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Large-Scale Re-Implantation Efforts for *Posidonia oceanica* Restoration in the Ligurian Sea: Progress and Challenges

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Abstract: The Ligurian Sea (NW Mediterranean) has been a focal point for numerous interventions aimed at restoring *Posidonia oceanica* meadows. The success of pioneer restoration actions in France during the 1970s stimulated similar initiatives across the Mediterranean Sea. Early attempts in the Ligurian Sea were implemented in 1993 and 1996 on limited seabed areas (i.e., tens of square meters) at the two coastal sites of Sori and Rapallo (Liguria, NW Italy). No further initiatives have been reported for the Ligurian Sea until 2022. In that year, a large-scale restoration project, which uses biodegradable mats coupled with metal mesh, began in Liguria. Different levels of anthropogenic pressure and wave exposure characterize the three investigated locations: (1) Portofino, on the eastern Liguria and on the border with the Portofino Marine Protected Area; (2) Bergeggi in the central Liguria and within the Isola di Bergeggi Marine Protected Area; and (3) Sanremo in the western Liguria, without any formal protection. Despite recent setbacks caused by severe storms in late 2023, which particularly damaged the Portofino site, ongoing monitoring revealed promising survival rates. Most notably, the site in Bergeggi displayed a 90% survival rate in September 2023. Although challenges to restore *P. oceanica* beds persist, such as mitigating damages caused by unpredictable events, this extensive re-implantation initiative offers the opportunity to evaluate the effectiveness of new basin-scale restoration strategies. This approach marks an important step in the conservation of *Posidonia oceanica* habitat.

Keywords: seagrass; biomats; NW Mediterranean

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Seagrass meadows are crucial habitats in coastal areas, providing essential ecosystem functions and services [1–5]. They are important primary producers, dissipate wave energy by preventing erosion of sandy coastlines, stabilize the seabed, provide habitats and breeding areas for many organisms, and play a significant role in the mitigation of climate change through carbon sequestration [6,7]. Despite their low taxonomic diversity [8], seagrasses are considered one of the most valuable ecosystems due to their global distribution: they have managed to colonize all but the polar seas.

Throughout their evolutionary history, seagrasses have undergone gradual changes in their global distribution and abundance in response to factors such as changes in sea-level and water temperature, physical shoreline modifications, and the global increase in carbon dioxide [9]. It is known that the increasing development and urbanization of coastal areas has led to significant direct and indirect damage to seagrass meadows [10–12]. Meadows of the endemic *Posidonia oceanica* (Linnaeus) Delile 1813 and *Cymodocea nodosa* (Ucria) Ascherson 1870 have been in sharp decline for several decades, especially in the north-western Mediterranean [1,13]. Increased nutrient and sediment fluxes, invasive species, hydrogeological alterations, commercial fishing practices, and anchoring are the primary factors that contribute to seagrass loss on a global scale [9].

Posidonia oceanica is the most threatened among Mediterranean seagrasses due to its slow growth (ca. 2 cm year^{-1}) [14,15]. Even when local anthropogenic pressures are removed, its natural recolonization would take an extremely long time [16]. Therefore, the inclusion of *P. oceanica* in the Red List of Threatened Marine Species and the designation of seagrass meadows as Priority Habitats in Annex I of EC Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora have required the designation of Special Zones of Conservation (SZC) for their legal protection. Despite the numerous laws and actions aimed at protecting *P. oceanica*, its decline is still noticeable.

Over the last 50 years, the Mediterranean experienced a significant loss of seagrass meadow extent, estimated at 34% [16]. This percentage increases to 56% when considering the loss in the north-western sector of the Mediterranean [17–19]. This notwithstanding, there have been some positive indications of partial recovery in certain Mediterranean seagrass meadows, particularly those that are under protection and management regimes [20].

As a result, there has been a growing need to safeguard seagrass meadows through active conservation actions in recent years. Transplantation or re-implantation of *Posidonia oceanica* has been extensively used to restore a degraded ecosystem. The term 'transplantation' refers to the relocation of *P. oceanica* shoots from donor meadows (e.g., for compensation activities) [21], while 're-implantation' emphasizes the restoration or replenishment of damaged portions of the meadow using shoots collected from the same meadow.

The first reported restoration efforts for *Posidonia oceanica* took place in the 1970s and the 1980s in France [22,23], particularly by the 'Jardinier de la Mer' [24,25]. The preferred method involved concrete frames with a metal grid to which the cuttings were attached. The 'Jardinier de la Mer' made initial attempts that led to several interventions in subsequent years, particularly in Italy [26–30]. The practice then spread to France [31,32] and Spain [33].

The Ligurian Sea (NW Mediterranean) has been a focal point for numerous restoration actions. The first historical sites selected for the restoration of *P. oceanica* were located in the two coastal localities of Sori [28] and Rapallo [29] (Genova, Liguria, NW Italy) and took place in 1993 and 1996, respectively (Figure 1). These pioneer interventions, as well as most of the early transplantation attempts elsewhere, were carried out on a limited area of the seabed (i.e., tens of square meters) and involved a narrow number of transplanted cuttings. In Sori and Rapallo, cuttings were fixed to the seabed using metal stakes. In Rapallo, the restored site was supplemented with cuttings on metal grids. The transplants had a high success rate in the following months, but monitoring activities were soon interrupted [28,29]. Upon revisiting the Rapallo site 23 years later, the transplanted plants were still visible and the transplant area appeared to be expanding [34]. However, despite these positive results, caution must be exercised in defining the success of restoration efforts, as the available data on transplantation are limited to isolated case studies, which are often difficult to compare due to differences in techniques [35].

Three new re-implantation interventions have been implemented in the coastal locations of Portofino, Bergeggi, and Sanremo (Figure 1), starting in 2022 and using the geocomposite 'R.E.C.S.®-Cocco' (Reinforced Erosion Control System) technique. This technique, successfully adopted for the first time at Elba Island (Tuscany, Italy) in 2019 [36], utilizes biodegradable mats made of coconut fibers, coupled with a double-twisted metal mesh that is fixed to the substrate by anchoring with metal stakes. Within each of the three sites, 10 biodegradable mats, each measuring 2 m × 5 m, were anchored preferably on the dead matte substrate in the bathymetric range of 9 m to 13 m, providing a total of 100 m^2 of useful re-implanting area. In total, approximately 2000 *P. oceanica* cuttings were collected and re-implanted in each intervention. Only naturally uprooted cuttings of *P. oceanica*, found drifting on the seabed, were used for the interventions [36]. Cuttings were attached to artificial substrates after cleaning and trimming the roots (Figure 2).

Approximately 128 man-hours were estimated for re-implantation activities in the field. Monitoring of the restored areas was planned for every 4 months during the first year after the re-implanting and for every 6 months thereafter.

The three sites selected for re-implantation were located in areas characterized by different levels of anthropogenic pressure and exposure to wave motion (Figure 1). The Portofino site is located in Eastern Liguria and on the border with the Portofino Marine Protected Area (MPA), specifically at Punta Pedale (44°19′15.55″ N; 9°12′57.65″ E); the Bergeggi site is located in Central Liguria and within the Isola di Bergeggi MPA (44°14′15.60″ N; 8°26′36.60″ E); the Sanremo site is located in Western Liguria, specifically in front of the locality of Pian di Poma (43°48′8.16″ N; 7°45′10.32″ E), and it does not benefit from any formal protection.

Both the Pian di Poma (Sanremo) and Punta Pedale (Portofino) sites face south-east winds. However, while the former is exposed to both Libeccio and Scirocco storms, the latter is only affected by Scirocco swells, being partly protected by the Portofino promontory. The coastline of Pian di Poma can be considered highly anthropized due to the proximity with the city of Sanremo, the fourth most populated city in the Ligurian region. Punta Pedale can be considered moderately anthropized due to the presence of touristic facilities along the coastline and the high pressure of leisure boating in the Portofino area. The site of Bergeggi is the least affected by human-related pressures, as it is included in the MPA. It faces east winds and is less affected by Libeccio swells because of the protection offered by the island. However, it is completely exposed to Scirocco swells.

Shoot density was the main parameter used to assess the effectiveness and the health status of the re-implantation. The Bergeggi site showed the most successful results, recording a 90% survival rate of cuttings during the first monitoring in September 2023. Despite differences in the environmental conditions between the two sites (e.g., depth, substrate, and exposure), the first monitoring at Punta Pedale in October 2022 also showed a high survival rate (88%) (Table 1).

During autumn 2023, severe storms caused significant damages to various coastal infrastructure throughout the region. Although no damage was observed on the biomats in Bergeggi, a decrease of 20% was recorded in the shoot density of replanted cuttings during monitoring in December 2023. At Punta Pedale, two out of the ten biomats were irreparably damaged, and a loss of 24% in the replanted cutting was recorded (Table 1). In Sanremo, data from the first monitoring are not yet available.

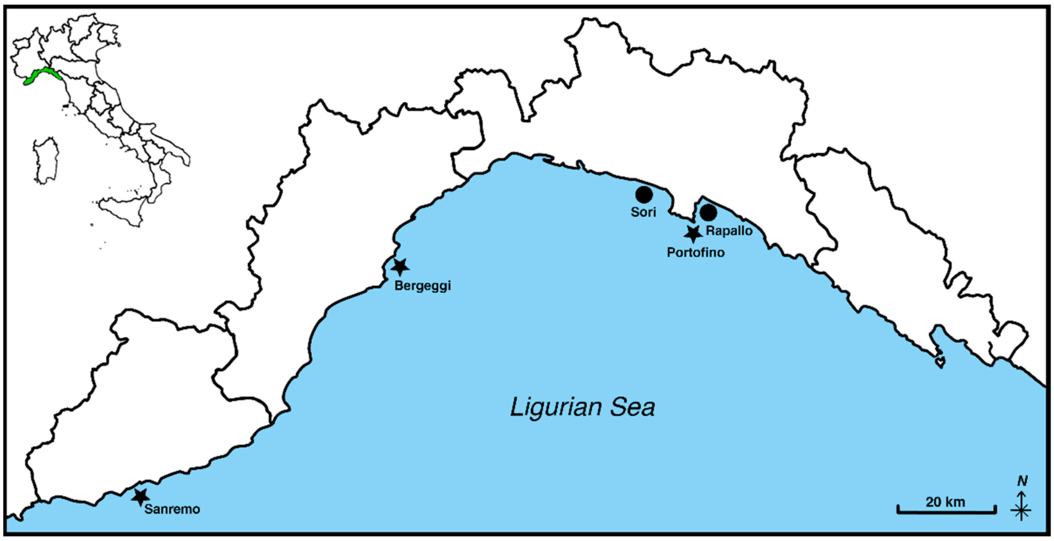

Figure 1. *Posidonia oceanica* restoration sites in Liguria (NW Italy). Historical sites are marked with dots; the new re-implantation sites are marked with stars.

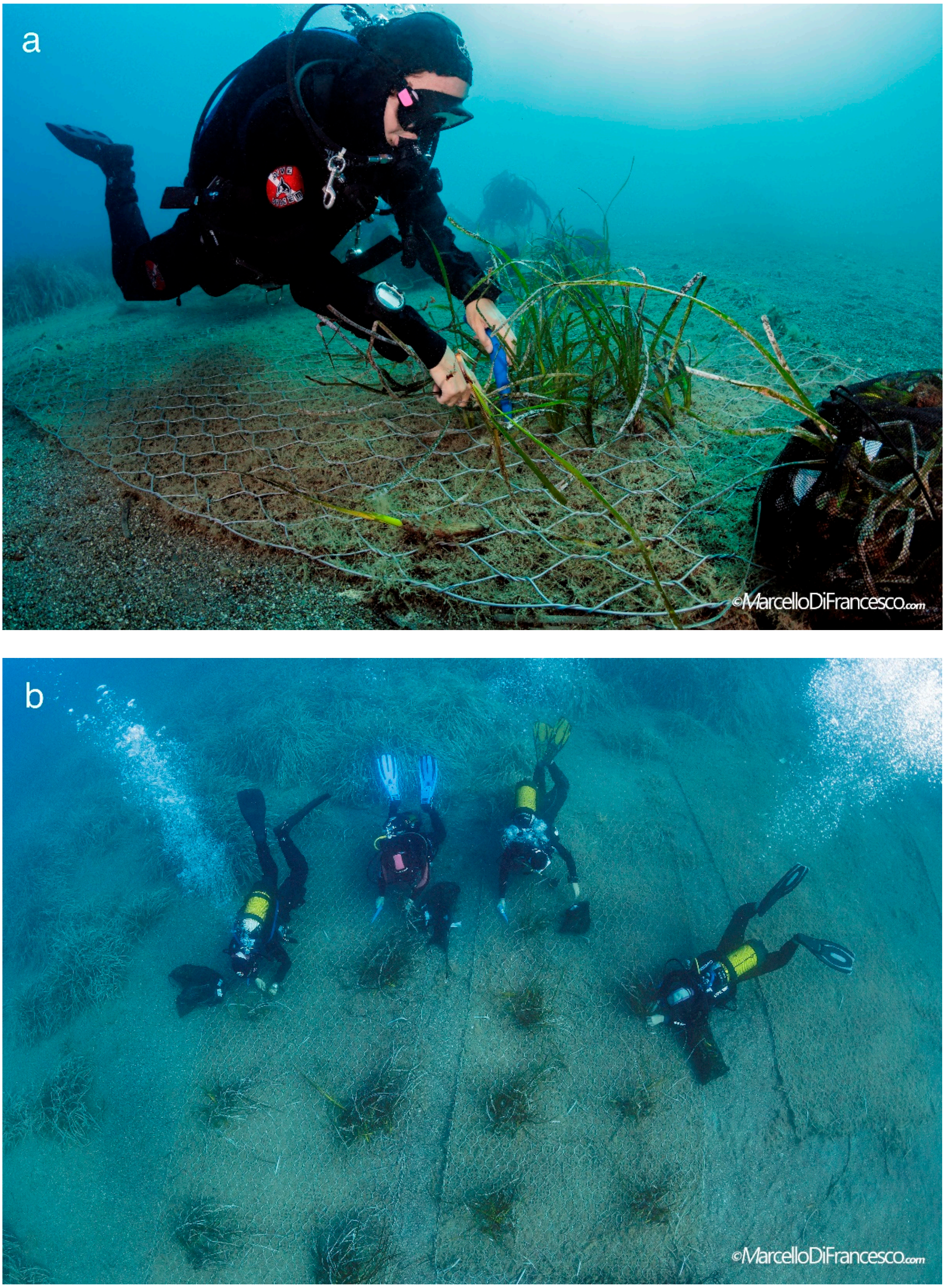

Figure 2. (**a**) Scientific diver involved in planting cuttings at the early phase of the re-implantation. (**b**) Overhead view of two out of ten re-implanted biomats.

Table 1. Survival rates of re-implantations at different monitoring times. The red bold numbers indicate the survival rate after the autumn 2023 storms (n.a. = not available).

		Survival Rate (%)			
Sites	**Starting Date**	**1st Monitoring**	**2nd Monitoring**	**3rd Monitoring**	**4rd Monitoring**
Punta Pedale (Portofino)	July 2022	88	64	64	**40**
Bergeggi	June 2023	90	**70**		
Pian di Poma (Sanremo)	September 2023	n.a.			

Although the loss of replanted shoots is similar in the two sites of Bergeggi and Punta Pedale, it is important to consider that, at the time of the storms, the cuttings at the latter had been in place for about 14 months, allowing them to consolidate in the substrate. In contrast, the restoration in Bergeggi was realized only 5 months earlier, so the cuttings were probably not yet firmly anchored to the substrate.

These preliminary results highlight the high initial success of replanting at Bergeggi, which is likely to be explained by the sheltered position of the site, with respect to both hydrodynamic and anthropogenic pressures. While it is mandatory to consider the potential influence of human pressures on the effectiveness of restoration, our experience suggests that one of the main factors contributing to the loss of cuttings is hydrodynamics, at least in the first months after the intervention. This natural factor is crucial for successful reforestation of *P. oceanica*. To select the most suitable areas for replanting, it will be essential to choose receiving sites that can provide the highest level of protection from prevailing marine conditions [37]. This is especially important given the predicted changes in wave climate in the Mediterranean Sea, which indicate a significant increase in the frequency of extreme events [38,39].

Furthermore, as shown by our findings, the substrate type should be taken into account in the selection of the proper receiving site: Bergeggi yielded the best survival rates, partly thanks to its substrate made by a thick layer of dead matte, which effectively stabilized replanted cuttings and biomats. Sand substrates (or dead matte covered by sediment) were less suitable for restoration because the cuttings were more prone to be easily uprooted from the bottom and the biomats can be severely damaged in the case of a severe storm.

In conclusion, although challenges persist, such as mitigating damages caused by unpredictable climatic events, this extensive re-implantation initiative offers the opportunity to evaluate the effectiveness of new basin-scale strategies for the restoration of *Posidonia oceanica*. Interventions conducted in the Ligurian Sea using biomats can now be considered as a restoration approach at the basin-scale rather than in isolated spots. Biomats have already been successfully tested at small and medium scales in pilot projects, demonstrating promising results for large-scale interventions. This method enabled the restoration of large areas of degraded *P. oceanica* meadows within a short period of time and with a limited workforce [36].

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References

1. Boudouresque, C.F.; Bernard, G.; Bonhomme, P.; Charbonnel, E.; Diviacco, G.; Meinesz, A.; Pergent, G.; Pergent-Martini, C.; Ruitton, S.; Tunesi, L. *Protection and Conservation of Posidonia oceanica Meadows*; RAMOGE and RAC/SPA: Tunis, Tunisia, 2012; pp. 1–202.
2. Campagne, C.S.; Salles, J.M.; Boissery, P.; Deter, J. The seagrass *Posidonia oceanica*: Ecosystem services identification and economic evaluation of goods and benefits. *Mar. Pollut. Bull.* **2014**, *97*, 391–400. [CrossRef] [PubMed]
3. Picone, F.; Buonocore, E.; D'Agostaro, R.; Donati, S.; Chemello, R.; Franzese, P.P. Integrating natural capital assessment and marine spatial planning: A case study in the Mediterranean Sea. *Ecol. Modell.* **2017**, *361*, 1–13. [CrossRef]
4. Vassallo, P.; Paoli, C.; Rovere, A.; Montefalcone, M.; Morri, C.; Bianchi, C.N. The value of the seagrass *Posidonia oceanica*: A natural capital assessment. *Mar. Pollut. Bull.* **2013**, *75*, 157–167. [CrossRef] [PubMed]
5. Monnier, B.; Pergent, G.; Valette-Sansevin, A.; Boudouresque, C.F.; Mateo, M.A.; Pergent-Martini, C. The *Posidonia oceanica* matte: A unique coastal carbon sink for climate change mitigation and implications for management. *Vie Milieu* **2020**, *70*, 17–24.
6. Hemminga, M.A.; Duarte, C.M. *Seagrass Ecology*; Cambridge University Press: Cambridge, UK, 2000; p. 298. [CrossRef]
7. Mcleod, E.; Chmura, G.L.; Bouillon, S.; Salm, R.; Björk, M.; Duarte, C.M.; Lovelock, C.E.; Schlesinger, W.H.; Silliman, B.R. A blueprint for blue carbon: Toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2. *Front. Ecol. Environ.* **2011**, *9*, 552–560. [CrossRef]
8. Short, F.; Carruthers, T.; Dennison, W.; Waycott, M. Global seagrass distribution and diversity: A bioregional model. *J. Exp. Mar. Bio. Ecol.* **2007**, *350*, 3–20. [CrossRef]
9. Orth, R.J.; Carruthers, T.J.B.; Dennison, W.C.; Duarte, C.M.; Fourqurean, J.W.; Heck, K.L.; Hughes, R.; Kendrick, G.A.; Kenworthy, J.; Olyarnik, S.; et al. A Global Crisis for Seagrass Ecosystems. *Bioscience* **2006**, *56*, 987–996. [CrossRef]
10. Turschwell, M.P.; Connolly, R.M.; Dunic, J.C.; Sievers, M.; Buelow, C.A.; Pearson, R.M.; Tulloch, V.J.D.; Côté, I.M.; Unsworth, R.K.F.; Collier, C.J.; et al. Anthropogenic pressures and life history predict trajectories of seagrass meadow extent at a global scale. *Proc. Natl. Acad. Sci. USA* **2021**, *118*, e2110802118. [CrossRef]
11. Abadie, A.; Lejeune, P.; Pergent, G.; Gobert, S. From mechanical to chemical impact of anchoring in seagrasses: The premises of anthropogenic patch generation in *Posidonia oceanica* meadows. *Mar. Pollut. Bull.* **2016**, *109*, 61–71. [CrossRef]
12. Abadie, A.; Richir, J.; Lejeune, P.; Leduc, M.; Gobert, S. Structural changes of seagrass seascapes driven by natural and anthropogenic factors: A multidisciplinary approach. *Front. Ecol. Evol.* **2019**, *7*, 190. [CrossRef]
13. Garrido, M.; Lafabrie, C.; Torre, F.; Fernandez, C.; Pasqualini, V. Resilience and stability of *Cymodocea nodosa* seagrass meadows over the last four decades in a Mediterranean lagoon. *Estuar. Coast. Shelf Sci.* **2013**, *130*, 89–98. [CrossRef]
14. Marbà, N.; Duarte, C.M. Rhizome elongation and seagrass clonal growth. *Mar. Ecol. Prog. Ser.* **1998**, *174*, 269–280. [CrossRef]
15. Alcoverro, T.; Duarte, C.M.; Romero, J. Annual growth dynamics of *Posidonia oceanica*: Contribution of large-scale versus local factors to seasonality. *Mar. Ecol. Prog. Ser.* **1995**, *120*, 203–210. [CrossRef]
16. Telesca, L.; Belluscio, A.; Criscoli, A.; Ardizzone, G.; Apostolaki, E.T.; Fraschetti, S.; Cristina, M.; Knittweis, L.; Martin, C.S.; Pergent, G.; et al. Seagrass meadows (*Posidonia oceanica*) distribution and trajectories of change. *Sci. Rep.* **2015**, *5*, 12505. [CrossRef] [PubMed]
17. Montefalcone, M.; Albertelli, G.; Morri, C.; Bianchi, C.N. Urban seagrass: Status of *Posidonia oceanica* facing the Genoa city waterfront (Italy) and implications for management. *Mar. Pollut. Bull.* **2007**, *54*, 206–213. [CrossRef] [PubMed]
18. Burgos, E.; Montefalcone, M.; Ferrari, M.; Paoli, C.; Vassallo, P.; Morri, C.; Bianchi, C.N. Eco-system functions and economic wealth: Trajectories of change in seagrass meadows. *J. Clean. Prod.* **2017**, *168*, 1108–1119. [CrossRef]
19. Oprandi, A.; Bianchi, C.N.; Karayali, O.; Morri, C.; Rigo, I.; Montefalcone, M. RESQUE: A novel comprehensive approach to compare the performance of different indices in evaluating seagrass health. *Ecol. Indic.* **2021**, *131*, 108118. [CrossRef]
20. De Los Santos, C.B.; Krause-Jensen, D.; Alcoverro, T.; Marbà, N.; Duarte, C.M.; Van Katwijk, M.M.; Pérez, M.; Romero, J.; Sánchez-Lizaso, J.L.; Roca, G.; et al. Recent trend reversal for declining European seagrass meadows. *Nat. Commun.* **2019**, *10*, 3356. [CrossRef] [PubMed]
21. Calumpong, H.P.; Fonseca, M.S. Seagrass transplantation and other seagrass restoration methods. In *Global Seagrass Research Methods*; Short, F.T., Coles, R.G., Eds.; Elsevier Science Publ.: Amsterdam, The Netherland, 2001; Volume 22, pp. 425–442.

22. Maggi, P. Les herbiers à Posidonies et la pollution urbaine dans le Golfe de Giens (Var). *Ann. Inst. Michel Pacha* **1972**, *5*, 1–11.
23. Maggi, P. Le problème de la disparition des herbiers à posidonies dans le golfe de Giens (Var). *Sci. Pêche Bull. Inst. Sci. Technol. Pêches Marit.* **1973**, *221*, 7–20.
24. Cooper, G.F. Jardinier de la Mer. Association-Fondation, G. Cooper pour la reconquête des milieux naturels détruits. *Cahier* **1976**, *1*, 1–57.
25. Cooper, G. Réimplantation de *Posidonia oceanica*: Protection des implants. *Bull. Ecol.* **1982**, *13*, 65–73.
26. Cinelli, F. La fanerogame marine: Problemi di trapianto e di riforestazione. *Mem. Biol. Mar. Ocean. Suppl.* **1980**, *10*, 17–25.
27. Giaccone, G.; Calvo, S. Restaurazione del manto vegetale mediante trapianto di *Posidonia oceanica* (Linneo) Delile. Risultati preliminari. *Mem. Biol. Mar.* **1980**, *10*, 207–211.
28. Sandulli, R. *Relazione Finale—Reimpianto Della Fanerogama Marina Posidonia oceanica Nel Golfo Paradiso*; Castalia S.P.A.: Genova, Italy, 1994; p. 31.
29. Bavestrello, G.; Cattaneo-Vietti, R. *Relazione Finale—Trapianto Sperimentale di Posidonia Oceanica Nel Golfo di Rapallo*; Castalia S.P.A.: Genova, Italy, 1997; p. 37.
30. Sandulli, R. Posidonia in regresso? Riforestiamo! Sperimentata con successo anche sui fondali liguri la tecnica di reimpianto delle talee. *Aqua* **1994**, *95*, 27–29.
31. Meinesz, A.; Molenaar, H.; Bellone, E.; Loques, F. Vegetative reproduction in *Posidonia oceanica* (L.) Delile. I—Effects of rhizome length and transplantation season in orthotropic shoots. *PSZN I Mar. Ecol.* **1992**, *13*, 163–174. [CrossRef]
32. Molenaar, H.; Meinesz, A. Vegetative reproduction in *Posidonia oceanica*. II—Effects of depth changes on transplanted orthotropic shoots. *PSZN I Mar. Ecol.* **1992**, *13*, 175–185. [CrossRef]
33. Sánchez-Lizaso, J.L.; Fernández-Torquemada, Y.; González-Correa, J.M. Evaluation of the viability of *Posidonia oceanica* transplants associated with a marina expansion. *Bot. Mar.* **2009**, *52*, 471–476. [CrossRef]
34. Robello, C.; Oprandi, A.; Mancini, I.; Bavestrello, G.; Montefalcone, M. Effectiveness of a *Posidonia oceanica* (L.) Delile transplantation in the Gulf of Tigullio (Ligurian sea) 23 years later. *Biol. Mar. Med.* 2024; *in press*.
35. Pansini, A.; Bosch-Belmar, M.; Berlino, M.; Sarà, G.; Ceccherelli, G. Collating evidence on the restoration efforts of the seagrass *Posidonia oceanica*: Current knowledge and gaps. *Sci. Total Environ.* **2022**, *851*, 158320. [CrossRef]
36. Piazzi, L.; Acunto, S.; Frau, F.; Atzori, F.; Cinti, M.F.; Leone, L.M.; Ceccherelli, G. Environmental engineering techniques to restore degraded *Posidonia oceanica* meadows. *Water* **2021**, *13*, 661. [CrossRef]
37. Fraschetti, S.; McOwen, C.; Papa, L.; Papadopoulou, N.; Bilan, M.; Boström, C.; Capdevila, P.; Carreiro-Silva, M.; Carugati, L.; Cebrian, E.; et al. Where Is More Important than How in Coastal and Marine Ecosystems Restoration. *Front. Mar. Sci.* **2021**, *8*, 626843. [CrossRef]
38. Oprandi, A.; Mucerino, L.; de Leo, F.; Bianchi, C.N.; Morri, C.; Azzola, A.; Benelli, F.; Besio, G.; Ferrari, M.; Montefalcone, M. Effects of a severe storm on seagrass meadows. *Sci. Total Environ.* **2020**, *748*, 141373. [CrossRef] [PubMed]
39. Rigo, I.; Dapueto, G.; Paoli, C.; Massa, F.; Oprandi, A.; Venturini, S.; Merotto, L.; Fanciulli, G.; Cappanera, V.; Montefalcone, M.; et al. Changes in the ecological status and natural capital of *Posidonia oceanica* meadows due to human pressure and extreme events. *Vie Milieu* **2020**, *70*, 137–148.