

# Technical data sheet on transplantation for each site

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| Specific objective  | 3.2 - Contribute to protect and restore biodiversity                     |
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## 1. INTRODUCTION

SASPAS (Safe Anchoring and Seagrass Protection in the Adriatic Sea) is a project financed by the European Foundation for Regional Development under the Interreg V-A Program IT-CRO CBC (Priority Axis 3 – Environment and Cultural Heritage).

The partners involved in the project are:

- Municipality Of Monfalcone (IT) - lead partner
- PP1 - Selc Cooperative Company (IT)
- PP2 - National Interuniversity Consortium for Marine Sciences (IT)
- PP3 - Provisional Management Consortium of Regional Natural Park „Coastal Dunes From Torre Canne To Torre San Leonardo“ (IT)
- PP4 - Association for Nature, Environment And Sustainable Development Sunce (CRO)
- PP5 - Kornati National Park (CRO)
- PP6 - University of Rijeka (CRO)
- PP7 - Consortium for coordination of research activities concerning the Venice lagoon system (IT)

Total budget of the project: 1.906.100,00 EUR

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Start of project: 01/01/2019

End of project: 30/06/2022

### 1.1. Aims and objectives

The main aim of the SASPAS project is to preserve and get a better status of conservation of biodiversity of the Adriatic Sea ecosystem.

The innovative approach in this project that goes beyond the existing practices consists in joint cross-border biodiversity protection and restoration 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 overall objective is to improve seagrass preservation and restoration through: laying safe anchorage innovative systems, performing pilot transplantations, carrying out monitoring activities and by defining an integrated management system for seagrasses in Adriatic area.

The change will result in an increased level of conservation status of habitat types and species in the involved Natura 2000 sites of the Programme area. To reach the foreseen change the project will take a scientific- applied 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.

Since the marine seagrasses and especially the *Posidonia Oceanica* beds (1120\*) do not know boundaries and are widespread in all the Program coastal areas, irrespectively to the state in which we are, and also the problems with the conservation status are similar in the two Member States, significant results can be reached only by setting up a good cross-border cooperation within 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 in developing the foreseen Marine Seagrass Safeguard Integrated Management Program with the guidelines with regulations for the management and the correct attitude and behavior in protected areas.

The expected main results of the project are:

- Implementation of the seagrass monitoring system and annual data collection / monitoring campaign
- Installation of environmentally friendly anchorage systems (anchorage and simple signal buoys)
- Seagrass pilot transplantation and integrated management system for seagrass in the Adriatic (GIS Digital Information Platform (DIP))
- Drafting of the Integrated Marine Flowering Management Program (MSSIMP) proposal.

## 1.2. Structure of Work Package 4

The WP4 of the project (Protecting and restoring marine seagrasses) aims to develop and install an environmentally friendly anchoring systems (anchorage and simple signalling buoys) that can cancel or significantly reduce impacts on marine seagrass meadows caused by the anchorage of leisure boats and to perform transplantations whose aim is to test the up-to-date methods and to assess the possibility to re-establish beds which have disappeared due to human activities.

The WP4 package consists of two activities:

- Activity 4.1. Laying and boot of Environmental-Friendly Anchoring system,
- Activity 4.2. Marine seagrasses pilot transplantations and surrounding seabed clearing.

This document describes the activities planned and carried out within WP 4 activity 2, reporting the transplantation actions in three project areas: Monfalcone (Panzano Bay), Regional Natural Park of Coastal Dunes from Torre Canne to Torre San Leonardo and Kornati National Park.

## 2. PROJECT AREAS

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

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

Natural Park of Coastal Dunes from Torre Canne to Torre San Leonardo and Kornati National Park are characterized by widespread coverage of *Posidonia oceanica*. In both sites, in the summer, there is a significant flow of pleasure boat; however, the development of the tourism industry 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 (*Cymodocea nodosa* and *Zostera* spp.) too.

Both *P. oceanica* and *C. nodosa* play a crucial role in the consolidation of coastal sediments, slowing erosive phenomena, thanks to their radical 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.



Figure 1. Location of the three project areas.

## 2.1. Monfalcone (Bay of Panzano)

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 Areas of Conservation (SAC) “Cavana di Monfalcone” and a Special Areas of Conservation (SAC) and Special Protection Area (SPA) “Foce dell’Isonzo - Isola della Cona” (Mouth of the Isonzo River and Cona Island) (Figure 2).

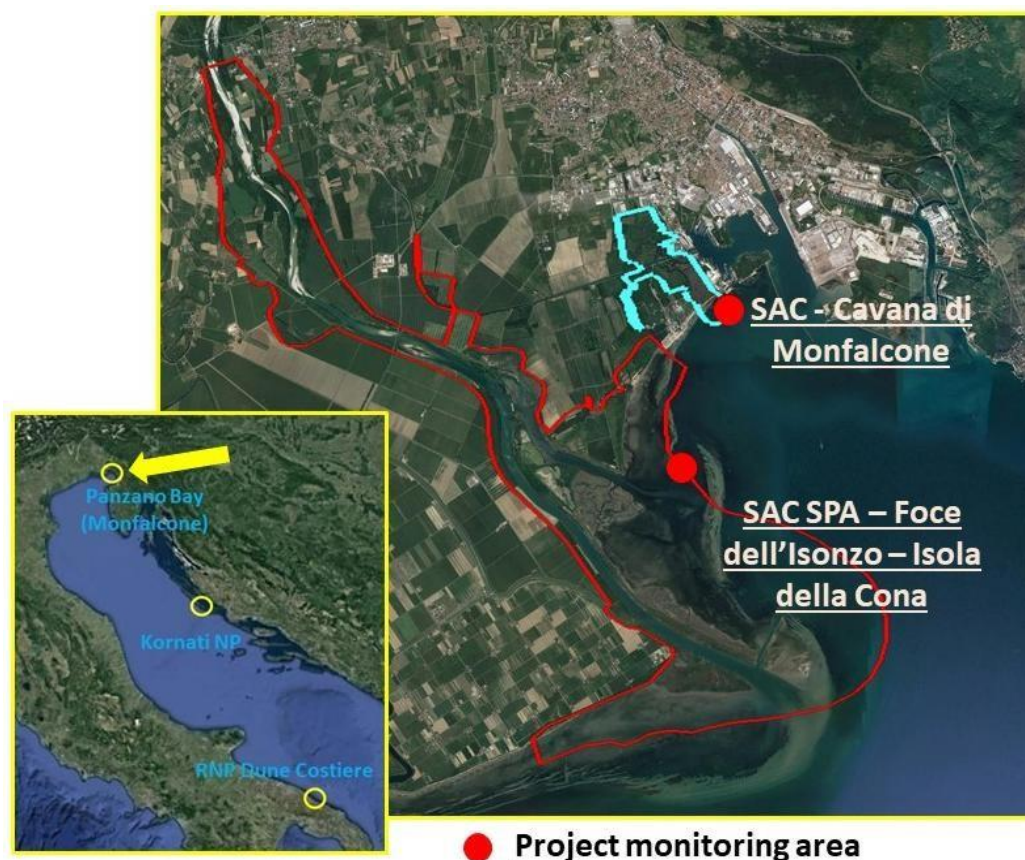


Figure 2. Location of the study areas in the Panzano Bay, positioned in two Natura 2000 sites.

- 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 and it is important because it includes a set of ecological systems characterized by rare habitats in a good state 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 state, water speed, depth and salinity preserve rich and well- diversified aquatic vegetation. The site covers an area of 133 ha, approximately 12 of which are in marine areas.



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 sizes, including boulders and cobbles, or smaller grain sizes including mud may also be present). These habitats are permanently submerged and predominantly surrounded by deeper water. Above the sand-bank the water depth is rarely greater than 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 noltii* and partly coated by green, blue, brown algae, 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 2.668 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. 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 Leonardo” 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 3). 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.

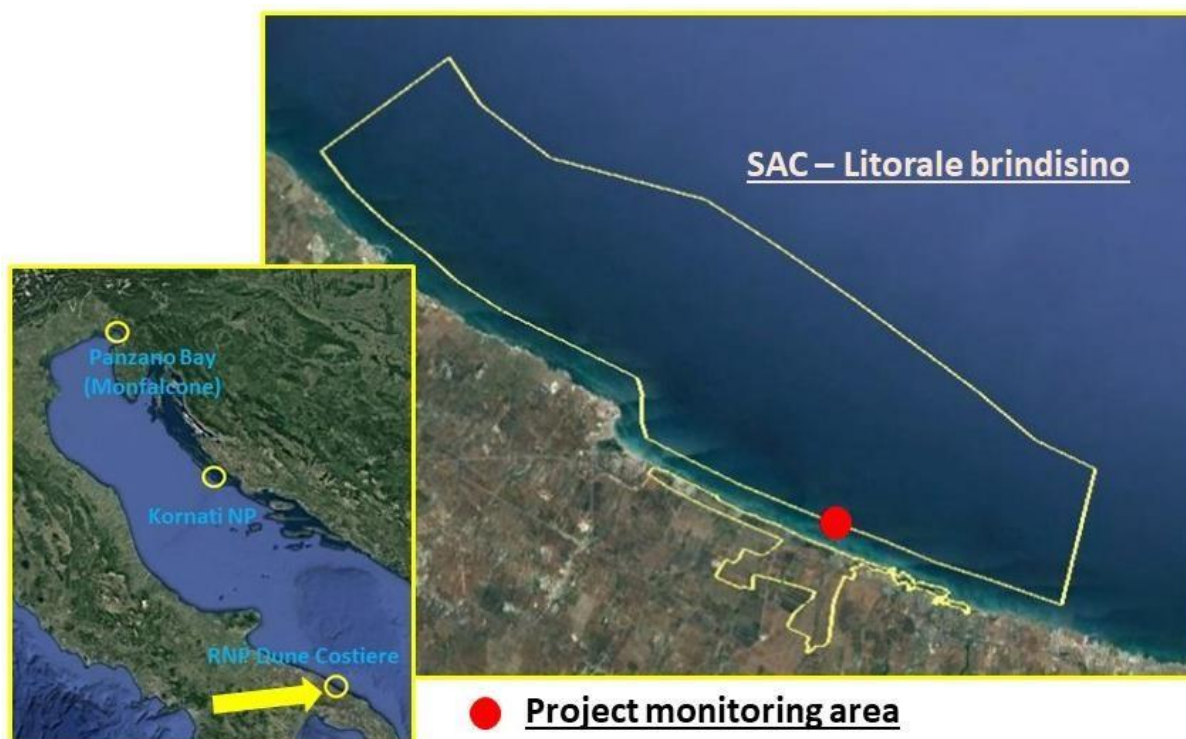


Figure 3. Location of the study area in the RNP Dune Costiere, positioned in a Natura 2000 site.

In the protected area, there are many habitats. Each habitat is a result of the geological, morphological and climatic features of the site that determine the presence of plant and animal species preferring those features. Some of those habitats are considered priority, such the *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 its total area. It is also characterized by the presence of coastal wetlands, where rare or endangered species of migratory bird stop or reproduce.

### 2.3. Kornati National Park

Kornati National Park is designated as Site of Community Importance SCI HR4000001 - Nacionalni park Kornati (**Pogreška! Izvor reference nije pronađen.**). The park<sup>1</sup> was established in 1980 and its management began in 1982. It currently includes 89 islands and reefs, a total area of 217 km<sup>2</sup>, of which almost 80% is marine territory (land 50 km<sup>2</sup> / sea 167 km<sup>2</sup>) and a total coastline of 238 km. Karst features dominate its geomorphology. 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 algae, 3 species of underwater flower plants as well as about 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 depths of 25-30 meters. The presence of alien species is included among the anthropogenic threats. *P. oceanica* is particularly threatened by some algal species: *Caulerpa cylindracea*<sup>2</sup> (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).

There are four no-take zones where only scientific research is 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.

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<sup>1</sup> The data cited in the following paragraphs are reported in the articles: Casier, 2011; Mihelcic and Ramov, 2018; Ivković N., 2015.

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

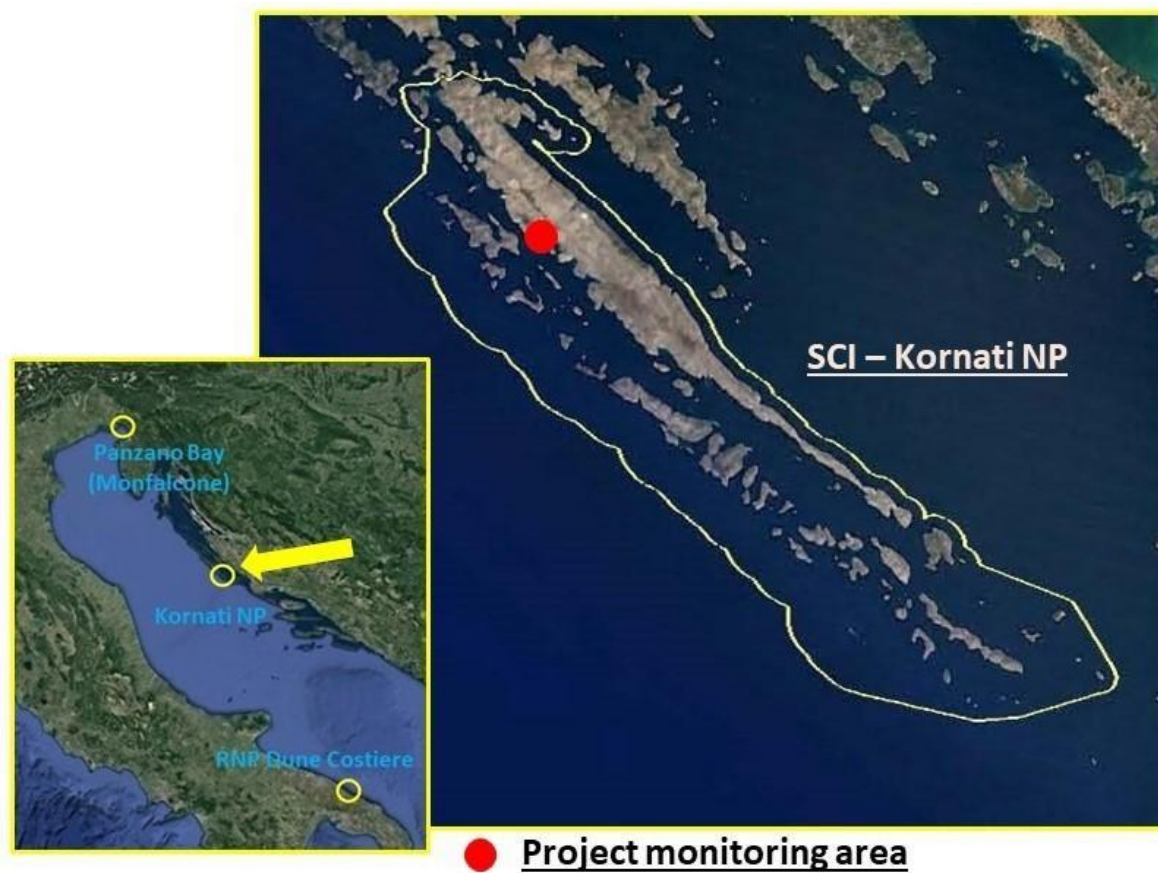


Figure 4. Location of the study area in the Natura 2000 site Kornati NP.

### 3. MARINE SEAGRASSES TRANSPLANTATION ACTIVITIES

#### 3.1. *Cymodocea nodosa* transplantation in Panzano Bay

As a part of the SASPAS project, two transplantations of the *Cymodocea nodosa* were performed close to each other near the site (SAC SPA) Foce dell’Isonzo – Isola della Cona. The pilot transplantation was performed in 2020, and an additional one in 2021.

##### 3.1.1. Transplantation areas

In September 2020, the partner SELC, in collaboration with the other partners – CORILA (UNI-VE) and CONISMA (UNI-TS), carried out the *Cymodocea nodosa* **pilot transplantation** in Panzano Bay. Technical support was provided by the Leader Partner, Municipality of Monfalcone and its suppliers.

In April 2021, the same partners team performed the *Cymodocea nodosa* **additional transplantation** in Panzano Bay, in an area nearby the first transplantation.

The transplantation areas are located near the site (SAC SPA) Foce dell’Isonzo – Isola della Cona, and are characterized by shallow depth (some 1.2 meters above mean sea level), and the presence of *Cymodocea nodosa* meadows mixed with other species (*Zostera noltei* and *Zostera marina*); in these areas anchoring pressures occur, due to the presence of small boats, mostly in fine weather. The meadows of the donor site have been selected in a nearby area (Figure 5; Figure 6). Donor meadow was continuous, with no visible signs of disturbance.

Two squares were selected for the **pilot transplantation** areas:

- Transplant area 1 (10 m x 10 m) (where the manual transplanting method by collection and planting of vegetated plugs was carried out). Coordinates:

|            |            |            |            |
|------------|------------|------------|------------|
| 45° 45,801 | 45° 45,544 | 45° 45,531 | 45° 45,790 |
| 13° 31,873 | 13° 31,897 | 13° 31,648 | 13° 31,602 |

- Transplant area 2 (10 m x 10 m) (where the transplanting by manual collection of shoots - bare root planting cuttings - was carried out). Coordinates:

|            |            |            |            |
|------------|------------|------------|------------|
| 45° 45,256 | 45° 45,108 | 45° 45,069 | 45° 45,217 |
| 13° 32,324 | 13° 32,385 | 13° 32,206 | 13° 32,140 |



Figure 5. Pilot transplantation - Host and donor sites in Panzano Bay (Monfalcone).

For the **additional transplantation**, also two squares transplant areas (m 10 X 10 each) were selected, where the manual transplant of vegetated plugs and bare root planting cuttings was carried out. Coordinates of vertices:

|            |            |            |            |
|------------|------------|------------|------------|
| 45° 45,757 | 45° 45,762 | 45° 45,760 | 45° 45,756 |
| 13° 31,799 | 13° 31,798 | 13° 31,794 | 13° 31,794 |

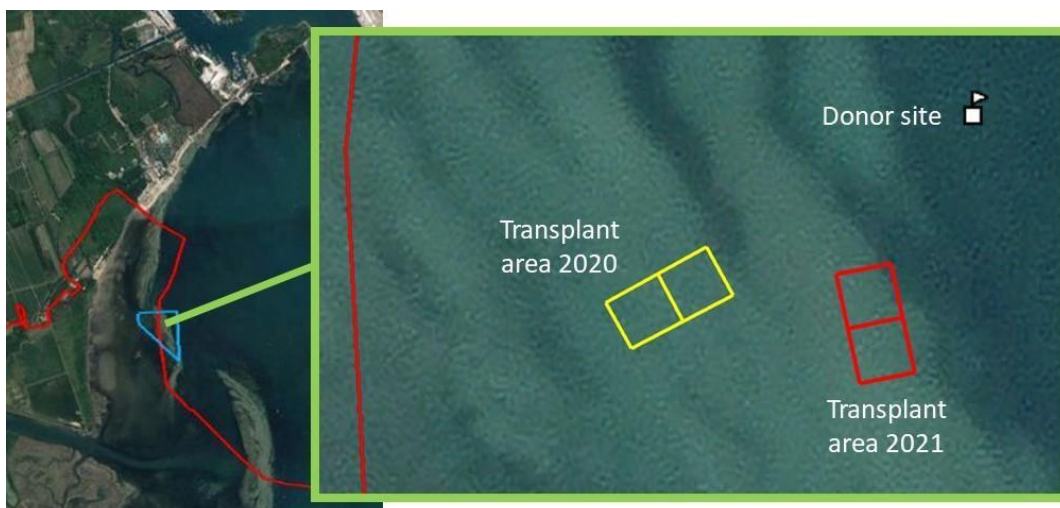


Figure 6. Additional transplantation - Host and donor sites in Panzano Bay (Monfalcone).

### 3.1.2. Methodology

On 17<sup>th</sup> September 2020 (pilot transplantation) and on 14<sup>th</sup> and 15<sup>th</sup> April 2021 (additional transplantation), *Cymodocea nodosa* shoots have been transplanted. Both transplantations were performed using two different manual techniques.

The first manual transplanting technique, prevalent, involves the collection and planting of plugs (vegetated units where the plant with leaves, roots and rhizomes is taken with the native sediment that surrounds it). The second manual transplanting methods involves the manual collection of shoots (bare root planting cuttings) and a subsequent re-planting, thanks to anchoring staples.

Technique n. 1 - **Manual harvesting from donor sites and transplanting by plugs**: sediment intact transplant units (plugs) were extracted from the donor site (unit with the leaf blades, roots, rhizomes and surrounding intact sediment) and transported to the host site where holes were excavated to receive them. Combined units of leaf blades, roots, rhizomes and sediment were collected from the donor site, using a round cylinder corer (core tube, 25 cm diameter) to harvest them. In the recipient site, plugs were planted into the substrate by means of hessian bags (made from biodegradable jute fiber) (Figure 7; Figure 8).



Figure 7. Pilot transplantation procedure by plugs: a) identification of the donor meadow; b) harvesting of plugs; c, d, e) temporary storage of plugs and their transport to the site to be reforested; f, g) plugs planting into the substrate by means of jute bags.



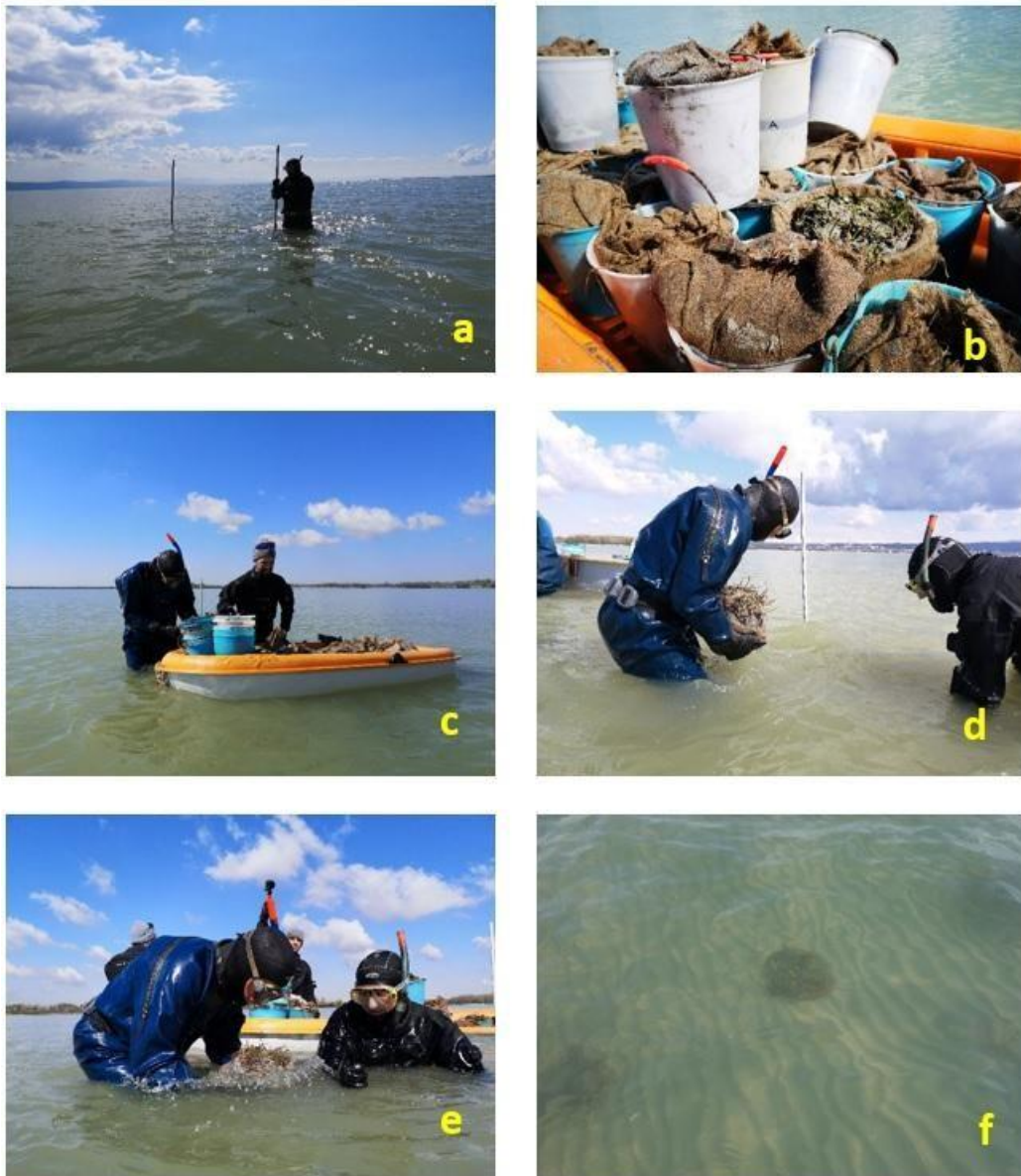


Figure 8. Additional transplantation procedure by plugs: a) identification of the transplant area; b, c) temporary storage of plugs and their transport to the site to be reforested; d, e, f) plugs planting into the substrate by means of jute bags.

Technique n. 2 - **Manual harvesting from donor sites and transplanting by bare-root transplant cuttings (sprigs<sup>3</sup>)**: sprigs were selectively collected from the donor site by hand and washed free of sediment. The sprigs were inserted directly in the substrate by staples: single sprig or bundle of sprigs were attached to staples by inserting the root-rhizome portion of the group under the bridge of the staple that was inserted in the sediment so that the rhizomes and roots were buried (Figure 9; Figure 10).

The donor site and the recipient site were marked using poles and georeferenced by a GPS. The transplant was conducted by operators with wet suits and other personal protective equipment, with the help of a support vessel for the execution of the field operations. Operators worked in a partial immersion mode, considering the depth and the tide.

Altogether, 200 plugs of *Cymodocea nodosa* and about 200 sprigs were placed in the transplantation areas (100 plugs and 100 spring for pilot transplantation and 100 plugs and 100 spring for additional transplantation).



Figure 9. Pilot transplantation procedure by sprigs: a) temporary storage of plugs and their transport to the site to be reforested; b, c) sprigs attachment to staples; d) sprigs planting into the substrate by means of staples.

<sup>3</sup> Sprigs: also referable as *ramet*, a length of seagrass rhizome with roots and shoots with leaves attached (but no sediment), which is usually at least 10–20 cm long and is used for transplanting into another area.



Figure 10. Pilot transplant by sprigs: a) temporary storage of plugs and their transport to the site to be reforested; b, c, d) sprigs planting into the substrate by means of staples.

## 3.2. *Posidonia oceanica* transplantation in Regional Natural Park of Coastal Dunes

### 3.2.1. Transplantation area

In September 2020, the partner SELC with the technical support of Coastal Dunes Park selected the area for the transplantation. The transplantation activity was supported by the specialized contribution of Biosurvey Srl, a spin-off of the University of Palermo, Italy.

A pilot implant was implemented using an updated transplant methodology, based on scientific evidence, in order to fully meet the spirit of the SASPAS project. For this purpose, a solution has been adopted in the panorama of national and international scientific literature, for which a track record of interventions was available, characterized by the use of innovative materials and plastic free. Transplantation activities were conducted from 26<sup>th</sup> to 27<sup>th</sup> February 2021.

The transplantation area is located on site Morelli (Ostuni), near to the SIC Area “Litorale Brindisino”. The transplant site is located inside a discontinuous meadow that shows the upper limit to a depth of 8 m, characterized by the presence of patches of *Posidonia oceanica*, dead matte and sand (Figure 11). The distribution of the dead matte is fragmented and is partially localized on sub-superficial rocky states.

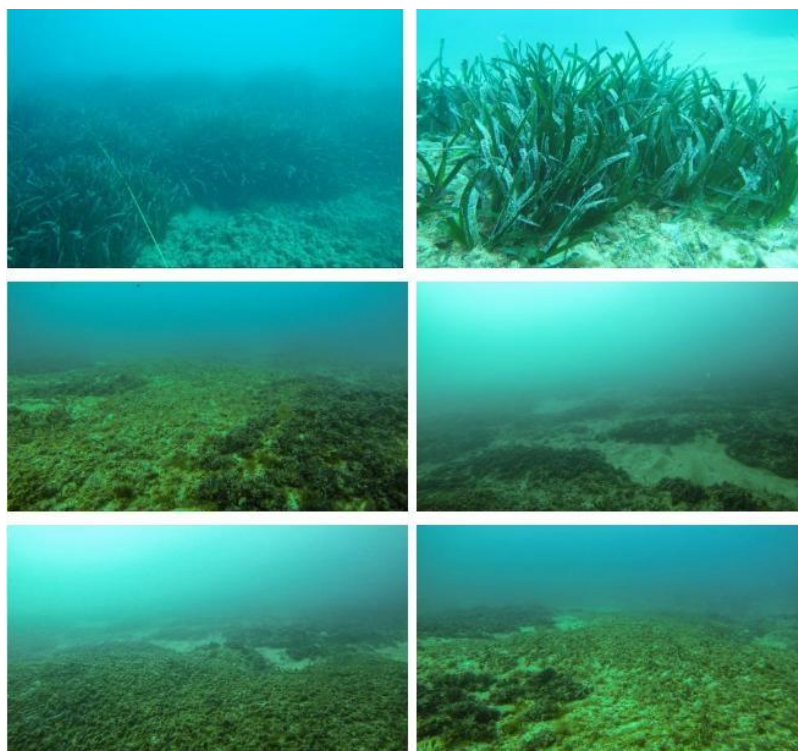


Figure 11. The presence of patches of *Posidonia oceanica*, dead matte and sand.

Two square transplant areas were selected:

The transplant area within the identified shoreline is shown in Figure 12. Specifically, there are two transplant parcels (marked by red crosses), indicated by the Park as potential transplant sites, and a yellow placeholder indicating the site where the transplant was carried out (UTM 712912E 4521378N).

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.

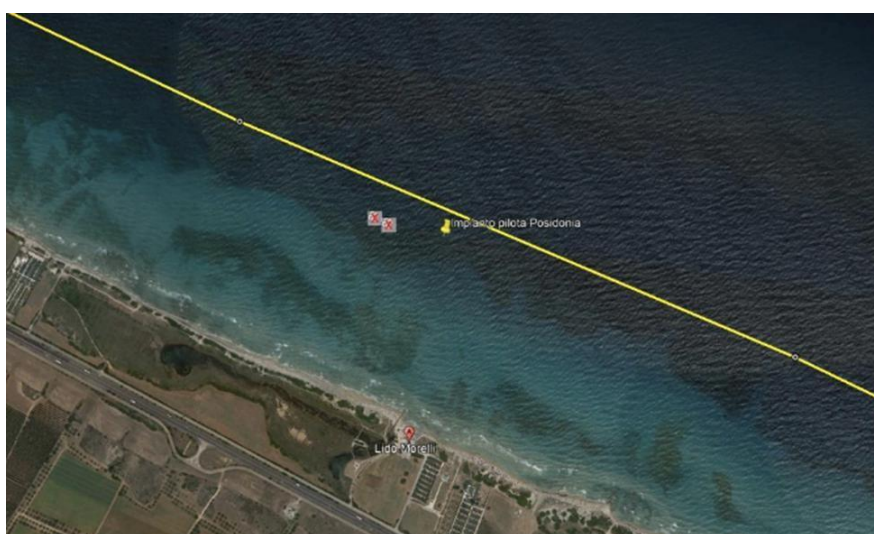


Figure 12. Transplantation area in Regional Natural Park of Coastal Dunes.

### 3.2.2. Methodology

In the period from 26<sup>th</sup> to 27<sup>th</sup> February 2021, *Posidonia oceanica* shoots have been transplanted using an innovative product (patent pending by Biosuvery Srl) consisting of a system made of totally biodegradable polymer (Mater Bi®) for the rapid, effective and really low cost positioning of *Posidonia oceanica* cuttings on the seabed, in order to ensure its rooting and growth and to facilitate the natural dynamics of development of the meadow.

This system consists of a radial structure fixable on the seabed by a picket. The structure is modular with five arms on which a variable number of clips for optimal fixation of *Posidonia oceanica* cuttings occurs (Figure 13). According to Scannavino et al. (2014), *Posidonia oceanica* anchor modular system allows the rapid attachment and expansion as evidenced by high survival rates and density increasing.

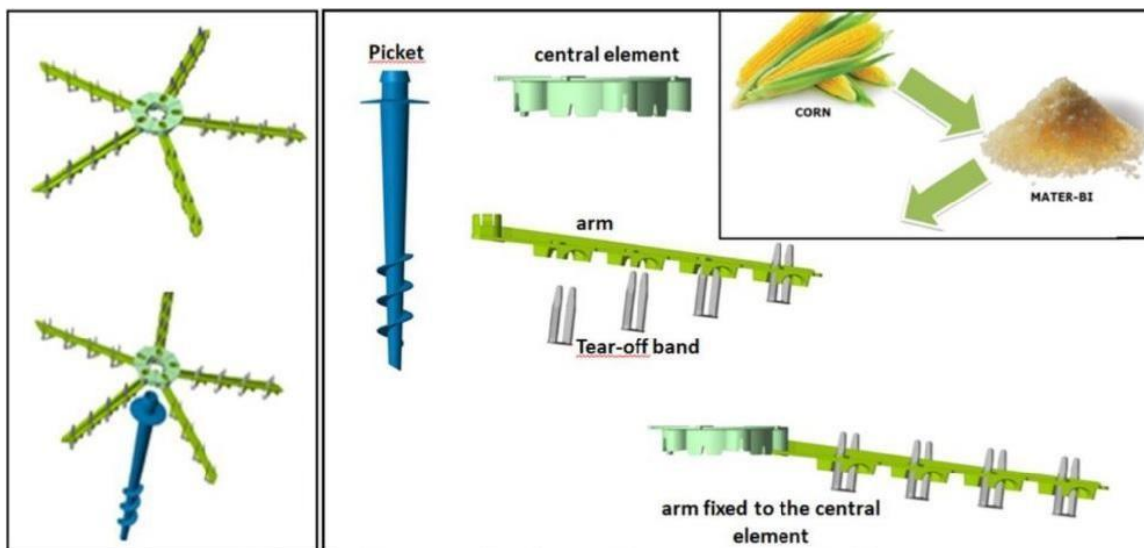


Figure 13. Biodegradable (Mater-Bi®) anchor modular system and details of the components.

*Posidonia oceanica* cuttings were collected from donor meadow which is located near the receiving site and at the same depth. The removal of cuttings/rhizomes was carried out according to sustainability criteria (1% of the density of the meadow), to minimize the impact on the donor meadow. In this regard, it should be noted that Díaz-Almela & Duarte (2008) claim that the levy not exceeding 1% of bundles/m<sup>2</sup> represents "... the level at which the loss can be compensated by the plant's annual vegetative recruitment in healthy meadows".

In particular, the harvest was limited to the plants present on the margins of the meadow. The material collected was stored in jute bags and transported submerged in water to shore for subsequent operations. At the host site, the two pilot plots were prepared, to receive the shoots by screwing the modules to the dead matte (Figure 14). The distribution of the pickets of the modules was partly conditioned by the presence of rocky layers just below the dead matte.



Figure 14. Receiving site – the distribution of the pickets.

In a base field ashore, cuttings and rhizomes were fixed by means of special straps to the arms of the biodegradable support. Once completed, supports were contained in large tanks filled with sea water. At least 30 rhizomes were fixed for each anchoring module (Figure 15). After preparing an appropriate number of anchoring modules with cuttings/rhizomes, they were transported by boat to the host site for subsequent final transplanting operations.



Figure 15. Ground fixing of cuttings to the arms (a), temporary storage of anchoring modules with cuttings/rhizomes.

In total, 14 patches were arranged in the area consisting of 6 supports each, for a total of 84 anchoring modules and about 2,500 rhizomes.

Once the positioning of the supports has been completed, video-photographic images have been acquired which, subsequently, have been elaborated with appropriate software (AgisoftMetashape), which performs photogrammetric processing of digital images and returns a detailed photomosaic of the pilot reforestation plant (Figure 16).

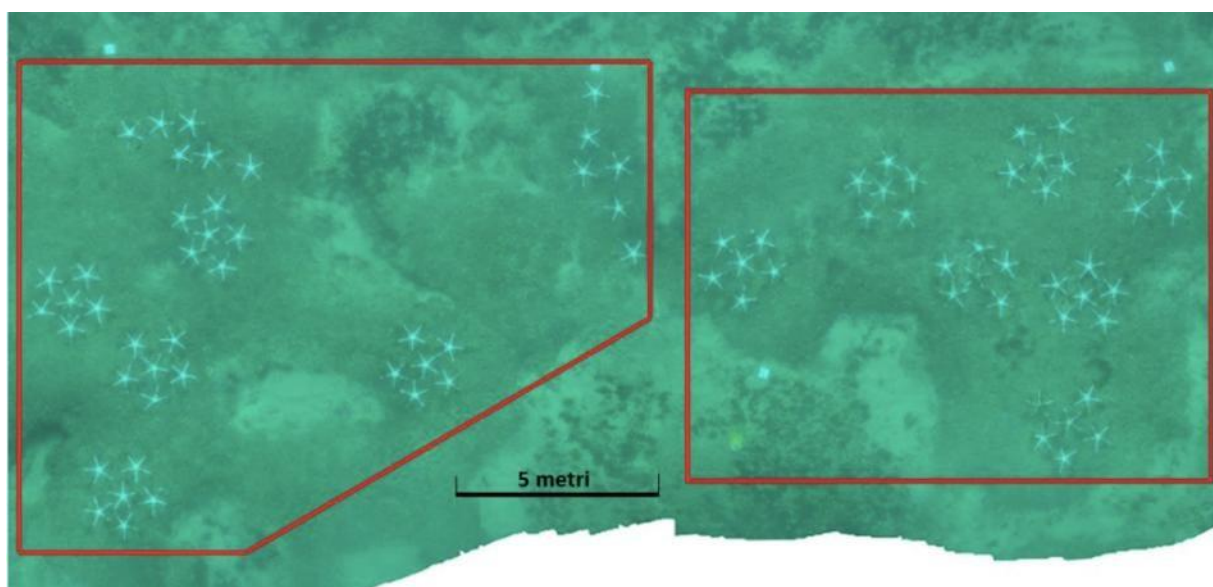


Figure 16. Photo-mosaic of the reforestation pilot plant in Regional Natural Park of Coastal Dunes.



### 3.3. *Posidonia oceanica* transplantation in Kornati National Park

Two *Posidonia oceanica* transplantation were performed in the Kornati National Park as part of the SASPAS project. First pilot transplantation was performed in October 2019 at the Kravljačica Bay and an additional transplantation was performed in October 2021 at the Anica Bay.

#### 3.3.1. Transplantation areas

##### Pilot transplantation

In October 2019, Kornati National Park, in collaboration with the other partners, carried out the *Posidonia oceanica* pilot transplantation in Kravljačica Bay. The activity was supported by the specialized contribution of Biosurvey Srl, a spin-off of the University of Palermo, Italy.

Kravljāčica Bay is situated on the north-western side of Kornat Island and represented one of the 19 anchoring sites in Kornati National Park. After preliminary survey, this bay has been selected as appropriate area for pilot transplantation.

Generally, the *Posidonia oceanica* meadow in the Kravljačica Bay shows signs of disturbance, clear regression phenomena, probably due to a high sedimentation of mainly muddy material. Many years of anchoring have caused the destruction of this marine habitat. The meadow is settled on matte, it is discontinuous and shows low density. The upper limit of the meadow is at a depth of -9 m.

The transplantation site (43°49'29,24" N, 15°16'30,15" E) in Kravljačica Bay is also characterized by the absence of seagrasses or by low meadows coverage values and the clues of frequent presence of anchored boats. The meadows of the donor site have been selected in the diving site, between Borovnik Island and Balun Island (43°48'32,23" N, 15°15'18,24" E) (Figure 17). Donor meadow was continuous with no visible signs of disturbance and low sedimentation.



Figure 17. Anchoring (host) and diving (donor) site in Kornati National Park.

### Additional transplantation

In the period from 11<sup>st</sup> to 13<sup>rd</sup> October, 2021, Kornati National Park, in collaboration with the other partners, carried out the *Posidonia oceanica* additional transplantation in Kornati National Park. The transplantation activity was supported by the specialized contribution of “Studio Emiliano Molin” and represented an alternative test to a previous intervention of similar scope, carried out using the modular supports (in degradable plastic) technique (Biosurvey, 2020).

The additional transplantation was performed at the Anica Bay, on the island of Levrnaka (Figure 18). The small island of Levrnaka lies off the SW coast of the island of Kornat in the Kornati National Park. It is separated from Kornat by a channel just 200 meters wide at its narrowest point. The island offers two anchorages – one of them is at Anica Bay.

Due to many years of uncontrolled anchoring, meadows of the *Posidonia oceanica* at the Anica Bay are partially destroyed, settled on dead matte with discontinuity and low density. The upper limit of the meadows is at a depth of 11-12 m.

The transplantation site (43°49'33.67"N, 15°15'13.9"E) is located in a submerged sandbank, near a monospecific rhizophytic vegetation of the *Cymodocea nodosa*. In this area there is already a *Posidonia oceanica* meadow which is however partially degraded, probably due to the high presence of pleasure boats at anchor during the summer season. Numerous anthropogenic wastes such as cans, bottles and plastics were also found at the site.

The donor site has been selected in the southern part of the island of Levrnaka, in the Prisluga Bay at two points (43°49'5.38"N, 15°15'20.2"E and 43° 49' 4.66"N, 15° 15' 41.29"E). The area is characterized by a rather dense seagrass which degrades the depth and keeps its edge along the leaf of approx. 8 - 10 m.



Figure 18. Additional transplantation and donor area on the island of Levrnaka, Kornati National Park.

### 3.3.1. Methodology

#### Pilot transplantation

In the period from 15<sup>th</sup> to 17<sup>th</sup> October 2019, *Posidonia oceanica* shoots have been transplanted by using an innovative product (patent pending by Biosurvey Srl) which is described in detail at the beginning of the chapter 3.2.2. of this document.

Cuttings of the *Posidonia oceanica* were collected from diving site between Borovnik Island and Balun Island according to sustainability criteria (1% of meadow density), minimizing the impact on donor meadow. The harvesting of the cuttings was limited to the plants present at the edges of the meadow.

The cuttings, taken at a depth of about -15 m, had the following characteristics: plagiotropic cuttings, about 15 cm long, carrying at least three shoots. The cuttings collected at the donor site were stored in jute bags and were quickly transported to the ground for the further treatment. The cuttings were fixed to the arms of the biodegradable support, by means of tear-off bands.

No. 2 cuttings for each arm and a total of 10 cuttings for each support were fixed. Throughout the activity, the plant material was constantly submerged in seawater to prevent dehydration. Once the fixing of the cuttings to the arms was completed, the supports were assembled to the central node.

Supports with cuttings have been piled up to facilitate transportation and placed inside plastic containers filled with seawater. After assembling a number of supports with cuttings, they were transferred by means of a boat to the receiving site for the following operations. The supports assembled cuttings were then fixed to the picket heads. Subsequently, using a tool, the supports were arranged to the substrate (Figure 19).

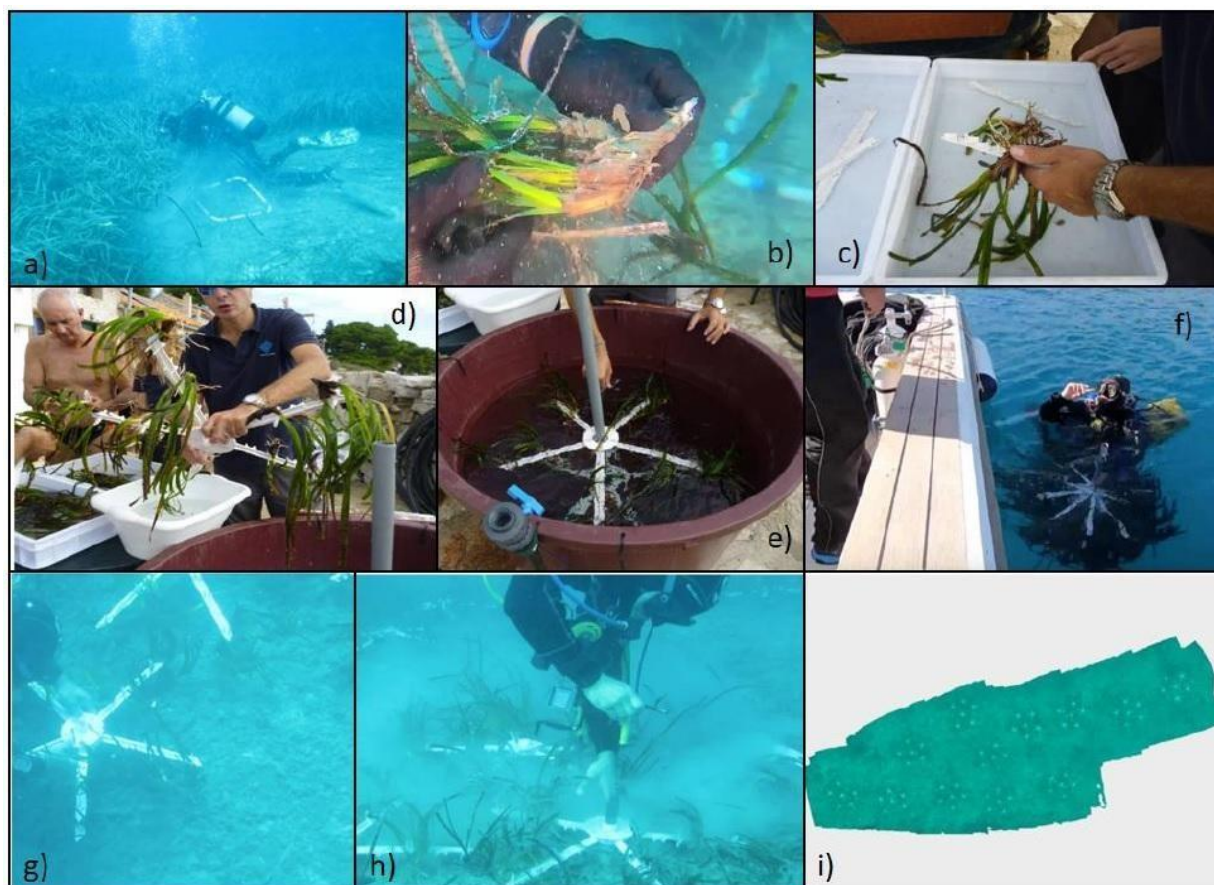


Figure 19. Pilot transplantation procedure: a) identification of the donor meadow (- 15 m), b) harvesting of cuttings, c) ground fixing of cuttings to arms, d) ground assembly of the "star" support, e) temporary storage of plant material fixed to the biodegradable support, f) transport of the supports with cuttings to the site to be reforested, g) and h) fixing of the support with cuttings to the picket, i) photo-mosaic of the reforestation pilot plant.

### Additional transplantation

In the period from 11<sup>st</sup> to 12<sup>nd</sup> October 2021, the cuttings of the *Posidonia oceanica* were collected in the donor area, taken by hand along the front of the seagrass and conserved in mat bags (Figure 20).



Figure 20. Collection of *Posidonia oceanica* cuttings.

Then they were mounted on exotic wood supports, heavy enough and characterized by a low degradability in order to resist on the sea floor at least for a couple of years. The cuttings, each of which is formed of at least three shoots of leaves, are attached with biodegradable plastic ties to the wooden supports (Figure 21).



Figure 21. *Posidonia oceanica* attachment scheme.

Once prepared, the cuttings were fixed along a metal rod in a circular way and placed in water until their final positioning and implantation (Figure 22).

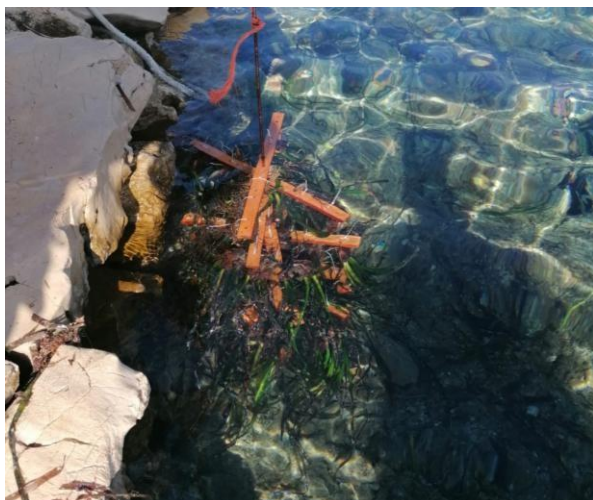


Figure 22. Cuttings fixed and ready for transport to the new host area

The plant scheme inside the transplant area has provided the positioning of 25 nuclei, each formed by 8 wooden bases (Figure 23). It allows to obtain a nucleus with sufficient density to allow an initial centrifugal colonization thrust and thus to have a meadow effect, which increases as the various nuclei come into contact each other.

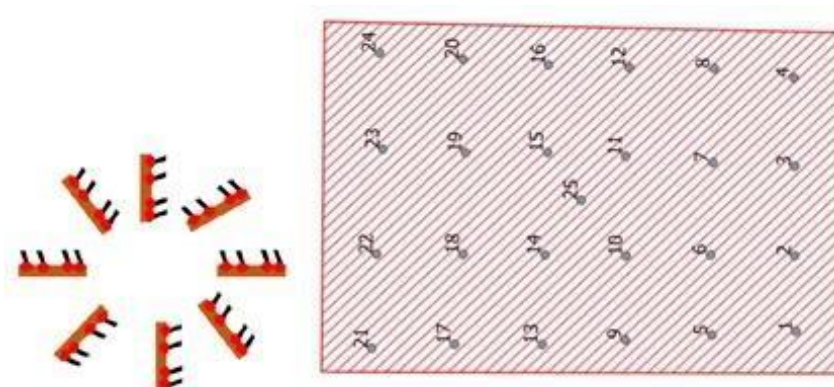


Figure 23. Example of nucleus of wooden bases and arrangement of the nuclei inside the transplanting area.

A total of 200 wooden basis were placed, on which approximately 800-900 cuttings were mounted (Figure 24). The 25 nuclei were placed to cover a surface of about 200 m<sup>2</sup> (Figure 25).



Figure 24. Wooden base fixed on mat.



Figure 25. Host area of about 200 m<sup>2</sup>.



## 4. CONCLUSIONS

As part of the SASPAS project, seagrass transplantations were carried out in three project sites: two locations in Italy - Monfalcone (Panzano Bay) and Regional Natural Park of Coastal Dunes from Torre Canne to Torre San Leonardo and one location in Croatia - Kornati National Park.

### Monfalcone (Panzano Bay)

- Two transplantations of the *Cymodocea nodosa* were performed close to each other near the site (SAC SPA) Foce dell'Isonzo – Isola della Cona in the Panzano Bay. The pilot transplantation was performed in September 2020, and an additional one in April 2021.
- Both transplantations were performed using the same method with two different manual techniques:
  - a) manual harvesting from donor sites and transplanting by plugs
  - b) manual harvesting from donor sites and transplanting by bare-root transplant cuttings (sprigs).
- Altogether, 200 plugs of *Cymodocea nodosa* and about 200 sprigs were placed in the transplantation areas (100 plugs and 100 spring for pilot transplantation and 100 plugs and 100 spring for additional transplantation).

### Regional Natural Park of Coastal Dunes

- In February 2021, *Posidonia oceanica* transplantation was successfully performed in the Regional Natural Park of Coastal Dunes, using a modular underwater anchor system consisting of starch-based biodegradable materials.
- The transplantation was carried out in two contiguous parcels, in relation to the area's bathymetry, and each one represented approximately an area of about 100 square meters, for a total of about 200 square meters of transplanted area.
- In total, 14 patches were arranged in the area, consisting of 6 supports for a total of 84 anchoring modules and about 2,500 rhizomes.

### Kornati National Park

- Two *Posidonia oceanica* transplantations were performed in the Kornati National Park. First pilot transplantation was performed in October 2019 at the Kravljačica Bay and the additional transplantation was performed in October 2021 at the Anica Bay (Levrnaka island).
- The pilot transplantation was successfully carried out by using an underwater anchor modular system consisting of starch-based biodegradable materials. Altogether, 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 to be reforested, for a total of about 200 square meters.

- The additional transplantation was successfully carried out with the technique of wooden supports, heavy enough and characterized by a low degradability in order to resist on the sea floor at least for a couple of years. A total of 25 nuclei, each formed by 8 wooden bases (approximately 800-900 cuttings) were placed in the Anica Bay, at a depth of 13-14 m. An area of approx. 200 m<sup>2</sup> was covered with the technique of the developing nuclei.

Transplanted areas in all three project sites should be regularly monitored in order to control further progress of transplants, survival rates and acceptance for the substrate.

The implemented methods for transplantation activities could represent effective techniques for successful restoration of marine seagrass habitats.

Concerning *P. oceanica*, it is important to add that a method with similar characteristics to the one used in the first Kornati NP transplantation (in October 2019 at the Kravljačica Bay) has been adapted and simplified in order to apply a certain criterion of degradability of the materials, although not patented, and to reduce as possible the quantity of donor plant material. This is viewed in the future perspective to adjust a “customed” and relatively inexpensive methodology for the Park.

## 5. LITERATURE

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