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Posidonia Spheroids Intercepting Plastic Litter: Implications for Beach Clean-Ups

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Abstract: This study represents the first assessment of plastic waste within *Posidonia* spheroids on four sandy, Mediterranean beaches, each characterized by varying levels of anthropogenic influence. Fifty-five (68.7%) spheroids, out of eighty examined, included plastic litter. A total of 202 plastic items were isolated. Plastic abundance was 2.5 items/spheroid corresponding to 132 items per kilogram. The length of plastic items ranged from 0.1 to 50 mm. Fibers, tangled fibers and fragments were the most common shapes. The spheroids exhibited a substantial capacity for trapping plastic waste, with notable differences among the beaches. Our results underscore the significance of implementing a beach clean-up plan aimed at removing all spheroids to prevent them from disintegrating and releasing trapped plastic waste into the environment. Manual removal is recommended to safeguard the beaches, and this process should target all spheroids, regardless of their size. This study provides valuable insights that can inform marine litter monitoring programs, contribute to the development of tailored management measures, and support the implementation of specific action plans to mitigate Mediterranean microplastic pollution.

Keywords: beach management; ecosystem service; marine litter; plastics; *Posidonia oceanica*; spheroid

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1. Introduction

In 2021, global plastic production reached approximately 390.7 million metric tons, leading to significant consequences for the marine environment [1]. Plastics found in the environment can be categorized into five classes based on their size like nanoplastics (<1 µm), microplastics (≥1 µm to <5 mm), mesoplastics (≥5 mm to 5 cm), macroplastics (>5 to 50 cm), and megaplastics (>50 cm) [2]. Plastic pollution poses a substantial threat to aquatic ecosystems and their inhabitants [3,4]. Plastic litter has the potential to adversely affect marine ecosystems by transporting toxic substances adsorbed on their surfaces [5]. Additionally, plastics can serve as vectors for invasive species [6] and can have detrimental effects on marine organisms [7–12]. Moreover, plastic litter can affect the marine trophic web [13,14] since plastics are also ingested by marine biota [15,16], and once ingested, can translocate into cells and tissues [17–19].

Seagrass meadows are recognized for their capacity to filter, trap, and store various particles, encompassing both organic and inorganic matter [20,21], among which plastics have been documented [22–25]. These particles are typically deposited on the leaves and within the sediment or on the soil surface [24,26,27]. Plastics have also been identified in wrack composed of other macrophytes, including seagrasses belonging to genera such as *Halodule*, *Syringodium*, *Thalassodendron*, *Zostera*, *Heterozostera*, *Amphibolis*, and *Cymodoces* [28]. In Singapore, Seng et al. [29] detected microplastic items on seagrass blades. In addition, in China, seagrass meadows of *Enhalus acodoides* harbored microplastics (from 80 to 885 items per kg of dry sediment), with fibers being the dominant shape [23], highlighting that seagrasses acted as a trap for microplastics. Jones et al. [24], in a *Zostera marina* bed in Scotland, found microplastics both in sediments and on eelgrass blades, as well as on the associated biota of sediments and blades.

Furthermore, Gutow et al. [30] discovered microplastics in vegetation and within the invertebrates that inhabit it. It is likely that herbivores or predators that feed on these invertebrates also ingest microplastics, as demonstrated in studies involving seaweed, thus introducing microplastics into the marine food web.

Additionally, in a study conducted by Remy et al. [31] focusing on the invertebrate community inhabiting the seagrass *Posidonia oceanica* near Corsica, it was revealed that 27% of the invertebrates examined contained viscose fibers.

Furthermore, the contamination of microplastics could have adverse effects on the growth and overall health of seagrass plants. Research has highlighted the detrimental impact of marine litter on seagrass ecosystems. Ganesapandian et al. [32] documented these effects in the Gulf of Mannar and also in seagrass areas in the Philippines [33]. In a study of seagrass habitats in Portugal, Cozzolino et al. [34] revealed that both macro- and microplastics accumulate in the canopies and sediments, raising concerns that seagrass may become a significant reservoir for plastic debris, posing serious threats to biodiversity and marine habitats. In a mesocosm experiment conducted by Balestri et al. [35], where plastic bags were placed on Mediterranean seagrass (*Cymodocea nodosa*), it was observed that these bags led to a decrease in pH and oxygen content in the sediments and also had an impact on plant growth.

Posidonia oceanica (L.) Delile is the primary and endemic seagrass species found in the Mediterranean Sea, forming extensive underwater meadows at depths ranging from 0.5 to 40 m [36]. It serves a crucial ecological role by contributing to water quality enhancement, CO2 absorption, stabilization of the sea floor and beaches, coastal protection, and providing refuge and nursery areas for numerous marine organisms [37–40]. *P. oceanica* is of utmost significance in the generation of organic carbon and stands out as the most proficient carbon storage entity. Its remarkable resilience lies in its structure, comprised of rhizomes and roots that can extend to great heights, allowing it to store carbon accumulated over years for extended periods, akin to certain terrestrial ecosystems renowned for their carbon storage efficiency, such as peatlands [41].

P. oceanica is a protected species under several international conventions ratified by Mediterranean countries and is a priority natural habitat type for conservation under the Habitat Directive (92/43/EEC). Moreover, *P. oceanica* has been selected as an indicator of the Good Environmental Status for marine areas within the Marine Strategy Framework Directive (MSFD, 2008/56/EC).

During the autumn season, *P. oceanica* loses its leaves which, through waves and currents, accumulate on adjacent beaches as wrack beds [42]. The leaves, when decomposed, can create huge banquettes that protect the beaches from sea erosion [43], provide feed for invertebrate communities [44], and nutrients for dune plants [45]. *P. oceanica* debris can also form fibrous assemblages, called aegagropilae (hereinafter EGs), through hydrodynamic movements [46]. EGs, commonly known as sea balls, sea rissoles, sea potatoes, beach balls, Neptune balls, or Kedron balls, are frequently found along Mediterranean beaches [47]. Their composition is an open question as the plant organ from which the fibers arise is not known. During the EGs' formation, plastic debris occurring on the sea bottom, shoreline, and beach gets trapped within the balls [43,48].

P. oceanica provides an ecosystem service, and in the context of beach litter management, EGs removal has been recently proposed to eliminate the associated plastic items [42].

This study represents the first assessment of plastic waste within *Posidonia* spheroids on four sandy, Mediterranean beaches characterized by different anthropogenic influences. The aims of this paper were: (i) to quantify plastic debris within EGs, (ii) to compare plastic litter in EGs along beaches with different anthropogenic impacts, and (iii) to evaluate the correlation between plastic abundance and EG size. The evaluation of plastic abundance within EGs is important as they can reflect the plastic pollution level of both marine and beached sediments. The relation between EG size and plastic abundance can have implications in the context of beach litter management. In accordance with Pietrelli et al. [48], we expect to find greater quantities of plastic items in the largest balls; moreover, with this study, we expect that the removal of EGs can be used as a strategy to mitigate the impact of microplastics in beaches.

2. Materials and Methods

2.1. Study Areas and Samplings

Mazara del Vallo falls within the geographical subarea 16—"South of Sicily"—that is affected by several anthropic activities (commercial and tourist ports, agricultural and industrial activities, mariculture facilities, oil refineries, and offshore platforms). The South of Sicily also represents an important crossroads for Mediterranean trade routes (including the oil traffic), due to its central position. The South of Sicily is one of the most important fishing areas in the Mediterranean Sea with the fishing fleet of Mazara del Vallo [49–51]. The territory of Mazara is crossed by two rivers, the Mazaro and the Delia (also called Arena), the latter starting from Lake Trinità, an artificial lake created by the homonymous dam, located on the border with the Castelvetrano area. According to a study carried out by the Sicily Region, the ecological status of the Mazaro River is sufficient while that of the Delia River is good [52]. There are also several streams (Iudeo, Bucari) and artificial canals used mainly in agriculture. EGs were collected from three beaches along the south-west part of Sicily close to Mazara del Vallo, namely Capo Feto (1), Tonnarella (2), and San Vito (3).

Capo Feto (37°39′35.3″ N 12°31′40.6″ E) is a Site of Community Importance (SCI), as well as an area deserving of special protection (92/43/CEE). In July 2011, according to the Convention on Wetlands of International Importance, inserted in the Ramsar wetlands' list, Tonnarella (37°39′36.5″ N 12°34′03.9″ E) and S. Vito (37°38′17.8″ N 12°36′38.7″ E) are beaches with high anthropogenic impact during the summer and represent important tourist destinations. The main features of the investigated beach are briefly summarized in Table 1.

Table 1. Description of four investigated beaches.

	Capo Feto	Tonnarella	S. Vito	Spiaggetta del Sole
GPS Coordinates	37°39′35.3″ N 12°31′40.6″ E	37°39′36.5″ N 12°34′03.9″ E	37°38′17.8″ N 12°36′38.7″ E	37°14′26.0″ N 15°14′11.3″ E
Area	South of Sicily GSA 16	South of Sicily GSA 16	South of Sicily GSA 16	Ionian Sea GSA 19
Beach composition	Sand	Sand	Sand	Sand
Major usage beach	Protected area	Local and tourist people swimming. fishing and other activities	Local and tourist swimming	Local people. swimming. sunbathing. fishing. Surfing
Distance from the city (Km)	4.5	1.6	0	1.3
How often is the beach cleaned	Never	Once a year, during spring	Once a year, during spring	Once a year, before summer
Method used to clean	-	Manual	Mechanical	Mechanical

GSA: Geographical Sub Area.

Augusta Bay (Siracusa, Italy), located in the geographical subareas 19—Western Ionian Sea— in a harbor area with high marine traffic activity. This area has hosted a variety of different chemical and petrochemical plants, a commercial harbor, and bases for the Italian Navy and NATO activities. The Augusta Bay is an area with high anthropic impact, considered one of the most polluted in the Mediterranean Sea due to the high presence of heavy metals. The Gulf of Augusta is considered an elevated environmental risk site by the World Health Organization and classified as a "site of national interest" by the Italian Ministry of Environment (G.U.R.I., L. 426/1998). Spiaggetta del Sole (37°14′26.0″ N 15°14′11.3″ E) is a touristic beach within the city of Augusta (Figures 1 and 2A). The investigated areas are briefly summarized in Table 1.

Figure 1. Study areas along the coast of the South of Sicily and the Ionian Sea. The investigated beaches: (1) Capo Feto; (2) Tonnarella; (3) S. Vito; (4) Spiaggetta del Sole. Map was created using Google Earth: https://earth.google.com/web/@37.58144601,14.57542175,322.02108172a,456382.74704598d,30.00066939y,0h,0t,0r (accessed on 1 May 2023).

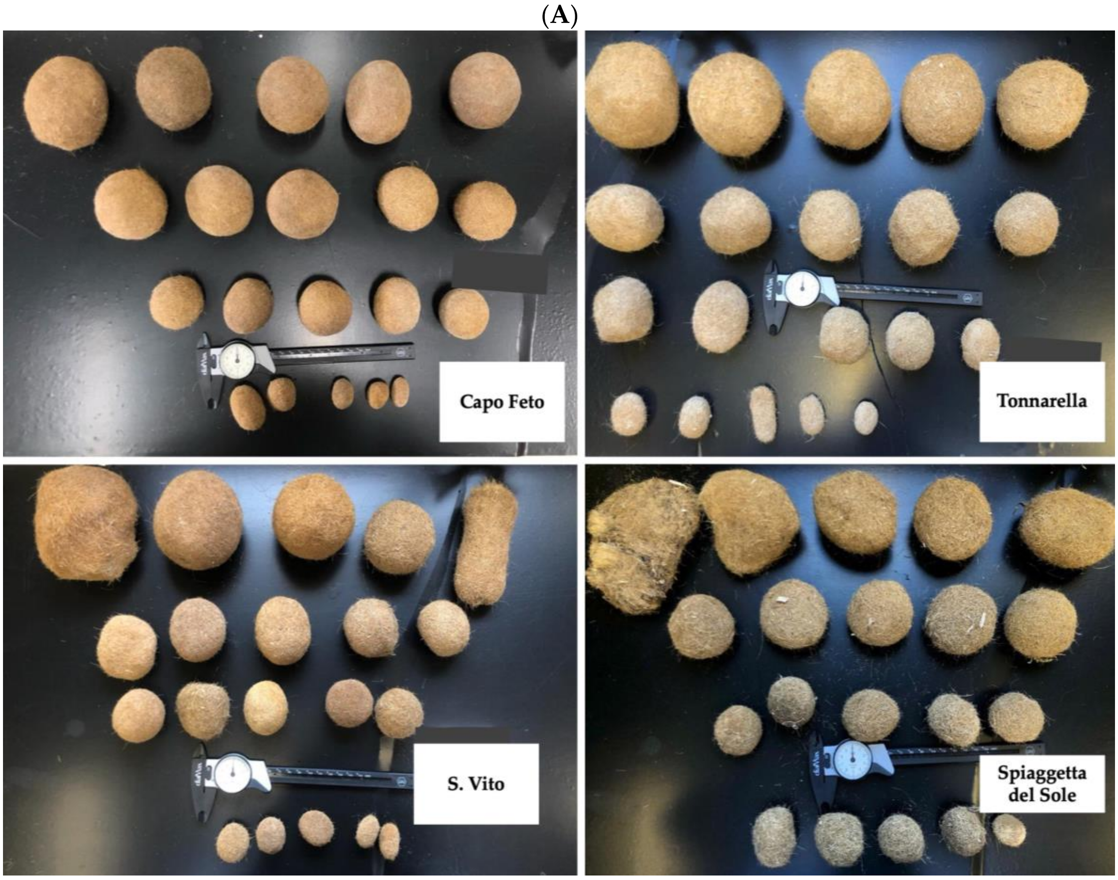
Four hundred EGs, one hundred for each site, were collected simultaneously on the beaches within a band 1 km long and 5 m wide starting from the shoreline, in summer 2022 before the beach clean-up.

2.2. Plastic Isolation

Once in the laboratory, samples were dried at room temperature (25 °C) and under low humidity for a week [42], then 20 EGs for each beach were selected to obtain the widest range size (Figure 2B). The samples were dried at room temperature for a week.

Selected samples were weighed (g) and the length (mm) of the three principal axes was measured with a digital caliper assuming that an EG is like an ellipsoid (Figure S1). After that, EGs were carefully disentangled manually into fibers under a laminal flow microbiological hood. The fibers were sieved at 8 mm, 5 mm, 1 mm, and 0.63 mm using stainless steel sieves, washed with water to remove sand and salt, and dried at room temperature [42]. Then, the disentangled EGs were observed under a stereomicroscope in order to isolate plastic debris. For each suspected item, the hot needle test was undertaken. The hot needle test is an accepted and cheap method used to verify plastic particles on the bases of their response [16,53,54]. The tip of a thin needle was heated, and each isolated particle was tested under a stereomicroscope. When particles melted after exposition to the hot needle, they were confirmed as plastic items [16]. Isolated plastic items were classified based on their size (small-microplastics: 0.1–0.9 mm; large-microplastics: 1–4.9 mm; mesoplastics: 5–25 mm; macroplastics: >25 mm) and shape (pellet, fiber, tangled fiber, foam, fragment, film, and sphere).

(**A**)



(**B**)

Figure 2. (**A**) Pictures of the investigated beaches; (**B**) images of selected EGs from the four beaches.

2.3. Prevention Contamination

To limit external contamination, the samples were processed in a restricted room and under a microbiological laminar hood. Moreover, all workspaces and tools were meticulously cleaned with ethanol and filtered deionized water. The operators wore cotton coats (100% cotton) and latex gloves. Moreover, the procedural blanks were run, and filters (cellulose nitrate membrane diameter of 47 mm) were put in open Petri dishes, both under the microbiological laminar hood and next to the stereomicroscope [14].

2.4. Data Analysis

The roundness of EGs was calculated using the equation:

$$\text{Roundness} = \frac{1}{3} \times \frac{\text{W} \times \text{H} \times \text{L}}{\text{D}_{\text{max}}}$$

where W represents the width, H is the height, L stands for the length, and D_{max} is the maximum dimension measured (see Figure S1). Roundness is 1 for a perfectly round object and less than 1 for any other object [55].

We compared the different sampling sites based on the frequency of occurrence (FO%) and abundance (number of plastic items per spheroid). To check for potential significant differences in the occurrence of plastic items between sites, we performed a chi-squared test (χ^2). Spearman correlation was performed to assess the correlation between: (1) plastic abundance vs. EGs weight; (2) plastic abundance vs. EGs length; (3) plastic abundance vs. EGs height; (4) plastic abundance vs. EGs width; and (5) plastic abundance vs. EGs roundness. The Kruskal–Wallis non-parametric test was used to test whether there were any significant differences in the plastic abundance between sampling sites. All graphs and statistical analyses were performed using GraphPad Prism 8.4.2.3.

3. Results

3.1. Plastic Abundance

A total of 80 EGs were analyzed (length: from 17.2 to 87.4 mm; width: from 13.7 to 72.3 mm; height: from 27.2 to 114.4 mm; weight: from 1 to 74 g). Detailed information about each beach is reported in Table 2. A total of 240 suspected items were isolated; of these, 202 were positive for the needle test. Fifty-five EGs (68.7%) included plastic items. Within these, 32.7% contained one plastic item, 14.5% contained two items, 9.1% contained three items, and 43.6% contained more than four items. The highest number of plastic items found within an EG was equal to 19. Plastic abundance was 2.5 items/spheroid, corresponding to 132 items/kg. The smallest EG with plastic items weighed 1 g.

Table 2. Morphometric data of EGs sampled in the four investigated beaches.

Beach	N	Length Range (mm) (mean ± SD)	Width Range (mm) (mean ± SD)	Height Range (mm) (mean ± SD)	Roundness (mean ± SD)	Weight Range (g) (mean ± SD)	N Items/Spheroid	N Items/kg
Capo Feto	20	17.2–73.0 (50.6 ± 18.2)	16.5–61.0 (45.8 ± 17.0)	27.2–86.5 (56.6 ± 18.4)	0.7–0.9 (0.9 ± 0.1)	1–49 (20 ± 15)	0.5	26.9
Tonnarella	20	21.8–87.4 (54.5 ± 23.0)	15.4–72.3 (41.5 ± 17.8)	29.1–98.3 (60.4 ± 19.8)	0.5–0.9 (0.8 ± 0.1)	3–73 (25 ± 22)	1.5	58.8
S. Vito	20	20.0–85.4 (47.6 ± 18.6)	17.5–57.6 (37.0 ± 14.0)	30.5–106.7 (57.7 ± 24.7)	0.5–09 (0.8 ± 0.1)	1–71 (18 ± 21)	3.2	175.7
Spiaggetta del Sole	20	23.7–79.2 (49.6 ± 14.6)	13.7–30.9 (35.4 ± 10.1)	28.2–114.4 (56.0 ± 20.4)	0.6–0.9 (0.8 ± 0.1)	1–34 (12 ± 9)	4.8	408.5
TOTAL	80	17.2–87.4 (50.6 ± 15.3)	13.7–72.3 (39.9 ± 20.6)	27.2–114.4 (57.7 ± 20.6)	0.5–0.9 (0.8 ± 0.1)	1–73 (19.0 ± 17.9)	2.5	132.5

SD: standard deviation.

No correlation between plastic abundance and weight/width/height/roundness was found (rs: from 0.15 to 0.19; $p > 0.05$). There was a weak positive correlation between plastic abundance and EG length (rs: 0.24; $p < 0.05$).

The length of plastic items, excluding tangled fibers (unmeasurable), ranged from 0.1 to 50 mm. The plastic items were categorized as follows: small microplastics (1%), large microplastics (26.7%), mesoplastics (54.5%), and macroplastics (17.8%). The types of debris found were primarily fibers (48.5%), tangled filaments (41.6%), fragments (8.4%), and films (1.5%). In terms of color, the most common were white (37.1%), followed by transparent (19.3%), green (9.9%), dark blue (8.9%), black (7.4%), red (5.9%), light blue (4.1%), and others (7.4%).

3.2. Beach Comparison

Plastic items were found in the EGs of all beaches. In particular, the occurrence was highest in the EGs from Spiaggetta del Sole (100%), followed by San Vito (80%), Tonnarella (70%), and Capo Feto (25%). Significant differences in the occurrence of plastic items were only detected between Spiaggetta del Sole and Capo Feto (χ^2: 62.5, $p < 0.05$).

Similarly, plastic abundance (items/spheroid) was highest in the EGs from Spiaggetta del Sole (4.8 items/spheroid), followed by S. Vito (3.2 items/spheroid), Tonnarella (1.5 items/spheroid), and Capo Feto (0.5 items/spheroid) (Table 2, Figures 3 and S2). The Kruskal–Wallis test revealed significant differences in plastic abundance values between beaches (H: 27.5, $p < 0.01$).

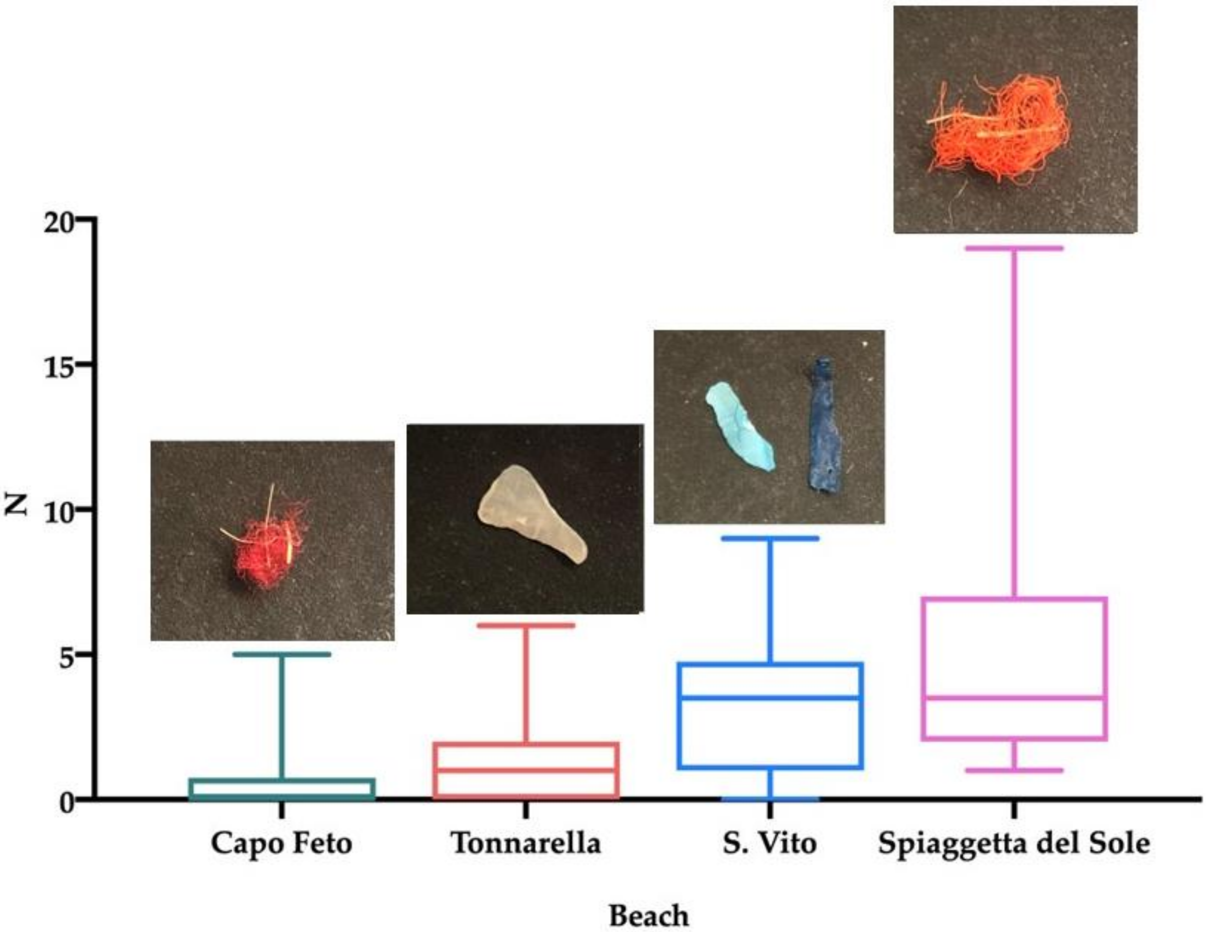


Figure 3. Box plot of plastic abundance in EGs from the four beaches. Pictures refer to plastic items found at each beach.

Concerning size, large microplastics were the most abundant in the EGs from Capo Feto beach; mesoplastics were more abundant in EGs from Tonnarella, S. Vito, and Spiaggetta del Sole beaches (Figure 4). Fibers and tangles fibers were the most frequent in all beaches investigated, except for Tonnarella, where fragments prevailed (Figure 5).

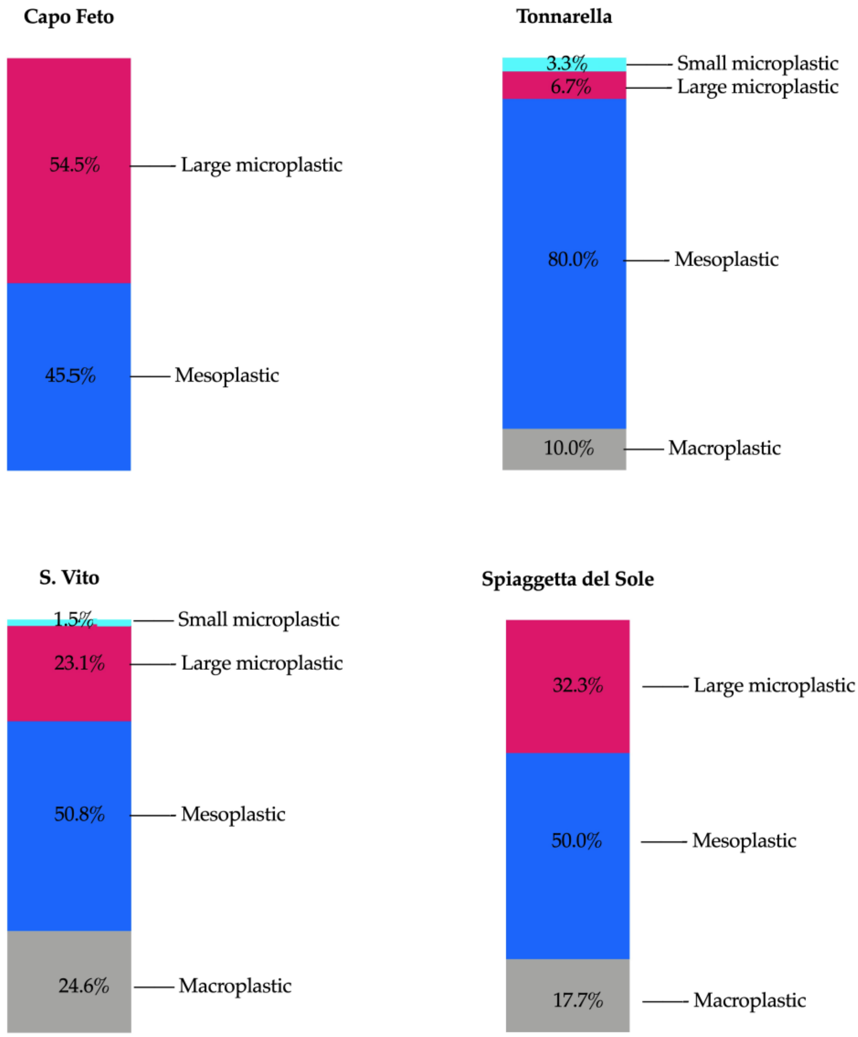


Figure 4. Size (%) of plastic items in EGs from the four beaches.

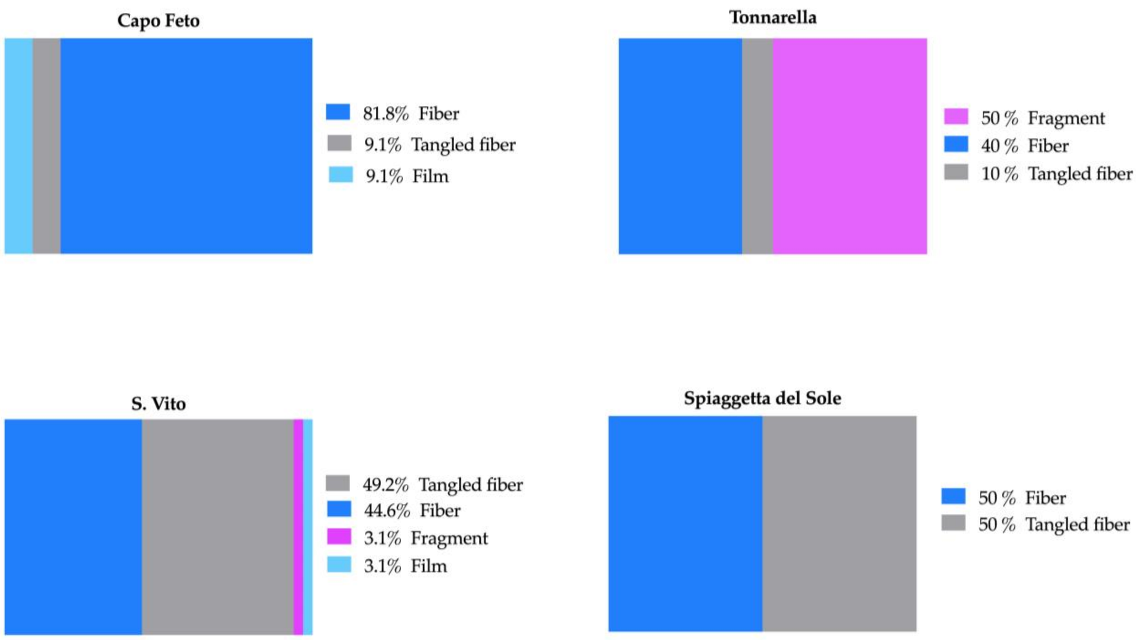


Figure 5. Shape (%) of plastic debris found in beached EG.

As for colors, Capo Feto had a higher quantity of green and white debris, while Tonnarella predominantly featured white debris. In San Vito, transparent debris was the most abundant, while Spiaggetta del Sole had predominantly white debris (see Figure 6).

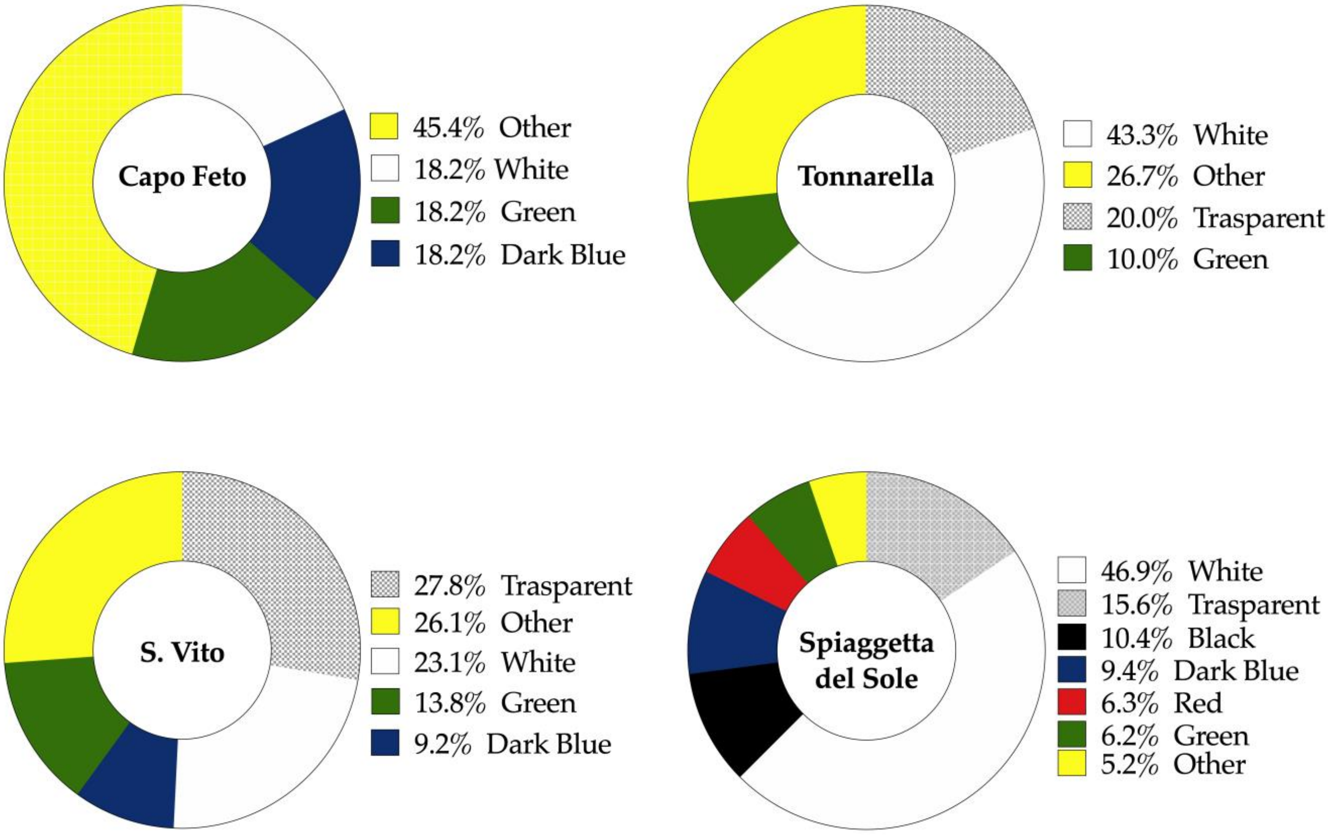


Figure 6. Colors (%) of plastic debris found in EGs.

4. Discussion

Studies focused on plastic litter have been carried out in marine and coastal ecosystems [56,57]; but only recently has the analysis of litter ashore from the sea to the beach received the attention of the scientific community [42,48,58,59].

This study evaluated, for the first time, the presence of plastic litter entrapped in *Posidonia* EGs on four Sicilian sandy beaches. Although the survey is limited to a single year and a single season, it was possible to collect the first data on plastic abundance within EGs in the considered areas. EGs, during their development, can incorporate debris from the sea bottom, seawater, beach sediments, and in the air. Plastic occurrence in the EGs used in this study (68.7%) is higher than those reported by Sanchez-Vidal et al. (17%) [42] and Pietrelli et al. (53%) [48]. Similarly, the plastic abundance reported in this study (2.5 items/spheroid) was higher than that reported in EGs in the central Tyrrhenian Sea beaches (0.6 items/spheroid) [48]. Unlike what we expected, there was a weak correlation between the size of the EGs and the abundance of plastic litter. In fact, plastic items were found even in the smallest EGs, and sometimes even in greater quantities than in the larger balls.

In this study, we found that EGs act as a trap for plastic litter ranging from micro (<5 mm) to macro (>25 mm), which aligns with findings in *P. oceanica* meadows [60]. Like other plants, including dune plants and mangroves [61–63], *Posidonia* EGs entangle a significant amount of plastic litter (132 items/kg). This underscores the valuable role of EGs in monitoring plastic pollution.

Regarding the shape of the plastic items, we predominantly found fibers, consistent with the results of the study by Sanchez Vidal et al. (filaments and fibers: 65%; fragments:

22%; film: 8%) [42]. The occurrence of fibers can be linked to textile pollution, as textiles are currently a primary source of microfibers in the environment. Manshoven et al. [64] reported that wearing and washing synthetic textiles is regarded as being responsible for the discharge of between 0.2 and 0.5 million tons of anthropogenic particles into the oceans each year. Conventional wastewater treatment, including tertiary treatment techniques, may remove up to 98% of microfibers. Fishing is the primary marine-based source of plastic pollution [65,66]. Abandoned, lost, or otherwise discarded fishing gear have been recognized as a major problem [67]. Fishing ropes, nets, and lines are the main contributors to beached fishing litter. Beached fishing litter may release hundreds of microplastic pieces per meter [68].

Tangled fibers have been reported in crustacea decapoda as *Nephrops norvegicus* [69], *Eriocheir sinensis* [70], *Aristeus antennatus* [71], *Pontastacus leptodactylus* [72], and *Parapenaeus longistroris* [73]. This is the first time that these kinds of fibers have been reported in the EGs.

4.1. Beach Comparison

The monitoring we conducted allowed us to identify differences between the beaches, which can be attributed to their different locations and varying degrees of use. The EGs collected at Spiaggetta del Sole exhibited the highest abundance of plastic items (4.8 items/spheroid). This may be attributed to the high level of urbanization along the coast, extensive fishery activities, and the presence of a wastewater treatment plant drain-pipe, all of which can contribute to the accumulation of debris on the sea floor [38,40]. The fragmentation and degradation processes acting on this debris can induce the formation of small particles. The ingestion of plastic items by mollusks, teleosts, and elasmobranch in the Ionian Sea has been reported [74,75].

Regarding the South of Sicily, Tonnarella and S. Vito beaches were also impacted by plastic litter and mainly by fibers. The South of Sicily falls in an area strongly affected by several anthropic activities (commercial and tourist ports, agricultural and industrial activities, mariculture facilities, oil refineries, and offshore platforms) and represents one of the most important fishing areas in the Mediterranean Sea. All these activities, together with environmental processes led to high marine litter abundance and density in the South of Sicily, as reported by Spedicato et al. [76] and Garofalo et al. [49]. Moreover, a high percentage of the small spotted catshark (*Scyliorhinus canicula*) ingesting microfibers has been recorded by Mancia et al. [77] and Mancuso et al. [16] in the South of Sicily.

EGs from Capo Feto beach (SCI) showed the lowest plastic items abundance (0.5 items/spheroid). This result could reflect the protected status of the site, characterized by a lower anthropogenic impact than Tonnarella and San Vito beaches.

4.2. Implications for Cleaning Up

The fact that plastics might be intercepted by EGs has useful implications for beach clean-up management. The removal of EGs should be carried out by being mindful of vegetation, in fact, the removal of the balls should be manual at least in those stretches of coast where the EGs are on the banquettes (which play an important ecological role within the beaches and should be preserved [78]. This kind of management should be the best practice, especially in protected areas (i.e., Capo Feto). Moreover, it is necessary to implement a beach cleaning plan for the removal of all EGs, both small and large, in order to prevent them from flaking and releasing the marine litter trapped inside them back into the environment. In this study, the small EGs could include up to eight pieces of plastic debris. In other words, EGs should be removed regardless of their size as their removal can help to mitigate plastic pollution in the marine environment. The degradation time of EGs is not currently known [42]. We can hypothesize that the dense outward shell of the EGs and the refractory character of their lignocellulosic fibers make EGs resistant to degradation. In any case, what happens to "old EGs" and relative plastic debris once ashore deserves further investigations.

The removal of the EGs would gain the approval of stakeholders (tourists, local administrators) that generally dislike their presence on the beach. EGs have structural, mechanical, and physical properties that make them useful in different applications. The uses of EGs might also help in the future to sustain the economic growth of all the countries of the Mediterranean Sea. The removed EGs could be used as a renewable substrate to produce bio-absorbents in environmental remediation, as insulation and reinforcing materials for building and construction, as new material to create paper, textiles, or biofuel, and for bioplastic generation for the next generation [79–82].

5. Conclusions

The analysis of four beaches along the Sicilian coast demonstrated a significant presence of plastic litter within *Posidonia* spheroids. In the future, additional data on a larger time scale should be acquired to understand the different dynamics of the beach. The fact that plastics might be intercepted by spheroids has useful implications for beach clean-up management. In general, beach clean-ups are carried out by volunteers and operators and are focused on beached macrolitter. Instead, specific clean-ups should focus on *Posidonia* spheroids where a large amount of plastics can accumulate. The removal of spheroids can represent an important step towards environmental sustainability as it helps to mitigate the severe negative impacts of plastic on the marine ecosystem and the health of the environment. To successfully promote environmental sustainability through the removal of spheroids from beaches, it is important to establish regular cleaning programs, involve local communities, and raise public awareness on the issue. Additionally, it is essential to address the underlying causes of plastic pollution, such as excessive plastic production and usage, through targeted policies and initiatives. The attention of administrations should used to set up "working groups" which analyze the situations and, depending on the case, adopt the right solutions. Additionally, the authors propose conducting citizen science initiatives for gathering *Posidonia* spheroids. Combining plastic pollution studies with citizen science not only enhances research capabilities but also fosters greater environmental awareness among the public, ultimately enabling the collection of substantial volumes of waste within a brief timeframe.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su152215740/s1, Figure S1: Biometry of *Posidonia* EG: length (L), width (W) and height (H); Figure S2: Map of abundance of plastic debris in EGs for each beach.

Author Contributions: N.P. Investigation, writing—original draft, formal analysis; T.B. Conceptualization, data analysis, writing—original draft, review and editing, project administration; F.F. Investigation, data and writing curation, review and editing; S.N. Investigation, formal analysis, data curation; M.M. Project administration, conceptualization, formal analysis, writing—original draft, review and editing, supervision. All authors have read and agreed to the published version of the manuscript.

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References

1. Ng, C.H.; Mistoh, M.A.; Teo, S.H.; Galassi, A.; Ibrahim, A.; Sipaut, C.S.; Foo, J.; Seay, J.; Taufiq-Yap, Y.H.; Janaun, J. Plastic Waste and Microplastic Issues in Southeast Asia. *Front. Environ. Sci.* **2023**, *11*, 427. [CrossRef]
2. Lebreton, L.; Slat, B.; Ferrari, F.; Sainte-Rose, B.; Aitken, J.; Marthouse, R.; Hajbane, S.; Cunsolo, S.; Schwarz, A.; Levivier, A.; et al. Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. *Sci. Rep.* **2018**, *8*, 4666. [CrossRef]
3. Andrady, A.L. Microplastics in the Marine Environment. *Mar. Poll. Bull.* **2011**, *62*, 1596–1605. [CrossRef] [PubMed]
4. Sharma, S.; Sharma, V.; Chatterjee, S. Microplastics in the Mediterranean Sea: Sources, Pollution Intensity, Sea Health, and Regulatory Policies. *Front. Mar. Sci.* **2021**, *8*, 634934. [CrossRef]
5. Mathalon, A.; Hill, P. Microplastic Fibers in the Intertidal Ecosystem Surrounding Halifax Harbor, Nova Scotia. *Mar. Pollut. Bull.* **2014**, *81*, 69–79. [CrossRef] [PubMed]
6. Barnes, D.K.A. Invasions by Marine Life on Plastic Debris. *Nature* **2002**, *416*, 808–809. [CrossRef]
7. Jepsen, E.M.; de Bruyn, P.J.N. Pinniped Entanglement in Oceanic Plastic Pollution: A Global Review. *Mar. Pollut. Bull.* **2019**, *145*, 295–305. [CrossRef]
8. Markic, A.; Gaertner, J.-C.; Gaertner-Mazouni, N.; Koelmans, A.A. Plastic Ingestion by Marine Fish in the Wild. *Crit. Rev. Environ. Sci. Technol.* **2020**, *50*, 657–697. [CrossRef]
9. Ryan, P.G. Ingestion of Plastics by Marine Organisms. In *Hazardous Chemicals Associated with Plastics in the Marine Environment*; The Handbook of Environmental Chemistry; 2019; Springer: Cham, Switzerland, 2016; Volume 78, pp. 235–266. [CrossRef]
10. Contino, M.; Ferruggia, G.; Pecoraro, R.; Scalisi, E.M.; Cavallaro, G.; Bonaccorso, C.; Fortuna, C.G.; Salvaggio, A.; Capparucci, F.; Bottari, T.; et al. Uptake Routes and Biodistribution of Polystyrene Nano-plastics on Zebrafish Larvae and Toxic Effects on Development. *Fishes* **2023**, *8*, 168. [CrossRef]
11. Contino, M.; Ferruggia, G.; Indelicato, S.; Pecoraro, R.; Scalisi, E.M.; Salvaggio, A.; Brundo, M.V. Sublethal Effects of Polystyrene Nanoplastics on the Embryonic Development of *Artemia salina* (Linnaeus, 1758). *Animals* **2023**, *13*, 3152. [CrossRef]
12. Porcino, N.; Bottari, T.; Mancuso, M. Is Wild Marine Biota Affected by Microplastics? *Animals* **2023**, *13*, 147. [CrossRef] [PubMed]
13. Provencher, J.F.; Ammendolia, J.; Rochman, C.M.; Mallory, M.L. Assessing Plastic Debris in Aquatic Food Webs: What We Know and Don't Know about Uptake and Trophic Transfer. *Environ. Rev.* **2019**, *27*, 304–317. [CrossRef]
14. Carbery, M.; O'Connor, W.; Palanisami, T. Trophic Transfer of Microplastics and Mixed Contaminants in the Marine Food Web and Implications for Human Health. *Environ. Int.* **2018**, *115*, 400–409. [CrossRef] [PubMed]
15. Mancuso, M.; Conti Nibali, V.; Porcino, N.; Branca, C.; Natale, S.; Smedile, F.; Azzaro, M.; D'angelo, G.; Bottari, T. Monitoring of Anthropogenic Microplastic Pollution in Antarctic Fish (Emerald Rockcod) from the Terranova Bay after a Quarter of Century. *Sci. Total Environ.* **2023**, *904*, 167244. [CrossRef] [PubMed]
16. Mancuso, M.; Panarello, G.; Falco, F.; Di Paola, D.; Savoca, S.; Capillo, G.; Romeo, T.; Presti, G.; Gullotta, E.; Spanò, N.; et al. Investigating the Effects of Microplastic Ingestion in *Scyliorhinus canicula* from the South of Sicily. *Sci. Total Environ.* **2022**, *850*, 157875. [CrossRef]
17. Brennecke, D.; Duarte, B.; Paiva, F.; Caçador, I.; Canning-Clode, J. Microplastics as Vector for Heavy Metal Contamination from the Marine Environment. *Estuar. Coast. Shelf Sci.* **2016**, *178*, 189–195. [CrossRef]
18. Farrell, P.; Nelson, K. Trophic Level Transfer of Microplastic: *Mytilus edulis* (L.) to *Carcinus maenas* (L.). *Environ. Pollut.* **2013**, *177*, 1–3. [CrossRef]
19. Collard, F.; Gilbert, B.; Compère, P.; Eppe, G.; Das, K.; Jauniaux, T.; Parmentier, E. Microplastics in Livers of European Anchovies (*Engraulis encrasicolus*, L.). *Environ. Pollut.* **2017**, *229*, 1000–1005. [CrossRef]
20. Kennedy, H.; Beggins, J.; Duarte, C.M.; Fourqurean, J.W.; Holmer, M.; Marbà, N.; Middelburg, J.J. Seagrass Sediments as a Global Carbon Sink: Isotopic Constraints. *Glob. Biogeochem. Cycles* **2010**, *24*, GB4026. [CrossRef]
21. Serrano, O.; Davis, G.; Lavery, P.S.; Duarte, C.M.; Martinez-Cortizas, A.; Mateo, M.A.; Masqué, P.; Arias-Ortiz, A.; Rozaimi, M.; Kendrick, G.A. RecDFonstruction of Centennial-Scale Fluxes of Chemical Elements in the Australian Coastal Environment Using Seagrass Archives. *Sci. Total Environ.* **2016**, *541*, 883–894. [CrossRef]
22. de los Santos, C.B.; Krång, A.-S.; Infantes, E. Microplastic Retention by Marine Vegetated Canopies: Simulations with Seagrass Meadows in a Hydraulic Flume. *Environ. Pollut.* **2021**, *269*, 116050. [CrossRef]
23. Huang, Y.; Xiao, X.; Xu, C.; Perianen, Y.D.; Hu, J.; Holmer, M. Seagrass Beds Acting as a Trap of Microplastics—Emerging Hotspot in the Coastal Region? *Environ. Pollut.* **2020**, *257*, 113450. [CrossRef] [PubMed]
24. Jones, K.; Hartl, M.; Bell, M.; Capper, A. Microplastic Accumulation in a *Zostera marina* L. Bed at Deerness Sound, Orkney, Scotland. *Mar. Pollut. Bull.* **2020**, *152*, 110883. [CrossRef] [PubMed]
25. Tahir, A.; Samawi, M.F.; Sari, K.; Hidayat, R.; Nimzet, R.; Wicaksono, E.A.; Asrul, L.; Werorilangi, S. Studies on Microplastic Contamination in Seagrass Beds at Spermonde Archipelago of Makassar Strait, Indonesia. *J. Phys. Conf. Ser.* **2019**, *1341*, 22008. [CrossRef]

26. Datu, S.; Supriadi, S.; Tahir, A. Microplastic in Cymodocea Rotundata Seagrass Blades. *IJEAB* **2019**, *4*, 1758–1761. [CrossRef]
27. Dahl, M.; Bergman, S.; Björk, M.; Diaz-Almela, E.; Granberg, M.; Gullström, M.; Leiva-Dueñas, C.; Magnusson, K.; Marco-Méndez, C.; Piñeiro-Juncal, N.; et al. A Temporal Record of Microplastic Pollution in Mediterranean Seagrass Soils. *Environ. Pollut.* **2021**, *273*, 116451. [CrossRef] [PubMed]
28. Menicagli, V.; Balestri, E.; Vallerini, F.; De Battisti, D.; Lardicci, C. Plastics and Sedimentation Foster the Spread of a Non-Native Macroalga in Seagrass Meadows. *Sci. Total Environ.* **2021**, *757*, 143812. [CrossRef]
29. Seng, N.; Lai, S.; Fong, J.; Saleh, M.F.; Cheng, C.; Cheok, Z.; Todd, P. Early Evidence of Microplastics on Seagrass and Macroalgae. *Mar. Freshwater Res.* **2020**, *71*, 922. [CrossRef]
30. Gutow, L.; Eckerlebe, A.; Gimenez, L.; Saborowski, R. Experimental Evaluation of Seaweeds as a Vector for Microplastics into Marine Food Webs. *J. Environ. Sci. Technol.* **2015**, *50*, 915–923. [CrossRef]
31. Remy, F.; Collard, F.; Gilbert, B.; Compère, P.; Eppe, G.; Lepoint, G. When Microplastic Is Not Plastic: The Ingestion of Artificial Cellulose Fibers by Macrofauna Living in Seagrass Macrophytodetritus. *J. Environ. Sci. Technol.* **2015**, *49*, 11158–11166. [CrossRef]
32. Ganesapandian, S.; Manikandan, S.; Kumaraguru, A.K. Marine Litter in the Northern Part of Gulf of Mannar, Southeast Coast of India. *Res. J. Environ. Sci.* **2011**, *5*, 471–478. [CrossRef]
33. Abreo, N.A.; Macusi, E.; Jimenez, L. A Survey of Subtidal Anthropogenic Marine Debris (AMD) in Mayo Bay, Mati City, Davao Oriental, Philippines. *Philipp. J. Sci.* **2018**, *147*, 599–602.
34. Cozzolino, L.; Nicastro, K.R.; Zardi, G.I.; de los Santos, C.B. Species-Specific Plastic Accumulation in the Sediment and Canopy of Coastal Vegetated Habitats. *Sci. Total Environ.* **2020**, *723*, 138018. [CrossRef] [PubMed]
35. Balestri, E.; Menicagli, V.; Vallerini, F.; Lardicci, C. Biodegradable Plastic Bags on the Seafloor: A Future Threat for Seagrass Meadows? *Sci. Total Environ.* **2017**, *605*, 755–763. [CrossRef] [PubMed]
36. Trache, D.; Tarchoun, A.F.; De Vita, D.; Kennedy, J.F. *Posidonia oceanica* (L.) Delile: A Mediterranean Seagrass with Potential Applications but Regularly and Erroneously Referred to as an Algal Species. *Int. J. Biol. Macromol.* **2023**, *230*, 122624. [CrossRef]
37. Bellissimo, G.; Sirchia, B.; Ruvolo, V. Monitoring of Posidonia oceanica Meadows in the Sicilian Coasts under the Water Framework Directive (WFD). In Eighth International Symposium "Monitoring of Mediterranean Coastal Areas. Problems and Measurement Techniques". 2020, pp. 510–518, ISBN 978-88-5518-146-4. Available online: https://library.oapen.org/bitstream/id/1dbb1e33-6c4b-4fdb-a246-253478891c43/14814.pdf (accessed on 1 May 2023).
38. Calvo, S.; Calvo, R.; Luzzu, F.; Raimondi, V.; Assenzo, M.; Cassetti, F.P.; Tomasello, A. Performance Assessment of *Posidonia oceanica* (L.) Delile Restoration Experiment on Dead Matte Twelve Years after Planting—Structural and Functional Meadow Features. *Water* **2021**, *13*, 724. [CrossRef]
39. Kalogirou, S.; Corsini-Foka, M.; Sioulas, A.; Wennhage, H.; Pihl, L. Diversity, Structure and Function of Fish Assemblages Associated with *Posidonia oceanica* Beds in an Area of the Eastern Mediterranean Sea and the Role of Non-Indigenous Species. *J. Fish Biol.* **2010**, *77*, 2338–2357. [CrossRef]
40. Ramírez, Á.; Urra, J.; Marina, P.; Rueda, J.; García Raso, J. Crustacean Decapod Assemblages Associated with Fragmented *Posidonia oceanica* Meadows in the Alboran Sea (Western Mediterranean Sea): Composition, Temporal Dynamics and Influence of Meadow Structure. *Mar. Ecol.* **2015**, *37*. [CrossRef]
41. Pergent-Martini, C.; Pergent, G.; Monnier, B.; Boudouresque, C.F.; Mori, C.; Valette-Sansevin, A. Contribution of Posidonia oceanica meadows in the context of climate change mitigation in the Mediterranean Sea. *Mar. Environ. Res.* **2021**, *165*, 105236. [CrossRef]
42. Sanchez-Vidal, A.; Canals, M.; de Haan, W.P.; Romero, J.; Veny, M. Seagrasses Provide a Novel Ecosystem Service by Trapping Marine Plastics. *Sci. Rep.* **2021**, *11*, 254. [CrossRef]
43. Boudouresque, C.; Pergent, G.; Pergent-Martini, C.; Ruitton, S.; Thibaut, T.; Verlaque, M. The Necromass of the *Posidonia oceanica* Seagrass Meadow: Fate, Role, Ecosystem Services and Vulnerability. *Hydrobiologia* **2016**, *781*, 25–42. [CrossRef]
44. Colombini, I.; Mateo, M.Á.; Serrano, O.; Fallaci, M.; Gagnarli, E.; Serrano, L.; Chelazzi, L. On the Role of *Posidonia oceanica* Beach Wrack for Macroinvertebrates of a Tyrrhenian Sandy Shore. *Acta Oecol.* **2009**, *35*, 32–44. [CrossRef]
45. Del Vecchio, S.; Marbà, N.; Acosta, A.; Vignolo, C.; Traveset, A. Effects of *Posidonia* Oceanica Beach-Cast on Germination, Growth and Nutrient Uptake of Coastal Dune Plants. *PLoS ONE* **2013**, *8*, e70607. [CrossRef] [PubMed]
46. Blondel, V.D.; Guillaume, J.L.; Lambiotte, R.; Lefebvre, E. Fast Unfolding of Communities in Large Networks. *J. Stat. Mech.-Theory Exp.* **2008**, *2008*, P10008. [CrossRef]
47. Lefebvre, L.; Compère, P.; Gobert, S. The Formation of Aegagropiles from the Mediterranean Seagrass *Posidonia oceanica* (L.) Delile (1813): Plant Tissue Sources and Colonisation by Melanised Fungal Mycelium. *Mar. Biol.* **2023**, *170*, 19. [CrossRef]
48. Pietrelli, L.; Di Gennaro, A.; Menegoni, P.; Lecce, F.; Poeta, G.; Acosta, A.T.R.; Battisti, C.; Iannilli, V. Pervasive Plastisphere: First Record of Plastics in Egagropiles (Posidonia Spheroids). *Environ. Pollut.* **2017**, *229*, 1032–1036. [CrossRef]
49. Garofalo, G.; Quattrocchi, F.; Bono, G.; Di Lorenzo, M.; Di Maio, F.; Falsone, F.; Gancitano, V.; Geraci, M.L.; Lauria, V.; Massi, D.; et al. What Is in Our Seas? Assessing Anthropogenic Litter on the Seafloor of the Central Mediterranean Sea. *Environ. Pollut.* **2020**, *266*, 115213. [CrossRef]
50. Dimech, M.; Camilleri, M.; Hiddink, J.; Kaiser, M.; Ragonese, S.; Schembri, P. Differences in Demersal Community Structure and Biomass Size Spectra within and Outside the Maltese Fishery Management Zone (FMZ). *Sci. Mar.* **2008**, *72*, 669–682. [CrossRef]
51. Bottari, T.; Rinelli, P.; Bianchini, M.L.; Ragonese, S. Stock Identification of *Raja clavata* L. (Chondrichthyes, Rajidae) in Two Contiguous Areas of the Mediterranean. *Hydrobiologia* **2013**, *703*, 215–224. [CrossRef]

52. Regione Sicilia. Available online: https://www.regione.sicilia.it/sites/default/files/2022-06/Relazione%20Generale.pdf (accessed on 1 May 2023).
53. Kapp, K.J.; Yeatman, E. Microplastic Hotspots in the Snake and Lower Columbia Rivers: A Journey from the Greater Yellowstone Ecosystem to the Pacific Ocean. *Environ. Pollut.* **2018**, *241*, 1082–1090. [CrossRef]
54. Silva, A.B.; Bastos, A.S.; Justino, C.I.L.; da Costa, J.P.; Duarte, A.C.; Rocha-Santos, T.A.P. Microplastics in the Environment: Challenges in Analytical Chemistry—A Review. *Anal. Chim. Acta* **2018**, *1017*, 1–19. [CrossRef] [PubMed]
55. Wadell, H. Volume, Shape, and Roundness of Rock Particles. *J. Geol.* **1932**, *40*, 443–451. [CrossRef]
56. Mghili, B.; Keznine, M.; Hasni, S.; Aksissou, M. Abundance, Composition and Sources of Benthic Marine Litter Trawled-up in the Fishing Grounds on the Moroccan Mediterranean Coast. *Reg. Stud. Mar. Sci.* **2023**, *63*, 103002. [CrossRef]
57. Cau, A.; Franceschini, S.; Moccia, D.; Gorule, P.A.; Agus, B.; Bellodi, A.; Cannas, R.; Carugati, L.; Cuccu, D.; Dessì, C.; et al. Scattered Accumulation Hotspots of Macro-Litter on the Seafloor: Insights for Mitigation Actions. *Environ. Pollut.* **2021**, *292*, 118232. [CrossRef]
58. Mghili, B.; Analla, M.; Aksissou, M.; Aissa, C. Marine Debris in Moroccan Mediterranean Beaches: An Assessment of Their Abundance, Composition and Sources. *Mar. Pollut. Bull.* **2020**, *160*, 111692. [CrossRef]
59. Mghili, B.; De-la-Torre, G.E.; Analla, M.; Aksissou, M. Marine macroinvertebrates fouled in marine anthropogenic litter in the Moroccan Mediterranean. *Mar. Pollut. Bull.* **2022**, *185*, 114266. [CrossRef]
60. Navarrete-Fernández, T.; Bermejo, R.; Hernández, I.; Deidun, A.; Andreu-Cazenave, M.; Cózar, A. The Role of Seagrass Meadows in the Coastal Trapping of Litter. *Mar. Pollut. Bull.* **2022**, *174*, 113299. [CrossRef]
61. Ben-Haddad, M.; Abelouah, M.R.; Hajji, S.; Rangel-Buitrago, N.; Alla, A.A. The Halophyte *Cakile maritima* Scop. 1772 as a Trap of Plastic Litter on the Moroccan Coast. *Mar. Pollut. Bull.* **2023**, *187*, 114574. [CrossRef]
62. De, K.; Sautya, S.; Dora, G.U.; Gaikwad, S.; Katke, D.; Salvi, A. Mangroves in the "Plasticene": High Exposure of Coastal Mangroves to Anthropogenic Litter Pollution along the Central-West Coast of India. *Sci. Total Environ.* **2023**, *858*, 160071. [CrossRef]
63. Mancuso, M.; Genovese, G.; Porcino, N.; Natale, S.; Crisafulli, A.; Spagnuolo, D.; Catalfamo, M.; Morabito, M.; Bottari, T. Psammophytes as Traps for Beach Litter in the Strait of Messina (Mediterranean Sea). *Reg. Stud. Mar. Sci.* **2023**, *65*, 103057. [CrossRef]
64. Eionet Portal. Available online: https://www.eionet.europa.eu/etcs/etc-ce/products/etc-ce-products/etc-ce-report-1-2022-microplastic-pollution-from-textile-consumption-in-europe (accessed on 1 May 2023).
65. Richardson, K.; Hardesty, B.D.; Wilcox, C. Estimates of Fishing Gear Loss Rates at a Global Scale: A Literature Review and Meta-Analysis. *Fish Fish.* **2019**, *20*, 1218–1231. [CrossRef]
66. UN Environment Programme. *UNEP Marine Plastic Debris and Microplastics—Global Lessons and Research to Inspire Action and Guide Policy Change*; UN Environment Programme: Nairobi, Kenya, 2016.
67. FAO. *The State of World Fisheries and Aquaculture 2018—Meeting the Sustainable Development Goals*; FAO: Rome, Italy, 2018.
68. Wright, L.S.; Napper, I.E.; Thompson, R.C. Potential Microplastic Release from Beached Fishing Gear in Great Britain's Region of Highest Fishing Litter Density. *Mar. Pollut. Bull.* **2021**, *173*, 113115. [CrossRef] [PubMed]
69. Welden, N.A.C.; Cowie, P.R. Environment and Gut Morphology Influence Microplastic Retention in Langoustine, *Nephrops norvegicus*. *Environ. Pollut.* **2016**, *214*, 859–865. [CrossRef] [PubMed]
70. Wójcik-Fudalewska, D.; Normant-Saremba, M.; Anastácio, P. Occurrence of Plastic Debris in the Stomach of the Invasive Crab *Eriocheir sinensis*. *Mar. Pollut. Bull.* **2016**, *113*, 306–311. [CrossRef] [PubMed]
71. Carreras-Colom, E.; Constenla, M.; Soler-Membrives, A.; Cartes, J.E.; Baeza, M.; Padros, F.; Carrasson, M. Spatial Occurrence and Effects of Microplastic Ingestion on the Deep-Water Shrimp *Aristeus antennatus*. *Mar. Pollut. Bull.* **2018**, *133*, 44–52. [CrossRef]
72. Yücel, N.; Kılıç, E. Microplastic Contamination in the Freshwater Crayfish *Pontastacus leptodactylus* (Eschscholtz, 1823). *Mar. Pollut. Bull.* **2022**, *185*, 114337. [CrossRef]
73. Bono, G.; Falsone, F.; Francesca, F.; Di Maio, F.; Gabriele, M.; Gancitano, V.; Geraci, M.; Scannella, D.; Mancuso, M.; Okpala, C.; et al. Microplastics and Alien Black Particles as Contaminants of Deep-Water Rose Shrimp (*Parapenaeus longistroris* Lucas, 1846) in the Central Mediterranean Sea. *J. Adv. Biotechnol. Bioeng.* **2020**, *8*, 23–28. [CrossRef]
74. Anastasopoulou, A.K.; Mytilineou, C.; Smith, C.; Papadopoulou, N. Plastic Debris Ingested by Deep-Water Fish of the Ionian Sea (Eastern Mediterranean). *Deep Sea Res. Part I Oceanogr. Res.* **2013**, *74*, 11–13. [CrossRef]
75. Digka, N.; Tsangaris, C.; Torre, M.; Anastasopoulou, A.; Zeri, C. Microplastics in Mussels and Fish from the Northern Ionian Sea. *Mar. Pollut. Bull.* **2018**, *135*, 30–40. [CrossRef]
76. Spedicato, M.T.; Zupa, W.; Carbonara, P.; Fiorentino, F.; Follesa, M.; Galgani, F.; Garcia, C.; Jadaud, A.; Ioakeimidis, C.; Lazarakis, G.; et al. Spatial Distribution of Marine Macro-Litter on the Seafloor in the Northern Mediterranean Sea: The MEDITS Initiative. *Sci. Mar.* **2019**, *83*, S1. [CrossRef]
77. Mancia, A.; Chenet, T.; Bono, G.; Geraci, M.L.; Vaccaro, C.; Munari, C.; Mistri, M.; Cavazzini, A.; Pasti, L. Adverse Effects of Plastic Ingestion on the Mediterranean Small-Spotted Catshark (*Scyliorhinus canicula*). *Mar. Environ. Res.* **2020**, *155*, 104876. [CrossRef]
78. Rotini, A.; Chiesa, S.; Manfra, L.; Borrello, P.; Piermarini, R.; Silvestri, C.; Cappucci, S.; Parlagreco, L.; Devoti, S.; Pisapia, M.; et al. Effectiveness of the "Ecological Beach" Model: Beneficial Management of Posidonia Beach Casts and Banquette. *Water* **2020**, *12*, 3238. [CrossRef]

79. Restaino, O.F.; Giosafatto, C.V.L.; Mirpoor, S.F.; Cammarota, M.; Hejazi, S.; Mariniello, L.; Schiraldi, C.; Porta, R. Sustainable Exploitation of *Posidonia oceanica* Sea Balls (Egagropili): A Review. *Int. J. Mol. Sci* **2023**, *24*, 7301. [CrossRef] [PubMed]
80. Verhille, G.; Moulinet, S.; Vandenberghe, N.; Adda-Bedia, M.; Gal, P. Le Structure and Mechanics of Aegagropilae Fiber Network. *Proc. Natl. Acad. Sci. USA* **2017**, *114*, 4607–4612. [CrossRef] [PubMed]
81. Pfeifer, L. "Neptune Balls" Polysaccharides: Disentangling the Wiry Seagrass Detritus. *Polymers* **2021**, *13*, 4285. [CrossRef]
82. Rubio-Portillo, E.; Martin-Cuadrado, A.-B.; Ramos-Esplá, A.Á.; Antón, J. Metagenomics Unveils *Posidonia* Oceanica "Banquettes" as a Potential Source of Novel Bioactive Compounds and Carbohydrate Active Enzymes (CAZymes). *Msystems* **2021**, *6*, e0086621. [CrossRef]