MONITORING CAMPAIGNS REPORT No 4 (Seagrass Transplantations)

Final Version of 31/May/2022

Deliverable Number D.3.3.1.

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Work Package Number	3
Work Package Title	Integrate real-time monitoring system of marine seagrasses (Phanerogamae) in the involved N2K sites
Activity Number	3.3
Activity Title	Monitoring Campaigns
Partner in Charge	PP1 - SELC Soc. Coop.
Partners involved	PP1 - SELC Soc. Coop. LP - Municipality of Monfalcone PP3 - Regional Natural Park "Coastal Dunes from Torre Canne to Torre San Leonardo" PP4 – SUNCE PP5 - Kornati National Park Public Institution
Status	Final
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Summary

Abstract

This document (deliverable D.3.3.1) describes the results of the activities planned in WP 3.3 (Monitoring Campaigns) to update the status and progress of the seagrass pilot transplantations planned in WP 4 Activity 2.

From a technical point of view, the tests carried out with *P. oceanica* and *C. nodosa* showed good results. In particular some different dynamics between Park Kornati and RNP Coastal Dunes can be identified. On the Kornati Island, the *P. oceanica* transplantations did not suffer significant physical damage at all, while at the Coastal Dune Park the supports where the cuttings were fixed suffered significant damage (storm events, amateur fishing and anchoring). In Kornati NP, the transplantation carried out is then affected by a condition of strong sedimentation which harms both the canopy of the transplanted cuttings and that of the natural adjacent patches.

The transplantations of sods of *C. nodosa* carried out at the Monfalcone site showed that a fundamental condition is represented by seasonality. Spring transplantation, compared to autumn one, allows a rapid and immediate development of the rhizomes and of the root system. The cuttings method (staples), although already favorably tested does not appear to be suitable because of the exposure of the area to the north-east winds (high impact on these shallows).

1. Introduction

1.1. Aim and objectives

SASPAS (Safe Anchoring and Seagrass Protection in the Adriatic Sea) is an INTERREG project that aims to provide a proposal to develop and share actions and advanced policies for the conservation and sustainable use of the territory.

The common challenge of Project SASPAS is to preserve and get a better status of conservation of biodiversity of the Adriatic Sea ecosystem in order to decrease its vulnerability.

The overall objective is to improve the conservation and restoration of seagrasses by installing safe anchoring systems, performing pilot transplantations, carrying out monitoring activities and establishing an integrated management system for seagrasses in the Adriatic area. The change will result in an increase in the level of conservation of habitat types and species in the Natura 2000 sites involved in the Project areas. To achieve the envisaged change the project will adopt a scientific-applicative approach, following the DPSIR (Driving force – Pressure – State – Impact - Response) causal framework, analyzing the interactions between society and the environment - the cause-effect relationships between interacting components of complex social, economic, and environmental systems. By doing so, it is possible to measure the effectiveness of responses put in place.

Since marine seagrasses and especially *Posidonia oceanica* beds (1120*) are widespread along the coastal areas of Interreg Programme and their conservation status is similar in the two Member States, significant results can only be achieved by establishing a good cross-border cooperation between the Italian and Croatian key partners. The cross-border approach ensures coordinated and cooperative actions in planning and performing the protection and restoration activities, as well as in the development of the envisaged Marine Seagrass Safeguard Integrated Management Program (i.e., the proposed guidelines for the management and proper behavior in protected areas). The innovative aspect, which goes beyond the existing common practices, consists in the joint protection and restoration of biodiversity at transboundary level through the development of specifically- tailored innovative solutions, harmonized for the Adriatic area and applicable to other similar realities facing with the same biodiversity protection and restoration issues.

The project activities have been carried out within the three project study sites (Figure 1):

- Monfalcone (Bay of Panzano),
- Kornati National Park – (Nacionalni Park Kornati),
- Regional Natural Park of Coastal Dunes from Torre Canne to Torre San Leonardo.

This proposal is well suited to the Adriatic, in particular to the Apulia (Regional Natural Park of Costal Dunes from Torre Canne to Torre San Leonardo) and Kornati National Park, characterized by widespread coverage of *P. oceanica*. In both sites, in the summer, there is a significant flow of pleasure boats, and the development of the industry tourism cannot fail to reckon with the need to preserve the quality of the

territory, understood as a whole between land, coast and sea. In Monfalcone (Bay of Panzano), there is an important coverage of marine seagrasses (i.e., *Cymodocea nodosa*) too.

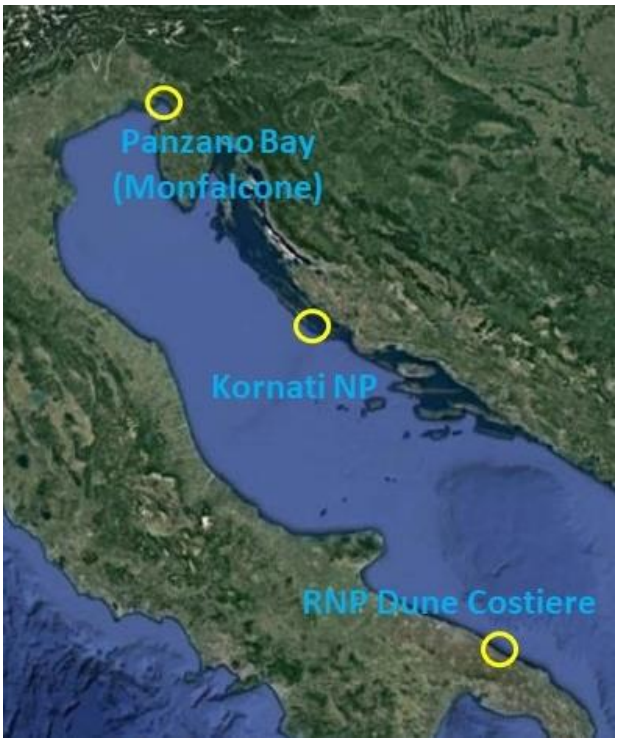

Figure 1. Location of the three project sites.

Both *P. oceanica* and *C. nodosa* play a crucial role in the consolidation of coastal sediments, slowing erosive phenomena, thanks to their rhizomial apparatus with which they anchor to the bottom; with the leaf they promote the capture of suspended sediments, helping to limit turbidity, not to mention a number of benefits for marine and lagoon organisms.

The main project outputs related to the planned activities are:

- monitoring system with data collections/monitoring campaigns,
- placement of environmentally friendly anchoring systems (anchorages and simple signaling buoys) and pilot seagrass transplantations,
- Integrated Management System for seagrasses in the Adriatic area, made by a GIS Digital Information Platform (DIP) and a Marine Seagrass Safeguard Integrated Management Program (MSSIMP).

Protected areas managers, local, regional, and national public bodies, environmental associations, and NGOs, as well as the public will mainly benefit from the project activities.

1.2. Structure of Work Package 3

The objective of the Work Package 3 - *Integrate real-time monitoring system of marine seagrasses (phanerogamae) - in the involved Natura 2000 sites* – is to monitor and gather data on marine seagrasses in the three project sites, to improve the protection and to restore the biodiversity in the cross-border area.

The WP3 package consists of three activities:

- activity 3.1 - Preliminary Environmental Survey,
- activity 3.2 - Driver and Pressure Identification and Assessment,
- activity 3.3 - Monitoring campaigns.

Monitoring campaigns were carried out to control the plants phenological life cycle and the spatial dynamics of marine seagrasses as a response to the concrete actions (activity 3.3). Moreover, they helped to identify the potential impacts that the project could have on seagrass meadows and other valuable habitats and species. They were also monitored the status and progress of the seagrass pilot transplantations planned in WP 4 Activity 2 (Marine seagrasses pilot transplantations and surrounding seabed clearing).

All the activities were conducted adopting up-to-date safety protocols, to reduce risks during underwater operations. Expert marine and transitional water biologists, according to standard operating procedures for the macrophytobenthos, performed laboratory analyses of collected samples.

This document (deliverable D.3.3.1) describes the results of the activities planned in WP 3.3 (Monitoring Campaigns) to update the status and progress of the seagrass pilot transplantations planned in WP 4 Activity 2.

Pilot transplantation tests of *Posidonia oceanica* and *Cymodocea nodosa* were conducted with the aim of evaluating the effectiveness of some methods in difficult environmental contexts, in relation to the existence of various pressures, such as mainly the anchoring of pleasure boats.

The controls carried out on the transplantation plots were aimed at quantifying, among other parameters, the percentage of development of the shoots of the relocated plants.

2. The three project areas and the Natura 2000 sites

2.1. Bay of Panzano (Monfalcone)

The Bay of Panzano is a small bay of the Adriatic Sea (Friuli-Venezia Giulia), located in the northern part of the Gulf of Trieste, limited to the south-west by the Punta Sdobba, at the mouth of the Isonzo River. Inside the Panzano Bay are located two Natura 2000 sites: a Special Area of Conservation (SAC) “Cavana di Monfalcone”, a Special Area of Conservation (SAC) and a Special Protection Area (SPA) “Foce dell’Isonzo - Isola della Cona” (Mouth of the Isonzo River and Cona Island) (Figure 2).

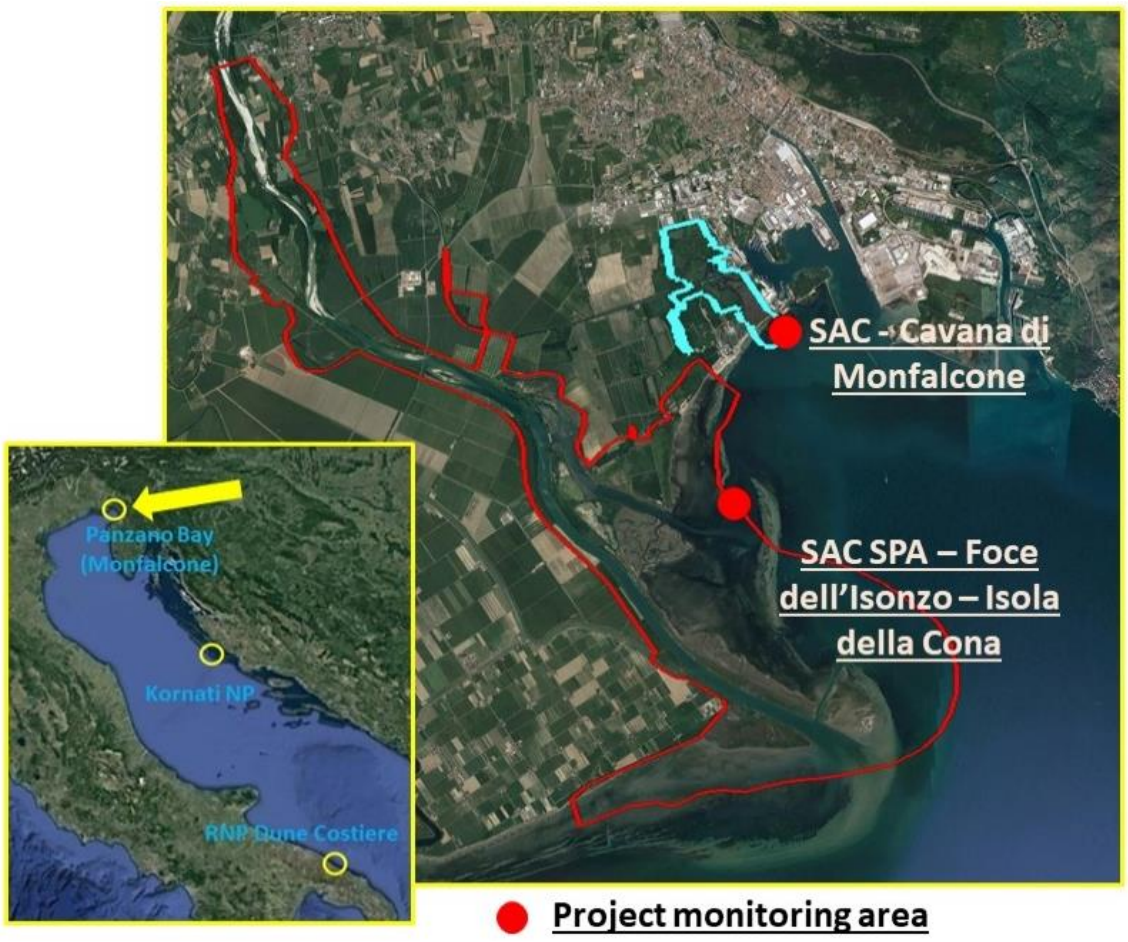

Figure 2. Location of the study areas in the Panzano Bay, positioned in two Natura 2000 sites.

Natura 2000 site: SAC IT3330007 - Cavana di Monfalcone

The "Cavana di Monfalcone" SAC extends over a surface of 133 ha, of which 12% is marine, in the transition area between the flat land and the Adriatic Sea. It is important because it includes a set of ecological systems characterized by rare habitats in a good status of conservation. A complex system of spring canals is still present, not modified by land reclamation. It is a site that includes the spring ecological system closest to the coastline and therefore in direct contact with salt and marine waters. Aquatic surfaces with different trophic status, water speed, depth and salinity preserve a rich and well-diversified aquatic vegetation.

Habitat 1110 ("*Sandbanks which are slightly covered by sea water all the time*") is present in the marine zone of the site. It consists mainly of sandy sediments (larger grain-size sediments, including boulders and cobbles, or smaller grain-size sediments including mud may also be present). These habitats are permanently submerged and predominantly surrounded by deeper water. Above the sand-bank the water depth rarely exceeds 20 m. In these sub-littoral sandbanks, seagrass meadows can be present: *Zostera marina* (in brackish-salt waters), *Cymodocea nodosa* (in salt waters) and *Zostera noltei* in shallower salty waters.

The other Habitat identified is the 1140 ("*Mudflats and sandflats not covered by sea water at low tide*") and is characterized by sands and mud emerging during the low tides, partially covered by *Zostera noltei* and partly coated by green, blue, brown macroalgae, and diatoms.

Natura 2000 site: SAC SPA IT3330005 - Foce dell'Isonzo - Isola della Cona

The "Foce dell'Isonzo – Isola della Cona" SAC SPA covers an area of 2668 ha, 40% of which is marine. It is situated in the eastern part of the Friuli Venezia Giulia region along the last stretch of the Isonzo River and coincides in large part with the "Foce dell'Isonzo Regional Nature Reserve".

The marine part of the site covers about 1.100 ha of shallow waters with relevant extensions of seagrass meadows; in the marine part of the site the Habitat 1110 ("*Sandbanks which are slightly covered by sea water all the time*") and the Habitat 1140 ("*Mudflats and sandflats not covered by sea water at low tide*") are present.

2.2. Kornati NP

Kornati National Park is designated as Site of Community Importance SCI HR4000001 - Nacionalni park Kornati (Figure 3). The park[1] was established in 1980 and its management began in 1982. It currently includes 89 islands and reefs, a total area of 217 km², of which almost 80% is marine territory (land 50 km² / sea 167 km²) and a total coastline of 238 km. Karst features dominate its geomorphology.

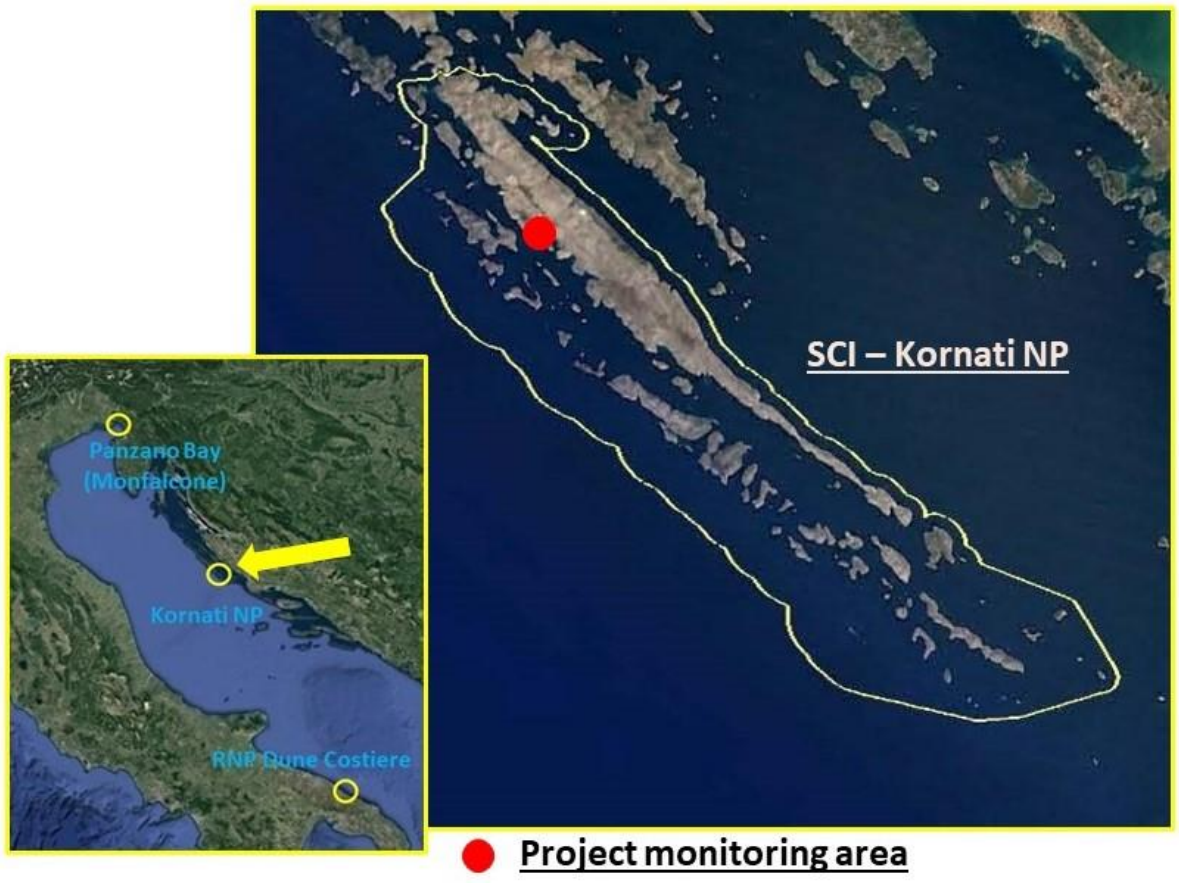

Figure 3. Location of the study area in the Natura 2000 site Kornati NP.

It is estimated that at least 2,500 to 3,000 families of benthic and pelagic fauna live in the Kornati archipelago such as 353 species of macroalgae, 3 species of underwater flower plants as well as about

[1] The data cited in the following paragraphs are reported in the articles: Casier (2011); Mihelcic and Ramov (2018); Ivković, (2015).

850 animal species – 61 species of corals, 177 species of mollusks, 127 species of polychaetes, 61 species of decapod crabs, 64 species of echinoderms and 185 species of fishes. Meadows of *P. oceanica* are also present in the park, up to a depth of 25-30 meters. The presence of alien species is included among the anthropogenic threats. *P. oceanica* is particularly threatened by some macroalgal species: *Caulerpa cylindracea*[2] (that has been observed in the last years and is spreading in the entire park) and the turf-forming red algae *Womersleyella setacea* and *Acrothamnion preissii* (two species that grow over *Posidonia* rhizomes).

Public Institution, under the competence of the Ministry of Economy and Sustainable Development, manages the Kornati National Park. The land part of the park is entirely privately owned (around 620 owners).

Four no-take zones are present where scientific research is only allowed. Sailing is allowed in the entire Kornati National Park except in the areas of strict protection. Anchoring and overnight stay are allowed only in 19 locations (bays and coves). Autonomous diving is allowed only in organized groups, with a license for autonomous diving in the Kornati NP obtained in advance.

Since 2013, traditional fishing in Kornati National Park is forbidden and only recreational fishing is allowed.

[2] *Caulerpa cylindracea* Sonder [previously known as *Caulerpa racemosa* var. *cylindracea* (Sonder) Verlaque, Huisman *et* Boudouresque]

2.3. Regional Natural Park of Coastal Dunes from Torre Canne to Torre San Leonardo

The “Regional Nature Park Dune Costiere from Torre Canne to Torre San Leonado” extends for 1.100 ha, along 8 km of coastline, and includes the inland agricultural areas occupied by centuries-old olive groves and ancient “masserie” (typical Apulian farms) (Figure 4). The perimeter follows the long course of the “lame” (55 km of erosion), which characterizes the Park's territorial morphology. They are linear clefts of the land perpendicular to the coastline, with flat bottom and slightly sloping sides originated by the erosive action of surface waters.

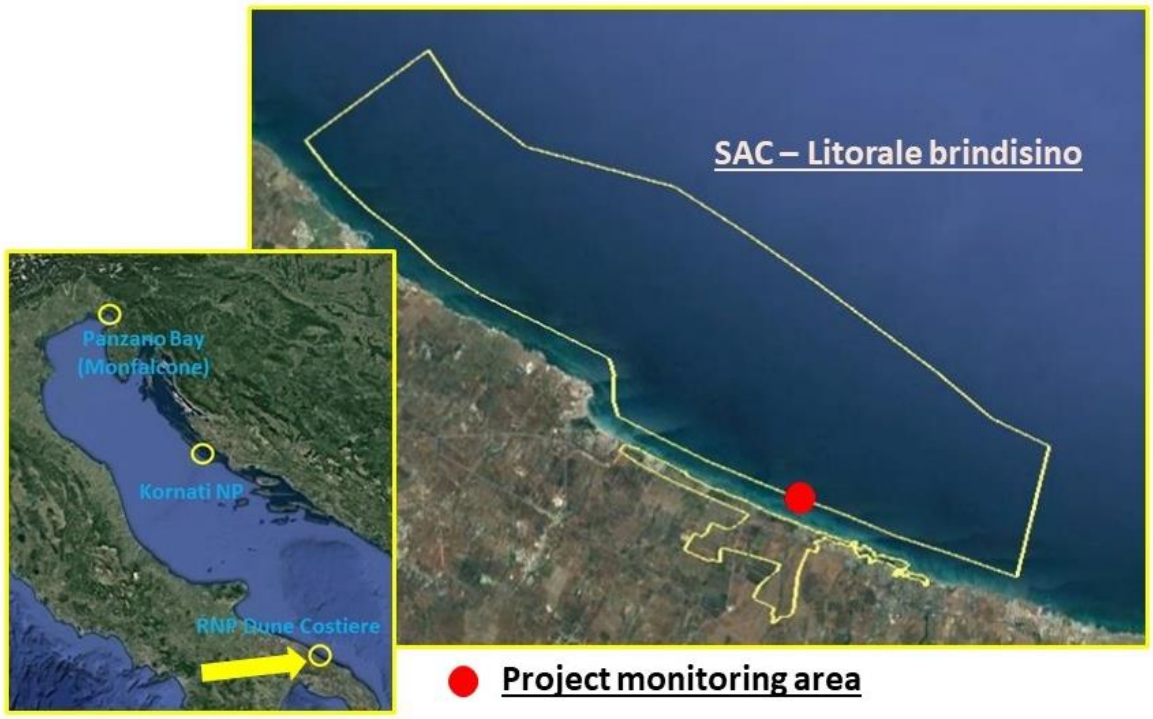

Figure 4. Location of the study area in the RNP Dune Costiere, positioned in a Natura 2000 site.

In the protected area, many habitats are present. Each habitat is a result of the geological, morphological and climatic features of the site that determines the presence of plant and animal species. Some of them are considered priority habitats, such as that colonized by *Posidonia oceanica*. Starting at a depth of 10-12 m, *P. oceanica* meadows are present on sandy bottoms.

The park includes the Special Areas of Conservation (SAC) “Litorale brindisino”.

Natura 2000 site: SAC IT9140002 - Litorale brindisino

The SAC “Litorale brindisino” covers an area of 7,256 ha, 95% of which is marine. The priority habitat 1120* (*P. oceanica*) covers 50% of the total area. It is also characterized by the presence of coastal wetlands, where rare or endangered species of migratory birds stop or reproduce.

3. Marine seagrass transplantations

3.1. Bay of Panzano (Monfalcone)

In Panzano Bay-Monfalcone, as planned in WP 4 activity 2, two pilot transplantation campaigns were carried out: the first in September 2020 and the second in April 2021. *C. nodosa* transplantation were carried out using two different manual techniques: a) manual harvesting from donor sites and transplanting by sods and manual harvesting from donor sites and b) transplanting by bare-root transplant cuttings (sprigs).

The acceptor sites for the pilot transplanting were identified in parcels near the SPA, SAC Foce dell'Isonzo - Isola della Cona, in areas characterized by the presence of *C. nodosa* meadows mixed with other species (*Zostera noltei* and *Z. marina*), shallow depth and the occurrence of anchoring pressures due to small boats. For both transplantations, a healthy continuous meadow was selected nearby as a donor site, where plants were collected with adequate spacing, to avoid stress (Figure 5).

Figure 5. Bay of Panzano: location of the pilot seagrass transplantation areas (host and donor sites).

For each transplantation, two square transplant areas (10 m x 10 m) were selected: one for the manual transplanting method by collection and planting of vegetated sods (Figure 6) and one for the transplanting by manual collection of shoots - bare root planting cuttings (Figure 7).

Altogether, 100 sods and about 100 sprigs of *C. nodosa* were placed in the transplantation areas during each transplantation campaign.

Figure 6. Pilot transplantation of C. nodosa *sods in Panzano bay-Monfalcone in September 2021: a) identification of the donor meadow; b) collection of sods; c, d) temporary storage of sods and their transport to the site to be reforested; e, f) manual planting of sods into the substrate by means of jute bags.*

Figure 7. Pilot transplantation of C. nodosa *sprigs in Panzano bay-Monfalcone in April 2021: a) temporary storage of sprigs and their transport to the site to be reforested; b, c) sprig attachment to staples; d) sprigs planting into the substrate by means of staples.*

3.1.1. Monitoring of seagrass transplantation

The main results of the monitoring campaigns are reported in Table 1.

Table 1. Sods and Staples survival rate (monitoring campaigns of January 2021, September 2021 and May 2022)..

		Monitoring campaigns		
		January 2021	September 2021	May 2022
First pilot transplantation (carried out in **September 2020**)	Sods survival rate (%)	95	50	50
	Staples survival rate (%)	?	< 10	0
Second pilot transplantation (carried out in **April 2021**)	Sods survival rate (%)	-	100	90
	Staples survival rate (%)	-	70	50

First pilot transplantation (carried out in September 2020)

January 21 campaign: approximately 95% of the sods transplanted in September 2020 were still present (Figure 8). Regarding the transplanted cuttings, the small leaf size of *Cymodocea* nodosa, due to the slow growth during the winter months, made it more difficult to identify them, so it was not possible to confirm their presence or absence.

September 2021 campaign: sods showed a good development in 50% of cases, as the remaining 50% got eroded (Figure 9 and Figure 10). Regarding the other technique, only few transplanted cuttings were found (<10%). These losses showed that the cuttings technique was not the most suitable for the area (exposed to the Autumn storms, that occurred shortly after the transplantation).

May 2022 campaign: although a yet scarce seasonal development of the aboveground compartment, some 50% of sods resulted growing with a limited enlargement of the colonized area (Figure 11). No sign of growing in the staple cutting area.

Additional pilot transplantation (carried out in April 2021)

September 2021 campaign: sods showed a rapid leaf/rhizome development and a rapid and wide colonization of the seabed reaching about 100% of success (Figure 12Figure 17). Regarding the transplanted shoots, by staples, about 70% survived the transplantation. These results, according to observations, are due to a) the vegetative period (spring), favorable to the development of plants and b) the refinement in the transplantation technique, with more care in levelling sods during positioning.

May 2022 campaign: the area presents a general coverage of rhizomes and very short shoots, which interests a large surface around the transplant parcel (sods showed about 90% of success) (Figure 14). Very scarce leaf canopy development due to yet scarce seasonal development. 50% of staple cuttings resulted present.

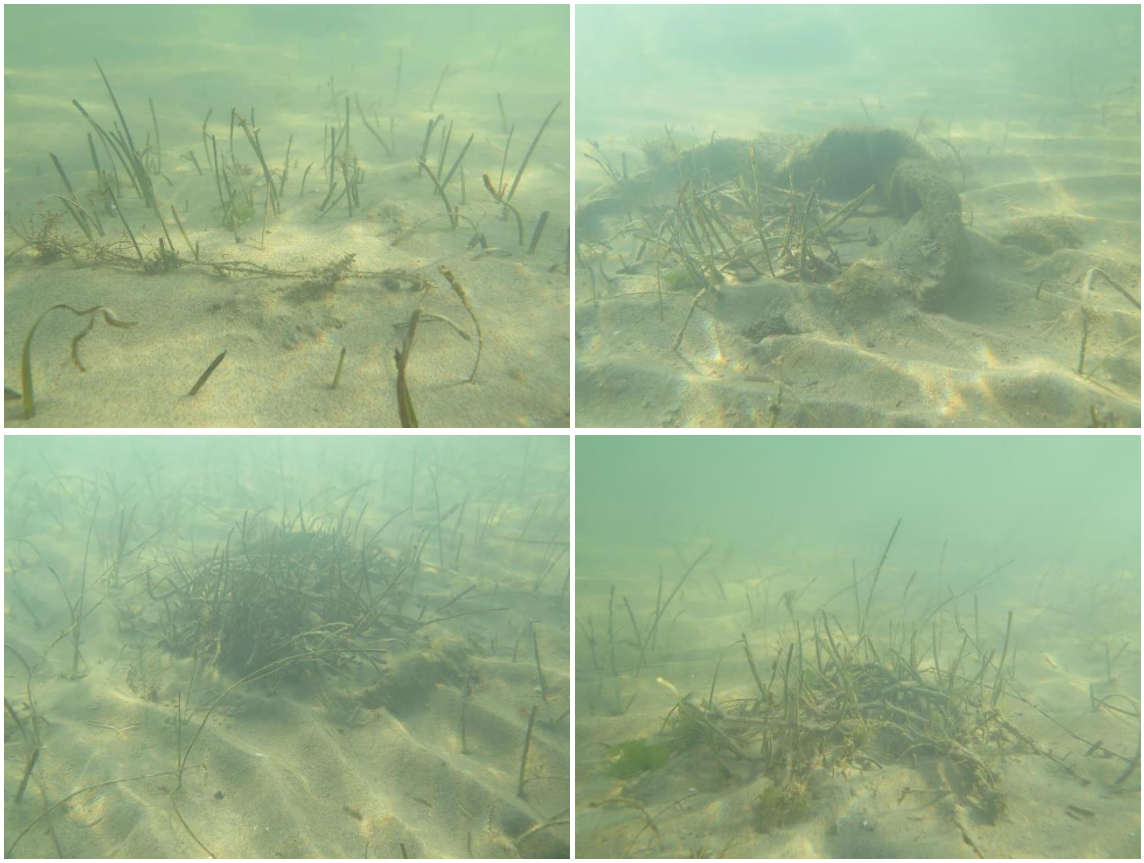

Figure 8. January 2021: sods of Cymodocea nodosa *tranplanted in September 2020.*

Figure 9. September 2021: sods of C. nodosa *tranplanted in September 2020 that got eroded.*

Figure 10. September 2021: sods of C. nodosa *tranplanted in September 2020 that showed a good development.*

Figure 11. May 2022: sods of Cymodocea nodosa *tranplanted in September 2020.*

Figure 12. September 2021: sods of C. nodosa *tranplanted in April 2021 that showed a good development.*

Figure 13. September 2021: sods of C. nodosa *tranplanted in April 2021 that showed a rapid and wide colonization of the seabed.*

Figure 14. May 2022: sods of Cymodocea nodosa *tranplanted in September 2020.*

3.2. Kornati NP

In NP Kornati, two pilot transplantation campaigns were carried out: the first in October 2019 and the second in October 2021 (Figure 15). *P. oceanica* transplantation were carried out using two different manual techniques: 1) biodegradable supports consisting of a patented[3] star-shaped anchoring system with 5 arms to which fasten the seagrass rhizomes (Scannavino *et al*., 2014) and 2) wooden supports (to which fasten the seagrass rhizomes) heavy enough and of low degradability in order to resist on the sea floor at least for a couple of years.

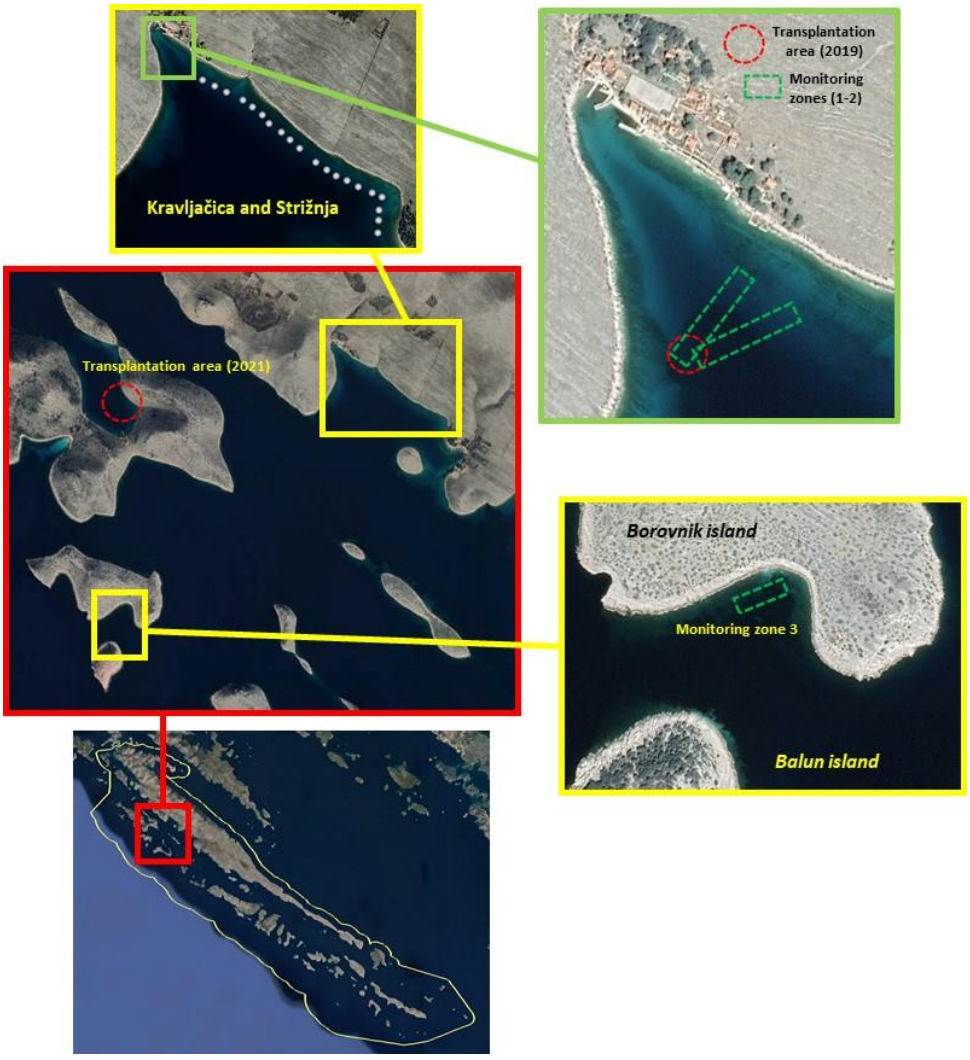

Figure 15. Kornati NP: location of the pilot seagrass transplantation areas and of the monitoring zones.

3 (Patents n. 0001400800/2010 and n. 102015000081824/2018 - Mater-Bi®; Biosurvey S.r.l. and IDEA S.r.l.)

For the **first transplantation**, two parcels (10 m x 10 m) were identified as acceptor areas in Kravljačica Bay (the "the Anchoring site"). These parcels were characterized by the absence of seagrasses or by low meadows coverage values and the evidence of frequent presence of anchored boats. The meadows used as donors were those in an area located between Borovnik island and Balun Island ("the Diving site") (Figure 16).

Altogether - using technique No 1 - 12 patches composed each of 6 supports, 720 cuttings and about 2160 shoots were placed, at a depth of -11 m, in the Kravljačica Bay, for a total of about 200 square meters.

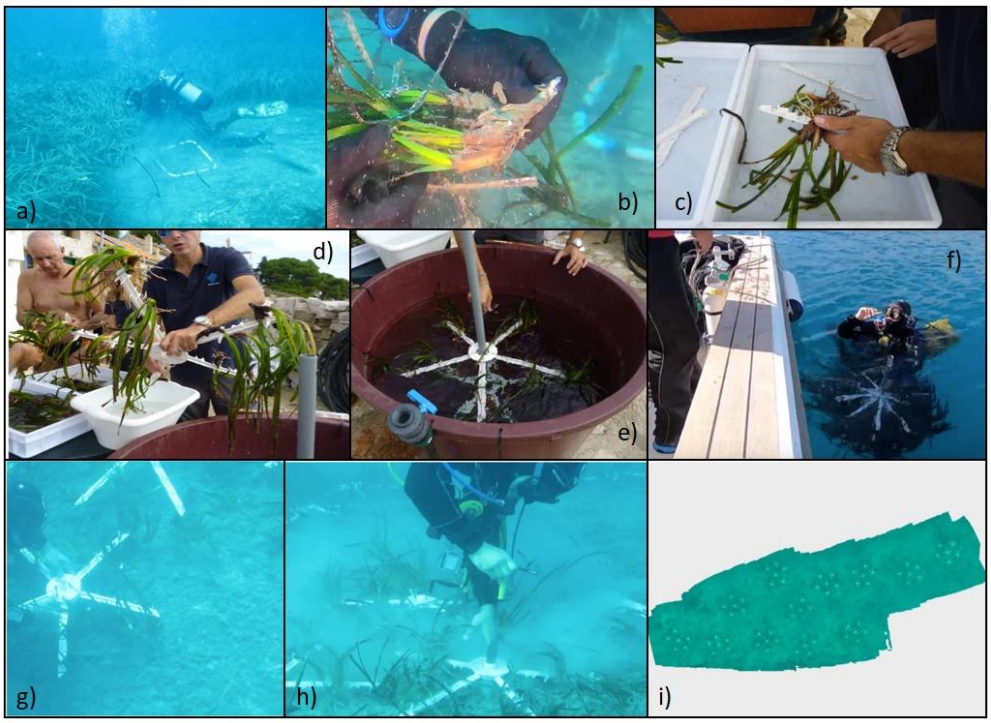

Figure 16. The pilot transplantation phases: a) identification of the donor meadow (- 15 m); b) harvesting of P. oceanica *cuttings; c) and d) fastening of cuttings to the biodegradable staple arms and assembly of the star-shaped support once back on the ground; e) temporary storage of planting units in plastic containers filled with seawater; f) transport of the planting units to the acceptor site; g) and h) fixing of the planting units to the picket; i) photo-mosaic of the reforestation pilot plant.*

For the **second transplantation** (using technique with the wooden supports), the two areas chosen for the collection of cuttings of *Posidonia oceanica* and subsequent planting were both located at the Anica Bay, on the island of Levrnaka. Due to many years of uncontrolled anchoring, meadows of the *P. oceanica* at the Anica Bay are partially destroyed, settled on dead matte with discontinuity and low density (Figure 17).

A total of 200 wooden basis were placed, on which approximately 800-900 cuttings were mounted. The 25 nuclei were placed to cover a surface of about 200 m².

Figure 17. Posidonia oceanica *attachment scheme and cuttings fixed and ready for transport to the host area.*

3.2.1. Monitoring of seagrass transplantation

***P. oceanica* transplantation in Kravljačica Bay**

Monitoring campaigns were carried out since October 2019, identifying, and labelling a total of 6 supports randomly distributed along the transplant patches. Shoot density, height of the longest leaf and increase length of the rhizome were regularly measured.

The results of the monitoring campaigns are reported in Figure 18 and Figure 19; it is important to underline that, since October 2019, the transplanted area in Kravljačica Bay has been frequently monitored and all transplantations were always in good conditions. In May 2021, *Caulerpa cylindracea* was observed in the transplant area.

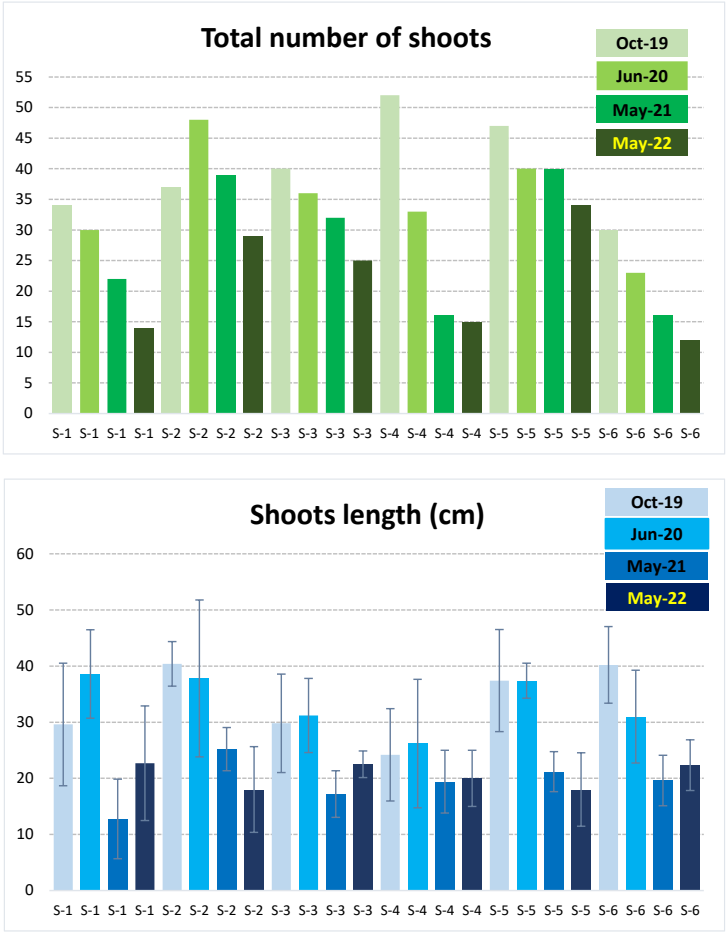

Figure 18. Total number of shoots and average values of shoot length of the 6 monitored support (S-1, S-2, S-3, S-4, S-5 and S-6) in October 2019, in June 2020, in May 2021 and in May 2022.

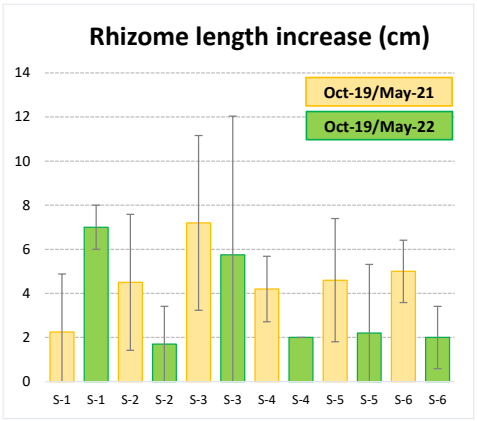

Figure 19. Average values of rhizome length increase of the 6 monitored support (S-1, S-2, S-3, S-4, S-5 and S-6) from October 2019 to May 2021 and from October 2019 to May 2022.

The total number of shoots and the leaf length showed a general slow decrease in all the six measured supports. The decrease was partly due to the high sedimentation trend still going. The rhizomes length showed an increase in all the supports from October 2019 to May 2021. Considering the average values of the parameter for the period October 2019 - May 2022, they are lower and this is because, between 2021 and 2022, some cuttings were lost or damaged.

***P. oceanica* transplantation in Arnica Bay**

The results of the monitoring campaign carried out in May 2022 showed a good survival and status of the transplanted shoots. However, as for the Kravljačica Bay, the high sedimentation of fine sediment particles onto seagrass leaves is a major stressor for *Posidonia*.

Figure 20. June 2020: seagrass transplantation in the Kravljačica Bay (in the Anchoring site).

Figure 21. May 2021: seagrass transplantation in the Kravljačica Bay (in the Anchoring site).

Figure 22. October 2021: seagrass transplantation in the Kravljačica Bay (in the Anchoring site).

Figure 23. May 2022: seagrass transplantation in the Kravljačica Bay (in the Anchoring site).

Figure 24. October 2021: seagrass transplantation in the Anica Bay.

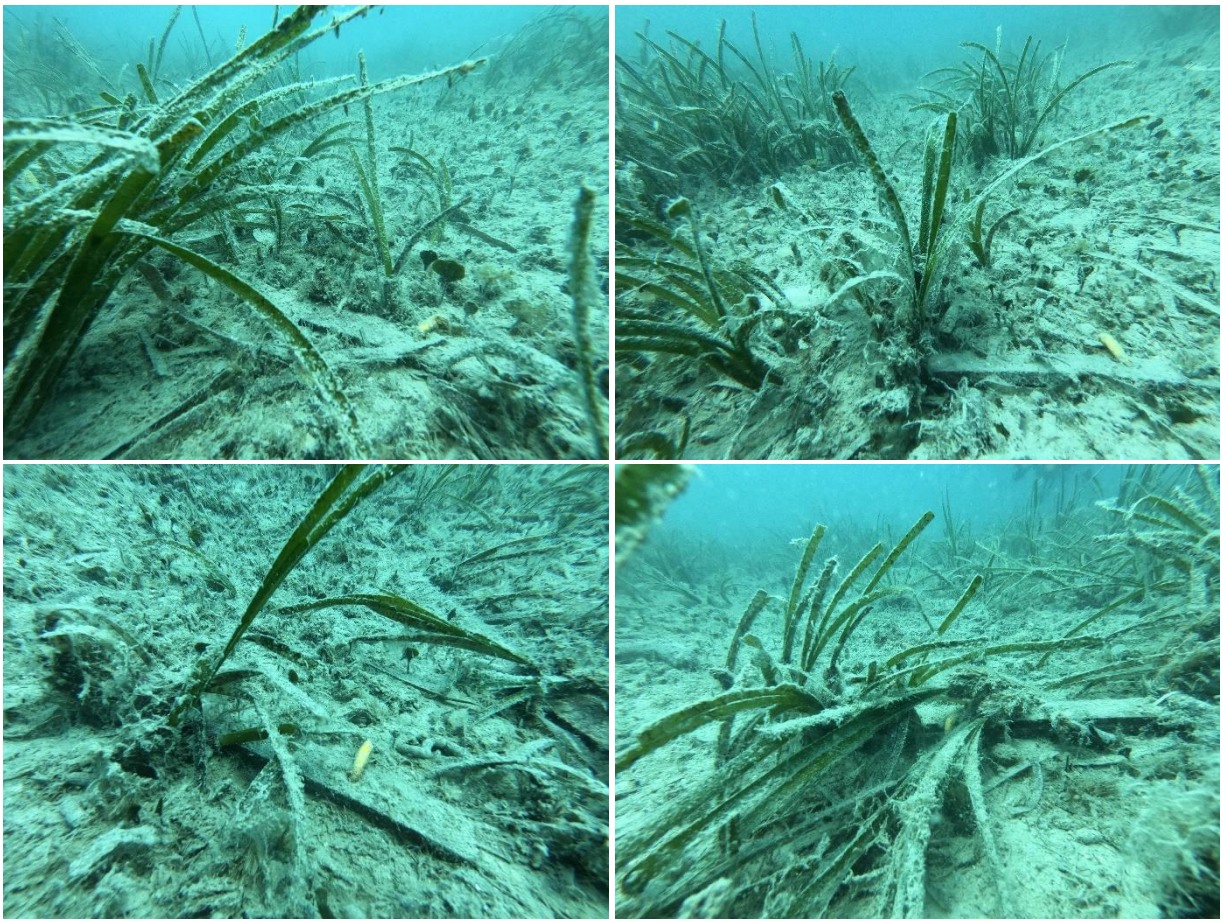

Figure 25. May 2022: seagrass transplantation in the Anica Bay.

3.2.2. Sediment traps

Seagrass meadows can decrease the amount of suspended sediment by trapping particles on the leaves and by enhancing particle sedimentation on the seabed (reducing flow velocity).

In May 2021, some "sediment traps" were placed on the seabed to collect the deposited material in the area in Kravljačica Bay where the seagrass transplantations were carried out and in nearby areas. They were truncated conical artifacts, with a square base, in plastic material for use as a "square sediment trap", with inox or plastic net, to cover the opening of the traps (Figure 26).

In October 2021, the sediment inside the traps was collected, placed in an oven, and the dry weight was calculated. The average value of the sediment inside the traps was twice the one of the areas outside the transplantations, proving the important role of the seagrass in decreasing the amount of suspended sediment.

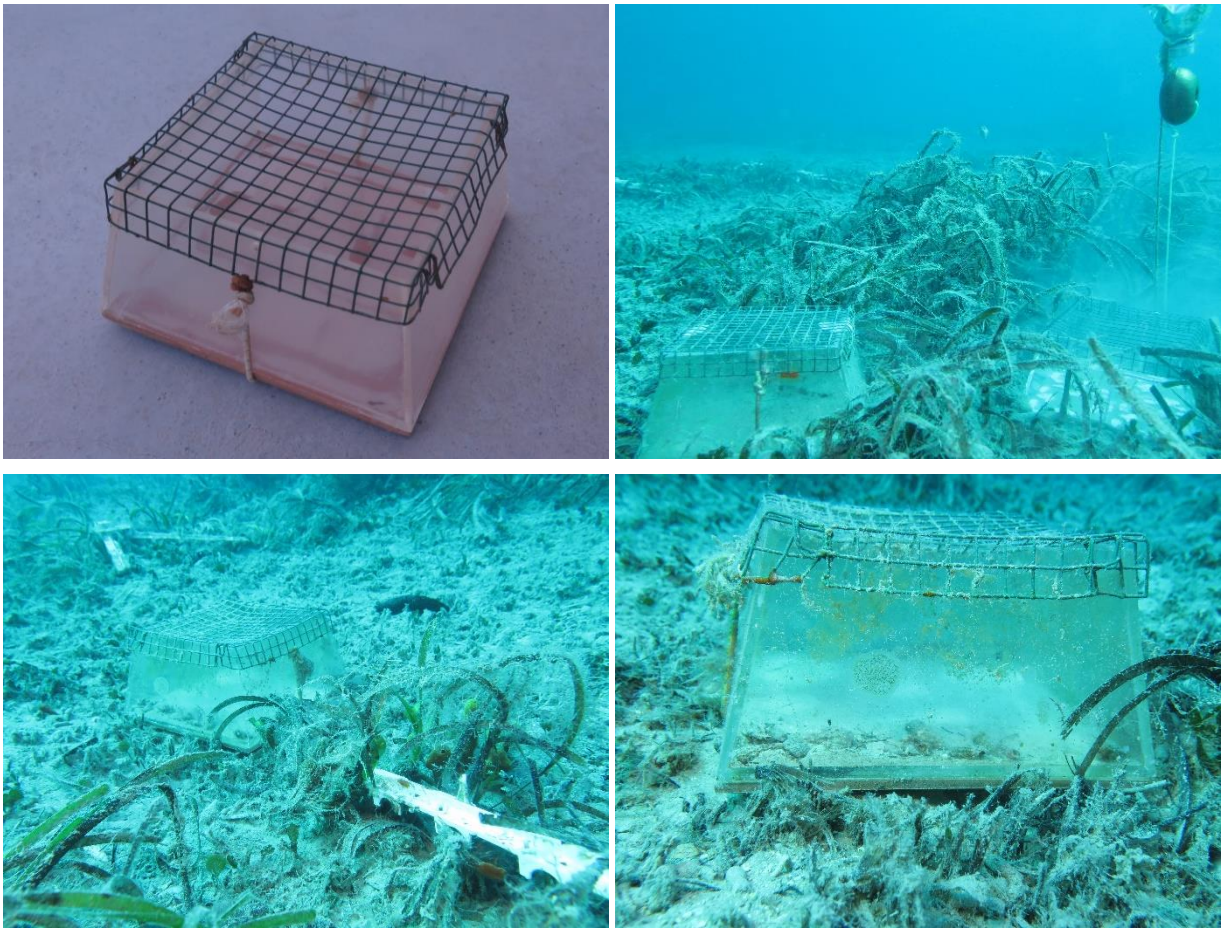

Figure 26. May 2021: Example of sediment trap, with inox or plastic net, to cover the opening. The traps were placed on the on the seabed to collect the deposited material in Kravljačica Bay.

3.3. Regional Natural Park of Coastal Dunes from Torre Canne to Torre San Leonardo

In the RNP Coastal Dunes site, the pilot *Posidonia oceanica* transplantation was carried out in February 2021, in an area located near the SIC Area "Litorale Brindisino" (and the monitoring Zone 1) where anchoring pressures occur (Figure 27).

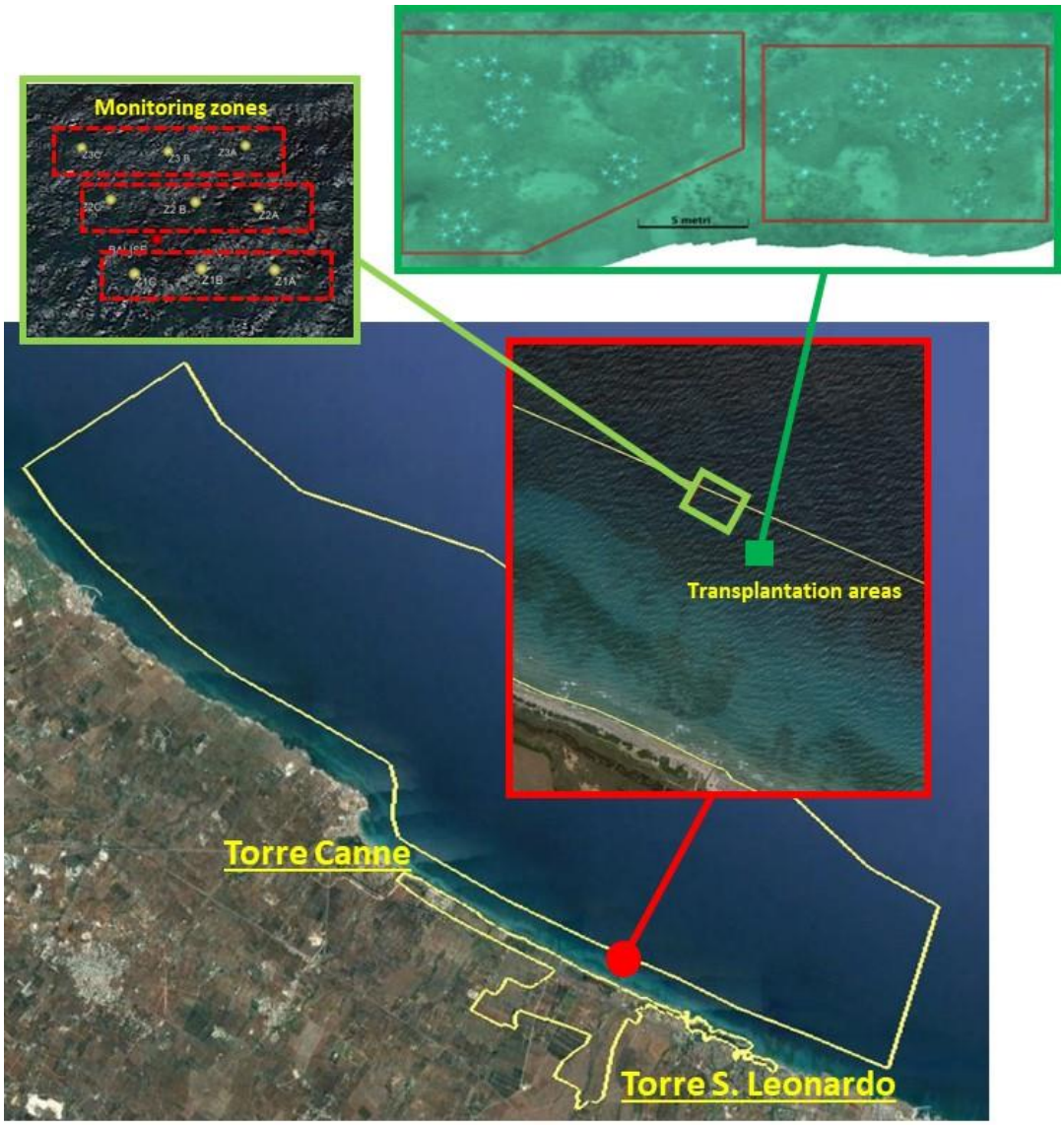

Figure 27. Sampling scheme applied to the monitoring Zones (1-2-3) in the Regional Natural Park of Coastal Dunes and Posidonia oceanica *pilot transplantation area.*

The transplantation site was located inside a discontinuous meadow, characterized by the presence of patches of *P. oceanica*, dead matte and sand. The donor meadow was located near the receiving site.

The transplantation was carried out in two contiguous parcels, in relation to the area's bathymetry, each of which represented approximately an area of about 100 square meters, for a total of about 200 square meters of transplanted area.

As for Kornati NP, the *P. oceanica* transplantation were carried out using biodegradable supports consisting of a patented star-shaped anchoring system with 5 arms to which fasten the seagrass rhizomes (Scannavino *et al*., 2014). Altogether, 14 patches composed each of 6 supports (in each one at least 30 rhizomes fixed) were arranged in the area, for a total of 84 anchoring modules and about 2,500 rhizomes (Figure 28). During the first monitoring campaign (May 2021), a total of 6 supports randomly distributed along the transplant patches was identified and labelled.

Figure 28. Fixing of cuttings to the arms (a), temporary storage of anchoring modules with cuttings/rhizomes.

3.3.1. Monitoring of seagrass transplantation

Monitoring campaigns were carried out in May 2021 and May 2022; in May 2021, 6 supports randomly distributed along the transplant patches were identified and labelled. As for the Kornati NP transplantation, shoot density, height of the longest leaf and increase length of the rhizome were measured.

Physical loss of some anchoring system or some arms and *Posidonia* shoots was found due to multiple causes that cannot be identified with certainty (i.e., fishing, anchoring, wave erosion) (Figure 31 and Figure 32). In particular, in May 2022, only two of the six biodegradable supports were found (support 2 and support 4).

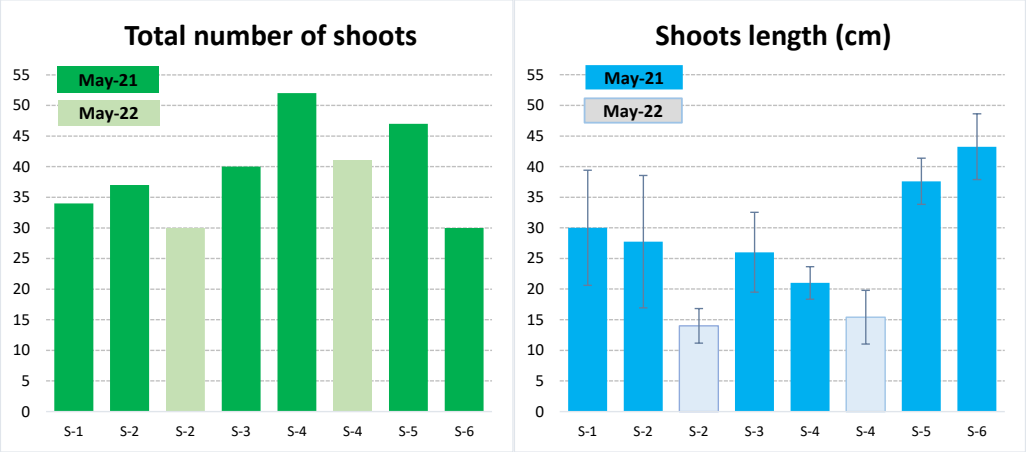

Figure 29. Total number of shoots and average values of shoot length of the 6 monitored support (S-1, S-2, S-3, S-4, S-5 and S-6) in May 2021 and in May 2022 (only for S-2 and S-4).

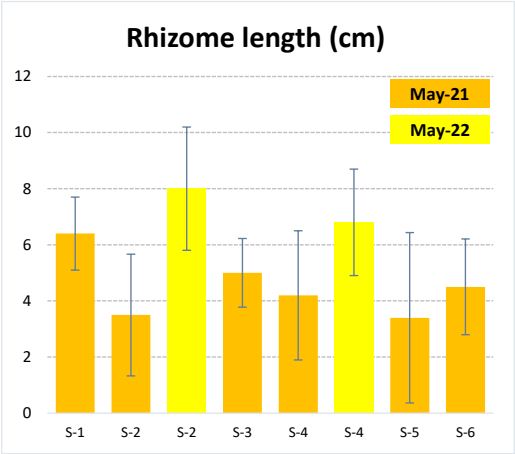

Figure 30. Average values of rhizome length increase of the 6 monitored support (S-1, S-2, S-3, S-4, S-5 and S-6) in May 2021 and in May 2022 (only for S-2 and S-4)

The total number of shoots and the leaf length showed a decrease in support S-2 and S-4 (Figure 29 and Figure 30); however, in general, shoot density and length showed good leaf conditions. The rhizomes length showed an increase in the supports S-2 and S-4 from May 2021 to May 2022.

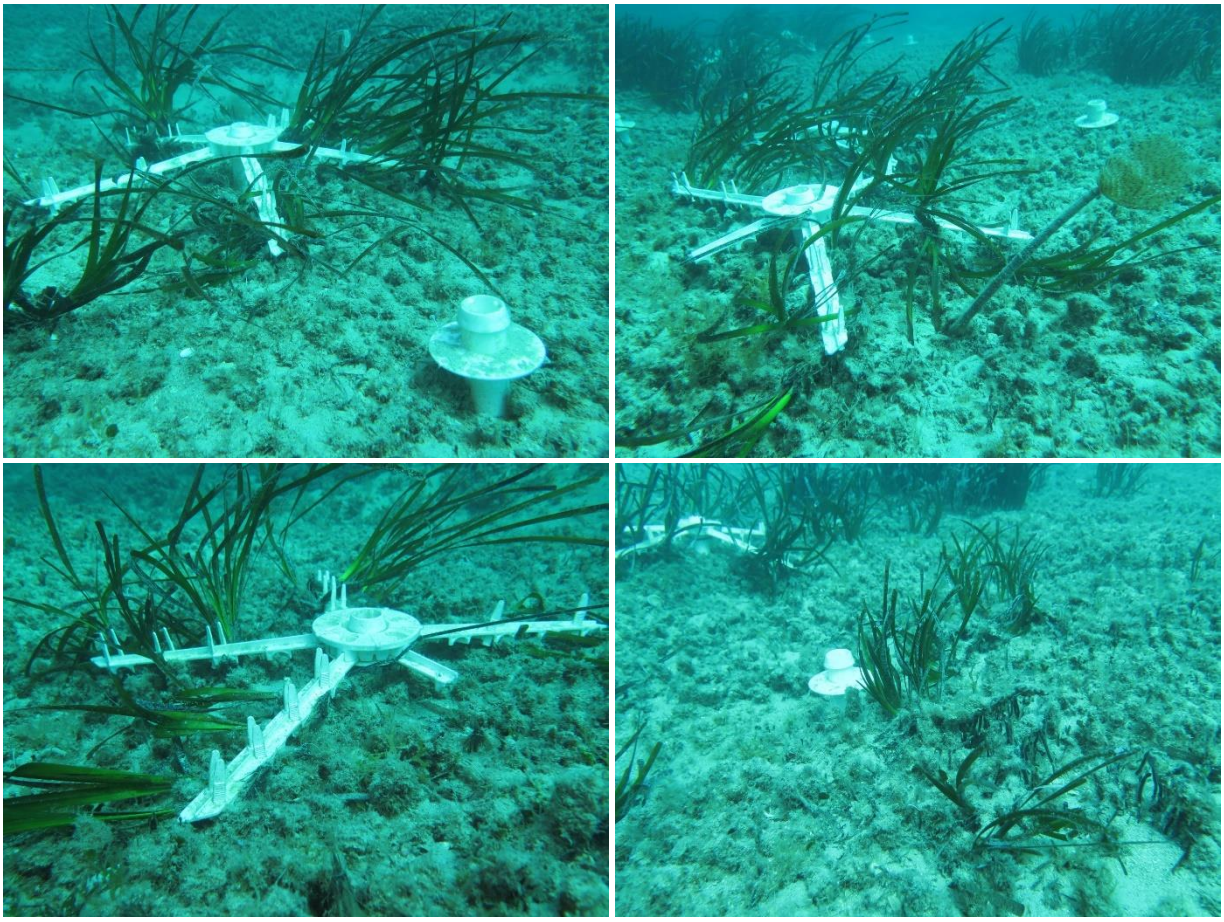

Figure 31. May 2021: seagrass transplantation in the RNP Coastal Dunes.

Figure 32. May 2021: seagrass transplantation in the RNP Coastal Dunes.

4. CONCLUSIONS

From a technical point of view, the tests carried out with *P. oceanica* showed good results. The plots created (the first dates back to 2019) are still in good condition and about 65% of the installed cuttings are growing, while the remaining 35% has different degrees of degradation or completely disappeared.

In particular some different dynamics between Park Kornati and RNP Coastal Dunes can be identified. On the Kornati Island, the transplantations carried out did not suffer significant physical damage at all, while at the Coastal Dune Park the supports where the cuttings were fixed suffered significant damage. These can be explained both by the effects of significant storm events, which are able to affect the sea-bottom despite the 8-meter head, and by impacts related to amateur fishing and anchoring.

The characteristic of Park Kornati is that of an archipelago that offers numerous shelters and has small inlets where the anchoring, even overnight, of numerous pleasure boats is an element of strong pressure against the meadows that often reach almost to the surface. These small embayments behave as sedimentation basins, also due to continuous mooring, anchoring, boat movements.

The transplantation carried out is then affected by a condition of strong sedimentation that harms both the canopy of the transplanted cuttings and that of the natural adjacent patches.

During controls, excellent vital conditions of the transplanted cuttings were always found on the Coastal Dunes Park site. Here the problem can be traced back, as mentioned, to physical impacts of another kind.

The transplantations of *C. nodosa* carried out at the Monfalcone site showed that a fundamental condition is represented by seasonality. It turned out that spring transplantation, compared to autumn one, allows a rapid and immediate development of the rhizomes and of the root system in a favorable moment for the plant, which is characterized by strong seasonality, being a marine seagrass of sub-tropical origin. The control at the end of summer 2021 showed a strong colonization which showed high densities and coverages outside the limits of the transplanted sods. Taking into account the exposure of the area to the north-east winds, which have a high impact on these shallows, the cuttings method, although already favorably tested and valid from a technical point of view, does not appear to be suitable.

5. REFERENCES

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