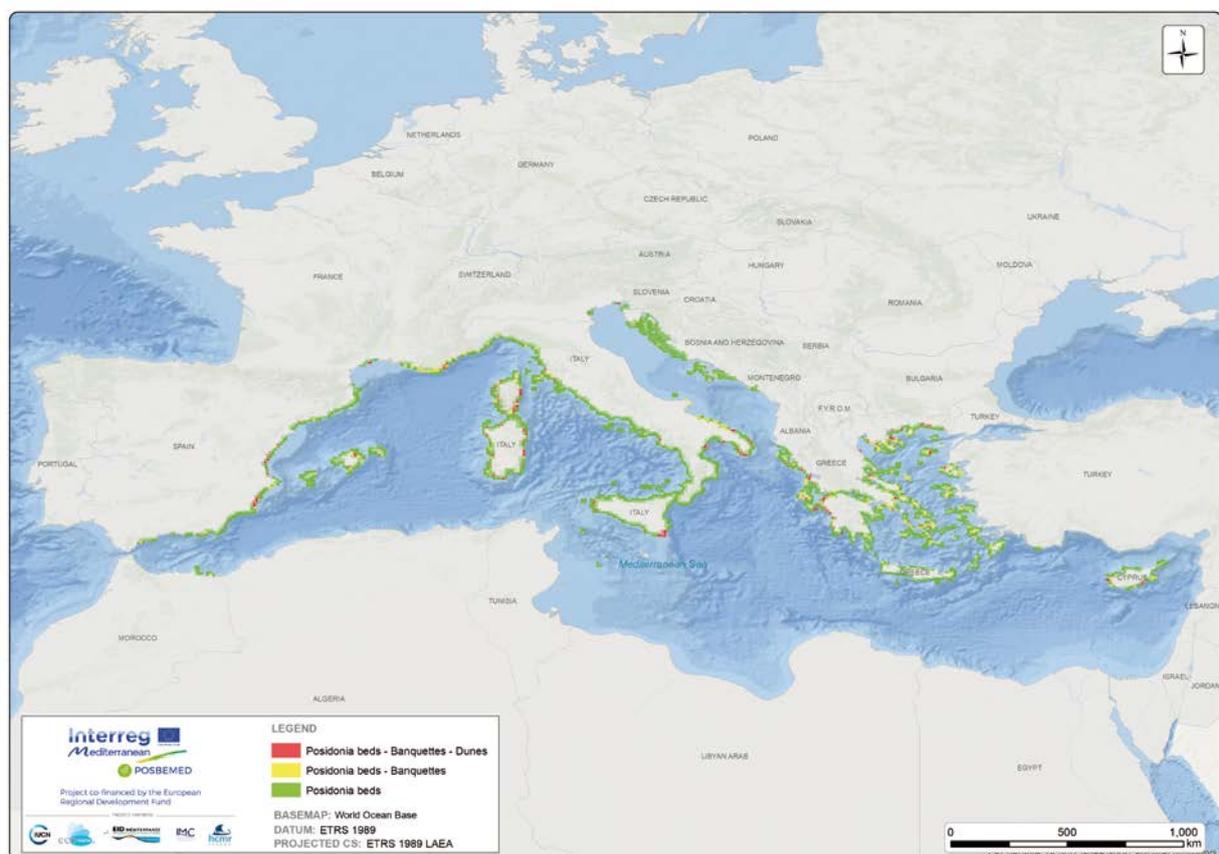
The drifting vegetation of *Posidonia* is a common feature of many Mediterranean sandy beaches and the continual deposition and removal of the wrack by wave action means the banquettes are in a continuously dynamic formation (Mateo et al. 2003). Thus, banquettes can be permanent (on the upper part of the beach) or temporary (on the driftline of the beach) features and can be moved back offshore within a matter of days or weeks.

On some beaches, seagrass deposits may also be buried below the sand surface as the banquette or berm edification/destruction is driven by the exchange of *Posidonia oceanica* material on the driftline of the beach.

As banquette deposits on the beach, they undergo a process of decomposition and remineralisation by bacteria. The bacterial decomposition of seagrass banquettes results in the release of various gas by-products. The decomposition under low oxygen conditions of accumulated seagrass, particularly in large accumulations containing fresh deposits, can result in a persistent release of gases that, depending on the precise chemical conditions, produces malodours (from sulphuric components, Mateo et al., 2003).

FIGURE 1

PRESENCE DISTRIBUTION OF POSIDONIA MEADOWS, BANQUETTES AND COASTAL DUNES ALONG THE NORTHERN MEDITERRANEAN COAST.

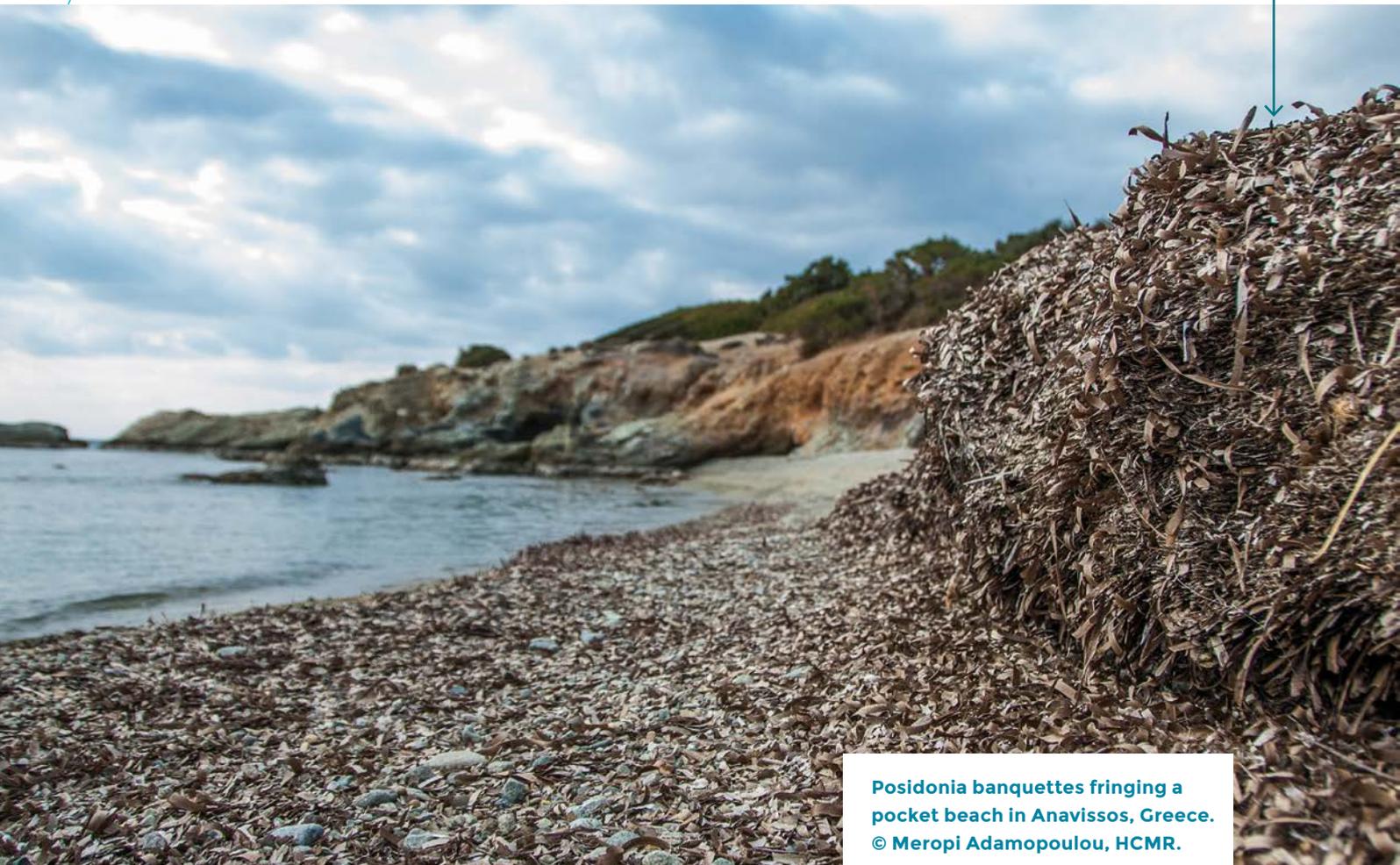


Wave action, intensity of prevailing winds and coastal morphological features are among the most important factors for the development of seagrass beach cast and banquettes on the Mediterranean coast (Vacchi et al., 2017). In addition to wave energy, the accumulation of seagrass cast on the shorelines depends on other factors such as the hydrodynamic conditions at each site, as these directly affect the detachment of the leaves from the plants, the transport of the material and its

accumulation onto the shore. Consequently, the material deposited on the shore may originate in nearby areas but can also be carried in as drifting seagrass mats from distant locations.

Despite the commonness of banquette formation on many Mediterranean beaches (Fig.1), there is still little information on how hydrodynamic effects impact the formation of banquettes.

Banquettes: Wedge deposit structures, made up of leaves and rhizomes of *Posidonia oceanica* with sediments, which are from a few centimetres to several metres thick (Boudouresque and Meisnesz, 1982; Jeudy de Grissac, 1984)



Posidonia banquettes fringing a pocket beach in Anavissos, Greece.
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Seagrass meadows of *Posidonia oceanica* on the coast of Andalusia, Spain. © M. Otero

ECOSYSTEM SERVICES ASSOCIATED TO POSIDONIA BEACH-DUNE SYSTEM

Seagrass meadows, sandy beaches and associated coastal dunes have outstanding ecological, socio-economic and cultural values as well as important roles in providing a diversity of ecosystem services linked to the nutrient and energy exchange in the coastal landscape (Boudouresque et al., 2016, 2017).

***Posidonia oceanica* seagrass meadows** are a key ecosystem of the Mediterranean environment. They protect the coast from erosion and regulate CO₂ absorption in the sea while storing it, mostly below its underground mat. Also well-known is their role as a habitat and food provider for a large number of fishes and invertebrates, including

commercial species. Moreover, the development of seagrass habitats around the coastline significantly influences the profile of beaches. In the meadows, the network of rhizomes consolidate the sediment acting as a reef that helps beach stabilization, while the leaf canopy assists in reducing wave energy through the incident friction of the plant leaves with the water. The consolidation of sediment by the seagrass meadow facilitates the generation of a steeper beach profile (Lopez et al., 2018).

In addition, the large diversity of fauna with carbonate skeletons associated with *Posidonia oceanica* will later on, after their detachment and fragmentation, increase the biogenic sediment supply to beaches (De Falco et al., 2017).



Posidonia wrack contributes to continuous formation of coastal dunes with sand supply and vegetation.

Beach habitats, on the other hand, provide multiple ecosystem services, which bring about welfare for society and are essential for human use of sandy coasts. They are linked to the marine ecosystem, and they also physically and biologically interact with coastal dunes, which means that sandy beach systems are an important part of the land-sea interface (Beck et al., 2017).

With the detached seagrass material and banquettes, beaches import marine organic matter and nutrients from the sea to the coastal ecosystems. Banquettes also form structural habitats that enhance the abundance of beach fauna (Colombini et al., 2009; Veccio et al., 2013) and play an important role in the continuous formation of dunes and backshore vegetation by capturing sands and seeds and allowing embryonic dunes to be continuously formed. More recent works further indicate that *Posidonia oceanica* beachcast and banquettes can contribute to the nitrogen nutrient requirements of dune vegetation and can be a considerable source of calcium carbonate to both beach and adjacent habitats (Jiménez et al., 2017). 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 a result of coastal erosion processes.

Furthermore, banquettes act as a natural protector, by minimizing beach erosion through absorption of seawave energy during storms and strong winds.

Banquettes are nature based coastal defenses that promote protection and minimize beach erosion

Where they occur, **coastal dunes** are an essential part of this complex as they provide a variety of functions as well. They host highly specialized fauna and plant communities sharing relatively few of them with other close-by environments and act as repositories for this singular biodiversity. Several studies have also demonstrated their role in coastal defence, groundwater storage and water purification, while their importance in nutrient cycling, soil formation and climate regulation (on carbon sequestration) is rather less known (e.g. Bazzichetto et al., 2016).

The dynamic of coastal dunes includes an important proportion of bare sand and young vegetation species (embryonic and mobile dunes) that evolve into a more stable ecosystem dominated by different stages of woody shrubs and three species (fixed and wooded dunes).

UNDERSTANDING THE POSIDONIA COASTAL ECOSYSTEM

The unique assemblage of near-shore *Posidonia* meadows, beach with banquette formation and associated dunes comprises a single ecological system, termed here the “**Posidonia littoral zone**”. This system occurs due to the strong environmental sea/land connection and the flow of energy and nutrients.

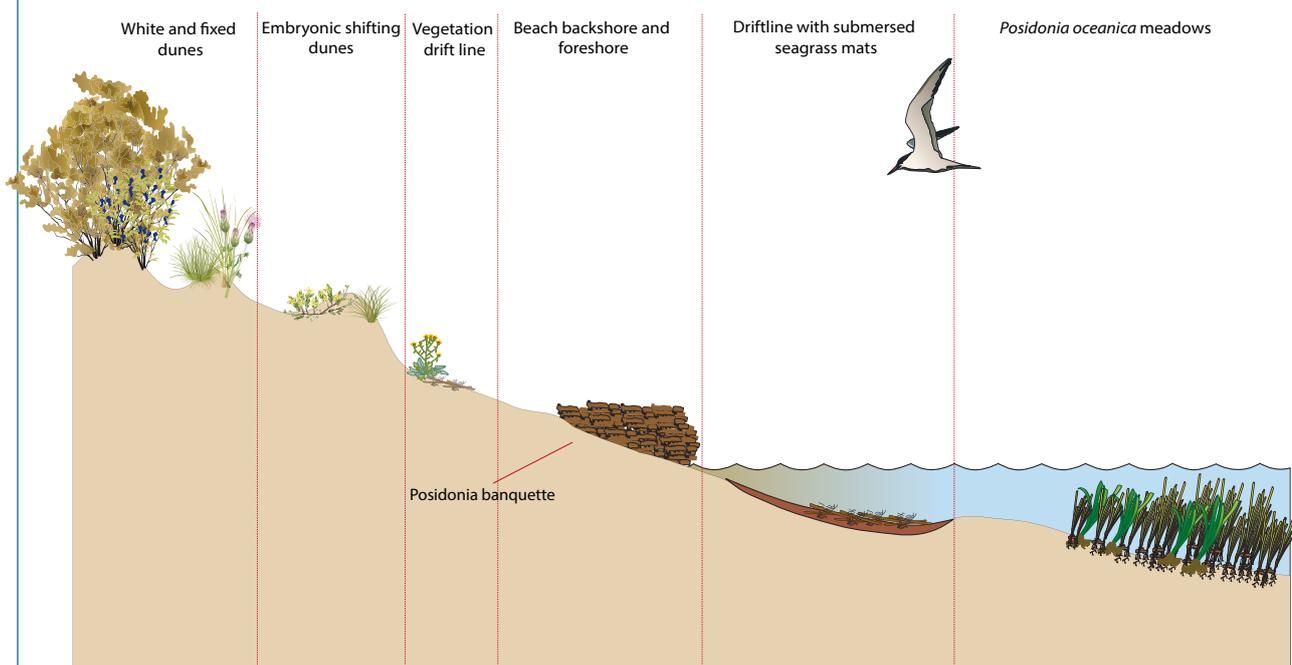
The basic topographic and main features of this system are illustrated in Figure 2. Typical of a sandy shoreline, the beach is divided into the underwater nearshore (here with *Posidonia* meadows); the beach foreshore, which is subject to wave action during low wave conditions; the beach backshore, which is only subject to wave action during storms; and the dune area which is subject to wave action near the beach and to the sand and plant material transported by wind over the whole area.

Storm waves that form *Posidonia* banquettes on the foreshore and the backshore of the beach can also erode the banquettes and transport part of the wrack material from the beach and dune. Subsequent calm weather with offshore winds will favour the return of the sand and seagrass wrack back to the beach and might transport them further into the sea. Thus, the dunes, the beach, and the nearshore seagrass meadows act as a dynamic, integrated unit, referred to as the *Posidonia beach-dune system*.

These features are nonetheless not found on all Mediterranean beaches with nearshore *Posidonia* meadows and may vary with seasonal and long-term changes in storm activity and human intervention.

FIGURE 2

Diagram /profile illustration of a typical Mediterranean coastal shoreline (*Posidonia littoral zone*) with the transition zone from *Posidonia* meadows to dune zonation evidencing the EU habitat types (Habitat 1120 *Posidonia* beds, Habitat 1210 Annual vegetation of the drift lines; Habitats 2110 and 2120 Embryonic dunes and the White dunes). M. Otero/IUCN Drawing with graphic elements courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science.



The **Posidonia littoral zone** is influenced by wave climate and, in the more landward area, by the wind.

In the marine environment, the thickness of the Posidonia mat and the production of seagrass leaves in the meadows will influence the amount of seagrass material produced that is later transported towards the land (beach or rocky shore) by the waves.

Once at shore, the composition and morphology of the banquettes themselves is conditioned by the exposure (e.g. predominant wave conditions in each site, shoreline orientation), sedimentology and morphodynamics of the beaches where these deposits form (Simeone and De Falco, 2012; Vacchi et al., 2017). As the deposits accumulate, the banquettes tend to decrease the transport of sand across the beach and increase sand deposition within the banquettes. The effect of the most energetic waves can erode the base of the banquettes, leading to scarp formation and promoting the collapse of the lower part of the structure (Mateo et al., 2003; Gomez Pujol, 2013), while on the uppermost part, sediment accumulates and forms the basis of the new foredune crest. Consequently, banquettes have an important role in the beach profile configuration and dune formation and stabilization.

In addition to the sensitivity of coastal response to these factors, the beach itself is also affected by controlling factors such as shoreline orientation, beach morphology, beach type, sediment size, and geology (De Falco et al., 2017; Simeone et al., 2013). As a result, while each Posidonia littoral zone can be regarded as unique and dynamic, it is possible to produce a simple classification scheme based on the combination of the most important controlling factors. This also enables us to identify the key elements that interact on the dynamic nature of these particular individual beaches and their application as a guide for selecting appropriate management measures to implement in each case.

The six primary criteria that reflect the controlling factors of the dynamic nature of Posidonia littoral zone on sandy shores and the formation of banquettes are: beach wave exposure, littoral profile, beach sediments and seafloor morphology, coastal dunes and the presence of large meadows of *Posidonia oceanica* (See Box 1.)

This leads to the division of beaches typically occurring along the Posidonia sandy coastline into 3 main types (Fig. 3):

BOX 1

CRITERIA FOR CLASSIFICATION OF POSIDONIA LITTORAL ZONE ON SANDY COASTS

- Beach Profile type (e.g. cliff, low plain)
- Beach materials (a) fluvial/cliff erosion sand sediments, (b) biogenic carbonate sands, (c) gravel, (d) boulders
- Littoral exposure of beaches (sheltered, fully exposed and semi-exposed)
- Near-shore marine substrate (sandy or rocky) on the upper limit of *Posidonia oceanica* meadows
- Presence of coastal dunes
- Near-shore *P. oceanica*

Note: The main marine carbonate for Mediterranean beaches comes from Posidonia oceanica meadows produced by the biota associated with the seagrass ecosystem, such as coralline algae, foraminifers, gastropods, bivalves, serpulid polychaetes, bryozoans and echinoids (Fornós and Ahr, 1997).

1 Exposed beaches with banquettes occur where beaches develop along a straight or a gently curving shoreline where there are no major capes or peninsulas to shelter a portion of the shoreline from waves from one direction or to act as a barrier to alongshore sediment transport. Exposed Mediterranean beaches are generally associated with high wave energy shores.

In fully wave-exposed beaches, *Posidonia* can be transported as floating material during storms and can be deposited, when the storm decreases in energy, far from the meadow from which the leaf material originates. Large volumes of these deposits and banquettes can then accumulate across the beach shoreline (along the beach-face), due to the high wave energy and strong winds on these sites (Simeone and De Falco, 2012; Jimenez et al., 2017). This accumulation seems to be linked to the timing of the maximum wave height and the period of strongest winds, usually occurring during winter and early autumn.

The exposed beaches have a variable slope and,

Exposed beach with banquettes



when extensive, they are often backed by large dune systems that are important repositories for sandy beach and dune biodiversity. The changes in beach elevation are mainly due to the deposition and erosion of sediments and secondly to the deposition and/or erosion of the banquette (DeFalco et al., 2017).

2 Low energy, sheltered beaches in the *Posidonia littoralis* zone have a narrow beach face in comparison to more high energy environments and usually include more steep slopes. They occur in gulfs, sheltered bays, embayments and behind islands on the open coast. Here, the beach sediment can be a mix of fluvial/cliff erosion and biogenic carbonate sands from *Posidonia* meadows.

Sheltered beach with banquettes



At these sites, the accumulation of *Posidonia* beach cast is related to the proximity of meadows to the shoreline and its formation is on the upper beach, forming wider and thicker bands than on higher energy beaches.

This accumulation has a pronounced effect on beach topography, as the deposits and banquettes formed can persist over longer periods of time (Mateo, 2010; De Falco, 2008; Jimenez, 2017), due to a more reduced effect of the waves and erosion process. The erosion and the growth of the banquette is mainly driven by the flow of material between the beach and the shore, while the sediment remains more stable (Simeone and De Falco, 2012). The sheltered environment from the winds may also result in the reduced possibility of the formation of foredunes and when they develop, they are small.



Semi-exposed beach with banquettes

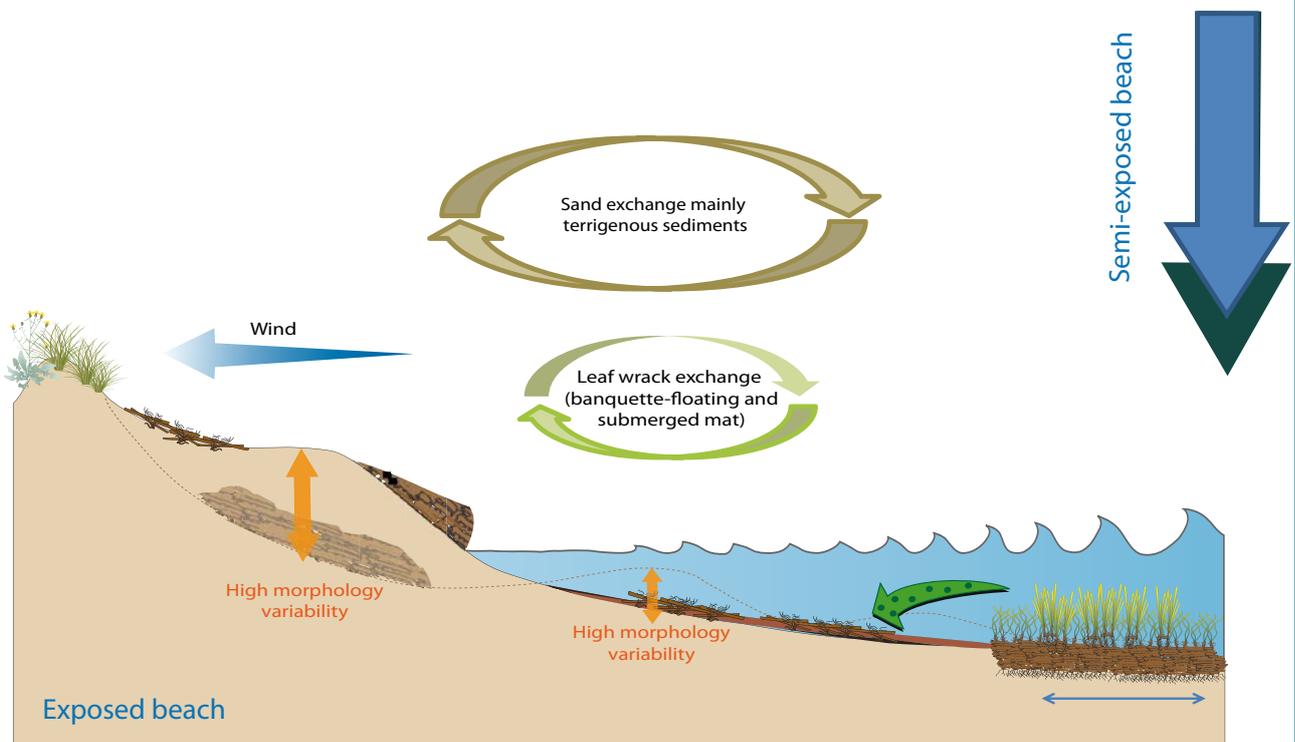
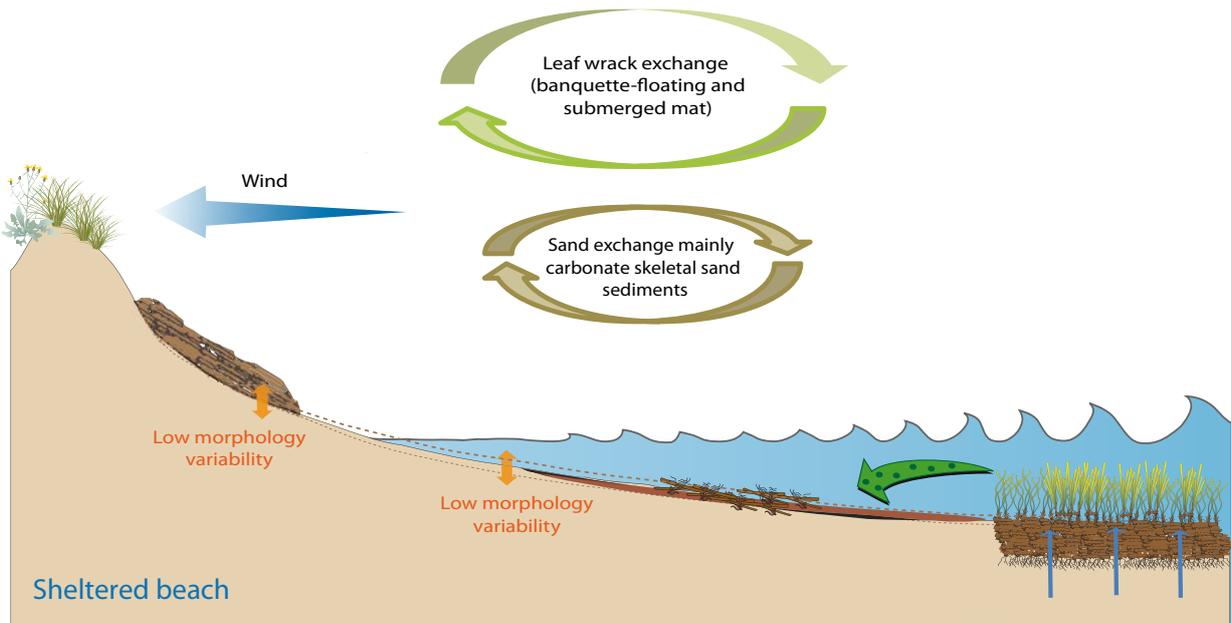
3 Semi-exposed beaches represent a transition status from fully exposed to sheltered littoral environments. They are characterized by large embayments and variable beach profiles with steep contours and sand ridges controlled by the swell.

These are the most common and most dynamic beach types, as sediments are highly mobile and banquettes vary greatly in response to the wave conditions and the repeated cycles of deposition and erosion that occur. The permanence of banquettes on the beach is also quite variable (Gomez-Pujol et al. 2013). Larger and more voluminous amounts can be deposited during the winter season while minor banquettes are usually accumulated in summer and during calm periods. The dismantling of the banquettes can occur during the intervals between storms or, alternatively, the deposition can persist on the beach as a permanent feature.

This classification scheme is based primarily on the physical attributes of the shoreline, the seagrass meadows and associated beach deposits, which in turn exercise some control on the dynamic behaviour of the Posidonia beach and the foredunes. Further on, we examine how this scheme is modified by the situation of coastal development and demand (natural and urban beaches).

FIGURE 3

Diagram /profile illustration Posidonia beach-dune system with banquettes in sheltered, semi exposed and exposed beaches. (a) Sheltered environments (b) Fully exposed environments. Matte develops mainly vertically in sheltered environments and laterally in wave-exposed areas. M. Otero/IUCN Adaptation drawing from Vacchi et al., 2017. Graphic elements courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science.



Pressures

ON THE POSIDONIA LITTORAL ZONE

The Posidonia littoral zone is subjected to different pressures and threats from the increase in the coastal population and tourism activities, eutrophication, coastal and marine pollution, land reclamation and other coastal activities.

The extent of *Posidonia oceanica* meadows have considerably declined with an estimated loss of approximately 34%, corresponding to a decrease of 368,837 ha in the last 50 years (Telesca et al., 2015). However, it is not only the loss of this habitat that is of concern, there is also localised and subregional decreases in the quality of the habitat (Pergent-Martini et al., 2016). This decline has been proved to be due to human impacts that produce changes in water quality (pollution and eutrophication from sewage or aquaculture), mechanical erosion (by trawling and anchoring) and indirect changes that cause burial of meadows by the construction of new coastal defences, marinas or other infrastructures (Boudouresque et al., 2009; Pergent-Martini et al., 2016). In addition to human activities, the regression of Mediterranean seagrass meadows has also been attributed to global climate change (Pergent et al., 2012).

The development of coastal projects, such as the construction of marinas and other urban and tourist infrastructures, has also had a significant effect on beaches and coastal dunes by altering

the erosion-accretion dynamics of the coastal zone and their quality and quantity. According to available information, it is inferred that at least 29% of the Mediterranean beach habitat has been lost over the last 50 years in European countries (Otero, 2016). 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 (EEA, 2008).

According to Plan Bleu, approximately one third of the Mediterranean population is concentrated along the coastal areas, whereas more than half of the population resides in the coastal hydrological basins (UNEP/MAP, 2016). Moreover, Mediterranean coastal areas are also one of the most popular tourist destinations in the world (Eurostat regional yearbook 2017) with tourism usually concentrated along its sandy beaches, driven by the so-called “3S tourism” – the three S’s standing for “Sea, Sand, and Sun”.

Population growth and an increase in the frequency of tourism is thus placing greater pressures on coastal resources and drives many local and regional coastal policies. Mediterranean beaches have become large tourist attractions bringing in much needed revenue for local economies. Consequently, beaches and their surroundings have undergone progressive development as human coastal populations have grown and the infrastructure has expanded.



**Coastal development along
the Mediterranean coast.
Villefranche-sur-mer, France.**

In addition to direct anthropogenic impacts, global climate change is already affecting the coastal systems and is expected to have intense, extensive and long-lasting consequences. Climate change projections for the Mediterranean include an increase in air and seawater temperatures, a rise in sea level, changing rainfall patterns and more frequent and intense extreme climatic events (Lionello et al., 2017). The expected rise in sea level, in combination with an increase in the frequency and/or intensity of storms, as predicted for some Mediterranean regions, is likely to lead to escalating erosion and a consequent loss of habitat, affecting the coastal infrastructure.

Predicted impacts from climate change on the beach, foredune and coastal seagrass environments include increased vulnerability of beach and dune systems due to coastal erosion, the retreat of the shoreline, withdrawal of the lower limit of

Posidonia meadows in bays, and saltwater intrusion (Gracia et al., 2018; Boudouresque et al., 2009). Urban beaches are particularly vulnerable, since human constructions have decreased natural wave buffering zones in much of these areas and interfere in longshore sediment transit.

The Posidonia littoral zone will play an important role in reducing the storm forces although, at the same time, it will be affected by all these impacts and pressures. Maintaining healthy meadows will provide cast material for the beaches that, together with well-vegetated dunes, offer the best protection and adaptation against the rising sea level, shoreline erosion and storm surge events, particularly when coastlines are retreating in response to rising sea levels.



Increased water turbidity and local impacts from the coast have effects on the health of Posidonia meadows. Photo close to Portofino MPA, Santa Margherita Ligure, Italy.



Oil spill reaching a Greek Aegean coast (Agios Kosmas beach, Saronikos Gulf) in September 2017. © Konstantinos Tsagarakis

Regulatory

AND LEGAL FRAMEWORK FOR THE MANAGEMENT OF POSIDONIA LITTORAL ZONE

INTERNATIONAL PROTECTION POLICIES

The degradation of the littoral landscape in general and of the different components of the *Posidonia beach-dune system* in particular, have resulted in a number of conservation policies and management strategies that seek better ways of managing the Mediterranean coastal landscape and reducing the impacts.

For EU Countries, the most salient regional policies and legislations that regulate activities and provide policy strategies for the *Posidonia littoral zone* are the Marine Strategy Framework Directive (MSFD), the Habitats Directive, the Directive for Maritime Spatial Planning (MSP), and the Mediterranean Fisheries Regulation (Council Regulation EC No 1967/2006).

For the management of beaches, another important legal document with significant influence is the Protocol on Integrated Coastal Zone Management (ICZM) of the Barcelona Convention, the major legal framework for the protection of the Mediterranean environment. Its articles 15, 16, 23, 25 and 26, explicitly cover the importance of knowledge, awareness raising and stakeholder involvement, and the need to establish appropriate monitoring and observation mechanisms for providing information and good governance of coastal environments, including beaches.

For the implementation of the Protocol, the ICZM Regional Common Framework (UNEP(DEPI)/MED IG.23/23), recently established, among its objectives, the use of ecosystem-based management to ensure sustainable development and the integrity of the coastal zone, its ecosystems and related services and landscapes. The Framework explains that, to achieve this, land-sea interactions should be taken into account as a natural dynamic phenomenon and as a criterion for defining areas to be managed and as a parameter in planning processes and procedures.

Altogether, these Mediterranean policies, including EU Directives (MSFD and MSP), constitute the umbrella for the development of national policies and coastal and marine area planning and management at a national level.

In addition, other regional and national policies aim to protect local coastal features such as dunes and seagrass meadows while maintaining a commitment to manage the development of coastal areas.

Posidonia oceanica is considered as a good biological indicator of coastal waters quality and, in general, of the ecological status of the Mediterranean marine environment (UNEP/ MAP-RAC/SPA, 2015). It is therefore used as a tool for the ecological evaluation of coastal waters by the EU Water Framework Directive, as well as to examine the status of the Mediterranean

habitats' typical species and communities under the Integrated Monitoring and Assessment Programme (IMAP) of the Barcelona Convention.

The European Member States adopted the Council Directive 92/43/EEC (Habitats Directive), which lists the habitats of European interest (EU habitat types) and establishes an extended network of sites of ecological importance across Europe, called Natura 2000.

Most of the plant communities growing on coastal dunes lining the Mediterranean have been listed as EC Habitats of interest in Annex I of the Habitats Directive, while *Posidonia oceanica* meadows are listed as a priority natural habitat in the same annex (code 1120) and in the SPA/BIO Protocol of the Barcelona Convention (Association with *Posidonia oceanica*, code III.5.1). The species is also included in Annex I (Strictly Protected Flora Species) of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). As it is a priority habitat, EU countries are also encouraged to designate Natura 2000 sites where *Posidonia* meadows are present, which resulted in a large number of designated sites for that habitat (Figure 4).

NATURA 2000 AND POSIDONIA LITTORAL ZONE

The connectivity of protected areas, such as those in the Natura 2000 network, is crucial for maintaining healthy ecosystems and for the delivery of ecosystem services into the wider landscapes in which they are embedded (Worboys et al., 2016). In this context, coastal dunes of different types (Habitat 1210 Annual vegetation of the drift lines, Habitats 2110 and 2120 Embryonic dunes and White dunes, respectively) and *Posidonia oceanica* meadows (Habitat 1120) should be conceived as a part of the *Posidonia* littoral zone and defined as a single connected management unit within the Protected Areas.

In the framework of the Posbemed project, the examination of the coverage of Natura 2000 sites that include these four habitats has been carried out. Findings indicate that the coverage of single habitats (*Posidonia* meadows or coastal dunes) is proportionally similar in comparison (approx. 50% of the total area of the habitat type is protected) and much higher than the one occupied by protected areas where both habitats co-occur (11.2%) (Table 1: Aljinovic et al., 2018).

TABLE 1

Coverage of target habitats in Natura 2000 network

Habitat type presence	Number of pixels (1 km ²)	Inside Protected Area	Outside Protected Areas
<i>Posidonia</i> meadows only	32.482	48.1%	51.1%
Coastal Dunes only	1.784	49.9%	50.1%
<i>Posidonia</i> and Dunes	4.080	11.2%	88.8%

This, along with a more detailed analysis of the target habitats per country, reflected clearly that sites with the presence of *Posidonia* beach-dune systems are underrepresented in the Natura 2000 network, possibly because the designation of protected areas has been focused on single habitats, while not considering their functional connectivity.

In terms of management, the current situation on joint (e.g. target habitats included in the same Natura 2000 site or MPA) and separate (e.g. target habitat types in separate but contiguous Natura 2000 sites) management was analyzed. Overall, 92 sites with potential for improvement in addressing the connectivity were identified in the network. Natura 2000 sites that have been recently designated, or those where management plans are still in preparation or have just recently been developed (e.g. Greece) have considerably the highest potential for the implementation of joint management actions and for a more comprehensive management of *Posidonia* beach-dune systems.



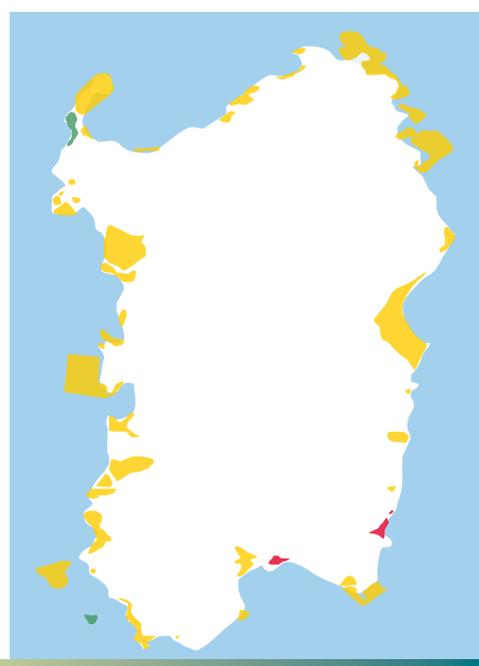
Example of adjacent Natura 2000 sites with potential for joint management (Mallorca, Spain - ES0000083, ES0000228 and ES5310128) **Green:** presence of *Posidonia* beds only; **Red:** presence of one or more dune habitats; **Yellow:** presence of *Posidonia* beds and one or more dune habitats

NATIONAL POLICIES AND MANAGEMENT OF POSIDONIA BANQUETTES

Posidonia banquettes and their management are situated at a regulatory crossroads within the protection of the environment, the regulation of bathing areas and the administrative jurisdiction of municipalities. The following section presents a synthesis of different regulatory aspects for a better understanding of the entanglement of regulations that apply to these areas and the coastline in general.

At a national level, seagrass meadows of *Posidonia oceanica* and the species itself are protected under different legal frameworks (see reviews presented by Pergent et al., 2016; UNEP-MAP RAC/SPA, 2012) and few countries apply these protection measures to all forms during its life cycle, including the banquettes.

Spain. The Spanish Royal Decree 139/2011 includes *Posidonia oceanica* in the List of Wild Species under the Special Protection Regime. The inclusion of a species, subspecies or population (dead or alive) in this list entails a series of generic prohibitions established in the state regulations, specifically



The example of Sardinia, where all the areas with 1120 *Posidonia* beds and one or more dune habitats (1210, 2110, 2120) are designated as single sites with joint management. **Green:** presence of *Posidonia* beds only; **Red:** presence of one or more dune habitats; **Yellow:** presence of *Posidonia* beds and one or more dune habitats

in article 57 of Law 42/2007 on Natural Heritage and Biodiversity. This prohibition includes the collection, destruction, damage, retention, transport, sale or exchange, import or export of live or dead specimens, as well as of their propagules or remains, except in cases where these activities, in some way, are controlled by the Authorities.

The same state law provides for a series of exceptions to these generic prohibitions, exceptions that apply to the corresponding administrative authorization (Article 61). Thus, all the life forms of *Posidonia oceanica* are protected and any removal of its wrack deposits need to follow administrative authorization.

France. A similar protection regime occurs in France where *Posidonia oceanica* is listed as a protected species (Order 19 July 1988 – espèces végétales marines protégées) under the Code de l'Environnement (Art. L. 411.1). The latter specifically prohibits "...the destruction, cutting, mutilation, grubbing, picking or removal of the species, their fructifications or any other form taken by these species during their biological cycle, their transport, peddling, use, sale, or purchase (...)". Similarly, the Order of July 19 (1988) forbids the destruction, peddling, offering for sale, selling or purchasing and use of any or part of the wild specimens of the species listed, including *Posidonia oceanica*.

For economic reasons, however, and despite all these prohibitions, derogations from prohibitions 1, 2 and 3 of Article L.411-1 may be granted to municipalities that wish to carry out the removal of the *Posidonia* banquettes, provided that there is no other satisfactory solution and that it does not interfere with the maintenance of a favourable conservation status of the population or the concerned species in their natural range.

These derogations defined in 4 of article L.411-2 are granted by the Prefect of the Department in charge after the consultation with CNPN (National Council for the Protection of Nature) and instruction of the file by the Regional Directorate for the Environment, Planning and Housing (DREAL) or the Directorate of Territories and Sea (DDTM), depending on the case. In practice, these derogations are not used by many coastal municipalities with high tourism demand (with the exception of the municipalities of the Department of Var, PACA Region), and the removal of *Posidonia* banquettes is somehow accepted or tolerated (CSIL-CREOCEA, 2011).



Greece. Although there is no specific regulation directly protecting seagrass banquettes or other marine deposits on shore in Greece, there is a nationwide general ban on any activity which “transforms or damages the morphology and biota of the coastal zone” (Official Gazette 1636 B’/12-05-2017). Moreover, wheeled vehicles and heavy machinery are also banned from beaches and other sensitive coastal ecosystems according to the Greek Law N. 3937/2011 (Protection of Biodiversity).

Italy. In Italy, the Ministry for Environment and Territory issued Circular No. 8123/2006 (DPN/VD/2006/08123) “Management of stranded Posidonia”, in which it reaffirms the opportunity to leave on-site deposits of stranded seagrass biomass because of their important ecological role. It proposes three possible intervention strategies: 1) on-site maintenance of the banquettes, 2) relocation of the deposits, 3) permanent removal and disposal in dumps.

Other countries (e.g. Malta) and regional governments have issued their own regulations for the management of Posidonia banquettes on the coastline (see Appendix 1). National or regional laws and policies have also developed a series of goals and policies aimed at protecting the coastal environment and particular habitats such as coastal dunes as part of their priorities.

In addition, the littoral zone where seagrass meadows can be found and banquettes and coastal dunes develop are part of the territorial limits of jurisdiction and administration of municipalities or councils.

MUNICIPAL ROLE IN BEACH MANAGEMENT AND RELATION TO EU LEGISLATION

Local councils and municipalities have a central role in managing the coast. They use management planning strategies and national and regional by-laws to establish and implement policies regarding the land and nearshore areas within their jurisdictional limits. Whereas regional or country policies might establish broad shoreline and beach management plans and grant titles of occupancy and use of that domain.

It is however within the role of local authorities (most municipalities and councils) to establish the specific regulations for arranging the use of coastal areas (including beaches), zoning of activities (e.g. anchorage on the nearshore) as well as maintaining access and the services to be provided to beach visitors. Given their territorial jurisdictional limits, local authorities might also have the legal capacity to regulate and administrate how beach cleaning activities are executed (if guidelines are not provided by higher regulatory and advisory agencies or authorities) and also to provide private concessions for their use and management. Some local authorities take charge of the day-to-day management of the beaches while others give contracts or concessions to third parties for this work.

Within a single local authority, such as a municipality, it is possible to find beaches in the vicinity of natural parks or protected areas, urban beaches, beaches managed by public-private consortiums (e.g. camp sites or hotel concessions with municipality agreements) and beaches included within protected areas (as Natura 2000 sites, Natural Parks or other National designations). When beaches are part of a protected area, the management commonly falls within the responsibilities of different authorities (e.g. Protected Area or Environmental National or Regional authority and Local Municipalities). As such, in Natura 2000 sites, any project or activity to be conducted should be assessed *a priori* for their impact on conservation objectives of the site and are subject to further authorisations.

In the case of beaches with Posidonia banquettes, the results from a questionnaire conducted with local authorities in Greece, Cyprus, France, Italy and Spain, during the course of the present project, reveal that most authorities rely on a contracted company to conduct the cleaning operations (Table 2).

TABLE 2

Entity in charge of beach cleaning and banquette removal operations (2017).

Country	Private company	Public technical Service
Greece	69%	31%
Italy	68%	32%
France	55%	45%
Spain	75%	25%
Cyprus	55%	45%

For some local authorities, as soon as the beach seagrass deposits are lifted from the beach (even to be reprocessed into products or materials for recycling), they are considered as organic waste and are disposed of according to the national and regional procedures for transport, storage, cleaning, drying and waste disposal.

In the EU countries, this matter follows, to some extent, the current EU Waste legislation (Directive 2008/98/EC, WFD2008) that defines 'waste' as "*any substance or object which the holder discards or intends to discard or is required to discard*". Current waste management practices are strongly influenced by the 'waste hierarchy' established by this Directive, with the 5 measures for prevention, preparing for reuse, recycling, other recovery and disposal. Its last amendment includes a comprehensive list of substances and products that should be considered as waste and with hazardousness properties (Commission Decision No. 2014/955/EU), although no seagrass or any algae material from the beaches are included in the list. Nonetheless, some national laws classify accumulated seagrass (or algae) wrack material as biological waste (e.g. Italy¹ and Greece²).

The omission regarding organic materials (plant, algae or animal origin) from marine ecosystems in the WFD2008 policy might contribute to the confusion among local authorities and result, to some degree, in reduced opportunities for the

recycling or processing of the materials for other uses, as well as inducing the wrong perception (from lack of clarity) of Posidonia banquettes as waste material. Local managers confirmed this during various consultations conducted over the course of the project and they perceived the legal situation as confusing and as a hindering factor for innovations.

Moreover, seagrass or algae deposits deposited on the shore are often seen as litter. This perception increases when Posidonia wrack is cluttered with manmade litter on the beaches, also brought in with the wind and tide. Even so, the related regulations and programmes under the IMAP process of the Barcelona Convention and the EC Marine Strategy Framework Directive (MSFD, Descriptor 10) on marine litter, do not consider them as such nor do they provide additional monitoring guidelines or regulations for these cases (EC Joint Research Centre 2013).

Unless specified by National policies, Posidonia banquettes are not considered waste or manmade litter under these regional regulations and policies and therefore their treatment must be different. They must be separated from the waste so that only the litter material part is treated as specified.

A final legal instrument that might pose some questions for detached Posidonia is when submerged mattes are formed on the nearshore. The Bathing Water Directive (2006/7/EC) specifies that if an excess of macroalgae and cyanobacteria (or 'blue algae') occurs on the foreshore of coastal bathing waters and this results in a deterioration of bathing water quality, investigations shall be undertaken to determine their acceptability and health risks and adequate management measures shall be taken, including informing the public. Considering that seagrass deposits are not covered by this definition, it is clear that local authorities should be judicious when interpreting what Posidonia wrack or detached deposits are, for decision making purposes, with regard to an appropriate course of action for any effective management.

¹ Italy, Legislative Decree n. 152/2006

² Greek National Plan for Waste Management (CM Act 49/15.12.2015)



Litter mixed with Posidonia wrack on the beaches of Albanian coast. © Mar Otero/IUCN

PRESENT MANAGEMENT OF POSIDONIA BANQUETTES

Over the course of this project, it was found that as much as 83% of the surveyed local authorities from the 5 surveyed countries (Spain, France, Italy, Greece and Cyprus) remove the seagrass wrack deposits and banquettes every year on some or all the beaches where they are found (Table 3). This process, called “beach grooming”, is common practice in other Mediterranean countries, where considerable accumulations of Posidonia wrack are accumulated, particularly on the sandy beaches and less frequently on the more coarse beaches or rocky shorelines.

According to our results, the banquettes are removed according to needs, and can reach up to more than 7,000 Tons per year in some authorities in Spain, Cyprus and France. In general, no accurate information is collected on this and, for many areas, this information is lacking or not accessible.

Removing the Posidonia beach wrack differs from beach to beach and among countries, as the accumulations on beaches vary between coastal sections and the management standards (when they exist) differ considerably (Fig. 4). Beach wrack cleaning is also conducted by some local authorities that have beaches included within protected areas, without showing very well defined differences in their management practices between beaches in and outside of protected areas, although in some cases, Posidonia banquettes are not removed at these protected sites.

Removal operations of the banquettes and Posidonia beach wrack was found to be a common practice conducted 3 or more times per year in over half of the locations (Table 4; Fig. 5). Most local authorities carried out this work during the summer season, between the end of April and September (83%), while 17% of them also remove and clean the beaches over autumn and the winter period.



Beach grooming poses a range of challenges for the municipalities and other stakeholders, including:

→ Significant economic cost. The municipal costs for beach cleaning vary significantly for different sites and countries, being estimated between 15,000 to 130,000 euros per municipality per year on average (Giunta Fornasin et al., 2018). This will vary depending on the type of treatment. For example, in France the removal and disposal at a landfill could cost from €60 to 80 per m³ (CSIL-CREOCEAN, 2011).

→ Organizational challenge for municipalities.

As soon as the Posidonia wrack is lifted from the beach, it is considered to be organic waste and needs to be disposed of accordingly, involving transport, storage, cleaning, drying and waste disposal.

The process of beach wrack removal involves removing a lot of sand from the beach and, therefore, some municipalities incur additional costs for replenishing the sand at the beaches.



Beach at Gallipoli, on Italy's Puglia coast, known as Spiaggia della Purità (Purity Beach).

Summary results of management practices by local authorities in 5 EU Mediterranean countries. Data Source: Results from 144 surveys. Interreg Med Posbemed project.

TABLE 3

Percentage of seagrass banquettes removed by the local authorities in different countries (%).

	On every beach	On some beaches	On none of them
Greece	38	43	19
Italy	14	56	30
France	49	46	5
Spain	32	58	10
Cyprus	40	35	25

FIGURE 4

Results on banquettes removal by local authorities in 5 EU Mediterranean countries.

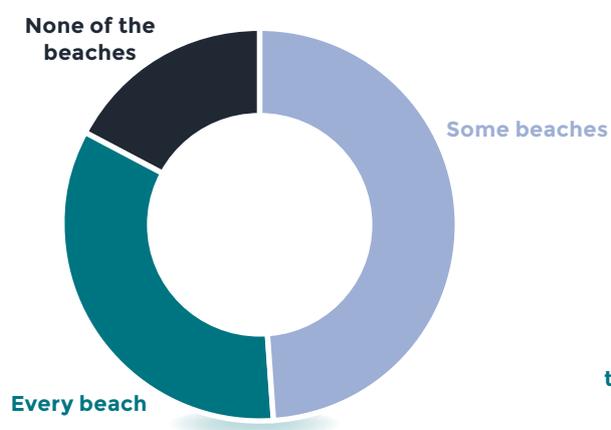


FIGURE 5

Results on frequency of banquette removal operations by Local Authorities in 5 EU Mediterranean countries.

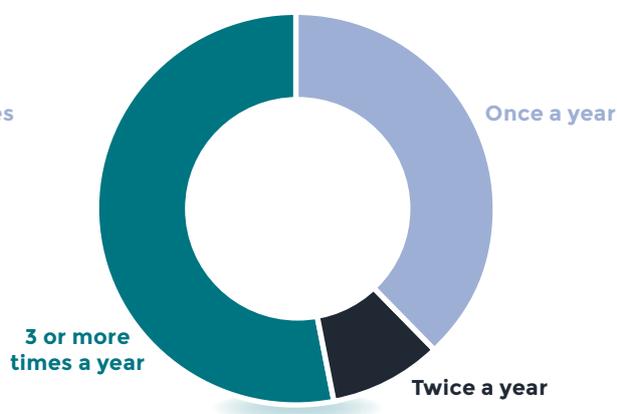


TABLE 4

Percentage of frequency of Posidonia banquette removal by the local authorities in different countries (%).

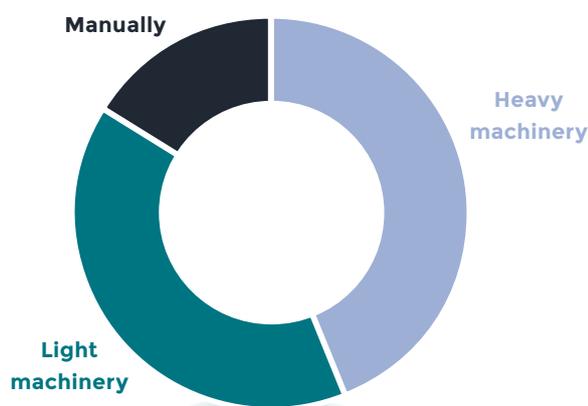
	Once a year	Twice a year	3 or more times a year
Greece	38	8	54
Italy	32	27	41
France	3	57	40
Spain	11	4	85
Cyprus	53	7	40

The general local beach management practices among the 5 different countries are listed in Table 4. During the summer season, beaches are mechanically raked or groomed to remove most of the man-produced waste and to take away organic material, including wrack deposits. Only in exceptional cases are *Posidonia* banquettes removed manually.

When it comes to the tools used, heavy machinery such as excavators is the number one choice in around 44% of cases, and a similar percentage (40%) is seen for light machinery such as beach cleaning screeners (Fig. 6).

FIGURE 6

Results on type of method and machinery used in banquette removal operations by local Authorities in 5 EU Mediterranean countries. Source: Interreg Med Posbemed project



THE SITUATION IN MARINE PROTECTED AREAS

Mediterranean MPAs attract thousands of tourists every year from all over the world. As a result, and on top of local developments, potential conflicts may arise in some areas in the effort to maintain conservation objectives with regard to coastal management and, particularly, the *Posidonia* littoral zone (e.g. anchoring, housing, banquettes on recreational beaches). The overlapping information on habitat type distribution (seagrass meadows, banquettes and dunes) and coastal tourist activities can thus highlight a variety of situations with potential conflict zones in and around MPAs, including Natura 2000 sites (Fig.7-10). From a screening of situations at each site, it is suggested that various underlying factors such as tourism intensity, proximity of large urban areas, stakeholder awareness of conservation values and, ultimately, management objectives and zoning within protected areas (or lack thereof) could be the main drivers of conflict in each case. Appendix 3 shows a selection per country of potential conflict areas in and around MPAs.



***Posidonia oceanica* wrack are a source of nutrient and moist for coastal dune vegetation.**

FIGURE 7

Protected area of Zakythos showing potential conflict areas.

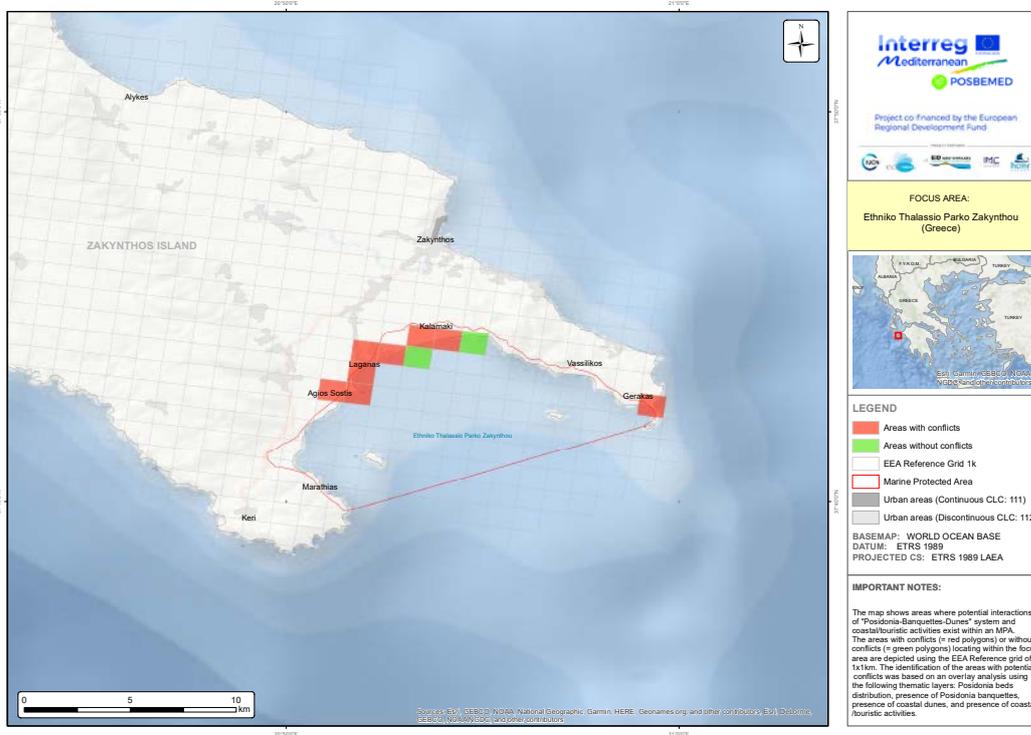


FIGURE 8

Protected area of Port Cros and Natura 2000 site of Rade d' Hyeres (France) showing potential conflict areas around the new Accession Protection Area of the Park.

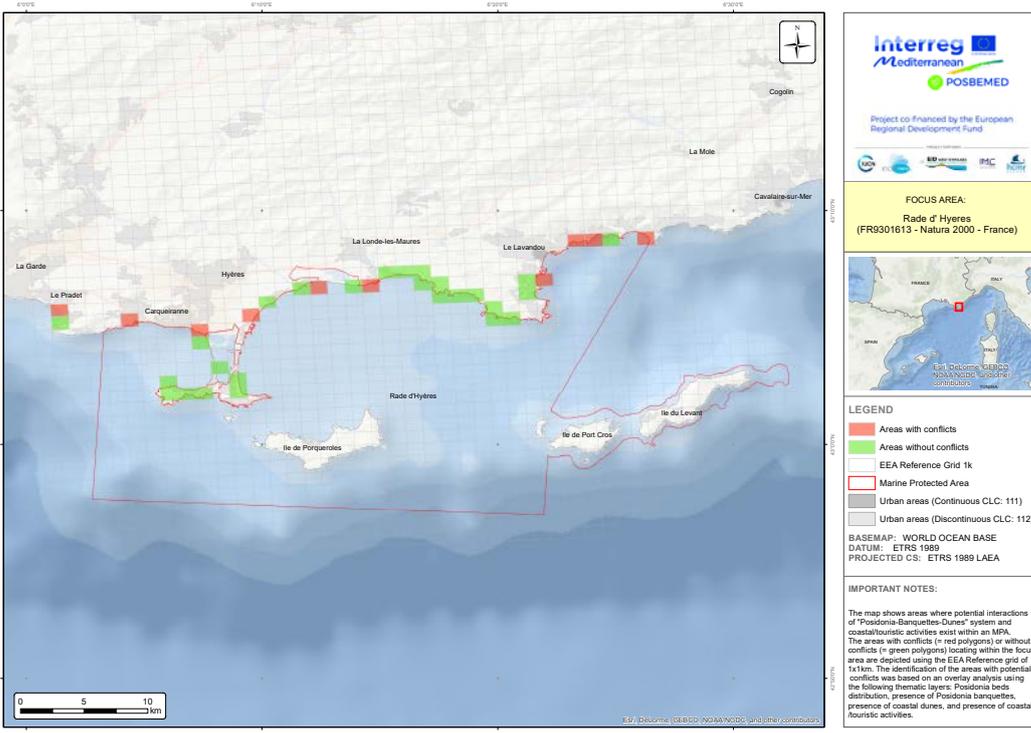


FIGURE 9

Natura 2000 site of San Pedro of Pinatar (Spain) showing potential conflict areas on the Posidonia littoral zone close to a marina and large urbanization behind the Salinas.

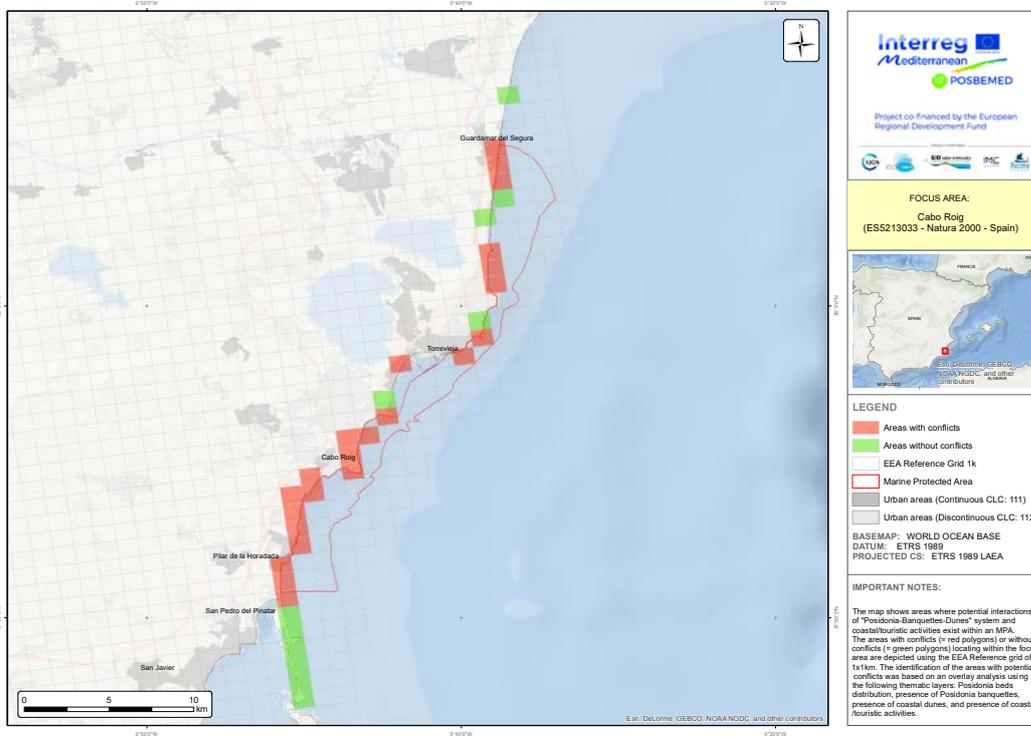
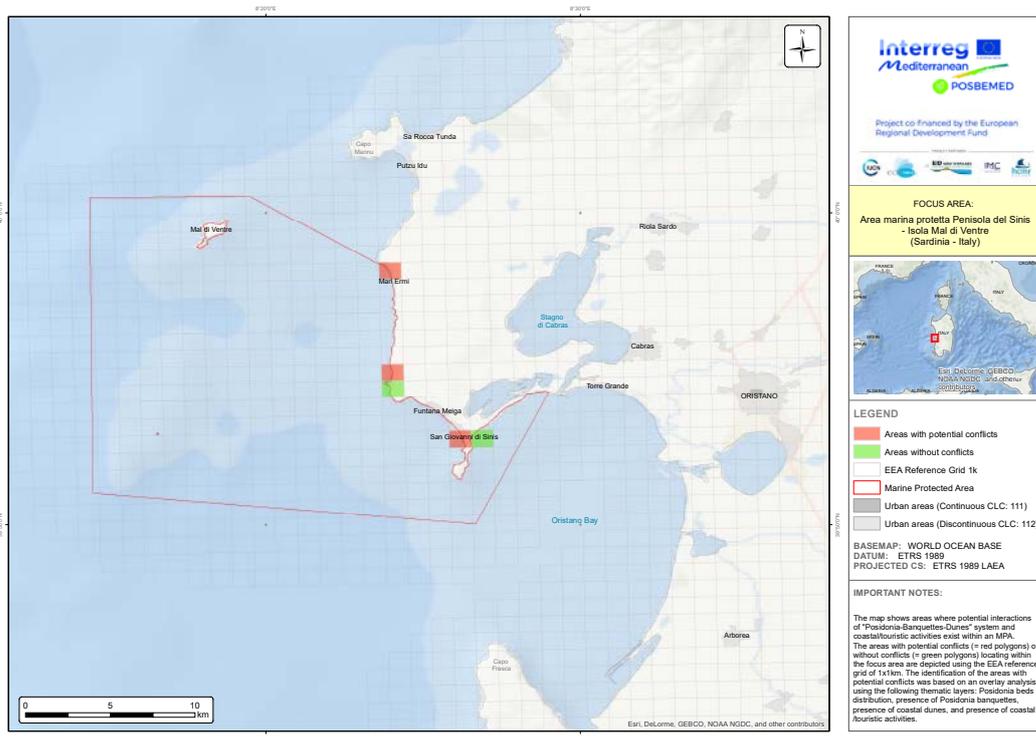


FIGURE 10

Natura 2000 site of MPA Peninsula de Sinis- Isola Mal di Ventre (Sardinia, Italy). Pressures and impacts on the environment resulting from tourism on the territory.



Voidkokilia beach (Messina), part of the Natura 2000 site of Limnothalassa Pylou (Divari) Kai Nissos Sfaktiria, Agios Dimitrios, Greece.



BEACH CLEANING EQUIPMENT

HEAVY MACHINERY

Any machine used for digging operations, can be tracked or wheeled.

Power shovels - digging and loading machines that consist of a revolving deck with a power plant and a front attachment (boom or crane), supporting a handle with a digger at the end. The mechanism is placed on a base platform with tracks or wheels. Power shovels can be mechanical, electric or hydraulic.

Skid-steers are used for excavating, but can also pull, push and lift materials. They can be equipped with grapple forks that filter out the sand collected with the banquettes. If the grapple fork is used together with a loader, it helps drain the trapped water and return it to the beach. This type of machinery allows the time spent in the cleaning process to be reduced.

Tractors are used for excavating, as well as other beach cleaning activities. They can collect large piles of banquettes together with sand. Tractors can be equipped with rakes - a rotating conveyor belt with many teeth that combs through the sand and removes surface and buried debris while leaving the sand on the beach.

A bulldozer (crawler tractor) is equipped with a metal blade that is used to push large quantities of sand. Usually it is tracked but it can also have wheels. It can perform digging, transport and spreading. The blade may be lifted and forced down by hydraulic rams. The material collected with a bulldozer is then unloaded into a skip or directly into the collecting tank of the accompanying trailer.

Power shovels



Skid-steers



Tractors



LIGHTER MACHINERY

Screeners. Used for sifting sand. The banquettes and sand are collected on a vibrating screening belt by a pick-up blade, which leaves the sand behind. The banquettes are gathered in a collecting tray which is often situated at the back of the vehicle. Can be implemented once the largest mounds of banquettes have been collected or simply for beach maintenance.

Screeners

© Brenik / Shutterstock.com



TRANSPORT MACHINERY

Trucks and dumpers. Trucks and dumpers are used to transport the collected banquettes to another location (landfill, another beach etc.), designed to carry large amounts of bulk material. The load skip can be located behind or in front of the driver.

Trucks and dumpers

© Radist | Dreamstime.com



TABLE 5

Percentage of type of method and machinery used in banquette removal operations by local Authorities in 5 EU Mediterranean countries.

	Heavy machinery	Light machinery	Manually
Greece	18	29	53
Italy	31	46	23
France	50	39	11
Spain	35	52	13
Cyprus	88	6	6

Previous work carried out by other initiatives and enquiries made to local authorities during the course of this project confirmed that seagrass wrack is often considered as beach waste by a significant number of local authorities. Consequently, local councils normally remove and dispose of it in different ways (Fig.11; Table 5). An average of 26% of the municipalities deposit them in a landfill, while in around 20% of locations, the materials are used for other purposes or are disposed of in the vicinity of the beach and returned to the original location at the end of the tourist season.

Some coastal communities produce compost from *Posidonia* and use this substratum as cheap fertilizer or soil improver in agriculture. Given the high presence of salt and sand in the wrack, additional requirements and operational process might be needed before it is used (Milano et al., 2018).

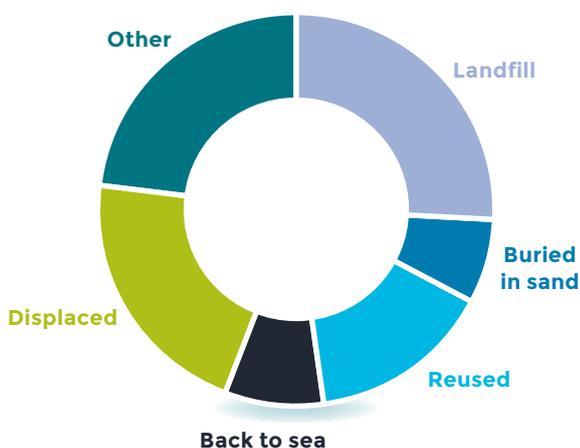
Other reuses of the deposits might include insulation material for buildings, composite reinforcement in noise insulation acoustic panels, packing material, mattresses and other recycling processes such as those for the preparation of materials used in restoration of emerged and submerged coastal areas (see review by Milano et al., 2018).



French technique “mille-feuilles” or “thousand leaves” where *Posidonia* wrack material is placed as undercoats on 30 to 40 centimeters thick layers covered with a layer of sand to restore dunes. Photo from Tombolo de Giens, Almanarre beach, Municipality of Hyères-les-Palmiers, Var Department - PACA. © EID Méditerranée

FIGURE 11

Reuse, recovery and disposal of banquettes after removal operations by local Authorities in 5 EU Mediterranean countries



Explanation legend of Figure 11

- “Put in landfill”: banquettes are removed from the beach and treated as waste and driven to the dump or a landfill for waste treatment.
- “Recovered”: banquettes are collected and recycled or used for another purpose (compost/ green waste, raw material, items...).
- “Put back in the sea”: Discharged with boats or trucks directly in the sea, using a combination of marine currents and winds to take banquettes away.
- “Buried in sand on the spot”: banquettes are mixed with the sand and spread over the beach /or banquettes are buried in a trench made on the beach /or layers of sand and banquettes are superimposed. Usually, when this option is chosen, banquettes stay where they have beached.
- “Displaced”: Every action that carries banquettes away from where they were beached. Banquettes are displaced as soon as they are removed from their original beach, regardless of what is done with them afterward. Corresponds also to beaches where banquettes are regrouped and pushed to the side or backwards.

Collected Posidonia wrack is sometimes placed on coastal dunes or pushed back from the beach into the water to use offshore winds to take the material away. In a few sites, Posidonia beach wrack is reported to be buried on the spot and used as a natural sand catching fence (e.g. technique “mille-feuilles”).

Commonly, to save the costs of disposal, the material is also temporarily stored in beach locations (e.g. side of the beach) or at close-by sites to dry and to compost. After several months, usually in winter, the material, if not used for compost or other use, is transported back to the beach.

Summary

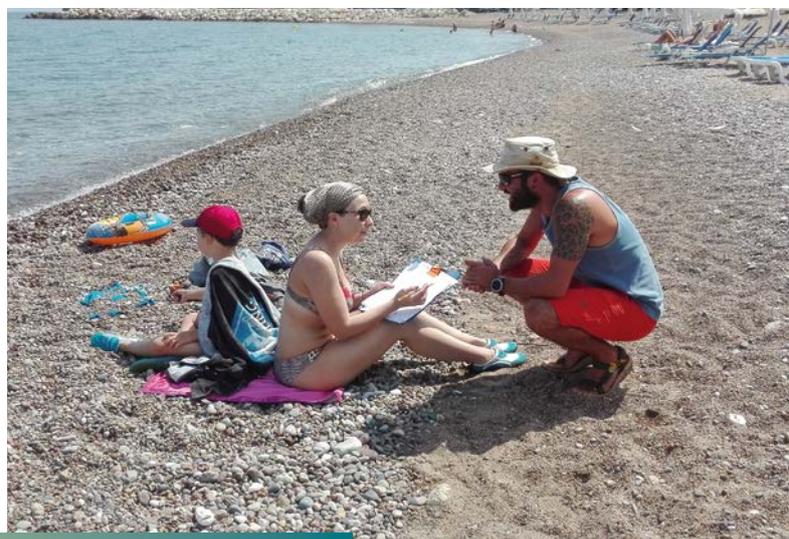
ON PERCEPTIONS AND EXPECTATIONS FROM DIFFERENT STAKEHOLDERS ACROSS COUNTRIES

Information on beach users' preferences and expectations from different stakeholders can be insightful in order to set up policy objectives.

Over the course of the project, we examined the attitude of beachgoers (tourist and local residents) towards the presence of Posidonia banquettes across 5 countries (France, Spain, Italy, Cyprus and Greece) and the expectations or preferences of different stakeholders on aspects of tourism

beach quality. In order to assess perceptions, two different beach types were targeted: (i) intensively used/urban and (ii) semi-natural or protected beaches. Detailed results of these findings can be found in Mossone et al. (2018).

Conducting interviews to beach users in Cyprus. © Louis Hadjioannou, AP Marine.



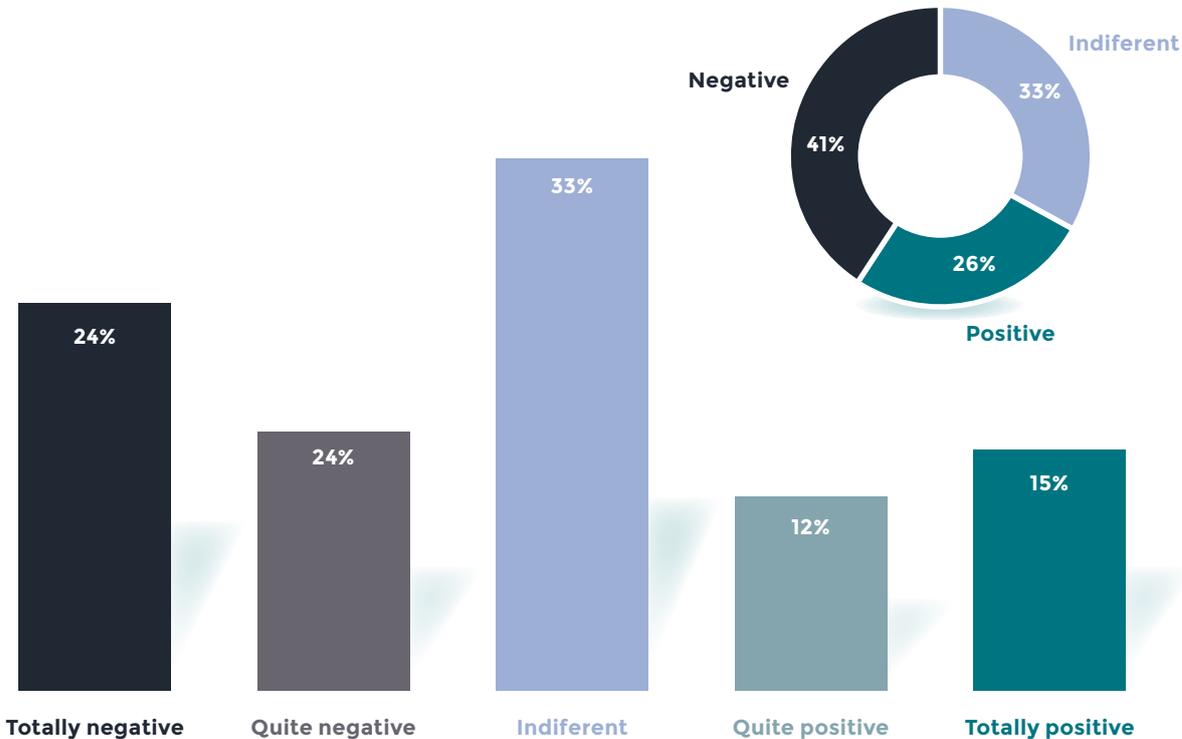
In general, the presence of banquettes on the beaches is shown to be a negative factor in choice for a significant portion of tourists (Fig. 12). This is particularly true for the localities that base their marketing on the offer of white beaches of the tropical model (intensively used/urban beaches). Nonetheless, taking into account that those who have a positive attitude and those who are indifferent can be considered as a single category, in the sense that neither of them require the removal of the banquettes, circa 60% of them show tolerance towards the presence of banquettes (Fig. 13). Among countries, there is also a clear indication that awareness and the type of users show a wide spectrum of sensitivity towards the banquettes (Fig. 14).

The comparison between the expectations of beachgoers and operators of local authorities and tourism companies also shows remarkable differences (Fig. 15). In practical terms, beach management is still primarily concerned with satisfying the users' expectations, however, the tourists' acceptance of the banquettes on the beaches is greater than that expected by both the tourist operators and the authorities.

Beachgoers' knowledge and awareness of the role that banquettes play varies between 39% to 66% among the countries and increases with their level of education and the information available. When confronted with choices of management measures, the majority of beachgoers (locals and visitors) prefer the alternative options that do not involve the removal of banquettes all year (Fig. 16).

FIGURE 12

Perception of presence of banquettes by all stakeholders consulted (beach users, tourist companies, and local administrations) in 5 Mediterranean countries.



SUMMARY ON PERCEPTIONS AND EXPECTATIONS FROM DIFFERENT STAKEHOLDERS ACROSS COUNTRIES

Results from perception and expectations of stakeholders (beach users, tourist companies, and local administrations) in 5 Mediterranean countries (Cyprus, Greece, Italy, France and Spain). Data from surveys to 1200 beach users, 200, tourist operators, 100 administrations.

FIGURE 13

Presence of banquettes as a factor in choosing a beach by resident and tourist visitors.

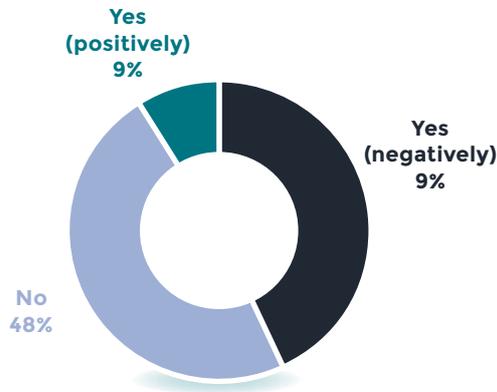


FIGURE 14

Presence of banquettes as a negative factor in the beach choice by local residents and tourist visitors per country (ES-Spain, IT-Italy, FR-France, GR-Greece, CY-Cyprus).



FIGURE 15

Perception of the effects of the presence of banquettes on tourism by local authorities and tourist operators of the 5 Mediterranean countries.

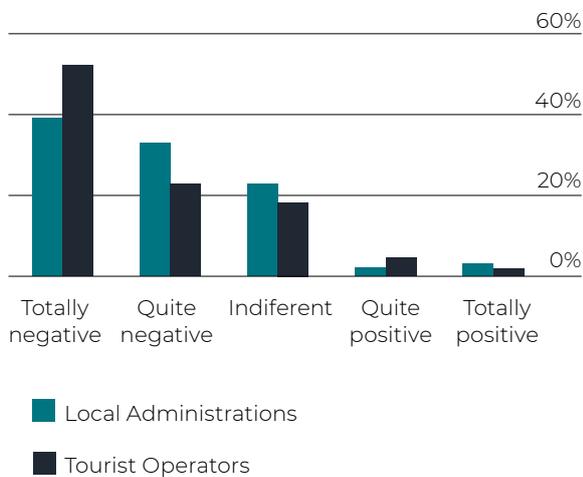
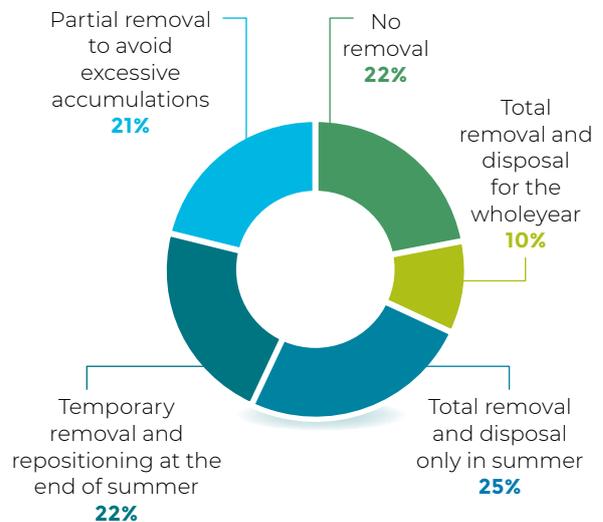


FIGURE 16

Choice related answers provided by beach goers (locals and tourists) on how banquettes should be managed.



NON-MARKET VALUES OF POSIDONIA WRACK MANAGEMENT (WILLINGNESS TO PAY)

As part of the survey on perceptions and expectations, a cost / benefit analysis was carried out in order to establish the different options for managing Posidonia banquettes from an economic point of view.

The direct cost caused by the presence of the banquettes can be determined as the result of the loss of tourists, already identified in the survey, multiplied by the average daily expense of tourists. The value calculated in this way is € 2.98 per m² of beach.

The benefits were consequently evaluated as a positive value perceived by the user of a beach in its natural state, without having the banquettes removed. The contingent valuation revealed that the potential demand to keep the beaches in a natural state, without removing the banquettes, is expressed in a willingness to pay up to €8,031,496.59. This amounts to €2.08 per m² of beach. Overall, the management's decision to keep the beaches in a natural state has a negative economic impact on the tourism industry, equal to about €1 per m².

Although the method of the contingent valuation is the one most used for the quantification of the total economic value of an environmental benefit, further information is still needed to complete the picture such as the avoidance of the loss of beach due to removal and erosion, in terms of the costs of sand replenishment or savings on removal and disposal.

All these considerations lead to the outcome of a probable increase in benefits compared to costs. Overall, it was shown that 2/3 of the potential economic loss of the tourism sector, due to the presence of Posidonia on the beach, are offset by the preferences of other tourists for a beach in a natural state.

Management administrations on popular beaches commonly remove banquettes from the shore to prepare the beaches for the holiday season.



EFFECTS OF BEACH CERTIFICATION

As the demand for the use of public spaces is growing, management becomes more complicated. In order to facilitate this, various Performance Awards and Environmental/Quality Management Standards have been developed based on diverse criteria: (i) quality (ISO Standards: ISO 14001, ISO 9001, ISO 13009:2015), (ii) EMAS (European eco-Management and Audits Scheme) and (iii) Blue Flag.

Among them, Blue Flag is the most widely used and internationally recognized certification in terms of eco-labels on beach quality. This beach



award is set up to provide indicators of quality in environmental education and information, water quality, environmental management, and safety and services (Blue Flag, 2018). One of the criteria required for compliance with the annual award, is that algae vegetation or natural debris are left on the beaches, or are managed when their presence creates a nuisance or a hazard (Criteria 16). Only if it is absolutely necessary should vegetation be removed, and then consideration should be given to disposing of it in an environmentally-friendly way, e.g. through composting, for fertilizer use or as a dune stabilizer. In the meantime, these deposits should not create a nuisance for beach users.

When asked to comment on how important a green label designation would be in influencing their future beach selections, 74% of beach goers said they favoured the use of specific green labels for information and promotion, which would be assigned to the beaches in a natural state, e.g. with a possible presence of banquettes. This indicates that the use of beach certifications like the Blue Flag beach designation, if correctly followed, could contribute to beachgoers' decisions with regards to the permanence of the banquettes on beaches in the future. Nonetheless, further criteria on the operational procedures (e.g. the deployment of heavy machinery) are still needed.

A local approach

TO MANAGE THE POSIDONIA LITTORAL ZONE

ANALYSIS OF CURRENT GOVERNANCE AND MANAGEMENT PRACTICES

Many municipalities and local stakeholders are demanding practical and economically sustainable solutions for the management of banquettes, along with much clearer regulations.

New management approaches have to focus on cost reduction and conservation of the integrated ecosystem, considering how management practices affect the health of the entire ecosystem and the resilience of the coastline.

Current management practices can be improved in terms of environmental criteria and social perspectives by using spatial zoning, technical or organizational adjustments in management and a more comprehensive and effective legal framework. Whatever method or strategies are decided upon, they need to consider different uses and values of the coastal environment in some way. Beach management plans may use criteria and descriptions to aid understanding of the coastal environment where they are located, but it will also depend on the specifics of its overall marine and coastal environment.

Some Mediterranean coastal environments have a strong human presence and, in many areas, beach tourism is the backbone of the local economy. Here, the requests of beach users should be considered

and might differ between residents and tourists as these two groups have different intentions, values and expectations regarding a given beach destination. Occasionally, the accumulation of seagrass banquettes can reach nuisance levels, especially as it starts to degrade, and therefore a balance must be achieved in meeting the requests of the people, both local and visitors, and the need to maintain the ecosystem integrity.

Following the results of the public perception study, we understand that there is a substantial negative attitude towards the presence of seagrass banquettes on the beaches, but at the same time there is a more positive acceptance by beachgoers, compared to operators, both public and private. In general, tourist operators and local authorities overestimate the negative impacts of banquettes on tourism in the same proportions, compared to the more neutral perception of beachgoers, particularly locals (Mossone et al., 2018). It is also noticeable that tourists' acceptance of the banquettes on the beaches increases with their awareness of the ecological benefits of banquettes and the amount of information available.

In addition, considering the information gaps that exist on most Posidonia littoral zones, management decisions require carefully thought out approaches and the need to invest in a good understanding of the complexity of this coastline. The application

of modelling of existing dynamics that include the formation of banquettes and the forecasting under different management scenarios might be useful for this. Examples from elsewhere (Aragonés et al., 2015; De Muro et al., 2018), illustrate how corrective measures might end up increasing the problem or enhancing erosion process of the beaches, therefore increasing the cost of artificial sand replenishment. Unfortunately, banquettes are often cluttered with beach litter, brought in with the wind or left on the beach by users, which aggravates the problem of their reuse and permanence on the beaches.

Moreover, some of the mechanisms applied for removing banquettes from the Mediterranean beaches with heavy machinery and their subsequent disposal also poses several challenges (Table 6).

Overall, the best option is that Posidonia banquettes are left in place in the coastal environment. As mentioned before, their presence on the beach plays a major role while also contributing to the protection and stabilization of the shoreline and coastal dunes, enhancing biodiversity and reducing sand erosion during winter.

Leaving banquettes untouched in protected areas, on receding beaches (e.g. under the erosion process) as well as on less popular beaches, can provide benchmark information about the dynamics of this natural environment and be used to forecast local assessments in similar situations elsewhere. Moreover, the permanence of the banquettes on such sites will enable the stabilization and nutrient supply to nearby ecosystems along the coastline.

Nevertheless, it is acknowledged that in some situations the presence of large amounts of banquettes may negatively affect the amenity of an area, particularly on very popular resort beaches. Regulatory government bodies and advisory agencies might need to provide operating procedures to guide local beach managers in the removal of waste and litter and, in some cases, also provide practical guidelines for maintaining the banquettes or for their removal and reuse, when authorized. Examples of existing regulations and management approaches and techniques are included in Appendix 1.

Some of the existing policies consider different approaches by distinguishing beaches by their natural character, uses and services provided, presence of adjacent dunes and/or receding coastlines. However, the majority of policies are still too narrow in their scope due to addressing single features (e.g. sediment type) or omitting the inclusion of important elements (e.g. amount of seagrass inputs or presence of shallow seagrass meadows) or lacking consideration of intermediate stages of development and perceptions of use (e.g. between intensive popular resort beaches and more conservation oriented-beaches).

Best management approaches should first take into account the criteria and the factors that control the dynamic nature of the Posidonia littoral zone and the formation of banquettes, the density of banquettes, presence of sensitive areas nearby or within the sites (e.g. protected sites), as well as beach user frequency and density, operational management limitations and the vulnerability of the coastline.



Small green tractor cleans the beach early in the morning at Gran Platja beach and Badia de Tossa bay in Tossa de Mar on Costa Brava, Catalunya, Spain.
© Olgacov | Dreamstime.com



TABLE 6

Approaches used to remove banquettes from beaches and issues encountered.

Technique	Issues
Dispose offshore	Cumulative or large quantities disposed in offshore waters can threaten the persistence and productivity of seagrass and other marine habitats and reduce water quality.
Dispose higher up the beach/to dune	Relocation to a point higher on the beach may also reduce the recycling of nutrients back to the sea. It may not be feasible if no beach area is available. High costs associated with handling of the banquette. Possible loss of beach surface area due to accumulations of banquettes on higher portions of the beach profile.
Dispose off-site from the beach	Reduces the recycling of nutrients back to the sea. Requires additional studies to analyse the implications for sand moved from the beach. General lack of beach wrack treatment facilities, due to high installation and maintenance costs and long application and approval procedures. The installation of sites for temporary storage, separation of sand from Posidonia biomass material, drying and decomposition of natural material near beaches is expensive and requires a long application and approval procedure.
Use of heavy machinery on sandy beaches	Flattens beach profile and eliminates sedimentary features (e.g. sediment berms, beach-face steps). Lower concentrations of organic matter in the upper zone, plus lower densities and diversities of invertebrates by comparison with neighbouring sites. Fine sands more vulnerable to wind erosion and reduced sand on beaches due to beach grooming practices.
Use of machinery on dunes	Leads to uprooting of dune flora resulting in bare dunes. Frontal embryonic dunes are most affected. Subsequent erosion of dune base due to the sand being blown inland, with impacts on dune stability.

GOVERNANCE FRAMEWORK AND RECOMMENDED MANAGEMENT MEASURES

Because Posidonia is a natural and important part of the Mediterranean coastal ecosystems, banquettes should be left in place whenever possible, and particularly so at protected beach and dune systems. When banquette removal is deemed necessary, however, local conditions and management considerations must be fully understood and addressed before selecting appropriate techniques (see below). A medium to long term management strategy or policy should be developed for all beaches where banquettes accumulate and this strategy should be part of a wider framework for achieving integrated coastal zone management.

Here, we propose a framework of reference for decision making, particularly for large Posidonia banquettes, considering beach functions (protection and recreation) and the integration of the ecosystem (Fig. 17). At the top level, **the strategic objective** is to achieve a sustainable management of Posidonia beaches, while maintaining the protection in high environmental value areas (Natural areas), such as protected areas, and the recreational values in others.

The tactical level reflects beach typologies in order to take into consideration the (local) social expectations and present perceptions while also maintaining the integrity, ecological function and environmental values of the Posidonia coastline.

Benchmarking will help to define a base line: the existing dynamics of the coastal zone and the seagrass deposition and formation of banquettes on the beach/es. The analysis of each beach type (topography, shoreline variations and geomorphology) can allow discrimination of the impact of different human interventions versus maintaining banquettes in place (e.g. on embayed beaches at the base of cliffs).

Coastal managers should also consider conducting a risk-based assessment of environmental, social and economic values and the general objectives of the area in the case of the existence of a Protected

Area on the beach, or in close proximity to the site.

Stakeholder community consultation on an annual basis will enable the coastal community to have up-to-date information about current management practices and participate in their review, ensuring the integration of their vision and needs.

At an **operational level**, measures for managing Posidonia banquettes are identified and implemented: a) to maintain the ecosystem (minimise interference with the process of sand and nutrient deposition from banquettes); b) to improve the situation if erosion is present or restoration activities are needed and c) to limit the impact on the recreational values of surrounding areas and to ensure that existing and planned recreational uses are balanced with maintaining ecosystem integrity. Assessments of feasibility for each option should be carried out for the evaluation.

Monitoring and evaluation of interventions:

This will consist of selecting a series of indicators to monitor the state of the coastal environment, including the beaches and associated dunes. These indicators will be used in the re-evaluation of the benchmarking process by comparing the present status against the status of coastal areas without banquette removal and those sites where different interventions have been used.

The collection of data on the total weight of the banquettes removed and the disposal methods used can provide very valuable information on trends in seagrass deposits, the conservation status of seagrass meadows and operational management costs. For this, it is also recommended that data on erosion processes that might occur on beaches as well as sand nourishment practices (quantities and temporality) are gathered simultaneously to assess the results of management practices.

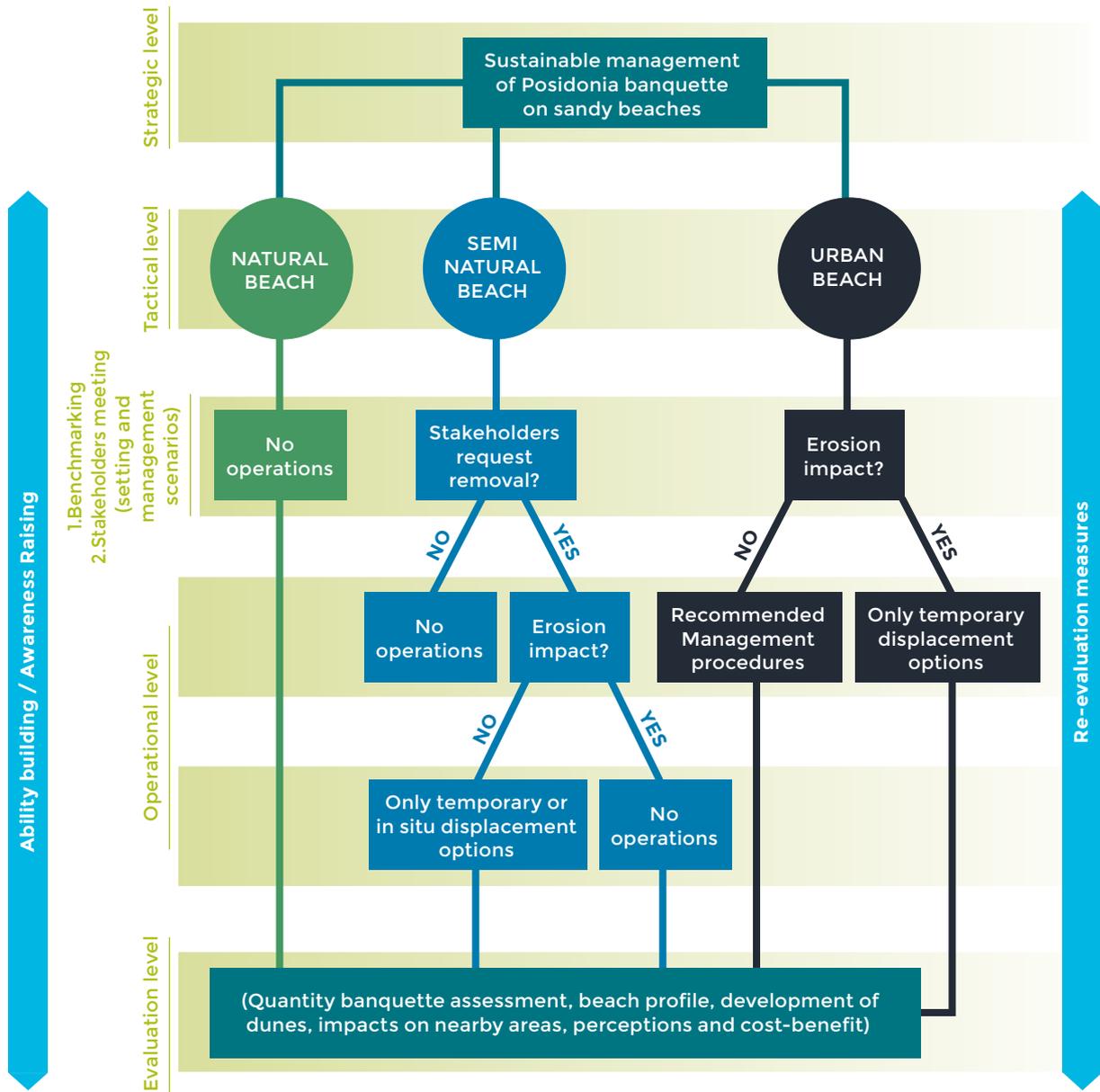
Local authorities should also collect data on types and numbers of visitors as well as on their knowledge and perception of the management strategies. This information can help to test the effectiveness of existing or introduced regulations, awareness raising programmes and changes in visitor's perceptions.

Natural beaches with Posidonia help protect from coastal erosion, retain sand and enhance biodiversity. M. Otero/IUCN



FIGURE 17

Governance framework for decision making on Posidonia banquettes on sandy beaches.



In addition, the strategic objectives and actions to carry out a comprehensive management of the Posidonia littoral zone should include:

- Ability building for the personnel involved in beach maintenance activities. Personnel should receive training each year on beach cleaning policies, characteristics of the Posidonia littoral zone and how to recognize and mitigate impacts.
- Awareness Raising. It is also essential to promote the ecological importance of banquettes, coastal dunes and Posidonia meadows on the littoral ecosystem for both visitors and the local community, including the use of interpretation panels at appropriate locations so that the public can understand the beach management strategy, particularly if there is a change in beach cleaning methods.
- Policy regulations. Regulations through management permits or authorizations for different management approaches as well as for the use of Posidonia banquettes for commercial purposes is highly recommended.

OPERATIONAL RECOMMENDATIONS

Whenever beach cleaning has to occur, it is recommended that authorities only use mechanical cleaning as a last resort and consider the following options:

- On beaches with low visitor numbers and certainly on beaches with high natural value (as those that are part of designated protected areas and/or with erosion problems), consider no removal and manual collection only in special circumstances with authorized permissions.
- On beaches with high visitor numbers, and only during the summer season, consider clearing only small sections of the banquettes to form "clean zones" (for summer period) and allow easier access from the top of the beach to the sea for the bathers. It is preferable to opt for a temporary displacement of the banquettes according to the guidelines below.

- On beaches where large accumulations of seagrass are causing public nuisance, the banquettes can be collected and composted but should not go to landfill sites unless contaminated with hazardous waste (e.g. in case of an oil spill). Where seagrass is heavily contaminated with human litter, the seagrass strands can be collected and composted – raking should allow the separation of plastics.



Tractor cleaning Posidonia cast from the beach. © Jose Juan Gonzalez Sans | Dreamstime.com

Whether hand raking, rake-type machines, or other machinery is used, these general guidelines should be followed:

- The lowest impact techniques available should be used.
- Removal should be focused on the areas of significant accumulations of seagrass banquettes, leaving a sufficient wrack line or thickness (min. 10cm) in the banquette to provide a nutrient source, and a structural habitat for fauna as well as to help build the beach and dunes. Machinery that uses top-down cleaning methods should be utilized to allow removal in layers, starting with the top layer.

- Effort should be made to remove as little sand from the beach as possible in order to minimize impacts and leave important substrate in place. Sieving to separate the sand from the vegetable material should be undertaken and the collected material redistributed afterwards along the beach. Sand sifting equipment should not penetrate more than 15 cm from the sand surface. Any sediment contained in the collector should be allowed to percolate through the collected seagrass to ensure that most of the sand can be returned to the beach.
- Machinery should avoid beaches being scraped, gouged or scoured. It is better that the heavy machinery does not penetrate in to the body of the beach, so as to avoid ploughing of the beach. Additionally, machinery should not work on the beach face in order to avoid the flattening or the modification in the slope, thereby encouraging the potential retreat of the shoreline.
- All machinery should operate at least 5m seaward of dunes and avoid any vegetation to protect the stability and ecology of the area.
- Mechanical beach cleaning equipment should only be used in areas with a large number of visitors and the frequency of its use should be kept to a minimum.
- To maintain the resilience of the coast that results from banquette formation, seagrass removal should be kept to a minimum and be performed after the storm period. This information could be obtained by the National Wave Buoys Statistics.
- To minimize the compaction of beach sediment, vehicles should be equipped with rubber tyres (chain or track tyres shouldn't be permitted).
- Mechanical cleaning should only be performed if the surface at 7-10 cm is dry.

Displacement options

Disposal strategies will vary depending on the space available for storage and drying of seagrass, the amount of material to be disposed of, the resources available for disposal, and ecological impacts. All options should be carefully evaluated and those that most successfully address and avoid impacts should be selected, opting for the least intrusive method possible and the ones that offer protection of the native vegetation. Options in order of priority are:

1. No disposal—the seagrass banquettes remain in place
 2. Temporal disposal— they are moved off to one side of the beach or to a non-recreational use area. After summer they are returned to the beach of origin to help the sand build up.
- It is advisable to consider approaches to ensure the adequate aeration of the banquettes while they are displaced if they are accumulated in large quantities. The deposition of material should only be located in the coastal areas without vegetation and be protected by appropriate containment structures that will allow sufficient aeration of the banquette and avoid dispersal with wind. Stakes fixed in the sand and connected by a close meshed net can be a good option.
3. On-site burial (for minor accumulations, max. 10cm height) below the mean high water line. Burial in the sand should be in the same spot where the banquettes are found and, preferably, only on exposed beaches.
 4. Return to the sea, when wind/tide conditions are favourable (only for minor accumulations).
 5. Permanent displacement—Advisable for sheltered beaches and cliff beaches with no erosion process.



Displacement of banquettes during summer time on one side of the beach.

In determining displacement, local authorities should consider the following factors:

- Prior to disposal, seagrass wrack (or banquettes) should be shaken or sorted to remove as much sand, sediment and live organisms as possible. Beach trash or debris should be removed if it is to be stored or stockpiled anywhere on the side of the beach or coastal beach system.
- Seagrass wrack material should not be deposited on any dune area where it can smother live plants, leading to dune erosion and destabilization.
- The displacement of banquettes to nearby areas is only advisable for stretches of high hydrodynamic coastline, so as to let the seagrass biomass go back into the sea and for those beaches in recession, to exploit the protective action of the banquette. This should be done to best simulate the banquette formation along the beach (and not as pointed stock piles).

Transport access

Removal of Posidonia banquettes may require access to the beach with vehicles or machinery which can cause damage to fragile dune areas and vegetation and has the potential to flatten the beach profile and affect biodiversity. It is therefore recommended that:

- Preferably compact and light-weight tyred vehicles (skid-steers, pick-up trucks, or small dumper vehicles) with front load skips or pick-up vehicles/ vans (e.g. no heavier than 2.5 Tons) may be used only for very large stretches of coastline. Consideration should be given to minimizing the number of trips to transport the banquette.
- Use access on existing roads and avoid affecting the profile of the beach, dunes and vegetation, maintaining a distance from sand dunes (5m) and turtle nests if present (15m).

Use of banquettes

Removal of Posidonia could sometimes be undertaken to make use of the resource. Approval should be required before removing the material from the beach. Further considerations to take into account include:

- For the reconstruction of eroded dunes and/ or sands with erosion trends, the site should be close to the site of origin of the banquettes.
- Any banquette collected (clean of beach litter) could be composted or used as a natural resource for other applications (e.g. paper/ plywood production, compost, biogas, agriculture compost, traditional house building). A harvesting

license should be required to regulate this practice and keep track of the destinations and amounts of materials used, following the regulations applicable in each case.

BEACH CERTIFICATION SCHEMES

The popularity of beach certification schemes (e.g. Blue Flag designation) across the Mediterranean countries has increased notably over recent years. Actions should however be taken to fill the gap in these schemes with regard to beach wrack material and the management and operational procedures to achieve this. Furthermore, the conditions for maintaining, conditioning or mechanized cleaning of beaches should be addressed more specifically within these criteria.

The surveys carried out in the course of this project also highlighted the importance of stakeholder awareness as there was little public recognition of the role of banquettes in beach ecosystems and the ecosystem itself. Environmental education and information components are needed as criteria in these awards that should place a stronger emphasis on the ecosystems and the importance and links of seagrass meadows and banquettes on sandy beaches with coastal dunes.

Building

A TRANSBOUNDARY MEDITERRANEAN STRATEGY

Through the surveys conducted and the revision of previous initiatives, the need to promote better management of the *Posidonia littoral* landscape and the banquette formation on beaches throughout the entire Mediterranean has become evident. Implementing a transnational strategy with medium and long term objectives is also required given the present trends in the growth in tourism and climate change. Common action plans could be better defined by cross-referencing challenges,

lessons learnt and opportunities arising in different regions and in different local situations. From these efforts, good practice guidelines could be used for testing its future implementation in protected Mediterranean areas, including Natura 2000 sites.

The transnational integrated strategy and action plan, as presented in this section, aims to gear regional and national policies, funding bodies and research institutions towards creating suitable conditions for implementing sustainable beach and coastal management practices across Mediterranean areas.

VISION

The strategy establishes a long-term vision “to manage the Mediterranean coastline by developing planning strategies that recognize the value of the Posidonia beach-dune environment and integrates them into the overall coastal strategy, while also addressing concerns and educating stakeholders”.

PRINCIPLES

The strategy is guided by an overarching set of principles and specific goals and actions to achieve this vision. Thus, it must have a clear emphasis on the protection of Posidonia littoral zones.

The Strategic principles are:

- Posidonia beach/dune system must be considered as an integrated system that depends on the sedimentary balance and flow of matter between the different compartments
- Given the limited knowledge on their interrelation, a precautionary principle should be applied in their management
- The resilience of this ecosystem depends on its level of naturalness and connectivity among its components
- High level conservation should be ensured for priority sites³
- The Ecosystem-based approach should be used with stakeholder participation and the setting of goals for good environmental status integrating the formation of banquettes in the beaches

Fibrous balls formed from leaves and rhizomes of Posidonia oceanica by the action of the waves breaking on the beach.

³ PRIORITY SITES are identified based on the level of biodiversity of the Posidonia beaches/dunes system,, what ecosystem services they offer and the connectivity between different components. These can be both sites with good connectivity between different components and sites particularly exposed to external threats.





Seagrass beds at Amorgos island, Naxos Region, Greece.
© Meropi Adamopoulou.

These five principles set the benchmark for planning and decision making on the coast, and are fundamental in the preparation of coastal management plans that include the Posidonia littoral zone.

Strategic objectives

- Maintain ecosystem integrity while enabling sustainable use
- Restore the damaged ecosystem to enhance the resilience of the Mediterranean coast
- Enhance the understanding of the functionality and services of Posidonia beach/dune system by society
- Ensure high level conservation of priority sites

Priorities

Priority 1. Knowledge challenges for management

Timely and good decision-making requires reliable information based on science and evidence. It also requires the collection of site-specific scientific information, research and monitoring in an integrated and multidisciplinary way to address the queries from the ecosystem/natural perspective and also from an economic and socio-aspects point of view.

Actions to address the following knowledge gaps on the environment and the key ecological processes as well as the results from impacts on these unique littoral zones are:

- ★ Action 1.1. Improve knowledge regarding the beach dynamics and the banquettes while also collecting proof of the benefits derived from the presence of banquettes:
 - Role in beach morphodynamics
 - Role in the fertilization of the foredune vegetation and seaward accretion of the foredune
 - Role for biodiversity
 - Role in coastal resilience

- ★ Action 1.2. Increase knowledge on how beaches with banquettes react to management impacts:
 - Exposed, semi-exposed and sheltered beaches
 - Information on the benefits of permanent banquettes vs. seasonal removal, such as the differences in the beach stabilization function or the emanation of unpleasant odours.
- ★ Action 1.3. Understand the dynamics of seagrass meadow productivity and its relation to banquette formation and dune ecosystems
- ★ Action 1.4. Increase knowledge on ecosystem service cost-benefits
- ★ Action 1.5. Enhance knowledge on the spatial distribution of the Posidonia beach-dune system

An improved knowledge and information available on these aspects is required in order to:

- establish baselines to examine and quantify trends and local variability of beaches and banquette formation in different settings (to target further observation and monitoring)
- better understand and predict future change to natural and human impacts (including climate change and different management actions), especially on highly frequented beaches or areas under the erosion process
- inform decisions about adaptation and mitigation actions
- monitor, evaluate and report on the effectiveness of local policies, planning and actual management of seagrass meadows, beaches and adjacent coastal dunes

Priority 2. Local management

As previously mentioned, in many Mediterranean countries the management of beaches is entrusted to regional and local governments. In many areas, the beaches are an integral part of the tourist offer and from analysing the views of stakeholders, it became clear that the level of support for more naturally-orientated practices (e.g. partial removal of banquettes) from beach users or local authorities could be further increased with more knowledge on the available management options.

Some of the key findings also showed that current practices are random, and without clear policies to guide them.

- ★ Action 2.1. Providing management guidelines. This will assist local governments in developing beach management plans and specific regulations for areas where Posidonia meadows occur as part of coastal management plans. It will also be important in guiding other coastal stakeholders, such as protected area managers, tourist operators and local community groups.
- ★ Action 2.3. Preparing local management strategies for the coastal zone with Posidonia meadows.

Local management strategies are needed to:

- Prepare a coastal planning framework that balances the need for sustainable management of the beaches with banquettes, seagrass ecosystems and coastal dunes;
- Enhance capacity building for effective best management practices
- Develop specific regulations for management measures or plans at local level
- There is a need for regulating the management of banquettes (type of machinery used, frequency/ timing of removal, conditions, amount of removal, and pathways for the machinery)
- Clearly identify management responsibilities.
- Evaluate feasibility and ways for separating plastic litter from banquettes.

- Establish monitoring programmes at local sites
- Support economic opportunities arising from the sustainable use of Posidonia banquettes and Posidonia beach wrack. It is important, nonetheless, that they do not undermine their natural function (see Governance Framework above) and the protective function of specific areas.

Priority 3. Communication and awareness raising

The results from the perceptions and expectations studies of different stakeholder groups in the five countries confirm that there is not enough available information on the importance of banquettes in the conservation of coastal ecosystems. Building the knowledge of local stakeholders, including visitors, and supporting their participation through local programmes and engagement activities, will enhance their understanding of the value of the Mediterranean coastal/ marine landscapes where key habitats like Posidonia meadows and coastal dunes are present. Furthermore, raising awareness will help to build stakeholder support for more nature-oriented management strategies.

For this, the challenges and actions that remain are:

- ★ Action 3.1. Increase awareness on the banquettes' role in the beaches and in the maintenance of a healthy ecosystem among managers and beach users (locals and visitors).
- ★ Action 3.2. Develop awareness raising and communication programmes and strategies at a local level (e.g. through Blue flag network or through environmental programmes)
- ★ Action 3.3. Develop active community participation programmes and coastal management activities to reduce the amount of marine litter (tackling the litter at its source) in order to preserve the banquettes (e.g. through beach clean-up networks)
- ★ Action 3.4. Encourage a better integration of the marine environment (including the role of Posidonia for land-sea connectivity and the associated ecosystem services) into the national education curriculum.

Priority 4. Policy for decision making

The Mediterranean coastal ecosystem is considered particularly vulnerable to climate change. In the Posidonia littoral zone, the rise in sea level, the increase in storm events and water temperatures pose additional pressures. Enhancing the resilience of this particular ecosystem with effective management and planning to address some of the identified problems (e.g. reducing the removal of banquettes to specific sites and only prior to the summer season) will also facilitate the retention of sand in the beaches and reduce erosion along the coast. The offer/demand for the so-called “tropical beaches” must also be reconsidered in ways to ensure the long-term good condition of the environment, particularly in Protected Areas, and coasts of a high conservation value.

The lack of clear regulations and specific legislation pertaining to the removal of banquettes and beach wrack in most areas is notable as many local councils apply their own specific regulations or arbitrary rules for their collection.

For Natura 2000 sites and other protected areas, there are still bottlenecks in adequate protection regimes that should consider the functional connectivity on the Posidonia beach dune system and effectively implement management measures. Appendix 4 provide a list of priority sites (not exhaustive) that gather habitat assemblages forming a Posidonia beach-dune system.

To achieve all of the above, policy and regulatory actions should be developed to:

- ★ Action 4.1. Encourage the integration of terrestrial and marine protected areas where the Posidonia littoral zone occurs so as to reduce its fragmentation and improve the ecological integrity of the coastal environment.
- ★ Action 4.2. Enhance national and local laws for the regulation of beach practices.
- ★ Action 4.3. Explain the role of Posidonia in carbon sequestration and storage, ensure the integration of seagrass meadows as a whole and banquettes (particularly on sheltered sites) into climate change mitigation policies.
- ★ Action 4.4. Integrate the role of Posidonia beach/dune systems as nature based solutions for coastal management plans and National Adaptation Strategies
- ★ Action 4.5. Consider the Waste Framework Directive, identify those institutions in charge of beach and waste management and align regulations and policies so banquettes are not considered solid waste. For those countries where there is no specific legislation pertaining to the removal of waste and/or banquettes on beaches, such legislation should be developed.
- ★ Action 4.6. Provide regulations and guidelines for the private sector (including marketing policies in tourism sector)



- ★ Action 4.7. Provide a description of beaches with banquettes as a habitat type for further regulations if they do not already exist.
- ★ Action 4.8. Support the enforcement of regulations and a local/regional legal framework for approval of operations (EIA) in the Posidonia littoral environment, including beaches.
- ★ Action 4.9. Ensure that all the components of Posidonia beach dune systems, including banquettes (currently not under protection through Natura 2000 network), are integrated into the legal framework for managing Natura 2000 sites or other designated Protected Areas.
- ★ Action 4.10. Finalize the elaboration of management plans for Natura 2000 sites and other Marine Protected Areas, where they are still lacking, including beach management considerations, especially in relation to Posidonia banquettes (where they are present).







Final words

The Mediterranean coastal environment is especially vulnerable to the tradeoffs which necessarily exist between the need to manage for both biodiversity and for people. Local governments are in the best position to lead the sustainability and ensure the resilience of the coastal environment with Posidonia meadows. The recommendations presented

will be useful in helping them, as well as other regional practitioners, to understand their role in building environmentally sound sustainable practices and working with a range of stakeholders and stakeholder groups in order to progress the actions for this strategy. This should be helpful in taking steps to overcome the challenges identified and any further actions that may be needed.



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Appendix 1

Management regulations for beaches with banquettes under different beach classifications.

Classification Beaches	Period established for NO removal	Model of removal	Ecological considerations	Operational considerations	Use of materials	Displacement considerations	Other considerations
MALTA							
Annex I beaches	1 Oct. – 14 April	Mechanical vehicles	Distance buffer areas and limitations close to sand dunes (5m) and turtle nests (15m)	Sand sifting equipment must not penetrate more than 15 cm from the sand surface. No access of motor vehicles to dunes. Vehicles equipped with rubber tires (no tracks) Allow use of mechanical rakes, blades or sand sifting equipment on sandy beaches	Disposal to follow Waste Management Permit Other users not specified		Need authorized permit outside the period (unless hand removal) and methods. Promote identification of areas for banquettes may be left or deposited
Annex II: Remote beaches		Not allowed only under exceptional circumstances					Need authorized permit
Annex III: MPAs (Natura 2000 sites)		Not allowed only under exceptional circumstances		No deposit back into the sea authorized unless special permission			Need authorized permit
BALEARIC REGION (Spain)							
Natural beach with services	30 Sept. – 1 May	Not allowed only under particular circumstances					Does not need authorization for traditional use and manual removal. Yes for others
Natural beaches in recession		No removal or consideration to leave banquette on exposed beach areas	Partial or full Reposition back before 15 Oct	Deposits cannot be mixed with beach debris			Personnel need training a priori
Natural beach without services	NA	Manual methods only	Reposition allowed in autumn under criteria		Traditional use		Does not need authorization

Classification Beaches	Period established for NO removal	Model of removal	Ecological considerations	Operational considerations	Use of materials	Displacement considerations	Other considerations
Urban beach	31 Oct-15 March	Sandy beach, mechanical vehicles	Distance buffer areas and limitations close to sand dunes and vegetation of 3m	Preferably, it must be provided with blades, shovels or spoons Shovels or spoons must have a perforated base of > 50% permeability Avoid large sand collection (use of track machines not allowed)	No deposition on dunes		Needs authorization Personnel need training a priori
VALENCIA Region⁴ (Spain)							
Sandy beaches		Mechanical in dry areas		Leave 10cm of banquette			No waste disposal Disposal on side of beach for dune formation or after summer
Gravel/boulder beaches	Only prior or during summer	Manual only					No waste disposal Place back to beach after summer
Var Prefecture (France)							
All	Only summer removal	1. Temporary displacement in situ 2. Permanent displaced to another beach with erosion 3. Back to sea		In situ and return to same location after summer	Not allowed	To another beach: for the reconstruction of eroded dunes or beach with erosion.	Admin procedure (authorization, permit) need scientific, environmental and technical justification for displacement to another beach

⁴ Recommended Guidelines of Diputacion of Valencia

Classification Beaches	Period established for NO removal	Model of removal	Ecological considerations	Operational considerations	Use of materials	Displacement considerations	Other considerations
Puglia Region (Italy)							
MC⁵1: Bathing beach in recession with high environmental value (protected area)⁶ and dunes	Not specified	1. No removal 2. Buried in the sand 3. Displaced within the same beach	To choose option see: 1. coastal morpho-dynamics 2. coastal morpho-logical traits 3. elements linked to the bathing use of the beaches 4. Cost-benefit analysis for each option.	Burial in the sand has to be in the same spot where the banquettes were found. The use of tracked vehicles ⁷ is forbidden.	Compost for banquettes from rocky coast and urbanized areas (not sandy beaches)	Making “containment structures” (in absence of dunes) with eco-compatible materials (wood) that will allow appropriate aeration of the banquette and avoid dispersal with wind.	Referred to stranded plant biomass (<i>Posidonia oceanica</i> , <i>Cymodocea nodosa</i> , <i>macroalgae</i>) Admin procedure (authorization, permit) necessary only outside of the “bathing season” or for extraordinary events (big quantities of biomass). Need to provide technical and scientific evidence that non-removal is not possible or feasible.
MC2: bathing beach in recession with environmental value (protected) and no dunes	Not specified	1. No removal 2. Buried in the sand 3. Displaced within the same beach.					
MC3: bathing beach in recession with no environmental value and with dunes	Not specified	1. No removal 2. Buried in the sand 3. Displaced within the same beach.					
MC4: bathing beach in erosion with no environmental value (protected) and no dunes	Not specified	1. No removal 2. Buried in the sand 3. Displaced within the same beach.					
MC5: bathing beach not in erosion with environmental value (protected) and dunes	Not specified	1. No removal 2. Buried in the sand 3. Displaced within the same beach.					
MC6: bathing beach not in recession with high environmental value (protected) and no dunes	Not specified	1. No removal 2. Buried in the sand 3. Displaced within the same beach.					

⁵ MC= coastal macrotypes⁶ Free translation from Italian of “vincolo ambientale”⁷ Mezzi cingolati (it.)

Classification Beaches	Period established for NO removal	Model of removal	Ecological considerations	Operational considerations	Use of materials	Displacement considerations	Other considerations
MC7: bathing beach not in recession with no environmental value and with dunes	Not specified	1. No removal 2. Buried in the sand 3. Displaced within the same beach.					
MC8: bathing beach not in erosion with no environmental value and no dunes	Not specified	1. No removal 2. Buried in the sand 3. Displaced within the same beach. 4. Displaced to another beach				To another beach: for the reconstruction of eroded dunes and/or sands with erosion trends. The site should be close to the site of origin of the banquettes and in any case in the same physiographic unit ⁸ .	
MC9: non-bathing beach		No removal					
Sardinia (Italy)		Options					
Not specified	Avoid winter period	1. No removal (preferable); 2. Displaced within the same beach and repositioned later 3. Permanent removal and disposal 4. Buried in sand 5. Placed on dunes	Machinery should not travel over the dunes or vegetation. Positioning on dunes cannot be carried out where dune vegetation is present.	1. Displacement/ removal of banquettes preferably done manually, the use of machinery of "appropriate size" that will not cause damage to the beach is allowed. 2. Use of tracked vehicles is forbidden. 3. Buried in the sand – only for banquettes of max. 10cm height, only in areas exposed to tides Any operation should minimize sand removal. Sand removed with the banquettes should be repositioned on the same beach.	1. Compost: possibility of transferring part of removed banquette to a composting facility.	1. Displacement on the same beach during spring and/or summer, and repositioning in autumn (if not biodegraded in the meantime). The collected material to be placed in a separated area to avoid any alteration of the beach morphodynamics and the biocenosis, in removable structures that ensure adequate aeration of the banquettes. Displacement/ repositioning: In case no appropriate site is identified on the same beach, the banquettes can be displaced on another beach.	Referred to stranded plant biomass (<i>Posidonia oceanica</i> , <i>Cymodocea nodosa</i> , macroalgae) Permanent removal: only if no removal or displacement is not possible in terms of objective difficulties and/or public health considerations in highly anthropized areas Placed on dunes option: no repositioning in autumn Burial in sand and positioning on dunes in Natura 2000 areas needs to undergo the environmental impact assessment.

⁸ "Le Unità Fisiografiche (U.F.) individuano tratti di costa in cui il trasporto solido, dovuto al moto ondoso e alle correnti litoranee, è confinato."
(it.) – coastal stretches where the solid transport, caused by wave motion and coastal currents, is confined.

Classification Beaches	Period established for NO removal	Model of removal	Ecological considerations	Operational considerations	Use of materials	Displacement considerations	Other considerations
Sicily (Italy)		Options					
Not specified	May and June for displacement and removal (recommendation)	<ol style="list-style-type: none"> 1. No removal 2. Displaced 3. Removed permanently and placed in a landfill 4. Reused 		Separate from solid waste prior to any action.	Compost, landscape reconstruction	Displacement can be carried out on the same beach or other (natural) beaches or those exposed to erosion. It can be seasonal (with repositioning in autumn) but not only.	<p>Authorization is necessary for all options except No removal, as well as an environmental impact assessment if the area is protected.</p> <p>In the event the banquettes are removed permanently they are treated as waste.</p> <p>No removal is recommended for areas without conflicts with beach use and/or in advanced stage of erosion.</p>
Abruzzo Region (Italy)							
Not specified	Not specified	<ol style="list-style-type: none"> 1. No removal 2. Displaced 3. Removed permanently and placed in a landfill 4. Reused 		<p>prior to any action.</p> <p>Use of adequate machinery that will ensure a high level of environmental protection and minimize the removal of sand.</p>	Material recovery - paper production, compost, biogas; Energy recovery - pyrolysis, gasification, anaerobic digestion of algal biomass, thermovalorisation		
Liguria Region (Italy)		Options by order of priority			Options	Options	
Not specified		<ol style="list-style-type: none"> 1. No removal 2. Displacement (temporary or permanent) 		Minimize the removal of sand	<ol style="list-style-type: none"> 1. Displacement 2. Waste disposal 	<ol style="list-style-type: none"> 1. Within the same beach 2. On coastal areas of elevated hydrodynamic activity 3. On other beaches of the same physiographic unit (for exposed beaches) <p>Material can be permanently displaced on:</p> <ol style="list-style-type: none"> 1. Non sheltered beaches 2. Foot of the cliffs 	

Note:

- ERA (2017). Operating Procedures on Beach Cleaning, Compliance & Enforcement Unit, Environment and Resources Authority, Malta, 12pp.
- BOIB (2018). Decret 25/2018, de 27 de juliol, sobre la conservació de la Posidonia oceanica a les Illes Balears. ANNEX 2. Bones pràctiques de retirada de restes de posidonia morta en l'àmbit territorial de competències de la Comunitat Autònoma de les Illes Balears. BOIB, 93, 28 de juliol de 2018, Fascicle 128 - Sec. I. - Pàg. 25543, 48pp.
- Region Puglia (2015). Linee Guida per la Gestione delle Biomasse Vegetali Spiaggiate, 31pp.
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- INTERLANDI (2009). Circolare inerente la gestione dei rifiuti sulle aree demaniali marittime e gli accumuli di posidonia spiaggiata. ASSESSORATO DEL TERRITORIO E DELL'AMBIENTE. CIRCOLARE 8 maggio 2009.
- DIREZIONE PROTEZIONE CIVILE – AMBIENTE (2011). DIRETTIVE REGIONALI PER LA GESTIONE DEI RIFIUTI ACCUMULATISI IN SPIAGGE MARITTIME. Regione Abruzzo. Circolare n. 1/2011. 4pp.
- Regione Autonoma de Sardigna, 2016. INDIRIZZI OPERATIVI PER LA GESTIONE DEI DEPOSITI DI POSIDONIA SPIAGGIATA SULLE COSTE. Allegato 1 alla Delib.G.R. n. 40/13 del 6.7.2016
- Var Prefecture (2015) Derogation article L411-2 du Code de l'Environnement. Service DPM et Environment marine. 2pp.

Appendix 2

MACHINERY ACCESS TO THE BEACH	
MALTA	Preferably compact vehicles (skid-steers, pick-up trucks, or small dumper vehicles with front load skips, with pick-up vehicles/vans not exceeding 5.4m in length, other vehicles not exceeding 4.0 metres in length, and no vehicles being heavier than 3,600 kg in kerb weight.
Balearic region (SPAIN)	Access on existing roads and avoid affecting the profile of the beach

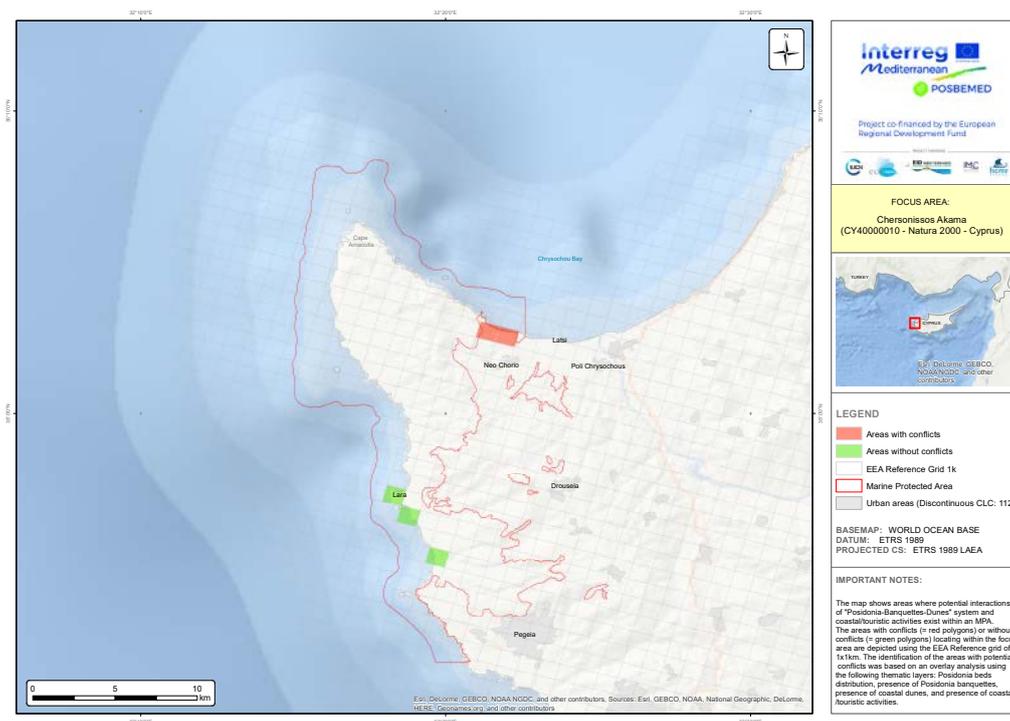
Note: References in Appendix 1

Appendix 3

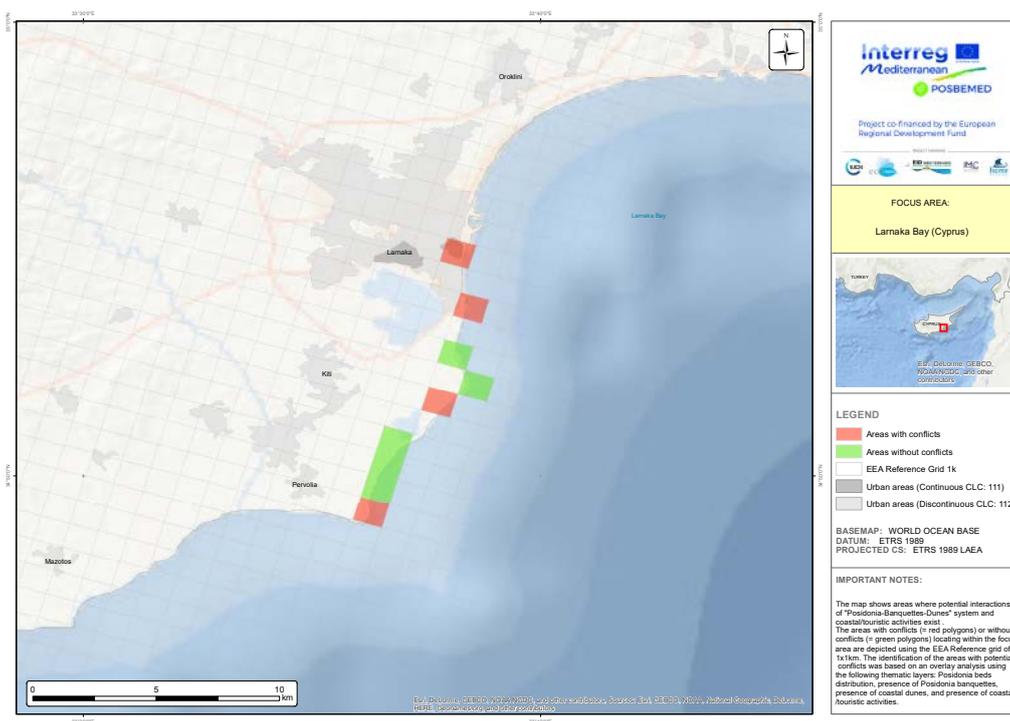
Maps of selected potential conflict zones between tourist sector, coastal activities and Posidonia beach-dune habitats in and around Protected Areas of 5 Mediterranean countries. Detailed methodology for the spatial analysis is presented in metadata files associated with shapefiles produced under Deliverable 3.3.1. GIS Database.

The identification of the areas with potential conflicts was based on an overlay analysis using the following thematic layers: Posidonia beds distribution, presence of Posidonia banquettes and coastal dunes, and presence of coastal/touristic activities.

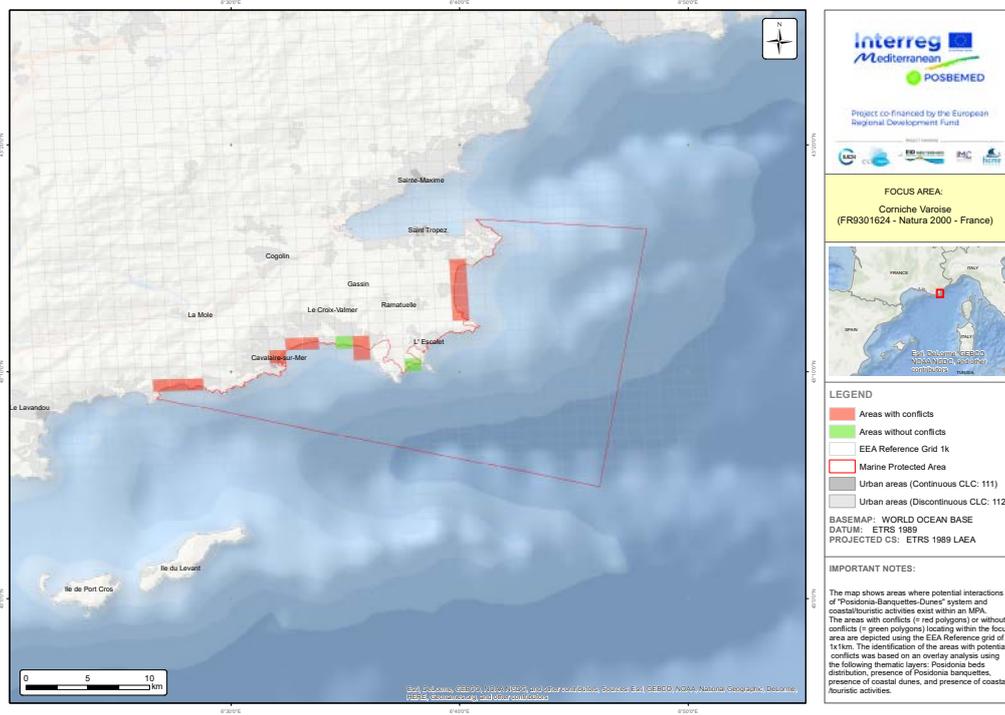
Protected Area Natura 2000 site of Chersonissos Akama. Cyprus



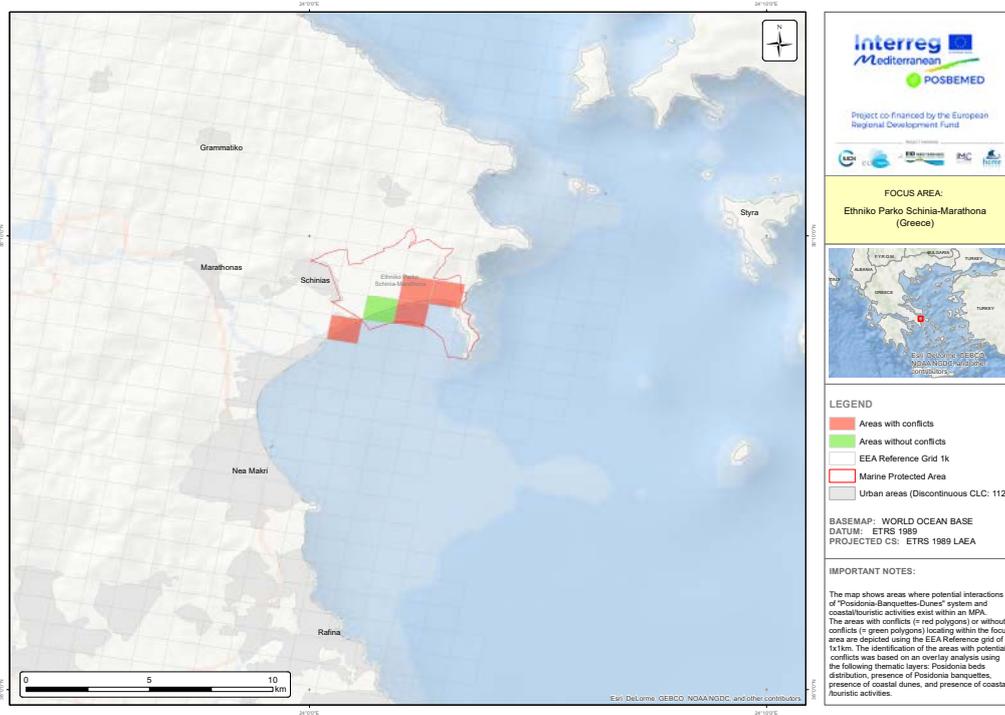
Larnaka Bay. Cyprus



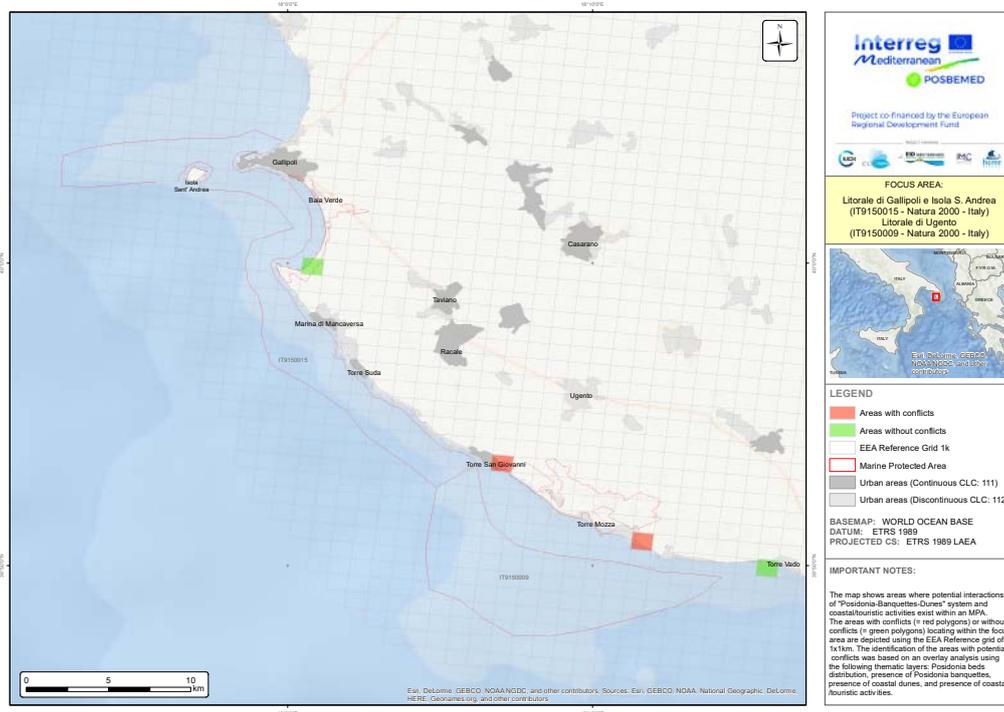
Natura 2000 site of Corniche Varoise. **France**



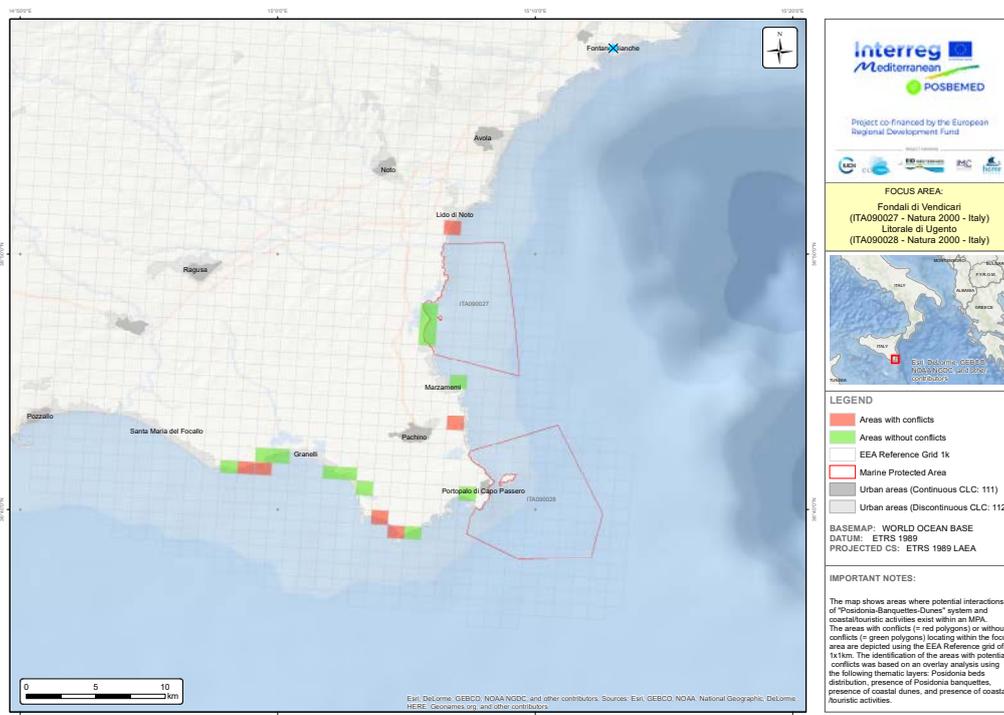
Natura 2000 site of Ethniko Parko Schinia-Marathona. **Greece**



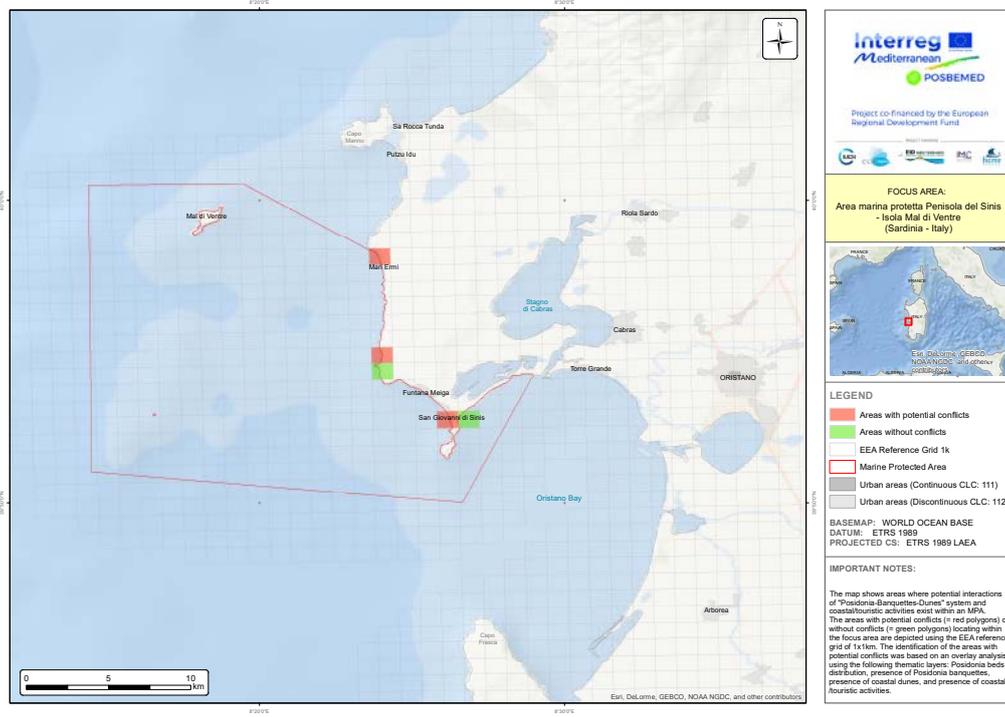
Protected Areas Litorale di Gallipoli e Isole S. Andrea, Litorale di Ugento. **Italy**



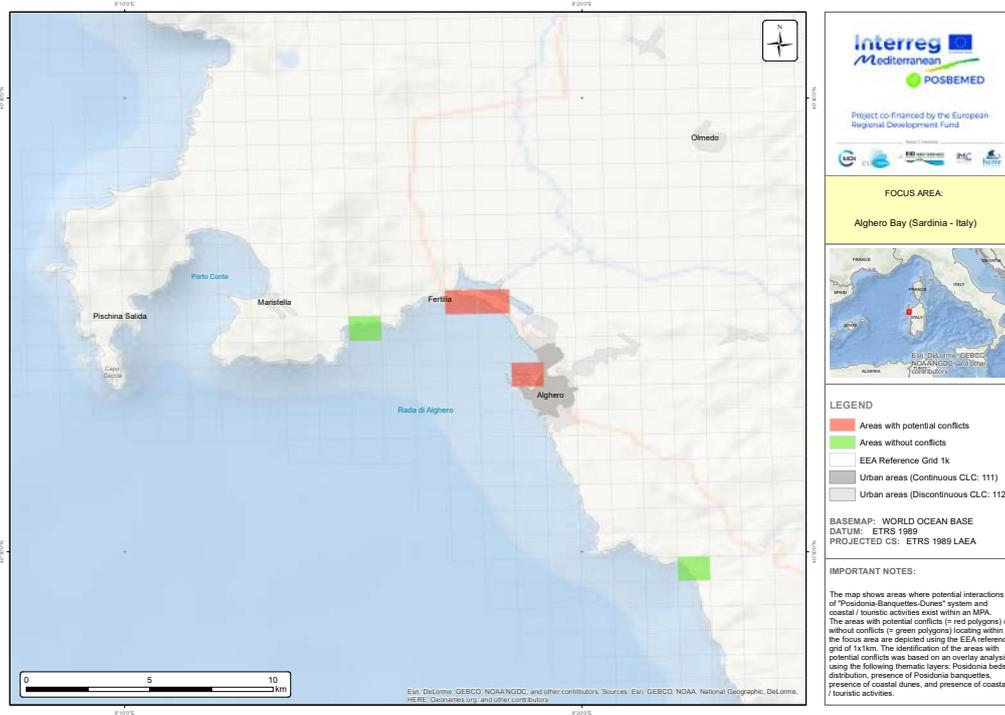
Protected areas of Fondali di Vendicari and Litorale di Ugento. **Italy**



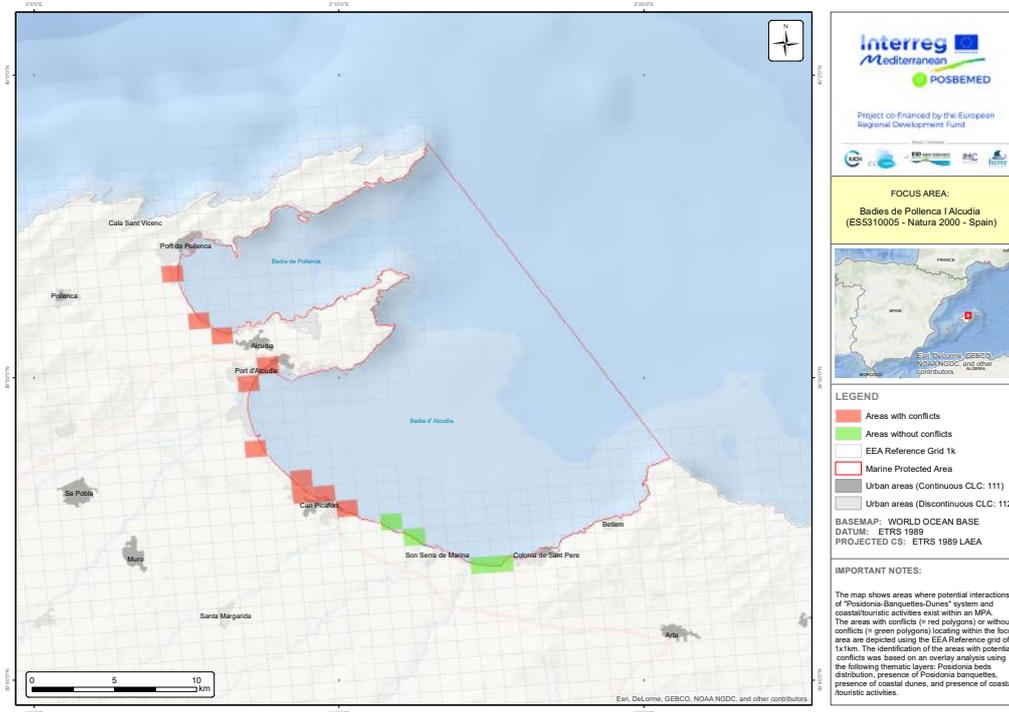
Peninsula del Sinis-Isola Mal di Ventre. **Italy (Sardinia)**



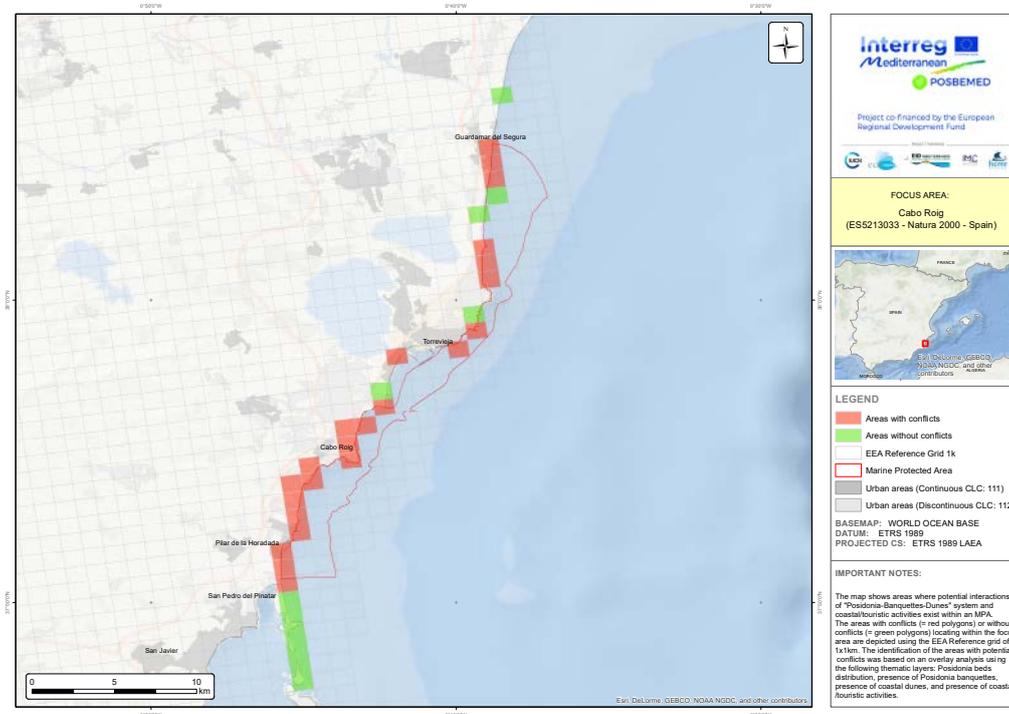
Alghero Bay. **Italy (Sardinia)**



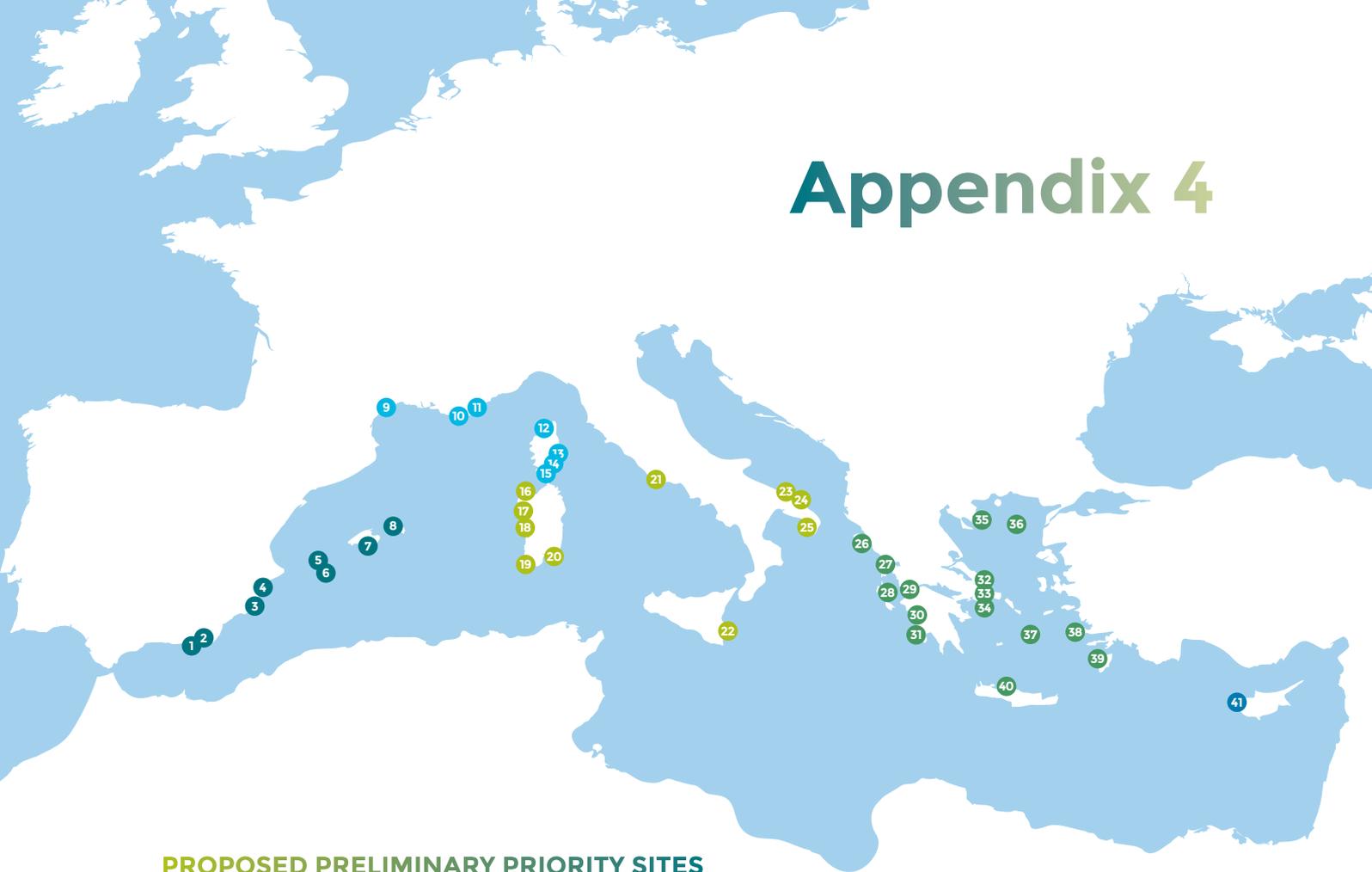
Bay of Pollença and Alcudia, Mallorca. **Spain**



Protected area of Cabo Roig, Alicante. **Spain**



Appendix 4



PROPOSED PRELIMINARY PRIORITY SITES

Criteria for the selection of preliminary priority sites:

Basic criteria

- Presence of banquettes, Posidonia meadows and coastal dunes in same site
- Potential sites for joint management: Adjacent site assemblages (or very close to each other) that include banquettes, Posidonia meadows and coastal dunes, and susceptible to develop joint measures for integrated management of the system

Additional criteria

- High level of biodiversity of the Posidonia beaches/dunes system
- Significant ecosystem services offered by the system
- Good connectivity between different components of the system
- Site particularly exposed to external threats

SPAIN

- Punta Entinas - Sabinar
- Roquetas - Aguadulce
- Salinas y Arenales de San Pedro del Pinatar
- Carabassí
- Es Cavallet
- Llevant
- Es Trenc
- Arenal de Son Saura

FRANCE

- Cap d'Agde - Côte palavasiennne
- Rade de Hyères
- Corniche varoise
- Agriates
- Pinarellu
- Iles Cerbicale et Franche littorale
- Plateau de Pertusato/ Bonifacio/iles Lavezzi

ITALY

- Stagno e ginepreto di Platamona
- Lido di Alghero
- San Giovanni di Sinis
- Promontorio, dune e zona umida di Porto Pino
- Isola dei Cavoli, Serpentara, Punta Molentis e Campulongu
- Parco Nazionale del Circeo
- Vendicari
- Torre Guaceto e Macchia San Giovanni
- Stagni e Saline di Punta della Contessa
- Litorale di Gallipoli e Isola di S. Andrea

GREECE

- Limnthalassa Korission
- Limnthalasses Stenon Lefkadas
- Kolpos Lagana Zakynthou
- Paraktia Thalassia Zoni Apo Akr.
- Thines Kai Paraliako Dasos Zacharos
- Limnthalassa Pylou (Divari)
- Ethniko Parko Schinia - Marathona
- Vravrona - Paraktia Thalassia Zoni
- Sounio - Nisida Patroklou Kai Paraktia Thalassia Zoni
- Oros Itamos - Sithonia
- Limnos: Chortarolimni - Limni Alyki Kai Thalassia Periochi
- Kentriki Kai Notia Naxos
- Kos: Akrotirio Louros - Limni Psalidi - Oros Dikaioi - Alyki - Paraktia
- Rodos: Akramytis, Armenistis, Attavyros, Remata Kai Thalassia Zoni
- Prassano Farangi - Patsos - Sfakoryako Rema

CYPRUS

- Chersonissos Akama









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