







Towards Sustainable Management of Beach-Cast Seagrass in Mediterranean Coastal Areas

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Abstract: Marine environmental conservation and tourist exploitation are often in conflict, particularly where anthropogenic pressure is greatest, such as along the coasts of the Mediterranean Sea. A case in point is the accumulation of beach-cast seagrass, a typical feature of the Mediterranean Sea that is nowadays perceived as an “obstacle” to tourist activities and thus treated and removed as waste, leading to environmental impacts. In this paper, we analyzed the legislative context at the Mediterranean basin level and the contribution of twenty virtuous research projects related to the topic. In our opinion, the main benefits for the beach–dune ecosystem would be generated by the use of seagrass *banquettes* directly within the beach system (temporary displacement, creating beach walkways, dune consolidation), while their uses outside the beach system (agricultural and farm solutions—compost and bedding) should be considered as alternative solutions for a circular economy, in case of consistent biomass deposits along the shores. In this perspective, we support the “Ecological Beach” model which integrates most of the science-derived solutions addressed in this study. This model provides good practices that can be usefully spread and shared along Mediterranean coasts: to achieve this result, it is necessary to create a regional or Mediterranean network involving local communities and stakeholders.

Keywords: beach-cast seagrass; deposits; *Posidonia oceanica*; *Posidonia banquette*; management; monitoring; governance; sustainable tourism; environmental education; science-derived management solutions



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1. Introduction

Seagrasses are marine vascular plants that evolved 70 million years ago from terrestrial plants that have colonized every continent except Antarctica, from shallow waters to depths of 90 m [1,2]. The seagrass meadows are known to play a key role in carbon sequestration (blue carbon), oxygen production, and sediment stabilization, and are marine biodiversity hotspots, providing shelter, permanent habitats, and/or nursery areas for many plant and animal species ([3] and references within). The most up-to-date global seagrass area is estimated at 160,000 km², with 72 species [4]. In the Mediterranean Sea, seven different seagrass species can be found, alone or combined in mixed meadows [5]. Apart from

Posidonia oceanica (Linnaeus) Delile, 1813, the most widespread and uniquely endemic species, there is *Cymodocea nodosa* (Ucria) Asch, 1870, *Zostera marina* Linnaeus, 1753, *Zostera noltei* Hornemann, 1832, and *Ruppia maritima* Linnaeus, 1753, restricted to transitional waters and coastal lagoons, as well as the introduced species *Halophila stipulacea* (Forssk.) Asch (lessepsian migrant [6]) and *Halophila decipiens* Ostenfeld, 1902 (via ballast waters [7]).

The seagrass leaf renewal processes with the concurrent action of waves and currents can produce large accumulations of vegetal debris along the seashores. Along Mediterranean coasts, the largest seagrass deposits are made up of the dead leaves of *P. oceanica* and rhizome residues, along with trapped sediments. These deposits can be either temporary or structured and permanent, the latter generally known as “*banquettes*” [8].

Nevertheless, other seagrass species are known to create these deposits [9–11].

The beach-cast seagrasses, and in particular the *banquettes*, fulfill numerous ecological functions: (i) they offer refuge to rich macrofauna (including invertebrates and sea birds); (ii) they provide nutrients to coastal ecosystems; (iii) they play an important role in the formation of dunes and backshore vegetation [8]. Moreover, their incorrect removal can cause shoreline retreat or beach erosion, which is frequently associated with sand removal, enhancing the sediment loss [8].

The presence of seagrass deposits, which can persist in situ for the whole year at some sites, has favored the emergence of conflicts related to the use of the beaches for bathing and/or other recreational purposes in recent decades. In addition, nowadays, increasing quantities of litter are found along the shores, mixed with natural beach casts, altering their ecological function within coastal ecosystems [12–14]. This scenario, in combination with limited knowledge about the seagrass beach-cast phenomenon, has enhanced the negative perception of seagrass accumulations in several areas of the Mediterranean Sea, resulting in low appreciation for natural coastal landscapes in favor of artificial “clean” beaches [15]. Consequently, beach-cast seagrasses are often removed from the seashore during the summer months; in the best-case scenario, they are temporarily stocked somewhere else but are often disposed of in landfills as special waste [16]. The removal of seagrass deposits and their disposal in dumps is a very common practice on most Mediterranean beaches, which can alter the integrity of the beach ecosystem and increase beach cleaning costs [15–17]. In addition, the lack of a legislation framework at both national and international levels does not favor the adoption of eco-sustainable management practices for this natural resource.

Therefore, due to the importance of beach-cast seagrass for marine and coastal habitats and the impacts related to their removal, in situ preservation is the best management option [15,16]. However, the management of litter mixed with beach-cast seagrass and their social acceptance are critical issues that need to be carefully considered. Due to the complexity of this issue, some research projects have recently dedicated their attention to the problem raised by these seagrass deposits, providing some crucial contributions for possible management solutions.

In this perspective paper, we highlight critical issues regarding beach-cast seagrass management at the scale of the Mediterranean basin and identify the most sustainable and effective solutions. For this purpose, we have addressed the topic according to the following aspects: (i) analysis of the legislative context at the Mediterranean basin level; (ii) critical survey of research projects developed around this topic; (iii) identification of the most suitable science-derived management solutions from an ecological viewpoint.

2. Legislation Framework

The legislation framework is changing, albeit slowly, to address the management of beach-cast plant masses and how these should be considered. According to an examination of legislation at the International, European, and Mediterranean basin levels, it is clear that the main legislative instruments concern only *P. oceanica* species (both alive and beached), leaving the beach-cast masses of other seagrass species to be regulated by legislative analogies. The protection of *P. oceanica* is regulated at the European level by Directive 92/43/EEC (Habitats Directive), which aims to preserve biodiversity through

the conservation of natural habitats, flora, and fauna. The regulation establishes a series of conservation measures to protect habitats and species with specific lists in annexes. *P. oceanica* is included as a priority habitat type, defined as ‘Posidonia grasslands’ (code 1120). Moreover, in Italy, *P. oceanica* has been identified as a bioindicator species and is used to establish the ecological status of marine systems with respect to Dir. 2000/60/EU (Water Framework Directive), which aims to protect aquatic environments and achieve good ecological status in coastal waters. As for marine waters, Directive 2008/56/EC (Marine Strategy Framework Directive), transposed in Italy by means of a legislative decree, is the EU’s main tool to protect the marine environment. The directive requires member states to maintain or achieve a good environmental status for marine waters, based on eleven descriptors. Among these descriptors, number one is biodiversity, which includes the monitoring of the extent and status of *P. oceanica* meadows.

At the international level, as far as the discarded leaves of *P. oceanica* are concerned, the London Dumping Protocol has listed a category under which *Posidonia* beach casts are assimilated. The protocol provides for exceptions to the general prohibition of dumping at sea, which includes dredging of sediments, residues from fishing activities, offshore ships, and platforms, aggregates and geological material, organic materials of natural origin, and raw materials and bulk raw materials, including iron and steel (Annex 1, point 1, paragraph 6). In this context, *Posidonia* residues could be similar to ‘organic materials of natural origin’, and the aforementioned protocol applies the regulation of sea dumping to both (including *Posidonia* residues in this interpretation). A specific authorization from a competent authority is required, according to a scheme for the assessment and identification of potential impacts of deliberate dumping.

At the level of the Mediterranean region, the Barcelona Convention is the regulatory instrument within the framework of the Mediterranean Action Plan for the countries bordering the so-called “*Mare Nostrum*”, including the southern coastline. Among the seven protocols adopted within the Convention framework, there is a protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA and Biodiversity Protocol). This was adopted on 10 June 1995 and came into force on 12 December 1999, taking over from the old 1982 protocol on the protection of special areas. *Posidonia* and/or other macrophyte residues accumulated on any type of substrate (biogenic and non-biogenic rocks, coarse sediments, sands, etc.) are included among the priority habitats of the protocol under compulsory conservation and protection (Annex II List of endangered or threatened species).

In the Mediterranean region, national legislation varies among European countries. France strictly protects *P. oceanica*, prohibiting the removal, transport, purchase, or sale of both live and dead specimens. Exemptions are systematically issued by local agencies. In Spain, *P. oceanica* is listed under a special protection regime, imposing general prohibitions, and local authorities control the removal of beach deposits. Italy, through the ‘Save the Sea Law’, allows the reintroduction of plant biomasses naturally deposited on shores, emphasizing waste recovery with screening processes. Greek legislation, while lacking specific *Posidonia* protection, utilizes laws like the Biodiversity Conservation Act to indirectly safeguard fragile habitats, including *Posidonia* beach–dune systems. Common Ministerial Decisions and prohibitions within Natura 2000 sites further contribute to *Posidonia* preservation efforts in Greece.

Legislation Limitations

The international and national legislation related to *Posidonia* beach-cast masses in the Mediterranean basin is patchy and lacks harmonization. The major legislative interventions concern the protection of *P. oceanica* meadows, protected both by individual national legislations and by European directives and international conventions. The same attention is missing for *Posidonia* beach casts: despite being protected by the Barcelona Convention, the principle has not been applied and implemented in different national legislations.

Moreover, many disparities currently exist among Mediterranean countries, along with legislative “deterioration”. In the case of Italy, the so-called “Save the Sea Law” does not exclude the possibility of transporting the beach casts to waste management plants, notwithstanding the previous Law Decree n. 41 and Law n. 108 which, on the contrary, excluded *Posidonia* beach casts from waste legislation.

Legislation also differs greatly among countries because of the existing differences in territorial jurisdiction over beaches. Therefore, the local territorial authority can decide autonomously, creating disparities even within the same country.

Overall, from the analysis of the legislation, it is clear that there is a need for European countries to supplement the existing directives and for all the countries of the Mediterranean basin to strengthen their legislative tools, implementing the Specially Protected Areas of Mediterranean Importance (ASPIM) protocol.

3. Research Project Survey

For our research project survey dealing with the topic of seagrass management on beaches, we have conducted a search of the web, up to February 2023, including the CORDIS database (<https://cordis.europa.eu/projects/en>, accessed on 28 February 2023), which is the primary source of results from EU-funded projects since 1990. The topics and/or keywords used for the research were: “characterization”, “alternative uses”, “management”, “guidelines”, combined with “beach-cast seagrass” or “seagrass deposits”, “*banquette*” and “*posidonia*”. Among the retrieved results, we only considered projects referring to the Mediterranean basin (Italy, Spain, France, Greece, Croatia, Cyprus, Malta, and Tunisia). At the final stage, twenty relevant research projects were selected and the following minimum information was collected for each project: acronym, project name, partner list, financial program, duration, pilot sites, objectives, management solutions, and outputs (summarized in Table 1).

Among the twenty examined projects, half of them were developed under national (5) or regional (5) contexts, involving a single country only. The remaining ones are international projects, involving partners from two or more countries. Countries participating in the examined projects were mainly located in Europe, facing the Mediterranean Sea: Italy (14), Spain (8), France (7), and Greece (4) comprised the majority of projects. Tunisia (2), Cyprus (1), Croatia (1), Malta (1), Germany (1), Lithuania (1), and the Czech Republic (1) also developed projects regarding the management of beach-cast seagrass.

Regarding the financial programs supporting the examined projects (Figure 1), the Interreg program was the most present (8). A relevant number of international or national projects (5) were also financed by LIFE, one project was financed by the European program ENPI CBC, and one by Horizon Europe. Local projects examined in this work were financed by National Ministries (Italy and France), Regions (Latium and PACA), or Municipalities.

The information regarding funding and geographic distribution showed the role of national and regional funding, especially for some realities (Latium in Italy and the PACA region in France), and highlighted the lack of resources in some areas, such as the Mediterranean southern coast that deserves more attention over time.

Table 1. List of research projects selected and relevant information about the acronym, project name, partner list, financial program, duration, pilot sites, objectives, management solutions, and outputs.

Acronym	Program	Country (Region)	Main Objectives	Specific Objectives for Seagrass Deposits	Management Solutions for Seagrass Deposits	Project Outputs
BARGAIN	POR-ERDF Lazio Region	Italy (Lazio)	(i) tourism and coastal protection combination, (ii) beached <i>Posidonia</i> management	(i) development of a sustainable management model (Ecological Beach model), (ii) education activities for improving <i>banquette</i> acceptability	(i) on-site <i>banquette</i> maintenance, (ii) temporal/partial deposit displacement (restoration solutions)	1 Guideline 2 Ecological Beaches 1 Educational kit 1 Comic 1 Cartoon 1 Game
RES MARIS	LIFE	Italy (Sardinia)	conservation and regeneration of ecosystems	focus on dunes and <i>Posidonia</i>	(i) on-site <i>banquette</i> maintenance, (ii) deposit displacement and repositioning in winter, (iii) Permanent removal and landfill disposal (iv) burying; (v) displacement on the dune	1 Guideline 1 Sardinian Beach List
PRIME	LIFE	Italy (Apulia)	integrated management system of beached <i>Posidonia</i> deposit	reuse for local agriculture (compost)	(i) on-site <i>banquette</i> maintenance (ii) deposit displacement (seasonal or permanent), (iii) stranded seagrass biomass agronomic use, (iv) landfill disposal	1 Software 1 Manual 3 Prototypes
POSIDUNE	INTERREG	Italy, Spain, France, Greece	beach-dune system management	effectiveness of innovative naturalistic technique	vegetal biomass to trigger the colonization of sand dunes by pioneering species and subsequent positive feedback processes such as sand accumulation	1 Guideline
GERER	INTERREG	Italy (Sardinia), France (Corse)	erosion impact mitigation	description of potential impacts of removal of <i>banquettes</i>	no <i>banquette</i> removal	1 Guideline
MEDCOT	ENPI CBC	Italy (Sicily), Tunisia	(i) coastal protection and sustainable development, (ii) local economic growth, (iii) tourism revival	reuse for local agriculture (compost and fertilizer)	(i) beached <i>Posidonia</i> sand recovery, (ii) collection pretreatment and composting	1 Guideline 1 Pilot plant
POSBEMED	INTERREG	Spain, Italy, Greece, France	enhancing the conservation hosting seagrass ecosystems, and beach and dune habitats	common strategy for the management of <i>Posidonia</i> dune systems	no removal and natural beach management	1 Guideline
POSBEMED2	INTERREG	Spain, Cyprus, France, Italy (Sardinia), Greece, Croatia	<i>banquette</i> preservation	enhancement of <i>Posidonia</i> resilience	on-site <i>banquette</i> preservation	7 Action Framework Plans 1 Manual for <i>Posidonia</i> beach management 1 Joint Charter of Commitment for Mediterranean Municipalities (tool)
POPRURA	INTERREG	Greece, Italy	beached <i>Posidonia</i> management	reuse for local agriculture (compost and fertilizer)	Compost production with leaves and fibers	1 Book
SEAMATTER	LIFE	Spain, Italy	beached <i>Posidonia</i> management	reuse for buildings (acoustic panels in buildings)	development of nonwovens using wet laid technology	1 Guideline
REUSING-POSIDONIA	LIFE	Spain	beached <i>Posidonia</i> management	reuse for buildings (constructive elements as walls, reinforced floors, etc.)	(i) partial removal (up to 4000 cm per year), (ii) sun-drying, compacting into pallets and storage	1 Catalog

Table 1. Cont.

Acronym	Program	Country (Region)	Main Objectives	Specific Objectives for Seagrass Deposits	Management Solutions for Seagrass Deposits	Project Outputs
ARENA	MIUR	Italy (Sardinia)	assessment of the impact of removal of <i>banquette</i> from beaches	management solution sharing with stakeholders	not available	1 short summary containing management suggestions
AGRO-POSIDONIA	Municipality	Spain (Valentia)	beached <i>Posidonia</i> management for reducing carbon footprints	reuse for beaches (protective barrier against storms) and for farms (bedding for livestock, healing agent for any wounds)	(i) biomass removal and storage (summer), (ii) reuse (winter)	1 application (30 tonnes of natural biomass reused) media news (in progress)
ÉCoMéd	Région Sud (PACA)	France Région Sud (PACA)	(i) Improve scientific knowledge on <i>Posidonia</i> beach casts; (ii) Awareness and education	(i) Collect scientific data of fish community / invertebrates of beaches with <i>Posidonia</i> biomass (ii) Convince the general public that the presence of <i>Posidonia</i> leaves on the beach is a sign of good ecological condition and not discomfort	<i>Banquette</i> Conservation: management on site (even if not focused on management solutions)	1 comic
SALINAS	LIFE	Spain	coastal dune conservation and erosion protection	<i>Posidonia</i> beached casts use for dune reinforcement (ecosystem restoration)	(i) removal before the start of the summer season, (ii) displacement and the establishment of a protective cordon of beached <i>Posidonia</i> for the front of the dunes	1 Guideline
BESS	INTERREG	Malta and Italy (Sicily)	beach conservation and erosion protection	seagrass <i>banquette</i> characterization	(i) removal before the bathing season, (ii) selective closure of the sections of beach being cleaned	1 Manual
GEBAPO	French Ministry of Ecology and Ecological Transition	France Region: PACA	<i>Posidonia</i> beach cast management	monitoring of (i) evolution of the coastline, and coastal erosion (ii) biological communities (iii) user beach perception to test the Suitability of the so called “Millefeuille (MF)” compared to natural <i>banquettes</i>	“Millefeuille (MF)” as a possible local-based management option to prevent coastal erosion and to maintain the ecological functions of the natural <i>banquettes</i>	Results on (i) coastal line profile evolution; (ii) microorganisms and arthropods communities’ composition (iii) user beach perceptions and acceptance of different management options
GIREPAM	INTERREG	Italy (Sardinia)	improve the conservation status of the marine coastal areas	<i>Posidonia</i> deposit characterization	(i) on-site preservation, (ii) removal of only the fresh type of deposits and storage (before summer), (iii) displacement to the beach of origin after the summer	Infrastructure realization studies on <i>banquette</i> dynamics evaluation of impact of tractor on beaches
MED DECOUPLAGES	INTERREG ITALY-TUNISIA	Italy (Egadi Islands); Tunisia (Mahdia and Kerkennah)	(i) innovative practices for reduction and reuse of plastic litter, (ii) sustainable management of <i>Posidonia</i> beach casts, (iii) improving <i>banquette</i> acceptability	(i) mapping of beached casts & data collection (Citizen Science), (ii) development of an Ecological Beach model, (iii) realization, education activities	(i) on-site preservation, (ii) temporal/partial displacements (use for beach furniture or environmental restoration)	1 technical document 1 Memorandum of Understanding (in progress)
BIO4EEB	HORIZON EUROPE (IA)	Germany, Spain, France, Lithuania, and the Czech Republic	(i) to develop a set of bio-based insulation products in the construction sector (ii) to increase the use of bio-based and sustainable material in renovation projects to meet the EU’s energy and environmental goals	<i>Posidonia</i> <i>banquettes</i> (and bio-based foams) used to develop and to prove the marketability of smart components for external and internal use as material application, prefab panels, or windows	alternative uses: bio-based insulation products in construction sector	just launched (March 2023), products in progress

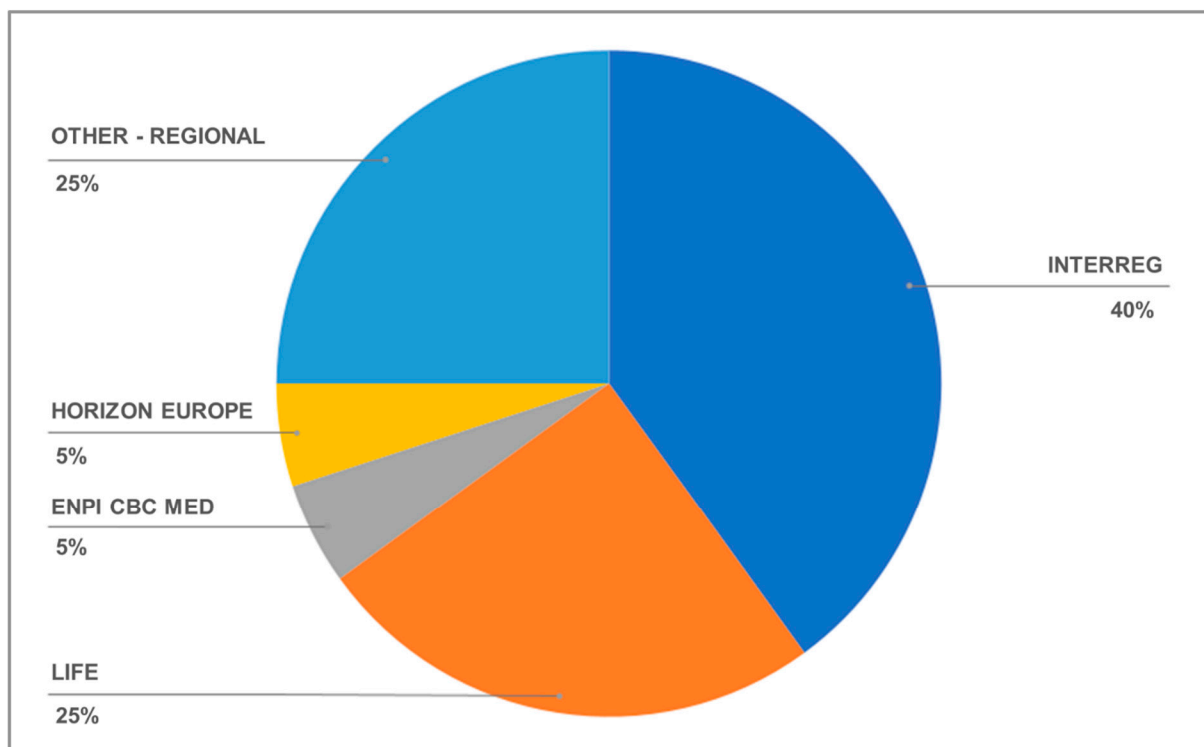


Figure 1. The financial programs supporting the twenty examined projects. Each pie fraction represents the percentage of projects financed by a specific program: INTERREG (40%), LIFE (25%), other financing instruments such as regional programs (25%; Horizon Europe (5%), ENPI CBC MED (5%)).

3.1. Critical Analysis of Main Project Results/Outputs

3.1.1. Manuals/Guidelines

One of the main outputs of the examined projects is the production of manuals/guidelines on the management of the *P. oceanica* deposits (*banquettes*). A total of twelve manuals/guidelines were produced: six manual/guidelines were produced by projects financed by Interreg (see as examples [18–20]), four were produced by projects financed by Life (see as example [21]), one was produced from projects financed by ENPI CBC [22], and one was produced from a regionally financed project (Bargain). Interreg-financed projects were mainly focused on the definition of strategies, the sharing of methodology, and promoting best practices for the sustainable management of *banquettes* and beaches. LIFE projects were also oriented toward the promotion of actions toward the circular economy, with seagrass rest reusing strategies to prevent disposal in landfills. This also occurred with the local projects, which in the case of regionally financed projects included communication activities to improve the awareness of the general public with respect to the *banquettes*. Some of the above-mentioned projects focused not only on the beach ecosystem but also on the conservation and restoration of dunes, considering the beach-dune system in its entirety. Communication toolkits and awareness-raising campaigns were also present in each European community-financed project as this aspect is compulsory during the realization of a project.

Although management guidelines and best practices represent valuable tools built up from ecosystem-based approaches, they are often not fully developed, applied, or diffused above the specific case study or the local geographic context. Indeed, since national and regional legislations are often lacking or unclear, the valuable guidelines and best practices produced by project efforts are not effective enough to force local administrations to fully apply them, remaining only soft law [23–25] at the end of the projects, especially when contrasting approaches are emerging from the specific legislation.

3.1.2. Management Solutions

The results obtained from the analysis of the projects, which is also reported in the relevant literature, showed that, depending on the project funding and the partnership, two main approaches can be identified.

On one hand, in the case of regional projects and/or transboundary cooperation (e.g., Interreg programs), the environmental processes are highly considered and the partnership generally involves all relevant stakeholders at the local scale, including scientific institutions for environmental research and protection, and valuable protected areas. Therefore, the maintenance of seagrass deposits in situ and the preservation of natural beaches with their ecological roles are fully encouraged, together with education and communication activities for stakeholders and the public to improve their acceptance. Nevertheless, other possible uses within the beach ecosystem may include: (i) temporary displacement (e.g., at the Italian Latium and Favignana sites and the French PACA and Corsica case-studies of the Bargain, Res Maris, PRIME, and MED Dé.Co.U.Plages projects, as well as pilot case studies of the POSBEMED2 project); (ii) covering of the beach casts with sand, using the so-called “millefeuille (MF)” approach (e.g., the French Gebapo project); (iii) creating beach walkways (e.g., the examples in the French PACA region); (iv) dune consolidation (e.g., Spanish case studies); (v) “stock de Posidonie” to deal with emergency situations, creating a storage area in contact with the marine environment and nearby erosion sites (e.g., French case studies). All these options should be fully investigated and selected depending on the specific site: as an example, the displacement of beach-cast seagrass at the beach back (far from the shoreline) and/or their covering with sand can have negative impacts on the loggerhead sea turtle's (*Caretta caretta*, Linnaeus, 1758) nesting habits. Observations on beaches on the south-western coasts of Italy provide evidence, especially when the covering is limited to a thin sand layer (less than 50 cm), that loggerhead females abandon nesting attempts when they encounter *Posidonia* casts while digging the egg chamber. Thus, improper displacements of *Posidonia* beach casts can impede the successful nesting of loggerhead turtles and force them to find more suitable nest sites elsewhere (pers. comm. Sandra Hochscheid).

A second type of approach, within projects involving pilot actions or technological developments (e.g., Life and Horizon programs), is focused on possible reuses of beach-cast seagrass outside of the beach ecosystem, in the framework of different industrial/circular economy applications. Some projects promoted the agronomic or other farm uses of beach cast biomass (see as examples the Medcot, Poprura, and Agro *Posidonia* projects). In particular, their reuse was studied for (i) compost for local agriculture or marketed to partly finance the removal and processing of the beach casts; (ii) compost in soilless crops, as fertilizer for growing horticultural and ornamental plants, as mulch to hinder the growth of weeds; (iii) other compost types obtained from mixtures with the organic fraction of municipal solid waste and/or civil sewage sludge; (iv) bedding for stables with animal-beneficial properties. Three projects deal with the re-use of *P. oceanica* and seaweed biomass as raw materials in the construction industry: (i) acoustic insulation panels for buildings; (ii) roofs, walls, or floors for residential buildings (see, Seamatter, Reusing-*Posidonia*, and Bio4Eeb). Despite the interesting and valuable scientific results achieved from the projects, the limitation of these approaches is the lack of resources. Beach-cast seagrass deposition is a complex and under-investigated phenomenon, and the seagrass biomass, apart from the pilot experiments, is not constantly available to ensure a reliable industrial chain with defined costs and benefits.

3.1.3. Monitoring Actions

Each project usually developed a series of monitoring actions for evaluating: (i) the features of the beach system including the features of beach-cast seagrass; (ii) the impacts of management solutions (e.g., seagrass maintenance in situ, removal, dumping, etc.).

One of the first attempts to monitor *banquette* features was performed in the Posidune project [26]. Then, other projects addressed the monitoring actions above possible man-

agement solutions, with a focus on the impact of removing and dumping *banquette* on beach geomorphology and ecology (e.g., Prime, POSBEMED, POSBEMED2, Bargain, and Gebapo). However, indirect attempts to test the effectiveness of the *banquettes* in contrasting coastal erosion were performed, as in Sardinia [27,28], Greece [29], and Spain [30].

It is pivotal to identify and adopt quick and easy monitoring protocols that can be used in different beach contexts by helping the local government authorities in the evaluation of the impacts deriving from different management approaches. For the realization of these monitoring actions, a good knowledge of the tools and procedures adopted for the monitoring of beach dynamics is required. Local authorities have often made an effort to apply the management guidelines proposed by research projects. However, the greatest criticism remains the monitoring of the impacts of management solutions in the long term, i.e., after the end of research projects, without external financing and specific expertise, a constraint that can also be complicated by site-specific beach typology. Furthermore, attempts to evaluate the perceptions of the beach users, local authorities, and local operators were also performed (e.g., the Posbemed project). However, more detailed studies will be required to understand how the beach-cast seagrass and *banquettes* may enhance the protection of beaches from coastal erosion during extreme storms.

3.1.4. Education of and Communication with Stakeholders

The analysis of the projects conducted in this study revealed a limited effort towards communication and education activities. In fact, among the twenty projects examined, with the exception of the five Life projects, only a few provided effective and impactful communication activities. The Life projects, which are required to include dissemination activities on the project topics, provided information materials (brochures, flyers), websites, and social networks, as well as the creation of specific dissemination programs and communication links among the project partners and the stakeholders (e.g., citizens, local authorities, local economic operators, etc.). Regarding the other projects, at the regional (Bargain) and transboundary (MED Dé.Co.U.Plages) scales, in parallel with the development of a new integrated management model called Ecological Beach, a series of education/communication activities with a multidisciplinary and participatory approach have been realized. Among others, those activities included free-of-charge access to educational materials (video lessons, documentaries) and dissemination products (comics, games), events on the beach with wide media exposure and the involvement of institutions, and citizen science activities for beach monitoring. Always conducted at a regional level, the ECoMed project aimed at improving ocean literacy for young generations by proposing ad-hoc educational activities to students from middle and high school, proposing field activities followed by discussion in class to improve the acceptability of *Posidonia* deposits. At the basin scale, the POSBEMED2 project, on top of communication activities and dissemination products (web series, brochures), realized some important roundtable meetings and workshops in order to develop joint management strategies in the Mediterranean countries that recognize the value of the *banquettes*, while also addressing concerns and educating stakeholders.

According to the current situation, awareness about the benefits of *P. oceanica* meadows and *banquettes* is generally low. Only a few local stakeholders, with a very close relation to the marine environment, recognize a direct benefit from seagrass. Most people are not aware of the contributions of the seagrass ecosystem to society's wellbeing [14,31–33].

In order to improve community knowledge and perceptions of the *banquettes* and beach systems, citizen science approaches appear to be a promising tool as they are able to improve data collection on beach-cast seagrass while reinforcing beach users' and stakeholders' engagement in beach management and protection [14,33]. Moreover, expert knowledge coming from local communities (known as Local Ecological Knowledge, LEK) can provide crucial insights about seagrass deposit occurrence in space and time, as well as management strategies from the past ([14] and references within). Furthermore, local

community-based management can be helpful in mediating conflicts and overcoming communication barriers among stakeholders ([34] and references within).

4. Main Conclusions of This Review

The present review focuses on current legislation synthesis and the analysis of twenty relevant research projects regarding the management of *P. oceanica banquettes* along Mediterranean shores.

The analysis highlighted three main constraints that can be summarized as follows:

- (i) The management of *Posidonia banquettes* along Mediterranean shores is undoubtedly a complex issue, including not only ecological aspects but also legislation, monitoring, education, and communication with stakeholders. All these aspects should be carefully taken into consideration together.
- (ii) The regulatory framework analysis at the Mediterranean regional level showed the fragmentary nature of existing legislation and the urgent need to advocate for common governance tools.
- (iii) Unfortunately, the best practices produced by many projects frequently remain only soft law at the end of the project activities.

5. Future Perspectives for *Posidonia banquette* Management

Despite the valuable results already achieved, it is clear that additional efforts should be made to ensure the sustainable management of beach deposits in the Mediterranean basin, taking into account site-specific situations.

Legislation at both European and Mediterranean scales must be improved to provide common legislative and managing options to Mediterranean countries. Moreover, it is crucial that the guidelines produced by different projects are then fully implemented to support the governance processes.

Additionally, to evaluate the effects of the different management options, monitoring activities should be implemented, especially to evaluate their effectiveness in the protection of coastal erosion during extreme storms, as well as in climate change scenarios, and maintained over time, regardless of the end of the dedicated research projects.

The science-derived management solutions could be fully achieved only if they consider all aspects, including education and communication activities: although they play a fundamental role, efforts are still limited.

Furthermore, it is mandatory to improve the efforts made at the regional, transboundary, and basin scales to consolidate a strong network, including all relevant stakeholders, to promote good management practices/approaches in the entirety of the Mediterranean Sea, especially along its southern shoreline (Tunisia, Morocco, Egypt, Lebanon, etc.).

In our opinion, beach-cast seagrass management in the Mediterranean region could only improve if two main issues are considered: (i) there cannot be a “one-size-fits-all” solution and (ii) the possible solutions must follow a hierarchical perspective, in the framework of the ecosystem-based approach, favoring beach deposit maintenance on site and/or within the beach ecosystem. The possibility of biomass displacement and/or reuse requires a careful evaluation of the costs, benefits, and possible impacts.

It is crucial that all of the components involved, both natural (habitats, species, physical processes, and ecosystem services) and anthropic (human activities), will be taken into consideration in accordance with the site-specific characteristics and local stakeholders.

In addition, the perspective for seagrass *banquette* management should take into consideration the possibility of applying “functional planning” to the areas along the Mediterranean shore. Importantly, in sensitive areas (e.g., protection zones for fish, sea turtles, or other biological resources, and areas subjected to coastal erosion), the seagrass *banquettes* should not be removed and their possible uses within the beach system (temporary displacement, creating beach walkways, dune consolidation) can be favored after considering the benefits derived for the beach-dune ecosystem. On the other hand, the uses for beach cast outside the beach system (agricultural and farm solutions [35,36], compost,

and bedding [37]) should be considered as possible alternative solutions for a circular economy [38–42], especially in cases of consistent biomass deposits along the shores.

The “Ecological Beach” model encourages the preservation of *Posidonia* beach casts on site, integrating natural and anthropic elements. The model is based on a hierarchical approach, devoted to enhancing sustainable tourism and socio-economic development, as well as maintaining the important ecosystem services provided by seagrass beach casts [15].

In this context, the “Ecological Beach” model is one of the most valid at the Mediterranean regional scale since it integrates most of the science-derived solutions and fully achieves all the relevant aspects herein discussed.

The creation of a regional or Mediterranean network, which involves local communities and stakeholders within the beach management, should be the first step towards the application of this model on a larger scale. A broader effort in terms of strengthening the legislative tools, harmonization of monitoring and management best practices, and improvement of public knowledge and perception are also required.

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