



The Action Plan for Management of Beaches with  
Posidonia Banquettes in the NW part of Dugi Otok with  
Emphasis on

## SAKARUN BEACH

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## 1. Introduction

The Action Plan for Management of Beaches with Posidonia Banquettes in the NW part of Dugi Otok with Emphasis on Sakarun Beach (hereinafter referred to as the Action Plan) is prepared as part of the project "POSBEMED2 - Governance and Management of Posidonia Beach- dune Systems across the Mediterranean" (hereinafter referred to as POSBEMED2).

The POSBEMED2 project brings together key stakeholders responsible for the management of the Mediterranean coastal area, enabling them to join their efforts and carry out activities necessary for the sustainable management of the Posidonia seagrass landscape and Posidonia banquettes on the beaches, located in protected areas and NATURA 2000 sites.

The aim of this Action Plan is to improve management and management strategies, increase the resilience of the coastal area with Posidonia in the NW part of Dugi Otok with emphasis on the pilot area - Sakarun beach, especially in the coastal zone with Posidonia banquettes. The Action Plan takes into consideration the following features of the area; the purpose of the beach, its integration into the ecosystem of the protected area; an increased value of the area as a result of nature-based solutions; increased resilience of coastal areas, and their integration into the general coastal strategy.

This Action Plan was developed through a participatory process with stakeholders, testing different approaches and tools to improve management strategies in protected areas with Posidonia banquettes.

## 2. General information about the NW part of Dugi Otok Island

The island of Dugi Otok is the largest island among the North Dalmatian islands. Dugi Otok translates literally to "Long Island", measuring 45 km in length, and between 1 km and 4 km in breadth, with the highest peak Vela Straža (338 m). The island has a population of 1 500 people, living in 12 settlements.

The sea-facing coastline of Dugi Otok Island is characterized by sharp contrasts: the part located in the Telašćica Nature Park (southeastern part of the island) is characterized by steep slopes, whereas the northwest side of the island boasts quiet bays, one of which is Sakarun beach.

The northwestern area of Dugi Otok Island is largely exposed to winds, however, the winds are usually not very strong. According to the data in the Plan for the Management of the Significant Landscape of the Northwestern Part of Dugi Otok (data for the period 2001 to 2010), winds reaching the intensity of 6 or more on Beaufort scale occur on average 5-10 days, whereas winds reaching the intensity above 8 on Beaufort scale happen only for 3-5 days. The most common types of wind are: Bora wind, Tramontane wind, and Mistral wind in the summer period. In the winter period, the most common winds are: the Jugo (or Scirocco), Levante wind, Bora wind, Tramontane wind and Leveche wind. Jugo/Sirocco wind arises in the front part of the cyclone vortex passing eastward across the Adriatic. Bora wind usually arises after a cyclone front passes, and strength and the direction of bora depend on the topography of the land, i.e., of coastal mountain massifs. The average duration of Scirocco and Bora winds ranges from 2 to 4 days, however, the winds will sometimes last up to more than a week. By contrast, frequent and prolonged periods without wind occur in the summer period. The data collected to date at the Zadar weather station (the closest one to the area subject to the Action Plan) show that during 2021 the most common wind was on average the wind coming from the north-northeast direction (Bora), reaching an average speed of 3.3 m/s (approximately 2.5 on Beaufort scale).

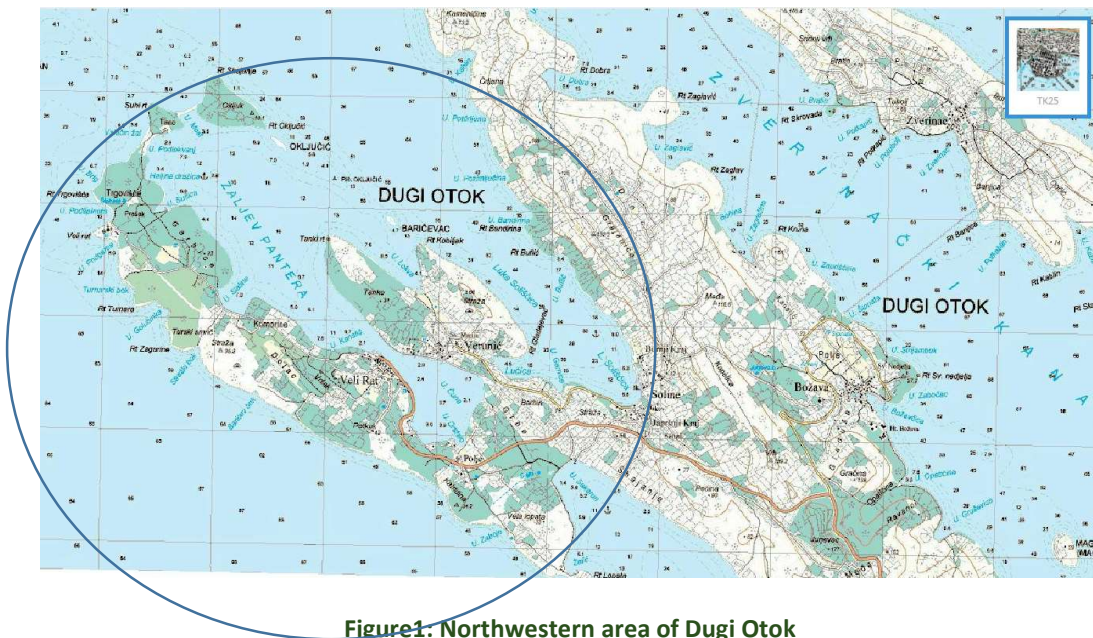


Figure1: Northwestern area of Dugi Otok

Source: Bioportal, <http://www.bioportal.hr/gis/>



The island boasts an extremely rich and diverse cultural and historical heritage. Centuries-old buildings are scattered all around Dugi Otok. The island was also well-known for its Glagolitic tradition, as evidenced by numerous Glagolitic texts found across the island. The earliest reference to the area of Soline dates back to as early as the 12th century. It is located in the Solišćica Bay, where salt pans used to be located. The village of Verunić is known for its cultural heritage with its most prominent sacral building, the Church of Our Lady of Mount Carmel. The Veli Rat village dates back to the period of ancient Rome, and is located at the northernmost point of Dugi Otok, on the shores of the Čuna Bay, which is connected by a narrow channel with the Pantera Bay. The village of Veli Rat boasts a parish church of St. Ante (St. Anthony) and a chapel of St. Nicholas in the courtyard of the lighthouse, housing a Roman Missal from 1869. The significance of this area lies in the fact that it is located on the most important maritime navigational route on the Adriatic (between Zadar and Ancona), consequently, the highest lighthouse on the Croatian part of the Adriatic Sea was built there in 1848/1849.

The northwestern area of Dugi Otok belongs to the Municipality of Sali and the island area of the Zadar Archipelago. The area includes the villages of Veli Rat, Verunić, and part of the village Soline and stretches to the northwest-southeast, with the entire southwest coast facing the open sea. The coastline is characterized by landforms such as bays and coves of Solišćica, Čuna, Pantera, Sakarun, and a number of smaller harbours and inlets, capes, coastal notches, cliffs, and beaches.

The northwestern part of Dugi Otok is considered one of the most attractive and interesting areas of Zadar County and has been designated as a protected area - significant landscape. The significant landscape of the northwestern part of Dugi Otok has been under conservation protection since 1967 and covers a total area of 652.16 hectares. The entire site is deemed a valuable landscape. The indented coastline consists of small bays and hidden beaches along the coast and of indented underwater landscape with numerous reefs. The most popular part of this significant landscape is the famous Sakarun Beach. The beach measures approx. 300 m in length at the northwestern end of the sandy bay. The shallow waters stretch as far as 100 m from the shore. Fine white sand gives the bay a particularly vivid blue-green sea color in the shallow waters, whereas the beach is made mostly of pebbles. The flora of Sakarun Beach consists of 4 endemic taxa (*Aurinia sinuata*, *Carduus micropterus* ssp. *micropterus*, *Limonium cancellatum* and *Lolium subulatum*), 6 endangered and 8 potentially endangered taxa, 12 strictly protected and only 2 taxa from the list of invasive taxa in the Croatian flora. The seabed is abundant with *Posidonia oceanica* seagrass meadows.

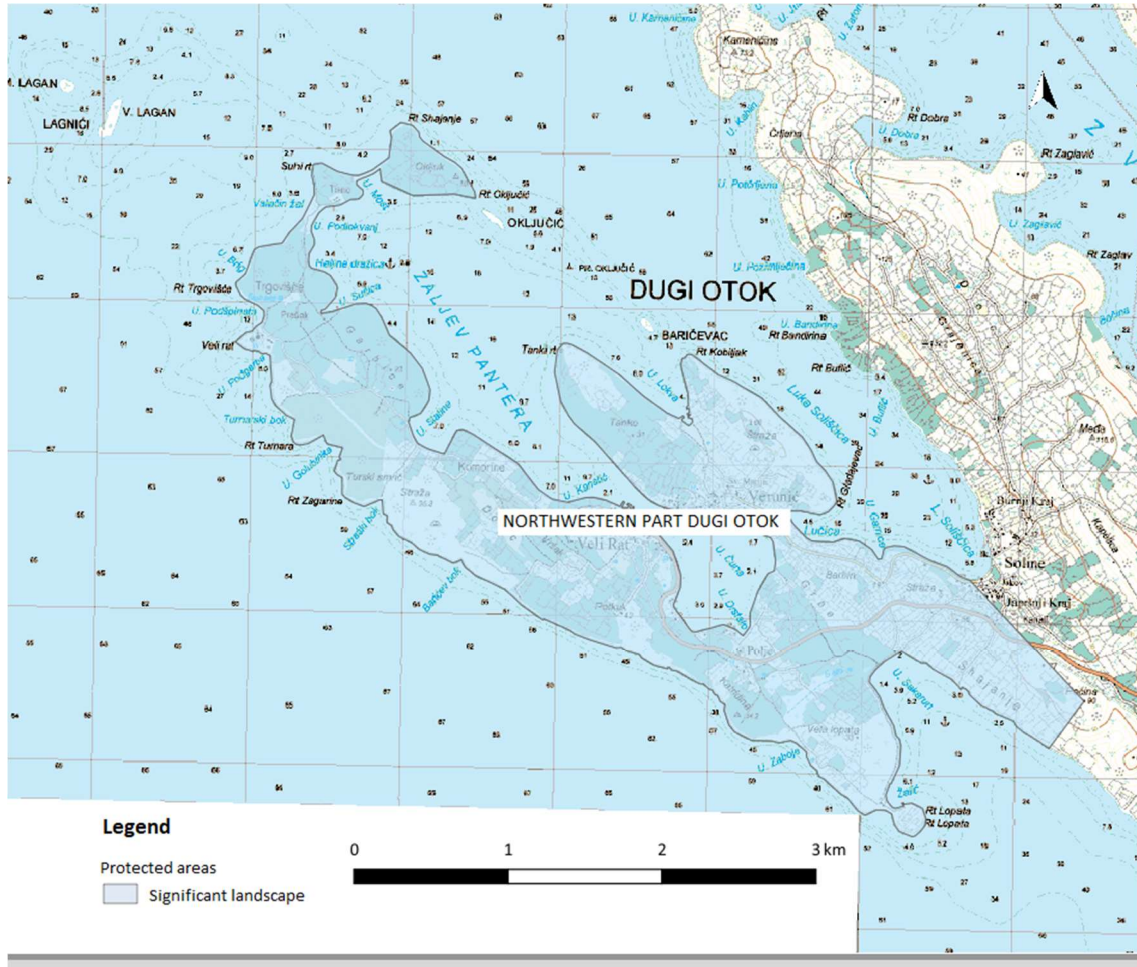


Figure2: Protected nature areas of the northwest part of Dugi Otok

Source: Biportal, <http://www.biportal.hr/qis/>

The northwestern area of Dugi Otok is also included in the following Natura 2000 sites (areas of the Croatian ecological network):

**HR3000067 Soliščica port Dugi Otok**

Habitats under protection: 1120 Posidonia beds (*Posidonia oceanica*), 1110 Sandbanks which are slightly covered by sea water all the time, 1160 Large shallow inlets and bays.

**HR3000068 Golubinka bay - Lopata Cape**

Habitats under protection: 1170 Reefs.

**HR3000069 Sakarun Bay**

The habitats under protection: 1120 Posidonia beds (*Posidonion oceanicae*), 1170 Reefs.

### HR1000034 Northern part of Zadar Archipelago

The goal is to protect 10 bird species, of which 3 species of Terns, European shag, and black-throated loon (Grebe) are important for the islands. The following threats to this area have been identified: transmission lines and telephone lines, fishing and collection of living marine resources, hunting, sports and outdoor recreational activities, interspecific competition, and intraspecific competition (fauna).

The area of the ecological network **HR3000069 Sakarun Bay** represents a priority area of interest, stretching over 438.55 ha on the northwest coast of Dugi Otok. The target priority habitats found in this Natura 2000 site are: \*1120 Posidonia beds and 1170 Reefs. Sakarun Bay covers a wide area, measuring 13 m in depth. The pebbled Sakarun beach is located along the enclosed section of the bay (northwestern part) while another beach is located south of it, in Žalić Bay. *Posidonia oceanica* meadow starts in the central part of the bay and stretches towards its end. The meadow is fragmented (patchy), consisting of larger and smaller islands broken up by a sedimentary seafloor or, in some areas, by rocks.

In environmental terms, *Posidonia oceanica* meadows represent the most important areas in this part of the Island. The *Posidonia oceanica* meadows and their banquettes play an important role in the absorption of CO<sub>2</sub> from the atmosphere, increase of transparency of sea water, reduction of wave intensity and consequently, protection of the coast against erosion, oxygen production, consolidation of sediment and prevention of its removal, importance in the circulation of nutrient salts (nitrates and phosphates) and are also relevant as bioindicators of the sea state and the accumulation of heavy metals. The Posidonia beds represent areas of the greatest biodiversity, and facilitate the formation of deposits on the shore and the establishment of gravel berms.

Threats and problems identified for the ecological network area primarily include: tourism and its related activities, such as (docks/touristic ports or recreational piers, nautical tourism/anchoring, diving, fishing, collection of living marine resources, other outdoor sports and recreational activities), presence of garbage and solid waste, marine pollution (plastic bags, styrofoam) and temperature changes (e.g., increase of temperature and extreme events). Plastic and other waste found in Posidonia deposits poses yet another problem for Sakarun beach. Development and growth of nautical tourism, and consequently the construction of nautical ports, inadequate anchoring of vessels and general pollution of the sea and coast caused by waste, bilge water and faecal contamination, have undermined the marine environmental quality.

The ecological network is facing additional risks in the future such as further development of tourism and the expansion of the tourism-related area (on land and sea) as specified under Spatial Plan, such as planned tourist resorts, areas intended for developed beaches (on land and sea) in the villages of Soline, Veli Rat and Verunić.

This Natura 2000 site is described in the Annual Plan of the Public Institution "NATURA JADERA" as an endangered area, specifying that the features of the area have been undermined / endangered, consequently, requiring that its use be changed, revitalized and /or that additional protection measures be undertaken. In particular, the Posidonia beds are endangered as a result of illegal anchoring outside the concession zone. Accordingly, the Annual Plan envisages that the concession zone for anchoring be moved.

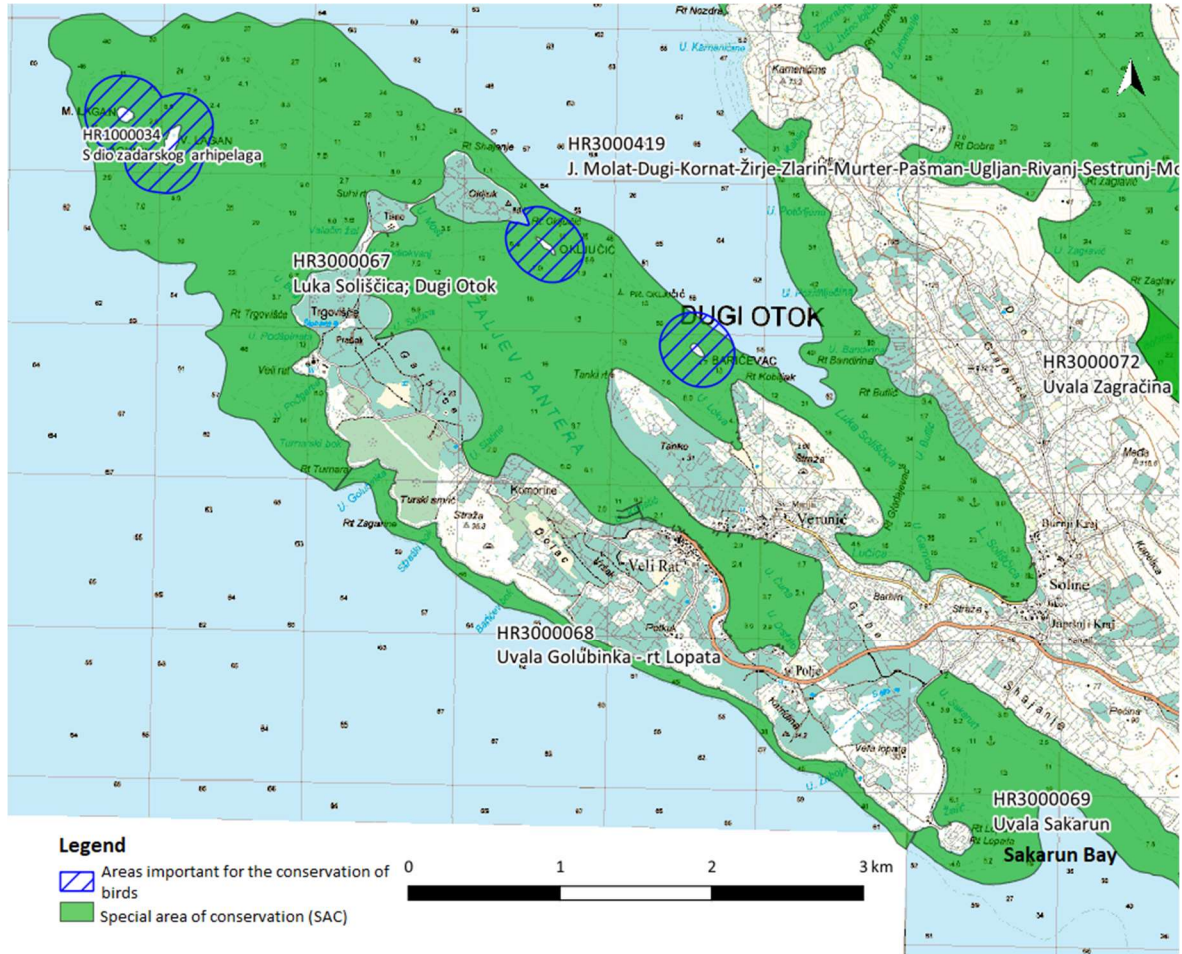


Figure3: The area of ecological network in the northwestern part of Dugi Otok

Source: Bioportal, <http://www.bioportal.hr/gis/>



### 3. Legal framework

Relevant laws and bylaws regulating the issue of Posidonia banquettes in the Republic of Croatia are as follows:

Nature Protection Act (OG 80/13, 15/18, 14/19, 127/19)

*Posidonia oceanica* is a strictly protected plant species pursuant to the Nature Protection Act. Furthermore, under Article 153 of the Nature Protection Act it is prohibited to *pick, cut, clear, dig up, collect or destroy strictly protected plants*, fungi, lichens and algae in their natural area of distribution.

Regulation on the list of habitat types and maps of habitats (OG 27/21)

According to Annex II to this Regulation - endangered and/or rare habitat types of national and European significance which are present on the territory of the Republic of Croatia, habitat G.3.5. *Posidonia beds* (Natura: \*1120; Bern – Res. 4.: has been identified as an endangered and/or rare habitat type of importance for both the Republic of Croatia and Europe.

Regulation on strictly protected species (OG 144/13, 73/16)

The Regulation declares strictly protected species and prescribes: detailed content of the application for a permit to depart from strict protection measures, treatment of dead or injured specimens of strictly protected species, content, method of preparation and procedure for adoption of a management plan for strictly protected species, together with an action plan, additional marking rules for strictly protected species, exceptions to the prescribed marking methods and the procedure in case of damage or loss of the original mark of the strictly protected species.

Pursuant to the provisions of Article 4, paragraph 3 of the Regulation, all provisions apply to both living and dead individual animals of strictly protected species, in all their developmental stages. *Posidonia (Posidonia oceanica (L.) Delile)*, also known as Neptune grass or Mediterranean tapeweed, is a strictly protected species and is listed in Annex 1 to this Regulation.

Strategy for Management of Marine Environment and Coastal Area and the Program of Measures for the Protection, Management of the Marine Environment and Coastal Zone of the Republic of Croatia (OG 97/17)

The Strategy for Management of Marine Environment and Coastal Area and the Program of Measures for the Protection, Management of the Marine Environment and Coastal Zone of the Republic of Croatia define as one of the goals and relevant measures:

2. *Capacity building for the management and protection of the marine environment and the coastal area*

### 2.3. Measures to identify and evaluate priority areas for the conservation of marine and coastal biodiversity

#### 2.3.1. Conservation of marine habitats by reducing anthropogenic-related eutrophication, pollution and other activities

#### Physical Planning Act (OG 153/13, 65/17, 113/18, 39/19, 98/19)

Pursuant to the relevant Act and its Article 56, it is prescribed that *spatial plans, depending on their level and scope, must contain or prescribe spatial indicators, spatial standards, cartographic presentation of the use of space, area surface or land, and also infrastructure corridors, conditions relevant for the implementation of the spatial plan, the development level of the area, environmental protection measures, nature protection requirements, cultural heritage and other protected values, and other necessary textual and graphical sections which prescribe the conditions for spatial developments, conditions and rules which regulate conditions on the site when carrying out activities in the specific area.*

#### Spatial Development Plan of the Municipality of Sali ("Official Gazette of the Municipality of Sali" No. 03/21)

Pursuant to Item 6.2. specifying measures for the protection of natural values, or more specifically, in line with *the provisions for the implementation of the Spatial Development Plan of the Municipality of Sali*, nature protection measures are prescribed, and apply, inter alia, to coastal habitats and Posidonia beds and within the Significant landscape NW Part of Dugi Otok Island (Article 170):

- *All activities are to be planned in such a way so as to prevent any adverse impact on protected areas and to avoid actions that could undermine the features based on which those areas have been granted their protected status.*
- *Biological species important for the habitat type are to be conserved, and alien (non-native) species and genetically modified organisms are not to be introduced.*
- *The existing landscape values are to be preserved to the greatest possible extent and planned activities in the area must not adversely affect the landscape values of the area.*
- *Composition and structure of the seafloor, coastline and coastal area are to be conserved in their original form as much as possible.*
- *In areas with natural coast, current state and appearance of the coast is to be preserved.*
- *All projects in the water area, which could adversely affect the coastline, habitats and the conservation of the ecological network, must be limited.*
- *Special care is to be taken to protect the underwater Posidonia oceanica habitats and to limit anchoring and backfilling in the area of their habitat.*

**Conclusion:**

The current legal framework of the Republic of Croatia recognizes the importance of Posidonia seagrass in its natural habitat – meadows. In addition, legal provisions prescribe the protection of dead leaves of this strictly protected species, however there are no special provisions referring to the possible use of Posidonia as a potential raw material.

Although dried Posidonia oceanica (as is the case with Posidonia banquettes) may be used as raw material, i.e. it can be used, for example, as an effective and cheap thermal insulation (as used in the project "*Life Reusing Posidonia*", Spain, 2021), such a use of Posidonia has not yet been regulated and implemented by the Republic of Croatia.

#### 4. Objectives and purpose of the Action Plan

The aim of this Action Plan is to establish a planning framework that would make the management of *Posidonia* banquettes, seagrass ecosystems, and coastal landforms (berms, dunes, etc.) a part of the sustainable practice of managing protected areas in the Mediterranean.

The purpose of the Action Plan is to examine possible management strategies, assess scenarios, put in place mechanisms to monitor changes, and identify a set of solutions that best safeguard the good state of the environment in protected areas, reduce a possible impact caused by management strategies and promote the natural Mediterranean landscape.

The northwestern area of Dugi Otok is recognized as a significant natural, landscape, cultural area and *Posidonia* beds with *Posidonia* banquettes which accumulate on the coast there represent an important environmental factor, that needs to be defined, in terms of protection, economy and social aspects, within a management action plan.

The following are the main activities of this Action Plan:

- establish area of intervention and area with no intervention
- implement activities directly on *Posidonia* banquettes
- implement activities in the backshore
- implement activities at sea
- build capacities, raise awareness and provide educational activities

## 5. Assessment of the current state of Sakarun beach

The coastal area is shaped through the interaction of the land, sea, and atmosphere, giving it its dynamic and changeable nature. Beaches are coastal landforms, consisting of unconsolidated sedimentary material and usually without any vegetation. They usually include the zone between the mean low water line and extend further up the shoreline until they reach the next geomorphological landform, vegetation area, or anthropogenic forms.

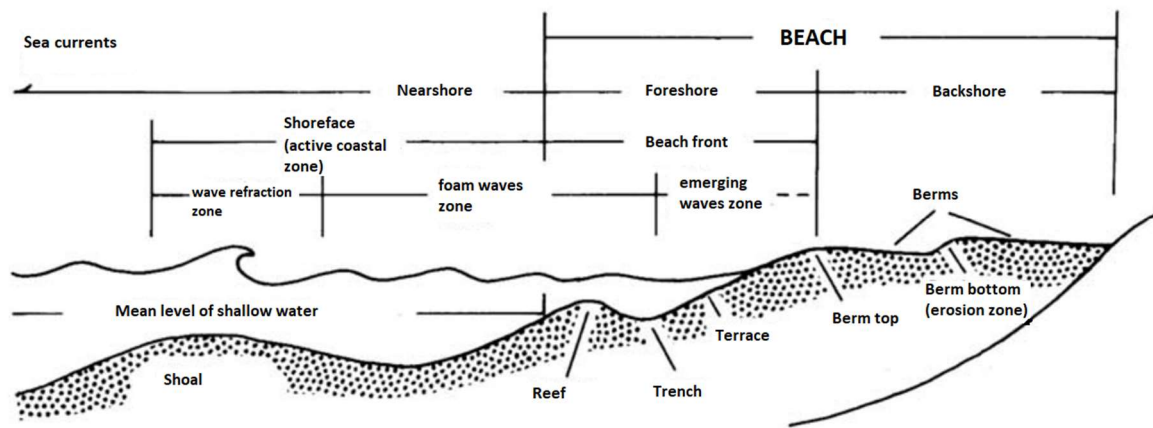
Sakarun beach on Dugi Otok is mostly built of carbonate pebbles, originated from the mechanical erosion of the underlying carbonate bedrock, caused by the wave activity. Minor part of the beach within the intertidal area is covered with sand of marine origin. Due to the beach orientation toward Jugo waves, the beach is susceptible to the formation of *Posidonia oceanica* banquettes. Beach sediment and banquettes build biogeomorphological structures, which play an important role in geomorphological processes on the shore, making it more resilient to external processes (e.g., wind and waves) and protecting it against further erosion.

### ANALYSIS OF THE COASTLINE CHANGES

The second preliminary report on geomorphological analysis of Sakarun beach<sup>1</sup> includes an analysis of beach profiles carried out in order to analyse coast morphology and identify any changes. Beach profiles provide useful information in beach morphology analysis as well as for monitoring studies and management purposes. Furthermore, beach profiles may reveal vulnerable beach segments particularly vulnerable to episode events, such as storms. They also provide a general insight into rapid beach morphology changes related to anthropogenic factors, such as usage for touristic purposes.

A beach profile refers to a cross-sectional trace of the beach perpendicular to the high-tide shoreline. It extends from the backshore structures (natural or anthropogenic; dunes, cliffs, walls etc.) to the subtidal area in which sediment is not transported to and from the beach. Naturally, beaches undergo seasonal changes, resulting in two typical profiles: a lower winter profile and a higher summer profile. Erosion plays a vital role in winter profile. The removed material accumulates and creates submerged shoals and reefs in the underwater coast area. A summer profile results from accumulation of materials on the shore during warmer and calmer (with fewer storms) season.

<sup>1</sup> Geomorphological analysis of Sakarun beach - Preliminary report II; doc. Kristina Pikelj, PhD, June 2021



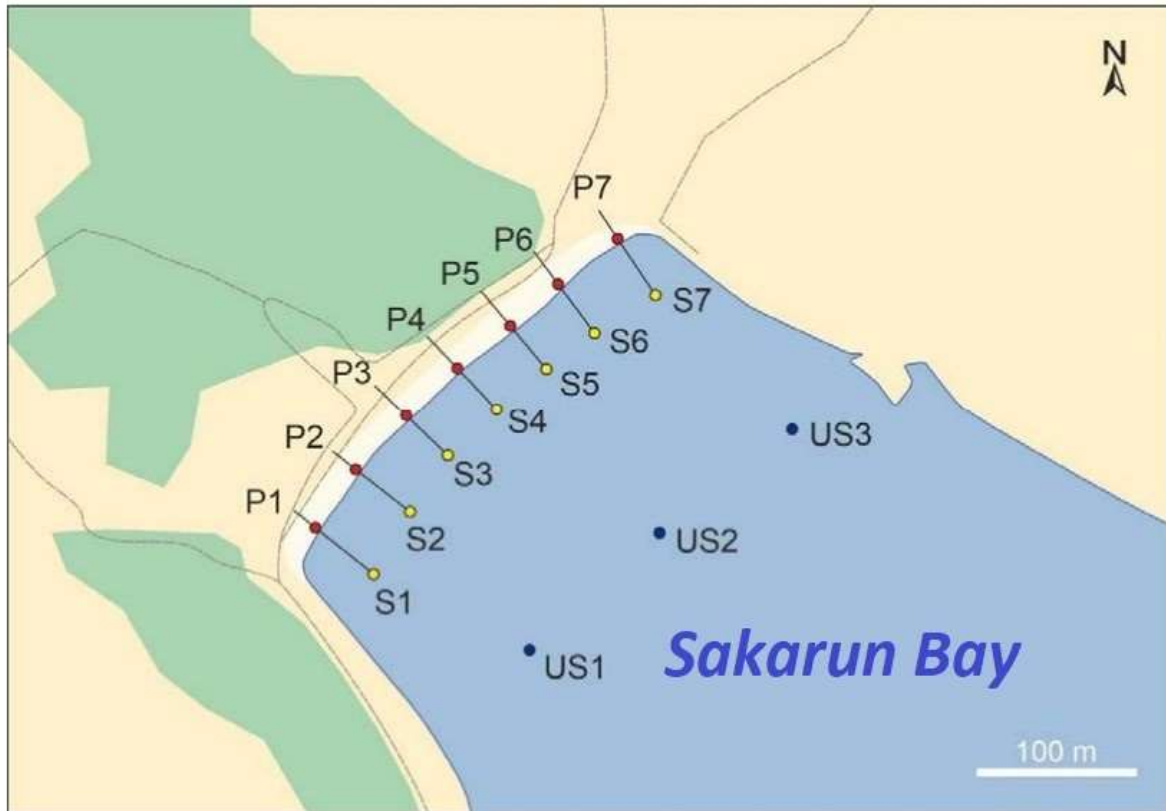
**Figure 5-1: A simplified overview of beach profile and near-shore areas, indicating main zones and landforms (according to Chrzastowski, 2005)**

Source: *Geomorphological analysis of Sakarun beach (2nd Report)*

Changes in the beach profile are usually caused by the interaction of waves and changes in the sea level combined with the grain size of the beach sediment. Landforms that can be found on the coastal section of the beach are as follows: berms (ridges formed by accumulated sediment, caused by the waves and landward transport of sediment) and steep slopes (sudden changes in beach elevation, caused mainly during storms), whereas reefs and trenches, and sometimes shoals, can be found in underwater area.

### PROFILE ANALYSIS OF SAKARUN BEACH

Changes in the profiles of Sakarun beach revealed changes in general beach morphology, mostly related to Posidonia banquettes erosion and accumulation, as well as with significant anthropogenic activity. The monitoring of profile changes on the Sakarun beach was carried out on seven profiles during nine months. The length of beach profiles depended on the tides and waves. Sakarun beach profiles and their changes were monitored in order to determine changes in the morphology of landforms (gravel berms, shoals), Posidonia banquettes, and significant anthropogenic impact.



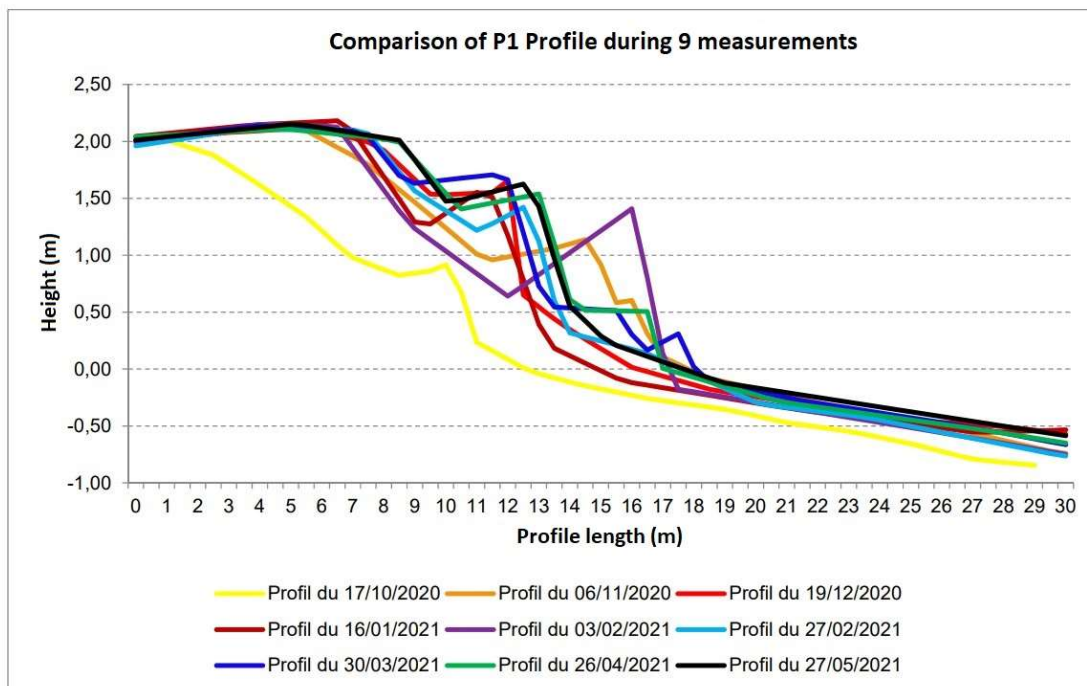
**Figure5-2: Approximate position of the beach profile (P1-P7) and sediment sampling locations (P1-P7: beach sediment; S1-S7: shallow intertidal sediment; US1-US3: seabed surface sediment)**  
(Source: *Geomorphological analysis of Sakarun beach (II. Report)*)

Profiling of Sakarun beach was made using a precise GPS device, with an accuracy of 2 cm horizontally and 4 cm vertically, in such a way that the GPS position is recorded each time along the profile when a significant change in the height of the beach along a particular profile was observed.

## INTERPRETATION OF SAKARUN BEACH PROFILE

### Profile P1

On the profile P1, a significant amount of Posidonia banquettes were recorded during the monitoring period compared to other beach profiles. Furthermore, the largest thickness of the banquette (>2 m) was recorded in this beach segment. The largest change along the Profile 1 was detected between the second and the third measurements (November/December), after an extremely strong storm after which the thick banquet was formed. The banquette remained thick during most of the monitoring period. However, the gradual lowering of banquette was detected during an incoming couple of months, indicating the absence of strong storms and the presence of waves frequent waves, powerful enough for the gradual erosion of the banquette. Another strong storm occurred in the middle of the monitoring period (February): the banquette was restored with new Posidonia leaves and the maximum height of the banquette was recorded (>2 m). The last three measurements did not show any significant changes along the Profile 1. In conclusion, Profile 1 showed general stability in banquette formation, except during storms. The most prominent morphological feature along the Profile 1 during all measurements was a steep step at the distance of approx. 10 m from the beginning of the profile, presenting an abrupt end of the Posidonia banquette and its contact with the sea. Sandy sediment, usually found in front of the banquette, was continuously eroded and accumulated, however, in general, the banquette height was not changed much.

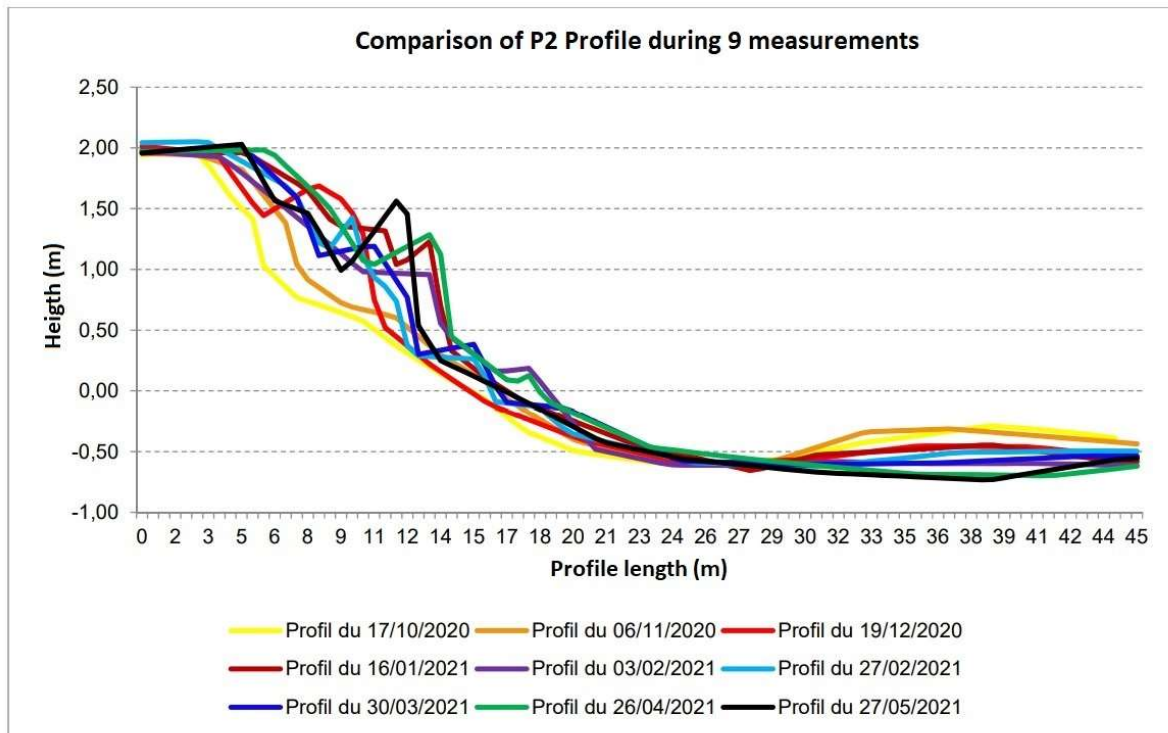


**Figure 5-3: Change of Profile P1 during nine field trips.**  
(Source: Geomorphological analysis of Sakarun Beach (II. Report))



Profile P2

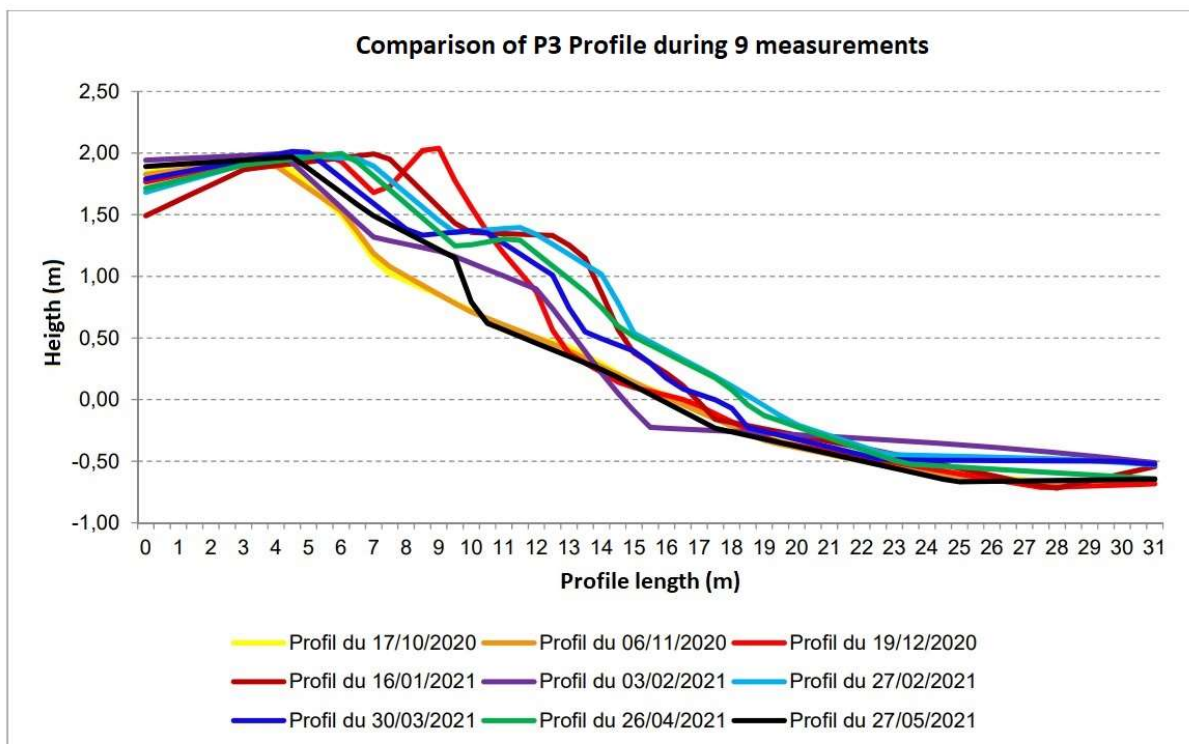
Changes along the Profile P2 were similar to those of the Profile P1. During stable weather conditions, changes were minimal, and after storms (after the second and fifth measurements) a significant deposition and a sharp increase in the height of the banquet was observed. Winter conditions and frequent waves were observed as a visible loss of sandy sediment in the shallow subtidal in front of the beach (approx. at the distance of 35 m from the beginning of the profile), where the submerged sand ridge was gradually moved away from the beach. At the end of the measurements, the sand ridge was completely replaced by the trough. Such sand ridge movement is a typical feature of semi-exposed beaches with Posidonia banquettes.



**Figure5-4: Change of Profile P2 during nine field trips.**  
(Source: Geomorphological analysis of Sakarun Beach (II. Report))

### Profile P3

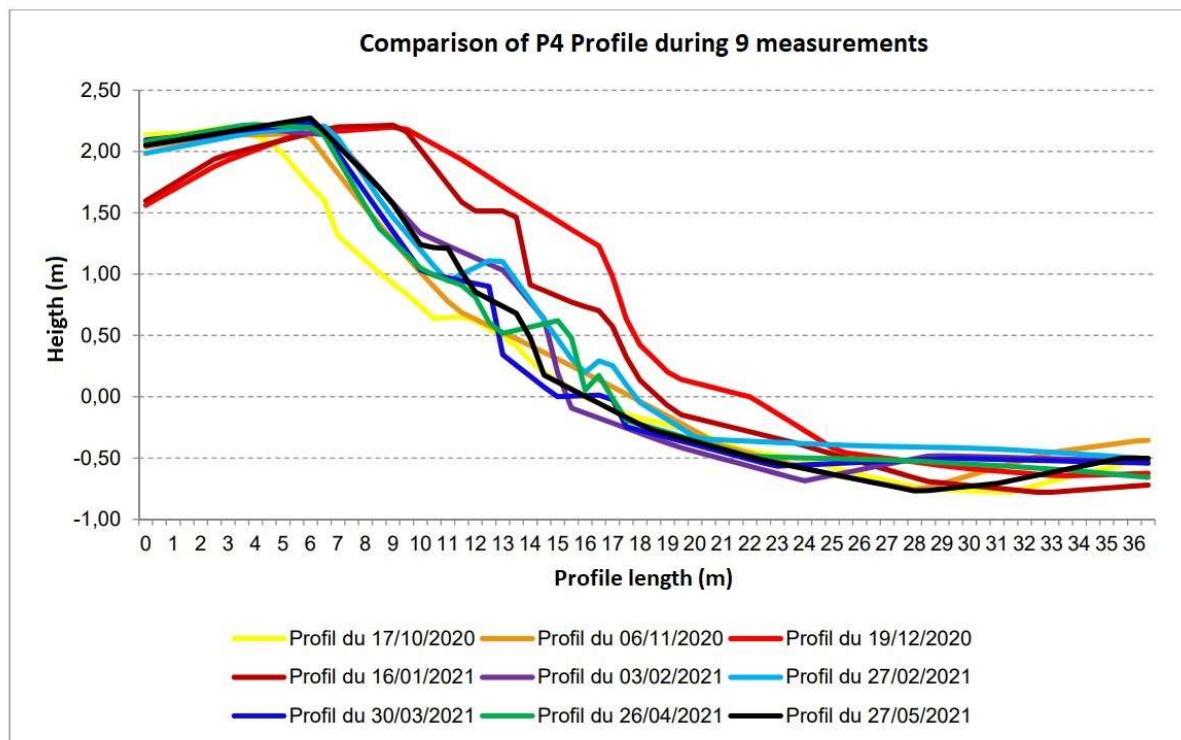
The most prominent change along the Profile 3 was the restoration of the banquette after the first strong storm. Profile P3 is located in the line of one of two main access roads to the beach. During the monitoring period, the anthropogenic impact was notable as many cars entered the beach within the area of the Profile 3. Such anthropogenic interference caused the highly variable height of a gravel berm at the beginning of Profile P3. Similar to the case of Profiles P1 and P2, a significant increase in *Posidonia* deposits was observed in the period after storms, while slight decrease in banquette height was observed during more stable weather conditions due to gradual erosion. The most prominent change in banquette shape and size (significant reduction in *Posidonia* deposits) was recorded in May, which was directly attributed to preparations for *reality* show filming during upcoming months (May and June).



**Figure 5-5: Change of Profile P3 during nine field trips.**  
(Source: Geomorphological analysis of Sakarun Beach (II. Report))

### Profile P4

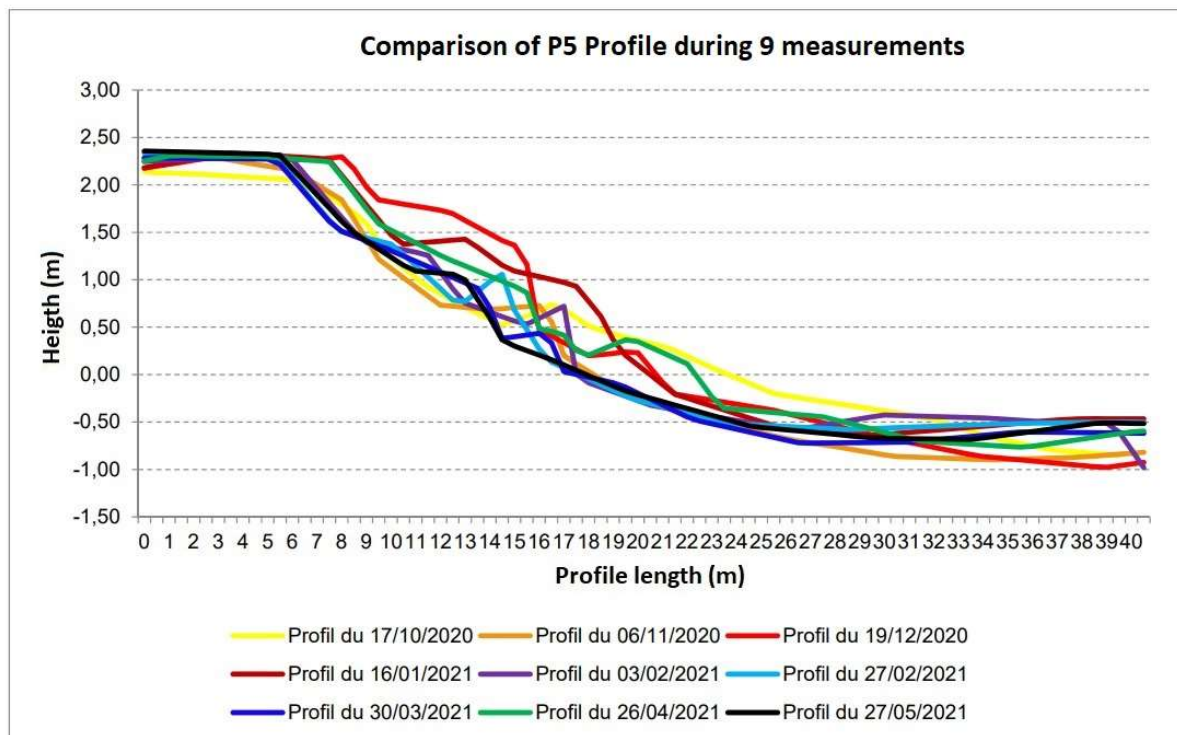
Profile P4 is located between two access roads to the beach, and thus it is heavily exposed to increased anthropogenic pressure, similar to the Profile 3. During winter period decreased anthropogenic pressure was observed, and accumulation of Posidonia leaves was recorded after storm events, indicating that thickness of the banquette directly depends on after-storm weather conditions. Restoration of its banquettes showed the similar dynamic as in the case of the first three profiles, however, unlike end profiles, its dynamic was much greater. Such change is attributed to the location of the Profile 4 in the central segment of the beach. Namely, small variations of incident angle of the most common Jugo waves may significantly increase or decrease the impact of the end profiles, however, the central segment of the beach is permanently affected by the wave action. Accordingly, the largest changes in the intertidal were recorded along the Profile 4, at a distance of about 30 m from the beginning of the profile, ranging from complete coverage by the thick sandy sediment layer to the exposure of the carbonate bedrock after the sand erosion, and to the complete coverage with Posidonia dead leaves after sand erosion and formation of shallow trough. Similar to Profile 3, during the last measurement in May Posidonia banquettes disappeared from the bottom of the profile, which is attributed to human activities and preparations for reality show.



**Figure 5-6: Change of Profile P4 during nine field trips.**  
(Source: *Geomorphological analysis of Sakarun Beach (II. Report)*)

### Profile P5

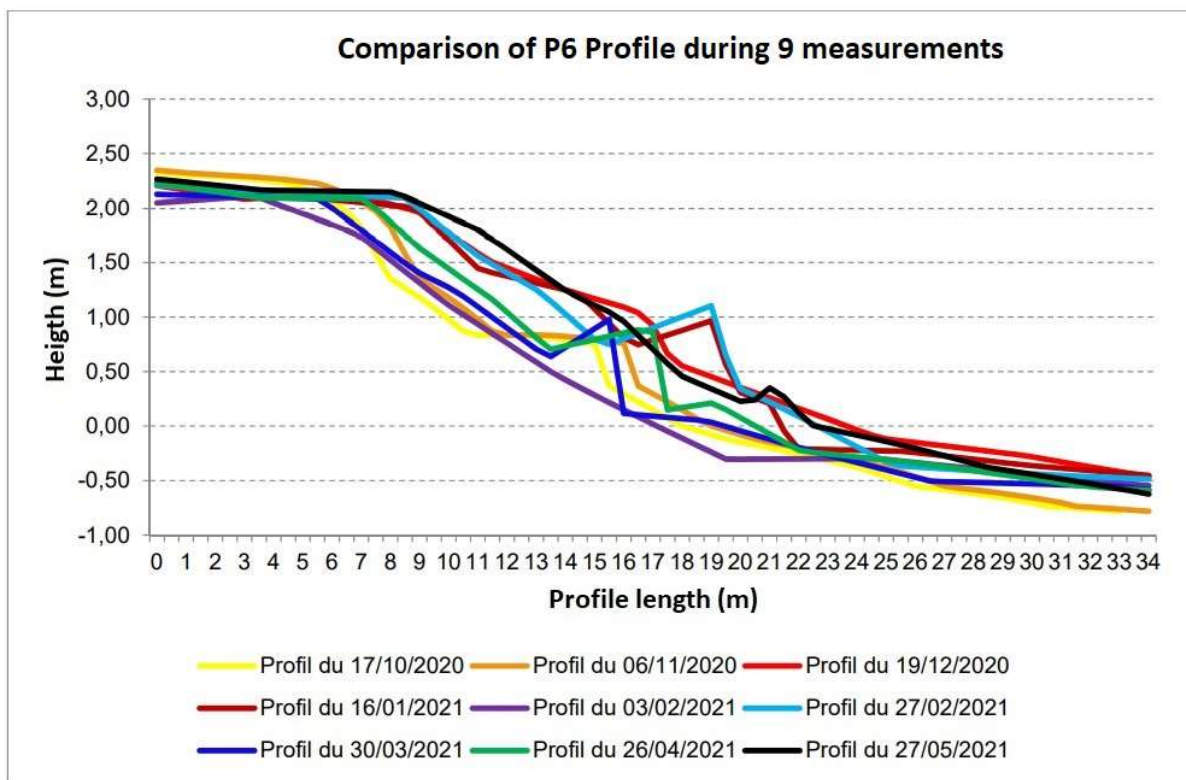
Profile P5 is also located in the zone of increased anthropogenic pressure. In contrast to Profiles 1-4, for which no significant change was recorded during the first two measurements, for Profile P5 in this period, significant erosion of the Posidonia banquette was recorded and it is attributed to the anthropogenic impact. Similar to other beach profiles an increased Posidonia deposition was recorded after the storm in December. A significant proportion of wet and submerged Posidonia leaves were accumulated in the shallow intertidal in the formed through, showing that the beach segment around the Profile 5 is both, constantly impacted by the waves and under anthropogenic pressure. Due to lowered wave energy during February, a slightly eroded banquette was restored with new Posidonia leaves. In May, during the period of stable weather conditions banquette erosion was recorded, which is attributed to human impact and preparations for the *reality* show.



**Figure 5-7: Change of Profile P5 during nine field trips.**  
(Source: *Geomorphological analysis of Sakarun Beach (II. Report)*)

### Profile P6

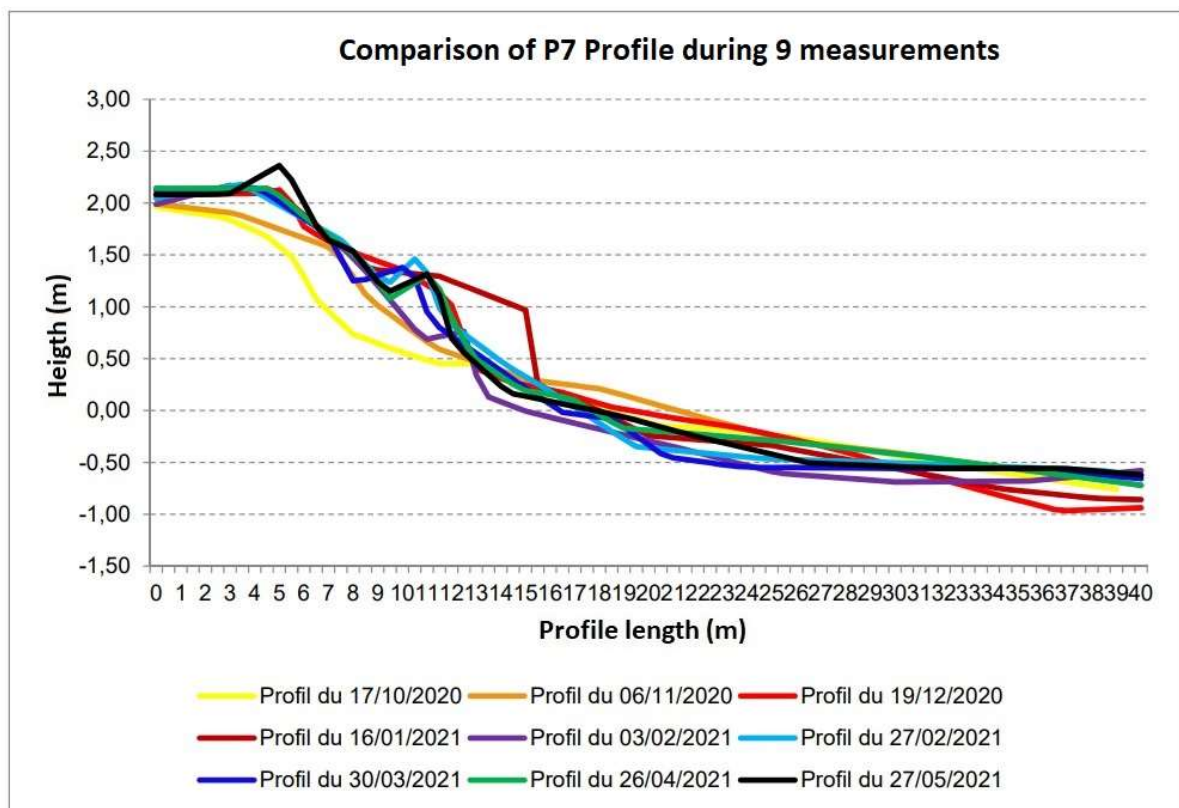
Profile P6 is located at one of the most visited parts of Sakarun Beach, where changes caused by human activities were expected. The greatest dynamic along P6 Profile was recorded at the bottom of the banquette, at a distance of about 18 m from the beginning of the profile. During the first two measurements, there were no significant changes along the profile. After the storm in December, the amount of Posidonia leaves and sediments increased in the shallow intertidal. At the end of January, a significant proportion of banquettes was eroded, which cannot be explained by the weather (and wave) conditions since there was no evidence of erosive processes in that period. Otherwise, the erosion should be visible along the whole beach. In the period after the February storm the size of banquettes increased, especially in contact with the sea. Mild variations in size of banquettes were observed from March to May, ranging from erosion along the entire profile to a slight deposition during May. It is assumed that during the dismantling of scenery used for the reality show some amount of the Posidonia banquette was removed from the lower part of the profile to the berm.



**Figure 5-8: Change of Profile P6 during nine field trips.**  
(Source: Geomorphological analysis of Sakarun Beach (II. Report))

### Profile P7

Profile P7 is an end profile located along the northeasternmost edge of Sakarun Beach. During the monitoring period, significant changes were recorded along this profile, starting with the almost complete absence of banquettes in October, with only a thin layer of Posidonia leaves (probably the result of the end of tourist season), combined with the notable amount of sandy sediment. After the December storm this sediment was covered with new banquettes. Mild erosion lasted until February when the thickness of the banquette increased again after the storm, and this condition remained unchanged until the end of March. A slight increase in sand and less in Posidonia banquettes occurred during April, while no significant changes were recorded until the end of May. Long-lasting retention of accumulated sand and Posidonia banquettes along the Profile 7 indicates that this part of the Sakarun Beach is a morphodynamically stable part of the beach, similar to the beach segment monitored along the Profile 1.



**Figure 5-9: Change of Profile P7 during nine field trips.**  
(Source: *Geomorphological analysis of Sakarun Beach (II. Report)*)



## CHARACTERISTICS AND ORIGIN OF GRAVEL ON SAKARUN BEACH

Characteristics and origin of gravel on Sakarun beach are taken from Geomorphological analysis of Sakarun beach<sup>2</sup>). Samples of gravel pebbles were collected from a berm at the middle of the northwestern section of the beach and in the backshore of the middle section of the beach. Analysis of thin sections of gravel pebbles showed their carbonate composition.

Microfossil content found in gravel pebbles plays an important role in depositional environment characterization of the initial stage of carbonate rock formation. Pelagic particles found in the carbonate mud indicated a deep-sea environment, while, the presence of benthic foraminifera, rudist bioclasts, and carbonate lithoclasts pointed to the downward sediment movement and deposition in deeper areas, i.e. the formation of carbonate turbidite breccia.

The comparison of lithofacies found in basement carbonate rock and carbonate pebbles showed that gravel sediment on the beach originates from the underlying base rocks under the Sakarun beach. Due to its composition (breccia) and the tectonic disturbance (sub-vertical rock layers) carbonate bedrock is susceptible to mechanical weathering. This weathering is facilitated by the orientation of the Sakarun Bay and the Sakarun beach to the dominant Jugo waves. Weathered base rock is resulting in angular carbonate debris or broken fragments, gradually shaped by the waves into well-rounded beach gravel sediment. Gravel fraction builds most of the beach body and it is often mixed with Posidonia leaves and admixed within Posidonia banquettes in various proportions.

## CHARACTERISTICS AND ORIGIN OF SAND ON SAKARUN BEACH

Preliminary sampling of the sandy fraction of the beach sediment was carried out during the first fieldwork. Sediment samples were collected in the intertidal along profiles P1, P4, P7, after which the sampling was repeated on all profiles (P1-P7) along the intertidal and shallow subtidal zone (S1-S7) (Figure5-2).

Granulometric analysis of the sandy fraction of the beach sediment revealed mainly uniform sedimentological characteristics: slightly gravelly sand, with the domination of medium to fine-grained sand fractions of predominantly carbonate composition (> 93%). As for mineral composition, calcite /magnesium calcite and aragonite dominate in all samples. In addition, bioclast grains predominate in all samples, while rare lithoclasts were found only in coarse sand fractions (1-2 mm) and fine gravel (2-4 mm). Subtidal sediment samples showed the same characteristics, except being slightly finer.

In general, sand collected along the Sakarun beach is of marine origin, consisting dominantly of skeletal and shell remains of marine organisms (bioclasts), accumulated on the seabed and transported to the beach by waves. Based on recognized bioclasts it was concluded that much of the organisms lived attached to the Posidonia leaves (e.g. foraminifera, gastropods) or in other parts of Posidonia meadow (mollusks in general), showing that a significant proportion of biogenous sediment originates from Posidonia meadows at the entrance or outside the Sakarun Bay.

<sup>2</sup> Geomorphological analysis of Sakarun beach - Preliminary report I; doc. PhD  
Kristina Pikelj and Petra Godec, univ. Bacc. Geol., March 2021

The results of conducted analyses showed that the sand fraction is almost entirely of marine origin (with rare lithoclasts originated from carbonate pebble weathering). Such a setting is extremely rare along the Croatian coast, where sandy beaches are generally rare and mostly composed of terrigenous sand. According to this, the Sakarun beach may be considered a unique example on the Croatian coast.

Marine organisms community found in the beach sand largely originates from Posidonia meadows. The seabed in Sakarun Bay is mostly bare, with sparse Posidonia meadows, mostly at the exit of the Bay and in its surrounding areas. Exposure to the Jugo waves is the main factor of sediment transport into the Bay, and consequently on the beach.

Biogenic marine sandy sediment accounts for a minor part of the total sediment on the Sakarun beach. At the same time, sandy sediment is the most desirable sediment of the beach, because of which the Beach is famous among tourists. Arough estimation of the sediment rate of biogenous marine sediment in the temperate realm revealed that only 14,000 m<sup>3</sup> of marine biogenic sediment can be formed within the Sakarun Bay in a period of 1000 years or in other words 14 m<sup>3</sup> per year.

### CHARACTERISTICS AND ORIGIN OF SEABED SEDIMENTS IN SAKARUN BAY

All sediment samples in Sakarun Bay were taken from a depth of 2 to 5 m. Conducted analyses have shown that this sediment is of properties similar to ones of sandy sediment collected on the beach. In general, it is predominantly carbonate fine-grained marine sand. Dominating minerals are calcite, magnesium calcite, and aragonite, all typical for marine bioclasts, the almost only component of the Sakarun Bay surface sediment cover. Accumulation, comminution, sorting, and transport of this sediment is due to wave action.

### CHARACTERISTICS AND ORIGIN OF SEDIMENTS FROM POSIDONIA BANQUETTES

Sediment found within a different part of banquettes along the Sakarun Beach is mostly sand, deposited together with Posidonia leaves or subsequently added to banquettes by repetitive wave action. The composition and grain size of the sand population found within banquettes is similar to those of sediment collected on the beach and in the Bay: it is sandy sediment is of marine biogenic origin with a high carbonate content. The minor part of sediment collected from banquettes during the monitoring period was carbonate gravel, admixed from the beach into the banquette.

The average amount of sediments in Posidonia banquettes during the entire monitoring period is ~ 64 kg/m<sup>3</sup>. Sediments proportion is larger in parts of banquette directly exposed to the sea, while the proportion of gravel material increases landward. The banquette face is the most exposed to mild waves which supply the banquette by splashing sand particles directly into the banquette from suspension. Gravel population is usually admixed during stronger waves, after the weakening of the storm. Without human activities of Posidonia leaves removal, banquettes remain full of gravel until the next storm when banquettes are eroded and further mixed with gravel.



## POSIDONIA BEDS IN BAYS IN THE NORTHWESTERN PART OF DUGI OTOK ISLAND

Research on *Posidonia oceanica* seagrass beds carried out in the area in the past decade includes mapping of selected locations and monitoring the condition of Posidonia beds. As an area for priority habitat 1120 "Posidonia beds", the survey of beds in the pilot area of Sakarun Bay has been conducted on several occasions with a different focus.

In 2009 Association "Sunce" conducted field research and developed an expert study "Marine biodiversity of the waters along the significant landscape in the NW part of Dugi Otok". The scope of the document and field research included measuring the status and trends of *Posidonia oceanica* seagrass beds. A total of 14 locations were surveyed among which 13 locations are positioned in the NW part of Dugi Otok. Locations are listed in Table 2. The sampling location in Sakarun Bay is marked in bold.

**Table5-1: Average density of posidonia beds at sampling locations, n=13**

(Source: Marine biodiversity of the waters along the significant landscape in the NW part of Dugi otok), Expert study, "Sunce" Association, Split, 2009.

Location	Average density
Pantera Bay_1	129.19/m <sup>2</sup>
Solišćica Bay_3	167.19/m <sup>2</sup>
Solišćica Bay_1	174.19/m <sup>2</sup>
Solišćica Bay_2	189.56/m <sup>2</sup>
Potčrljena Bay	226.69/m <sup>2</sup>
Veli rat (lighthouse)	281.69/m <sup>2</sup>
Shajanje	297.94/m <sup>2</sup>
Mali Lagan	321.38/m <sup>2</sup>
Sakarun Bay	325/m <sup>2</sup>
Podgarba Bay	354.56/m <sup>2</sup>
<b>Sakarun Bay_1</b>	<b>363.56/m<sup>2</sup></b>
Cape Lopata_1	381.25/m <sup>2</sup>
Mežanj_1	414.56/m <sup>2</sup>

Taking into account all average shoot densities at different depths and at all surveyed locations, the best status was determined in the area of the island of Mežanj, where the total average shoot density was 414.56 leaf shoots per m<sup>2</sup>. The worst status was recorded in Pantera Bay, where the shoot density was only 129.19 shoots per m<sup>2</sup> as well as in the bay Solišćica, where the average shoot density ranged between 167.19 and 189.56 leaf shoots per m<sup>2</sup>. Results obtained from the research performed by "Sunce" association clearly demonstrate that geographical position has an impact on the status of Posidonia beds. In more exposed locations, a higher shoot density was observed, while in more sheltered locations, the shoot density was significantly lower.

Marine Explorers Society - 20.000 leagues conducted a field survey in Sakarun Bay during June 2016. Marine habitats in the selected area were mapped. The entire habitat of the seagrass *Posidonia* in the area of Sakarun Bay was mapped and the geomorphological characteristics of the bay were recorded. As part of the research, the wider area of Sakarun Bay was surveyed, including Cape Lopata and Mala and Velika Miholjina Bays. *Posidonia* seagrass beds are located in the central part of the Bay (Figure 5-10). Seagrass beds demonstrate a fragmented discontinuous pattern (patch) in the form of islands with intermittent patches of sand or rocks.



Figure 5-10: The map of *Posidonia* seagrass beds in the selected area is marked in green

(Source: *Exploration of seagrass meadows (Posidonia oceanica) in Sakarun bay*), Zadar county, 2017, Expert report, Marine Explorers Society - 20.000 leagues

Mapped areas of *Posidonia* seagrass beds account for 110 hectares within that particular Natura 20000 site. Based on the data available prior to that period and the official habitat map, the surface under *Posidonia* seagrass beds accounted for 127 hectares, which is 17 hectares more than obtained by this research (Figure 5-11). Because of these differences, a detailed map of marine habitats with a focus on *Posidonia* seagrass beds has been made. A bathymetric map of the area has also been made (Figure 5-12).

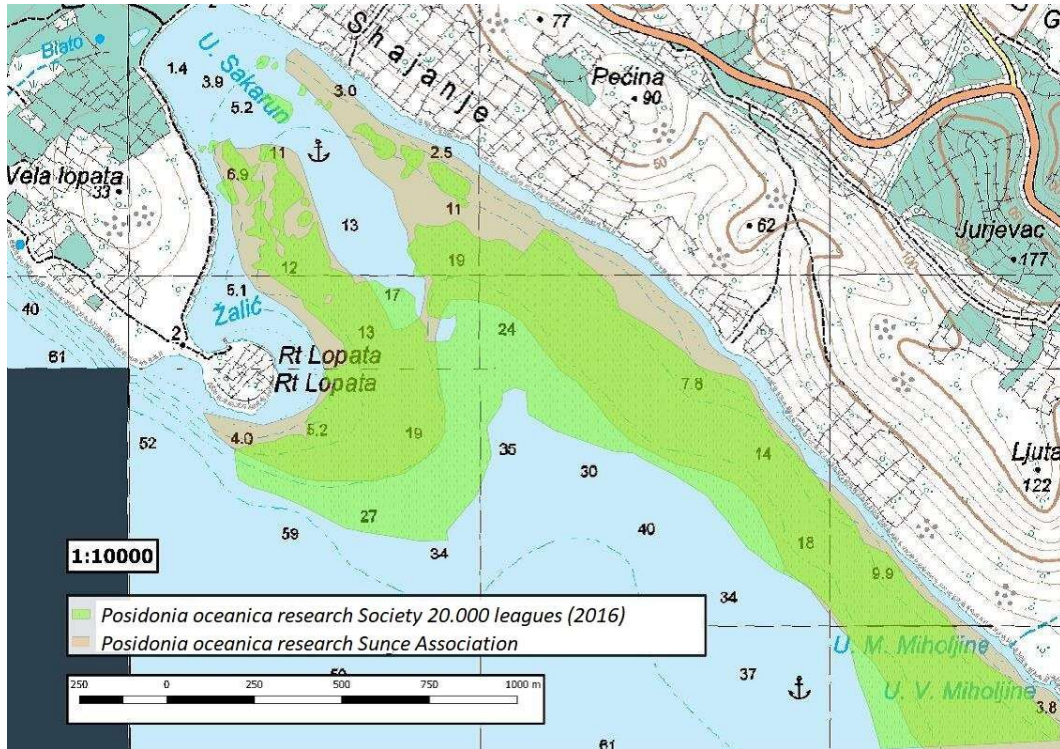


Figure 5-11: Comparison of data obtained from two studies with different methodologies, diving with GPS and sonar

(Source: Exploration of seagrass meadows (*Posidonia oceanica*) in Sakarun bay), Zadar county, 2017, Expert report, Marine Explorers Society - 20.000 leagues

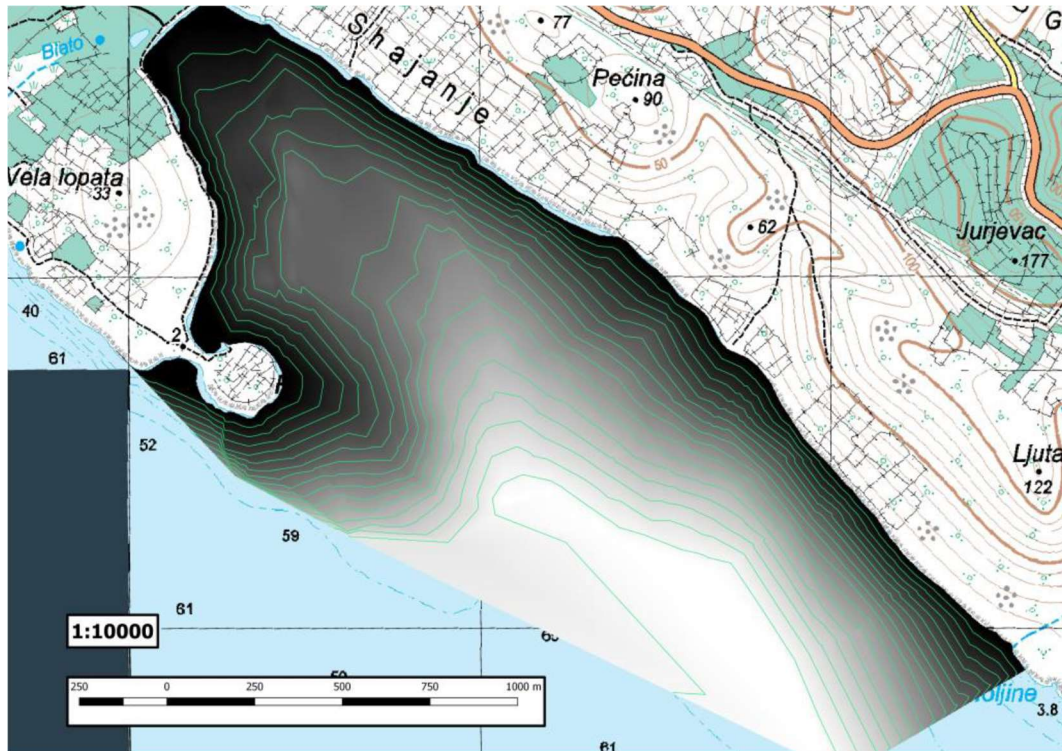


Figure 5-12: Bathymetric map of the area made using sonar and data processing in GIS software

(Source: *Exploration of seagrass meadows (Posidonia oceanica) in Sakarun bay*, Zadar county, 2017, Expert report, Marine Explorers Society - 20.000 leagues

The obtained results contributed to the completion of Natura 2000 habitat map of the sea area of Sakarun Bay and enabled conditions for putting forward a proposal for establishing a monitoring system of *Posidonia* seagrass beds.

As a follow up on the research conducted in 2016, within the project *Monitoring the condition of seagrass habitats and meadows (Posidonia oceanica) in selected areas of ecological network in Zadar county*, a field research was conducted in September 2020 in the area of Ecological network within a significant landscape where *Posidonia oceanica* beds are priority habitat type. The research was conducted in the area HR3000067 Luka Solišćica; Dugi Otok. The research of the selected habitat of *Posidonia* seagrass beds was conducted at two locations within the Natura 2000 area with fairly low uniform features including areas with visible human impact and areas with no human impact. Each location had three sampling stations. Location within impact area is situated at the bottom of Stolišćica port, in the immediate vicinity of Soline settlement, while sampling stations in the area with no human impact were positioned in the shallow bay Valačin žal at the open sea opposite Lagnić. Natura 2000 site Solišćica port; Dugi Otok island demonstrates a clear difference between *Posidonia* seagrass beds under pressure (mostly boat anchoring) from the *Posidonia* seagrass beds situated at the open sea. The poor condition of the affected *Posidonia* seagrass beds is extremely disturbed at certain parts. Beds at locations with no impact demonstrated fairly good to favorable conservation status. The research was also conducted in the area HR3000069 Sakarun Bay. *Posidonia* seagrass beds in this area, although in the bay, are close to the open sea with high exposure to sun, winds, and sea



in the previous area, the research was conducted at two locations depending on the level of human impact - in Sakarun Bay (Sakarun 1) and at the southern border (Sakarun 2). Location within impact area is situated in Sakarun Bay, while sampling stations in the area with no human impact were positioned south of the bay, in the area of M. Miholjine Bay and V. Miholjine Bay. The mean value for the location with no impact is  $610.2 \pm 163$  at an average depth of 10 meters (good), while for the location within the impact area, the mean value is  $578.9 \pm 202$  at an average depth of up to 8 meters (moderate/good). (Table 5-2 and Table 5-3).

**Table5-2: Average shoot density in quadrats ( $40 \times 40 = 0.16 \text{ m}^2$ ) and per  $\text{m}^2$ , along with standard deviation of shoot density at each sampling station and mean value at the location within impact area Sakarun 1, Natura 2000 site - Sakarun Bay, including status of meadows according to Table 1.**

(Source: Monitoring the condition of seagrass habitats and meadows (*Posidonia oceanica*) in selected areas of ecological network in Zadar county, 2020, Expert report, Marine Explorers Society - 20.000 leagues, Zadar)

	SAMPLING STATIONS			LOCATION
	Sakarun 1.1	Sakarun 1.2	Sakarun 1.3	Sakarun 1
Shoot density [in $0.16 \text{ m}^2$ ]	122	82	74	92
Shoot density [in $\text{m}^2$ ]	$761 \pm 197$	$515 \pm 125$	$460.62 \pm 129$	<b><math>578.9 \pm 202</math></b>
Mean depth (min-max) [m]	6 (6 – 7)	9	10	8
<b>Meadow condition</b>	<b>good</b>	<b>moderate</b>	<b>moderate</b>	<b>moderate/good</b>



**Table5-3: Average shoot density in quadrats (40x40 = 0.16 m<sup>2</sup>) and per m<sup>2</sup>, along with standard deviation of shoot density at sampling stations and mean value at the location with no impact area Sakarun 2, Natura 2000 site - Sakarun Bay, including status of meadows according to Table 1.**

*(Source: Monitoring the condition of seagrass habitats and meadows (Posidonia oceanica) in selected areas of ecological network in Zadar county, 2020, Expert report, Marine Explorers Society - 20.000 leagues, Zadar)*

	SAMPLING STATIONS			LOCATION
	Sakarun 2.1	Sakarun 2.2	Sakarun 2.3	Sakarun 2
Shoot density [in 0.16 m <sup>2</sup> ]	81	96	116	<b>97</b>
Shoot density [in m <sup>2</sup> ]	508.13 ± 125	597.5 ± 92	724.37 ± 180	610.2 ± 163
Mean depth (min-max) [m]	11 (11 – 12)	9 (9 – 10)	8 (7.5 – 8)	<b>10</b>
<b>Meadow condition</b>	<b>good</b>	<b>good</b>	<b>good</b>	<b>good</b>

The condition of meadows at sampling stations at locations within the impact area was assessed as good and moderate. The mean value at the location also indicates the moderate condition of Posidonia meadows with an average shoot density of 578.9±202 per square meter at the average depth of 8 meters (Table 5-3 and Figure 2). According to data in Table 2, these values are at the upper limit of moderate to good condition. At the location with no impact, Sakarun 2, sampling stations constantly have high shoot density at all depths. Therefore, the condition of meadows at sampling stations including the mean value at the location was assessed as good. On average, the condition of meadows at both locations was assessed as moderate to good what is shown in colour in Figure 2.

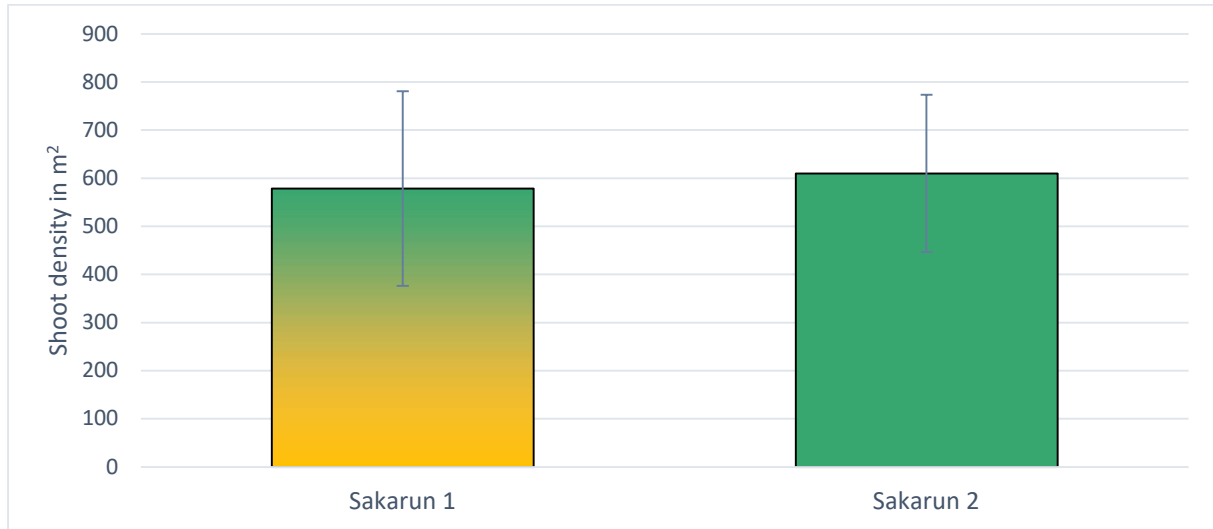


Figure 4 Shoot density in m<sup>2</sup>, along with standard deviation, by location in SAC

(Source: Monitoring the condition of seagrass habitats and meadows (*Posidonia oceanica*) in selected areas of ecological network in Zadar county, 2020, Expert report, Marine Explorers Society - 20.000 leagues, Zadar)

At different locations, the level of data variability and standard deviation in data on shoot density per square meter is mostly the result of differences in depth at the sampling station. Based on the results of the previous research in the Mediterranean Sea that contributed to the design of Table 5-2 *Posidonia* seagrass beds in this Natura 2000 site are classified as having a fairly good condition (Figure 3) which has been marked in colour; this, however, should be carefully considered for location within impact area since *Posidonia* beds in this area can be quite damaged (which was expected as a result of intensive boat anchoring in the past and nowadays occasional anchoring among marine buoys operated under concessions present in the research area).

Using LIT method in surveying Natura 2000 area in Sakarun Bay, the percentage cover of live *posidonia* was monitored in comparison with other habitats at two locations and six sampling stations. Other habitats observed along the Line Intercept Transect are *dead matte*, rock, and sand. At each of the sampling stations, four LIT's were carried out, a total of 12 per location, 24 in the entire area. The highest percentage cover of *Posidonia* at the sampling stations at locations within the impact area was at Sakarun 1.3 sampling station accounting for 88%, while percentage cover at sampling stations Sakarun 1.1 and Sakarun 1.2 were significantly lower, 55% and 52%. The percentage of "dead matte" is highly important for assessing conservation status, and it is fairly high at sampling stations Sakarun 1.1 and 1.2 (45% and 42%). These two sampling stations recorded fairly equal results, while Sakarun 1.3 sampling station recorded a low share of "dead matte" (9%). Other habitats were recorded on a smaller area (Table 5-4).

**Table5-4: Average percentage cover of habitat type with associated conservation status according to the conservation index along the transect at sampling stations and mean values at the location within impact area Sakarun 1, Natura 2000 site - Sakarun Bay**

(Source: Monitoring the condition of seagrass habitats and meadows (*Posidonia oceanica*) in selected areas of ecological network in Zadar county, 2020, Expert report, Marine Explorers Society - 20.000 leagues, Zadar)

	SAMPLING STATIONS			LOCATION
	Sakarun 1.1	Sakarun 1.2	Sakarun 1.3	Sakarun 1
<i>sediment</i>	0%	4%	2%	<b>2%</b>
<i>rock</i>	0%	2%	1%	<b>1%</b>
<i>Posidonia oceanica</i>	55%	52%	88%	<b>65%</b>
"dead matte"	45%	42%	9%	<b>32%</b>
<i>CI</i>	0.55	0.55	0.90	<b>0.67</b>
<b>Conservation status</b>	<b>moderate 3</b>	<b>moderate 3</b>	<b>good 4</b>	<b>moderate 3</b>

At sampling stations at locations with no impact, the highest percentage cover of *Posidonia* is 80% at the sampling station Sakarun 2.2, and the lowest at sampling station Sakarun 2.3 with 62%. The percentage of "dead matte" is highly important for assessing conservation status, and it is the highest at sampling station Sakarun 2.1 (32%). Only at sampling station Sakarun 2.3 other habitats were recorded alongside *Posidonia* and "dead matte". The results from the sampling stations show a fairly uniform pattern on average per location, with 70% accounting for *Posidonia*, with the presence of a "dead matte" of 23% along with rocks and sediments (Table 5-5., Figure 3.).

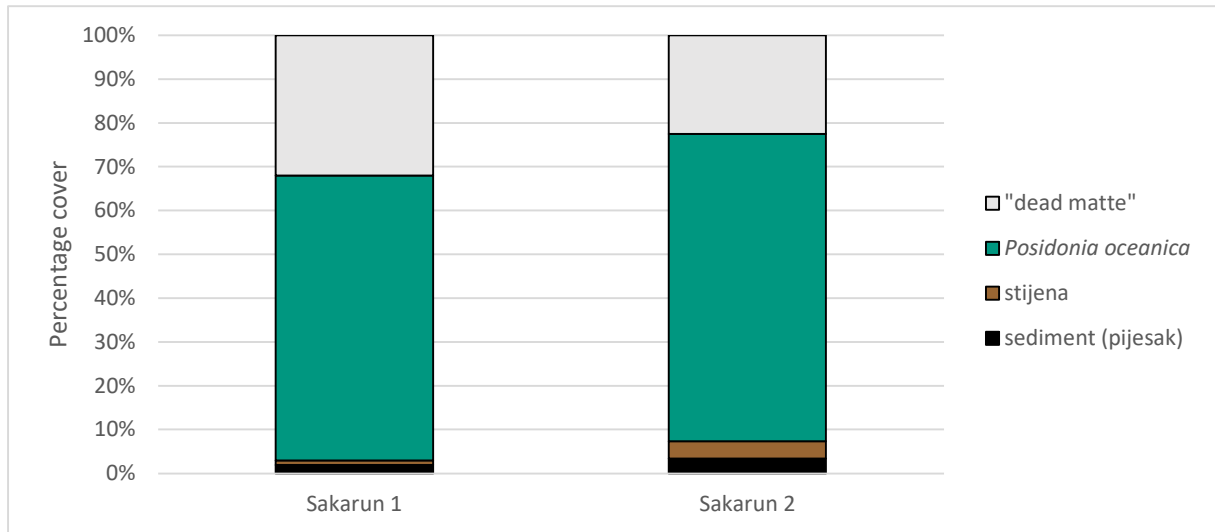


**Table5-5: Average percentage cover of habitat type with associated conservation status according to the conservation index along the transect at sampling stations and mean values at the location with no impact Sakarun 2, Natura 2000 site - Sakarun Bay**

(Source: Monitoring the condition of seagrass habitats and meadows (*Posidonia oceanica*) in selected areas of ecological network in Zadar county, 2020, Expert report, Marine Explorers Society - 20.000 leagues, Zadar)

	SAMPLING STATIONS			LOCATION
	Sakarun 2.1	Sakarun 2.2	Sakarun 2.3	Sakarun 2
<i>sediment</i>	0%	0%	10%	<b>3%</b>
<i>rock</i>	0%	0%	12%	<b>4%</b>
<i>Posidonia oceanica</i>	68%	80%	62%	<b>70%</b>
"dead matte"	32%	20%	16%	<b>23%</b>
<i>CI</i>	0.68	0.80	0.79	<b>0.76</b>
<b>Conservation status</b>	<b>moderate 3</b>	<b>good 4</b>	<b>good 4</b>	<b>good 4</b>

The conservation index (CI) (Tables 5-4 and 5-5) was calculated according to Montefalcone (2009). The percentage cover of *Posidonia* is slightly lower (0.55) at two out of three sampling stations at Sakarun 1, resulting in the lower index (between 0.55 and 0.9) indicating the conservation status of the location as moderate (0.67). The percentage cover of *Posidonia* is on average higher at the location Sakarun 2, resulting in a higher index (between 0.68 and 0.80) indication conservation status of the location as good (0.76).



**Figure 5: Average percentage cover of habitat type along transect, by location in SAC, Sakarun Bay**

*(Source: Monitoring the condition of seagrass habitats and meadows (Posidonia oceanica) in selected areas of ecological network in Zadar county, 2020, Expert report, Marine Explorers Society - 20.000 leagues, Zadar)*

These results support the conclusions stated in the Annual Plan of the Public institution for management of protected areas, "Natura Jadera", where this Natura 2000 site has been characterized as a special area for conservation due to illegal boat anchoring outside the concession zone. At both locations, shoot density is high, but there is also a significant proportion of "dead matte" at both locations. Areas with "dead matte" are transversely laid and can be connected with mechanical damage caused by boat anchoring.

Table5-6: Status of Posidonia beds at all sampling locations, n=4

(Source: Monitoring the condition of seagrass habitats and meadows (*Posidonia oceanica*) in selected areas of ecological network in Zadar county, 2020, Expert report, Marine Explorers Society - 20.000 leagues, Zadar)

Natura 2000 area	Locations	Meadow condition (quadrants)		Conservation status (LIT method)	
HR3000067 Solišćica harbour; Dugi Otok	Solišćica 1 - impact area	2	poor	2	disturbed
	Solišćica 2 - no impact	3	moderate	4	good
HR3000069 Sakarun Bay	Sakarun 1 - impact area	3	moderate	3	moderate
	Sakarun 2 - no impact	4	good	4	good

Significant differences can be observed at locations within Natura 2000 site - Sakarun Bay; Sakarun 1 is located within Sakarun Bay where anthropogenic influence is prominent, while Sakarun 2 is located outside Sakarun Bay with significantly lower anthropogenic pressure (boat anchoring, waste, etc.). Location Sakarun 1 situated within the bay is under higher anthropogenic pressure, and consequently has a significant proportion of "dead matte". However, a significant proportion of "dead matte" is also present at the location Sakarun 2, which in the initial design was characterized as a location with no impact. In other words, there appears to be damage that is probably caused by boat anchoring, although to a lesser extent than at Sakarun 1.

During the nautical season, Sakarun Bay is visited by a large number of vessels anchoring inside and outside the concession zone. Due to the exceptional value of this Natura 2000 site, it is necessary to implement the recommendations for the expansion of the concession zone.

Based on the current status of Posidonia seagrass beds, it is possible to provide a rough estimate about the status and potential for Posidonia banquettes formation at locations in the northwestern part of Dugi Otok island.

## ASSESING STATUS OF POSIDONIA BANQUETTES IN BAYS IN THE NORTHWESTERN PART OF DUGI OTOK ISLAND

The basic precondition for Posidonia banquette formation is the presence of Posidonia beds. However, this cause-and-effect relationship is not limited to a narrow geographical area. More specifically, Posidonia leaves that are deposited on the shore come from naturally discarded leaves from Posidonia seagrass beds that can be located up to several kilometres away from the shore, particularly from more exposed locations. Besides factors like Posidonia beds, another important precondition is orientation of the coast and exposure to winds that can develop strength and intensity to form banquettes. Additionally, the fact whether banquettes will remain at the shore, and for how long, is again influenced by winds and exposure to waves that may cause erosion of leaf litter from banquettes.

The whole marine area of NW part of Dugi Otok island is abundant with fairly developed Posidonia seagrass beds (Figure 5-13.). The conclusions based on the results of the research summarized in Chapter 2 with regard to selected areas, clearly suggest moderate to good condition of Posidonia beds. The largest continuous Posidonia beds are located north of Dugi Otok island at the stretch towards Lagnići islets and south of Sakarun Bay due to seabed bathymetry. Posidonia beds are also located along the greater part of the southwestern coast between Veli Rat (lighthouse) and Cape Lopata, however, due to considerably steep seabed and specific bottom surface, Posidonia beds are located in a fairly narrow belt. Due to specific features of the coastal rocks and fairly small areas with Posidonia seagrass beds in the selected area, a more significant deposition of Posidonia leaves is not expected.

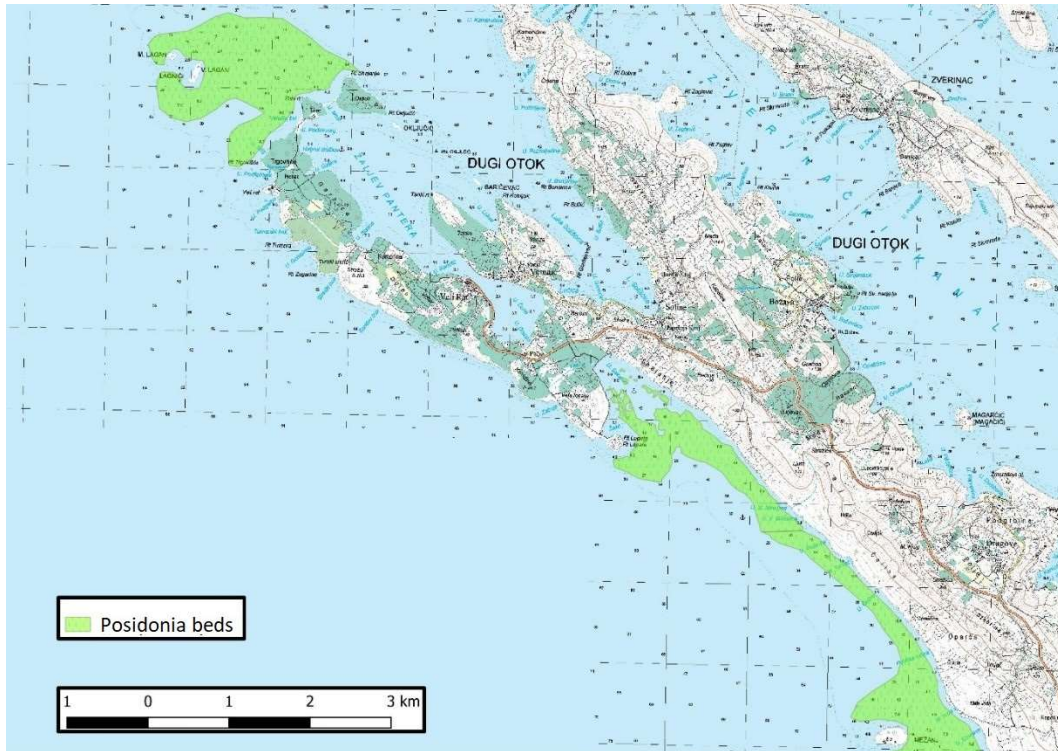


Figure 5-13: Areas with significant percentage cover of priority habitat 1120 Posidonia beds within the area of significant landscape of the northwestern part of Dugi Otok

In the coastal area, we can define areas where leaves deposition occurs and areas with the potential for the formation of banquettes.

Given the high variability and dynamics of banquette formation at familiar deposition sites in the Adriatic (such as Sakarun Bay), in the area of NW part of Dugi Otok we can make a distinction between two types of deposition areas:

- a) Short-term Posidonia banquettes
- b) Long-term Posidonia banquettes

In order to obtain precise information on the locations with the presence of banquettes, it is necessary to perform multi-year research to determine whether and to what extent certain area exhibits potential for the formation of banquettes.

The seabed area on the north, towards Lagniči islets, has a high percentage cover of Posidonia beds (Figure 5-14). The area is also exposed to northwest winds. The eastern part of the Adriatic is characterized by northwest winds, their resulting waves, and the occurrence of storms. Such intense winds contribute to deposition of seagrass leaves that form banquettes. They also cause erosion of the banquettes and consequently bringing leaves back to the sea.

Therefore, banquettes are formed in this area, however, the dynamics and frequency of their occurrence have to be examined. It is necessary to conduct research throughout all seasons.

In the coastal area between Cape Shajana and Suhi Cape there are well-preserved Posidonia beds which are close to the coast turn into sedimentary forms. There is gravelly beach with Posidonia banquettes. For status assessment it is necessary to establish constancy of banquette occurrence in that area, however, preconditions (coast orientation, surface, marine habitats and exposure to winds and waves) suggest that the area has high potential for the formation of long-term banquettes. In the immediate vicinity to the west, there is the bay Valačin žal, which also has the potential to retain banquettes, however, it's still not known to what extent and at which part of the bay. It is assumed that, due to different coastline configuration being mostly rocky, formation of banquettes is difficult. It is expected that short-term banquettes with fairly quick erosion and small quantity of leaves will be formed in this area.

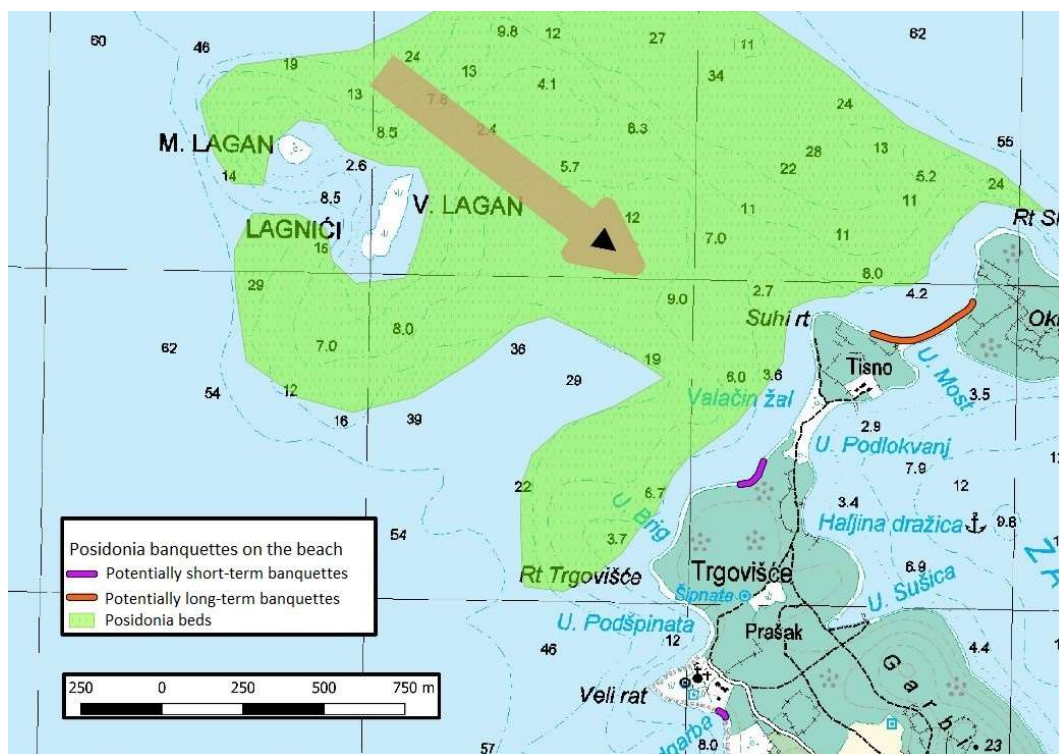


Figure 5-14: Areas with potential for banquettes formation in the northern part of the significant landscape NW part of Dugi Otok

The area in front of Sakarun Bay (Figure 5-15.) is rich in Posidonia beds. Posidonia beds within the bay are well developed but create a complex mosaic with sedimentary forms, also-called biogeomorphologic structures. Within the bay, at the bottom (5 meters and more shallow) Posidonia beds are not developed. The entire area of Sakarun Bay and Cape Lopata is exposed to southeast winds. The eastern part of the Adriatic is characterized by southeast winds, their resulting waves, and the occurrence of occasional storms.

Stormy waves in the bay cause erosion of banquettes, however as the wind intensity ceases banquettes are formed again. Geomorphological analysis is conducted from September 2020 to May

2021, and its preliminary results indicate fairly high dynamics of banquettes occurrence in the bay, more precisely on the beach, along with a significant amount of leaves and rhizomes. It is necessary to continue monitoring the status of banquettes on the beach within Sakarun Bay in order to establish yearly cycles and dynamics through multi-year research.

The coastal area towards Cape Lopata has potential for banquettes formation, particularly the area within Sakarun Bay. The area is not directly exposed to the southeast wind, but the resulting waves bring dead leaves material to the shore. It is assumed that, due to mostly rocky coast, formation of banquettes is difficult. It is expected that short-term banquettes with fairly quick erosion and small quantity of leaves will be formed in this area.

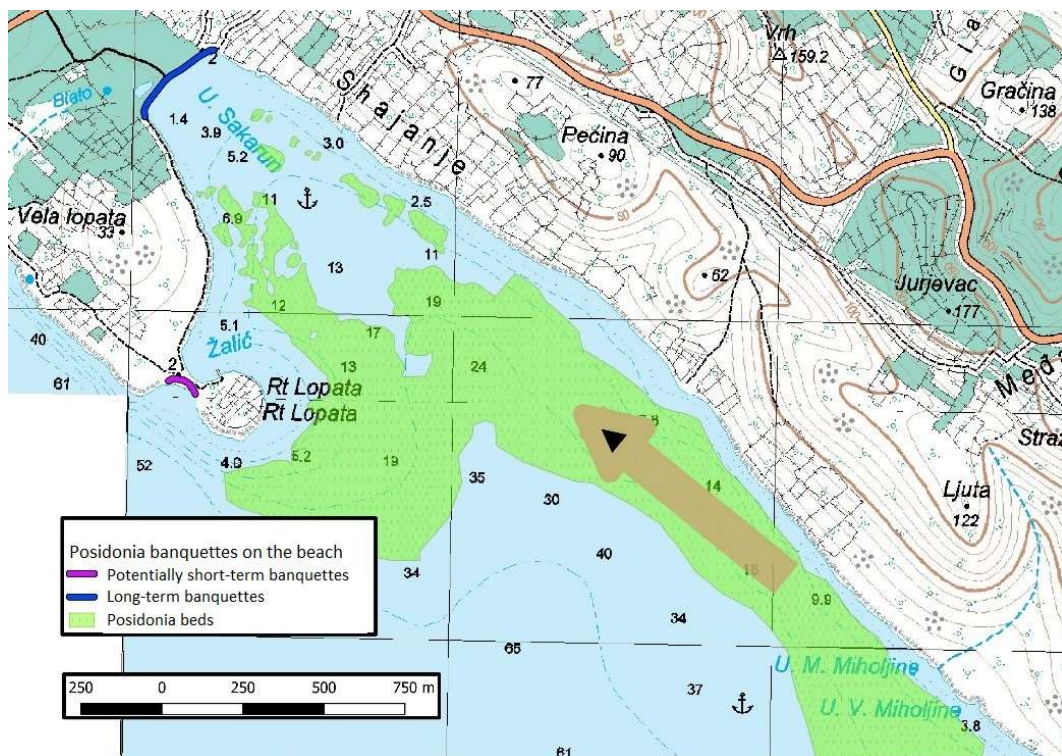


Figure 5-15: Areas with *Posidonia* banquettes and the potential for their formation in the south part of the significant landscape NW part of Dugi Otok



## STATUS OF HABITATS IN THE BACKSHORE IN SAKARUN BAY

Based on the result of geomorphological analysis conducted in Sakarun Bay (Pikelj, 2021), no sand dunes are formed in the backshore, however, this area along with the pebble part receives a smaller amount of Posidonia leaves only in cases of extreme deposition and continuous Jugo wind. The typology and composition of the backshore is mostly gravel, and its morphology, habitats, communities, and ecosystems have not been sufficiently investigated. New deposits of Posidonia and sediments are rarely formed in this area, and consequently, they rarely erode. This type of deposit along with this type of area demonstrates features of the transitional type of semi-protected beaches with Posidonia banquettes. Posidonia deposits in the area behind the beach are thin and primarily act as stabilizers. Besides acting as stabilizers of beach structure, a large number of terrestrial plants can grow there that may also contribute to protection against erosion, particularly during extreme weather conditions (storms and similar).

Coastal vegetation is present in such habitats and due to its proximity to banquettes, they may become a habitat for specific organisms, including plant and animal species that may not be present elsewhere in the area. Preliminary research was conducted in 2016 (Milović & Pandža, 2016) during which ten plant communities (habitat types) were recorded in the coastal belt of the bay. In the area of Sakarun Beach, including the backshore, several endangered habitats were recorded with the community of milkweed and coastal poppy being visibly fragmented. Milović and Pandža (2016) emphasize in their research that a better insight into the floral communities of Sakarun Bay (including the beach and backshore) requires systematic year-round research that will include community through all vegetation seasons.

Changes to communities happen as a result of exposure to extreme conditions. Semi-protected beaches exhibit a fairly high level of dynamics of their profile, which, as a result, has an impact on habitats in the area behind the beach. Sakarun Bay and the beach within the Bay are characterized as semi-protected areas. For the proper management of the area, it is important to gain knowledge about habitat types developed in the backshore bearing in mind geomorphological, climatological, oceanographic, and ecological conditions.

During the geomorphological analysis of the Sakarun beach (Pikelj, 2021), a significant traffic disturbance in form of and vehicle traces were observed on the beach, especially in its central part. Part of the traffic occurs in the area behind the beach. Such activities disrupt the dynamics of the area.

It is necessary to conduct research in the backshore in Sakarun Bay in order to establish the importance of the area for specific communities that may potentially develop in such habitats and the importance of these habitats in the protection of Posidonia banquettes.



## 6. Analysis of previous and newly applied management measures

One of the goals defined within the Management Plan for the Northwestern part of Dugi Otok Significant Landscape (2013) is to keep the area clean from litter and deposits. As set out in the Plan, as part of biodiversity conservation activities, it is necessary to educate the public about the value of sandy shores and the potential threats facing them, to remove deposits of anthropogenic origin, however, at certain beach parts to leave deposits of natural origin (marine vegetation) and to establish systematic monitoring of terrestrial and marine ecosystems.

One of the goal-related activities implies controlled removal of flooded Posidonia seagrass leaves and litter of anthropogenic origin from beaches. For the implementation of the stated activity, a project for the removal of flooded Posidonia seagrass leaves from the beach is yet to be developed. An estimate of the planned annual costs of removal has also been provided.

The project has not been developed until now and there has been no systematic removal, but occasional periodic cleaning, usually before and during the summer period, as private beach business owners complain about the decreased number of visitors probably caused by accumulated Posidonia banquettes. The management of Posidonia oceanica leaf litter has been realized through the mechanical removal which includes the removal of a large amount of sediments from the sandy beaches.

During the process of preparing Action plan for the management of beaches with Posidonia banquettes in the NW part of Dugi Otok with emphasis on Sakarun beach, two participatory workshops were held during the course of 2021 in April and July, the first in Sali and the second in Veli Rat, respectively. The aim of the workshops was to initiate building the network of local community actors and to discuss innovative ideas and suggestions for intervention options for the management of the beach and preserving Posidonia banquettes as a key coastal habitats and structures with important geomorphological features recognized within the POSBEMED2 project.

The main conclusions of the first workshop significantly contributed to the development of the Action Plan, because the main problem was identified, and the proposals by the participants included continuous removal of seagrass litter from the beach, preparation of education materials (digital tools), installing information boards, employing new staff, as well as educating and rebranding of Sakarun beach.

The conclusions of the second workshop included the possibility of performing activities to "clean" the beach of Posidonia banquettes in a way to arrange distribution of banquettes on the left side and on the right side within the Sakarun bay. One of the suggestions made by the workshop participants is to have the Posidonia banquettes "raised" above the tidal area, and then to have it returned to their original locations after the summer tourist season. It is necessary to consider that storms are becoming more frequent due to climate changes, which means that large amounts of Posidonia deposits, as well as sand, will be dragged into the sea.

## 7. Implementation of restoration measures and activities (strategic framework)

### Implementation of restoration measures and activities

Activity	Implementation methods	Short-term implementation goals	Long-term implementation goals	Planned funding for implementation:							
<b>1. ESTABLISHING AREAS OF INTERVENTION AND AREAS WITH NO INTERVENTION</b>											
A.1.1 Establishing areas of intervention and areas with no intervention	<p>On-site maintenance and supervision. The intervention includes all activities of relocating <i>Posidonia</i> banquettes on the beach. The area of intervention is the beach (naturally and anthropogenically the most dynamic part of the beach) accounting for two thirds of the total beach length. The area with no intervention is the remaining part of the beach accounting for one third of the total beach length.</p>	<p>A.1.1.1a Development of an internal act defining the scope within the area of intervention and area with no intervention including designated areas for removal of deposits A.1.1.1b Incorporating the act into the Management Plan for the Northwestern part of Dugi Otok Significant Landscape</p>	A.1.1.2a Re-evaluation of the zoning system within area of intervention and area with no intervention following up on the results of the monitoring program	<b>10,000.00 HRK</b>							
<b>FINANCIAL PLAN FOR IMPLEMENTATION OF ACTIVITY 1</b>											
Activity 1.1.	Priority	Planned funding for implementation, by years (HRK)									
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A.1.1.1a	1	0.00									
A.1.1.1b	1	0.00									
A.1.1.2a	2						10,000.00				

2. ACTIVITIES IMPLEMENTED DIRECTLY ON POSIDONIA BANQUETTES

<p>A.2.1. Maintaining favorable condition of Posidonia banquettes on Sakarun beach as a means of protection against erosion</p>	<p>Removal of Posidonia banquettes from the area of intervention to the area with no intervention should be done without using heavy machinery (manually or by using light machinery) in May (prior to swimming season) and should be returned to the original position in September/October (after the swimming season). Along with restoring of banquettes to the original position, it is necessary to restore residual sediments left after relocating Posidonia banquettes, also manually and/or using hand tools.</p>	<p>A.2.1.1a Removal of Posidonia banquettes from the area of intervention to the area with no intervention according to the internal act during May for the needs of the tourist season A.2.1.1b Restoring of displaced Posidonia deposits and residual sediments from the area with no intervention to the area of intervention in September/October for the purpose of reducing sand erosion during autumn, winter and spring A.2.1.1c Establish a monitoring program of banquette status A.2.1.1d Establish a monitoring program of beach morphology</p>	<p>A.2.1.2a Building a corridor/passage through Posidonia banquettes narrowing the area of intervention to the corridor only A.2.1.2b Re-evaluation of monitoring programs and activities following up on the results after 5 years</p>	<p><b>286,000.00 HRK</b></p>
<p>A.2.2. Maintaining favorable condition of Posidonia banquettes on Sakarun beach</p>	<p>Posidonia banquettes are manually cleaned from deposited litter without affecting the compactness of deposits on the entire area of Sakarun beach (particularly after strong south winds).</p>	<p>A.2.2.1a Manual cleaning of banquettes (recommended every two weeks to once a month) A.2.2.1b Organization of several consecutive cleaning activities after strong south winds</p>	<p>A.2.2.2a Procurement of light machinery such as beach cleaning screeners used for sifting sand and removal of litter during relocation</p>	<p><b>250,000.00 HRK</b></p>

<p>A.2.3. Biodiversity conservation of Posidonia banquettes on Sakarun beach</p>	<p>Faunistic and ecological survey. Implementation of monitoring program through field work.</p>	<p>A.2.3.1a Determine ecological and faunistic features of Posidonia banquettes for the purpose of community composition analysis and the periods required for increased protection (reproduction period, and similar) A.2.3.1b Establish a monitoring program of observed communities</p>	<p>A.2.3.2a Re-evaluation of monitoring programs and activities following up on the results after 5 years</p>	<p><b>80,000.00 HRK</b></p>
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**FINANCIAL PLAN FOR IMPLEMENTATION OF ACTIVITY 2**

Activity 2.1.	Priority	Planned funding for implementation, by years (HRK)									
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A.2.1.1a	1	6,000.00	4,000.00	4,000.00	4,000.00	4,000.00					
A.2.1.1b	1	4,000.00	4,000.00	4,000.00	4,000.00	4,000.00					
A.2.1.1c	1	20,000.00	20,000.00	20,000.00	20,000.00			15,000.00			15,000.00
A.2.1.1d	1	20,000.00	20,000.00	20,000.00	20,000.00			15,000.00			15,000.00
A.2.1.2a	2						20,000.00	1,000.00	1,000.00	1,000.00	1,000.00
A.2.1.2b	2					0.00					
Activity 2.2.	Priority	Planned funding for implementation, by years (HRK)									
A.2.2.1a	1	5,000.00	2,000.00	2,000.00	2,000.00	5,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
A.2.2.1b	1	14,000.00	12,000.00	12,000.00	12,000.00	14,000.00	12,000.00	12,000.00	12,000.00	12,000.00	12,000.00

A.2.2.2a	2										100,000.00
Activity 2.3.	Priority	Planned funding for implementation, by years (HRK)									
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A.2.3.1a	1		20,000.00								
A.2.3.1b	1			10,000.00	10,000.00	10,000.00	10,000.00	10,000.00			10,000.00
A.2.3.2a	2								0.00		

### 3. IMPLEMENTING ACTIVITIES IN THE BACKSHORE

<p>A.3.1. Maintaining favorable condition and habitat integrity in the backshore of Sakarun beach</p>	<p>On-site maintenance and supervision.</p>	<p>A.3.1.1a Controlling traffic route and traffic volume in the area behind the beach by installing ramps and barriers</p>		<p><b>20,000.00 HRK</b></p>
<p>A.3.2. Biodiversity conservation of habitats in the backshore of Sakarun beach</p>	<p>Floristic and faunistic survey. Implementation of monitoring program through field work. On-site maintenance and supervision.</p>	<p>A.3.2.1a Conduct a comprehensive biological (floristic and faunistic) survey of the habitat in the backshore for the purpose of community composition analysis</p>	<p>A.3.2.2a Conduct a detailed floristic and faunistic survey of the habitat in the backshore in order to establish a monitoring program A.3.2.2b Establish a program for monitoring community ecosystems in the backshore</p>	<p><b>60,000.00 HRK</b></p>

#### FINANCIAL PLAN FOR IMPLEMENTATION OF ACTIVITY 3

Activity 3.1.	Priority	Planned funding for implementation, by years (HRK)									
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A.3.1.1a	1	15,000.00					5,000.00				
Activity 3.2.	Priority	Planned funding for implementation, by years (HRK)									
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A.3.2.1a	1				5,000.00						
A.3.2.2a	2					15,000.00					
A.3.2.2b	2							10,000.00	10,000.00	10,000.00	10,000.00

### 4. IMPLEMENTING ACTIVITIES AT SEA

<p>A.4.1. Maintaining favorable condition and integrity of priority habitat 1120 Posidonia beds in Sakarun Bay</p>	<p>Program of monitoring the status of Posidonia beds. On-site maintenance and supervision.</p>	<p>A.4.1.1a Continuously implement a monitoring program every three years</p>	<p>A.4.1.2a Implementation of active conservation and restoration measures of Posidonia beds - planting of seeds and young seedlings of Posidonia and transplantation of healthy seedlings to damaged areas</p>	<p><b>60,000.00 HRK</b></p>
<p>A.4.2. Improvement of the boat anchoring system in Sakarun Bay</p>	<p>Cooperate with the county of Zadar in order to address the issue of anchorage area and concession domain in Sakarun Bay.  Establishment of an environmentally friendly boat anchoring system in Sakarun Bay. On-site maintenance and supervision.</p>	<p>Develop a model of transition onto a more environmentally friendly boat anchoring system - define conditions, volume, location and possible phases of investment in cooperation with Zadar County A.4.2.1b Relocate current blocks from Posidonia beds onto sedimentary seabed. A.4.2.1c Expand concession domain, which is conditional on establishment of environmentally friendly boat anchoring system. A.4.2.1d Impose a year-round ban on anchoring on the entire area of Sakarun Bay.</p>	<p>A.4.2.2a Replacement of sediment blocks with an environmentally friendly sand-screw type A.4.2.2b Installing environmentally friendly steel coil type anchorages in Posidonia beds (if necessary)</p>	<p><b>87,000.00 HRK</b></p>
<p><b>FINANCIAL PLAN FOR IMPLEMENTATION OF ACTIVITY 4</b></p>				
	<p>Priority</p>	<p>Planned funding for implementation, by years (HRK)</p>		

Activity 4.1.		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A.4.1.1a	1		10,000.00			10,000.00			10,000.00		
A.4.1.2a	2							25,000.00		5,000.00	
Activity 4.2.		Planned funding for implementation, by years (HRK)									
	Priority	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A.4.2.1a	1	0.00									
A.4.2.1b	1		5,000.00								
A.4.2.1c	1		2,000.00								
A.4.2.1d	1		2,000.00								
A.4.2.2a	2								48,000.00		
A.4.2.2b	2										30,000.00



**5. BUILDING CAPACITY, RAISING AWARENESS AND PROVIDING EDUCATIONAL ACTIVITIES**

<p><i>A.5.1. Building capacities of local stakeholders</i></p>	<p><i>Public workshops, round tables, public consultations, targeted trainings for employees of local stakeholders.</i></p>	<p><i>A.5.1.1a Prepare and implement activities aimed at strengthening capacities of local stakeholders, enabling them to conserve Posidonia banquettes and related habitats.</i> <i>A.5.1.1.b Organise regular trainings designed to strengthen capacities of stakeholders' staff managing the area.</i> <i>A.5.1.1.c Prepare and implement activities to strengthen capacities of local stakeholders (concessionaires, renters and similar) showing them how to educate their users and customers.</i></p>	<p><i>A.5.1.2a Use strengthened capacities for implementation and educational activities in other areas in the Republic of Croatia</i></p>	<p><b>54,500.00 HRK</b></p>
<p><i>A.5.2. Raising awareness among beachgoers to Sakarun beach</i></p>	<p><i>Prepare and distribute educational materials and tools.</i> <i>Emphasis placed on digital distribution of educational tools - QR codes on information signs, ships, tourist trains, information boards.</i></p>	<p><i>A.5.2.1a Maintenance of information boards which promote Sakarun beach, emphasizing the importance of Posidonia oceanica in the sea and of Posidonia seagrass deposits</i> <i>A.5.2.1b Preparation of multi-lingual educational brochures/ leaflets for digital distribution.</i></p>	<p><i>A.5.2.2a Maintenance (appropriate replacement in case of wear and tear) of information boards</i></p>	<p><b>24,500.00 HRK</b></p>

<p>A.5.3. Educational workshops</p>	<p>Non-formal educational workshops.</p>	<p>A.5.3.1a Non-formal educational workshops designed for children, young people and adults, held on Sakarun beach. A.5.3.1b Non-formal workshops for children and young people in the county of Zadar, organised within the framework of the educational system.</p>	<p>A.5.3.2a Setting up a model of "eco-friendly beach" - seasonal educational displays and play area, showcasing Posidonia oceanica</p>	<p><b>162,000.00 HRK</b></p>
<p>A.5.4. Rebranding of the beach in Sakarun Bay</p>	<p>Develop communication and educational tools.</p>	<p>A.5.4.1a Prepare communication strategy "Sakarun - sandy bay" intended for all tourist boards promoting Sakarun beach.</p>	<p>A.5.4.2a Set up a payment model for the use of beach, which would generate part of the funds for maintenance and research operations as well as for the monitoring ecosystems in Sakarun Bay.</p>	<p><b>12,000.00 HRK</b></p>

**FINANCIAL PLAN FOR IMPLEMENTATION OF ACTIVITY 5**

Activity 5.1.	Priority	Planned funding for implementation, by years (HRK)									
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A.5.1.1a	1	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00		2,500.00		2,500.00	
A.5.1.1.b	1	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00		2,500.00		2,500.00	
A.5.1.1.c	1	3,500.00	2,500.00	2,500.00	2,500.00	3,500.00		2,500.00		2,500.00	
A.5.1.2a**	2						0.00 **	0.00 **	0.00 **	0.00 **	0.00 **

Activity 5.2.	Priority	Planned funding for implementation, by years (HRK)									
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A.5.2.1a	1	500.00	500.00	500.00	500.00	500.00		500.00	500.00	500.00	500.00
A.5.2.1b	1	10,000.00									
A.5.2.2a	2						10,000.00				
Activity 5.3.	Priority	Planned funding for implementation, by years (HRK)									
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A.5.3.1a	1	4,000.00	2,000.00	2,000.00	2,000.00	2,000.00					
A.5.3.1b	1	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
A.5.3.2a **	2						60,000.00	10,000.00	10,000.00	10,000.00	10,000.00
Activity 5.4.	Priority	Planned funding for implementation, by years (HRK)									
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A.5.4.1a	1		10,000.00								
A.5.4.2a	2						2,000.00				

\* Expenditures for particular activities were estimated in accordance with the possibilities and circumstances occurring at the time of drafting the action plan and include the costs of consumables, equipment and/or costs of services of external experts. Public Institutions may plan to include detailed costs for particular activities in their annual program for the following year. Public institution's staff costs are not included in the projected budget.

\*\* Activities with income opportunities for Public Institution.

## Elaboration of activities

### 1. ESTABLISHING AREAS OF INTERVENTION AND AREAS WITH NO INTERVENTION

#### A.1.1 Establishing areas of intervention and areas with no intervention

**Types of activities:** *Passive*

**Area of activity** *Posidonia banquettes on Sakarun beach.*

**Current status:** *Formal zoning system does not currently exist.*

**Goal of the activity:** *Maintain natural appearance of the beach whilst ensuring the use of tourist potential and minimizing impacts on seagrass deposits.*

**Proposed technique:** *Development of an internal act and implementation in accordance with the guidelines resulting from geomorphological analysis.*

**Technical description:** *The intervention includes all activities of relocating Posidonia banquettes on the beach.*

**Proposed methodology:** *Developing an internal act.*

**Description of the method:** *Developing an internal act.*

**Priority and implementation period:** *High, not seasonal.*

**Frequency of the activity:** *Establishment of zones and reevaluation after 3 to 5 years.*

**Funding for implementation:** *Funds of the Public Institution.*

**Environmental benefits:** *Basis for intervention activities. Minimize the impact of relocation.*

**Indicator of activity implementation:** *Implementing zoning system into management plan.*

**Desired outcome:** *Narrowing the area of intervention to the corridor/passage.*

**Expected outcome:** *Area of intervention is limited to two thirds of the beach.*

**Partners:** *Municipality of Sali, expert associates*

## 2. ACTIVITIES IMPLEMENTED DIRECTLY ON POSIDONIA BANQUETTES

### A.2.1. Maintaining favorable condition of Posidonia banquettes on Sakarun beach as a means of protection against erosion

**Types of activities:** Active

**Area of activity** Posidonia banquettes on Sakarun beach.

**Current status:** Long-term relocation of Posidonia banquettes from the beach without restoring to original position. In recent years, an attempt to relocate only a small amount with the potential of restoring the deposit to its original position. There is a trend of decreasing the amount of sediment on the beach.

**Goal of the activity:** Maintain Posidonia banquettes in a natural form to ensure effective natural protection against erosion.

**Proposed technique:** Maintaining banquettes - removal of deposits before the season and restoring deposits and sediments to their original position at the end of the season.

**Technical description:** Maintaining banquettes.

**Proposed methodology:** Manual removal of banquettes.

**Description of the method:** Removal of Posidonia banquettes from the area of intervention to the area with no intervention is done manually in May (prior to swimming season) and are manually returned to the original position in September/October (after the swimming season).  
Along with restoring of banquettes to the original position, it is necessary to restore residual sediments left after relocating Posidonia banquettes, also manually and/or using hand tools.

**Priority and implementation period:** High priority, preseason (May) and postseason (September/October).

**Frequency of the activity:** Once during the period.

**Funding for implementation:** Volunteer activities managed by the Public Institution and associated partners

**Environmental benefits:** Maintaining the natural mechanism of protection against erosion.

**Indicator of activity implementation:** Number of relocations. Area and amount of displaced deposits. Trend of coastal features.

**Desired outcome:** Reduce coastline retreat and increase natural processes of protection against erosion.

**Expected outcome:** Reduce coastline retreat and increase natural processes of protection against erosion.

**Partners:** Sali Municipality, local associations

### A.2.2. Maintaining favorable condition of Posidonia banquettes on Sakarun beach

**Types of activities:** Active

**Area of activity** Posidonia banquettes on Sakarun beach.

**Current status:** Marine litter is present in Posidonia banquettes - mostly larger waste that is deposited together with the formation of banquettes.

**Goal of the activity:** Maintain Posidonia banquettes clean and in a natural form so they may pose no risk to visitors whilst preserving the beauty of landscape.

**Proposed technique:** Maintaining banquettes - removal of waste from banquettes.

**Technical description:** Maintaining banquettes.

**Proposed methodology:** Manual removal of waste.

**Description of the method:** Banquettes are cleaned from marine litter in a manner that does not impact its compactness, manually once in two weeks throughout the year in the entire area of Sakarun beach, however more intensely during the period of heavier depositing.

**Priority and implementation period:** High priority, year-round activity.

**Frequency of the activity:** Depending on the weather conditions, preferably once every two weeks to once a month.

**Funding for implementation:** Volunteer activities managed by the Public Institution and associated partners

**Environmental benefits:** Retaining waste and preventing its return to the sea. Preventing forming of microplastics.

**Indicator of activity implementation:** Number of cleaning activities. The amount of waste collected.

**Desired outcome:** Reducing the amount of litter deposits in the area of Sakarun beach (including the beach plus banquettes)

**Expected outcome:** Reducing the amount of litter deposits in the area of Sakarun beach (including the beach plus banquettes)

**Partners:** Sali Municipality, local associations, Mulić d.o.o.

### A.2.3. Biodiversity conservation of Posidonia banquettes on Sakarun beach

**Types of activities:** Active

**Area of activity:** Posidonia banquettes on Sakarun beach.

**Current status:** Biodiversity level at the site has been insufficiently researched.

**Goal of the activity:** Perform survey and maintain Posidonia banquettes in a natural form to achieve functional characteristics of specific habitat.

**Proposed technique:** Non-invasive ways of community survey and status monitoring.

**Technical description:** Faunistic and ecological survey.

**Proposed methodology:** Species inventory, abundance and biomass estimation.

**Description of the method:** Describing main features of the community depending on the layer structure of Posidonia banquettes and seasonality - species composition, abundance and size structure (if applicable).

**Priority and implementation period:** Medium priority, year-round activity.

**Frequency of the activity:** Performing research throughout the year and through all seasons (once a month).

**Funding for implementation:** Partners' funds (associations, citizens, scientific institutions), Public Institution funds

**Environmental benefits:** Conservation of functional habitat. Added value in terms of protection of the area. Presence of endemic species.

**Indicator of activity implementation:** Survey reports.

**Desired outcome:** Trend in the growth of number of species due to better management of banquettes and less habitat devastation.

**Expected outcome:** Maintaining community ecosystems in Posidonia banquettes.

**Associated partners:** expert associates, associations

### 3. IMPLEMENTING ACTIVITIES IN THE BACKSHORE

#### A.3.1. Maintaining favorable condition and habitat integrity in the backshore of Sakarun beach

**Types of activities:** Active

**Area of activity:** Habitats in the backshore of Sakarun beach

**Current status:** No special targeted habitat protection measures have been implemented in the backshore

**Goal of the activity:** Prevent habitat devastation in the coastal part behind Sakarun beach.

**Proposed technique:** Control the level and intensity of different interest related activities.

**Technical description:** Installing physical barriers and restrictions.

**Proposed methodology:** On-site maintenance and supervision.

**Description of the method:** Controlling traffic route and traffic volume as well as use of the beach by installing ramps and barriers.

**Priority and implementation period:** Medium priority, year-round activity.

**Frequency of the activity:** Continuous activity with more intense supervising activities during season.

**Funding for implementation:** Funds of the Public Institution.

**Environmental benefits:** Maintaining the natural mechanism of protection against erosion.

**Indicator of activity implementation:** Records of supervision made by the security service.

**Desired outcome:** Complete absence of traffic in the area

**Expected outcome:** Reduced pressure on the area and less traffic.

**Partners:** Municipality of Sali, concessionaires/business owners



### A.3.2. Biodiversity conservation of habitats in the backshore of Sakarun beach

**Types of activities:** Active

**Area of activity:** Habitats in the backshore of Sakarun beach

**Current status:** No detailed research of the area has been carried out

**Goal of the activity:** Perform survey and maintain habitats in the backshore in a natural form

**Proposed technique:** Non-invasive ways of community survey and status monitoring.

**Technical description:** Floristic and faunistic survey

**Proposed methodology:** Species inventory, abundance and biomass estimation.

**Description of the method:** Describing main features of the community in relation to habitat and its ecosystem and seasonality along with monitoring of the main indicators - species composition, abundance and size structure (if applicable).

**Priority and implementation period:** Medium priority, year-round activity.

**Frequency of the activity:** Performing research throughout the year and through all seasons (once a month).

**Funding for implementation:** Partners' funds (associations, citizens, scientific institutions), Public Institution funds

**Environmental benefits:** Conservation of functional habitat. Added value in terms of protection of the area. Presence of endemic species.

**Indicator of activity implementation:** Survey reports.

**Desired outcome:** Preserved habitats in the backshore of Sakarun beach

**Expected outcome:** Preserved habitats in the backshore of Sakarun beach

**Associated partners:** expert associates, associations

## 4. IMPLEMENTING ACTIVITIES AT SEA

### A.4.1. Maintaining favorable condition and integrity of priority habitat 1120 Posidonia beds in Sakarun Bay

**Types of activities:** Active

**Area of activity** Posidonia beds in Sakarun Bay.

**Current status:** A habitat map has been prepared with a detailed area with Posidonia beds. The first year of the monitoring program in the Natura 2000 area has been completed at two locations, a total of six stations.

**Goal of the activity:** Implement monitoring program of Posidonia beds status to enable monitoring of the community status and maintain favorable condition of Posidonia beds in a natural form to achieve functional characteristics of specific habitat and explore the potential for implementing innovative conservation measures.

**Proposed technique:** Non-invasive ways of community survey and status monitoring, implementation of innovative conservation measures.

**Technical description:** Faunistic and ecological survey.

**Proposed methodology:** Prvan M, Jakl Z, Guala I (2014): Field manual for monitoring of Posidonia oceanica seagrass meadows (Posidonia meadows), Project MedMPAnet

**Description of the method:** Monitoring the status of Posidonia beds and damage levels as well as presence of other threats.

**Priority and implementation period:** Medium priority, late summer, early autumn.

**Frequency of the activity:** The monitoring program should be implemented every three years.

**Funding for implementation:** Funds of Public Institution and associated partners (associations, scientific institutions)

**Environmental benefits:** Conservation of functional habitat. Added value in terms of protection of the area. Presence of endemic species.

**Indicator of activity implementation:** Survey reports.

**Desired outcome:** Trend in the growth of number of species due to better management of Posidonia beds and less habitat devastation.

**Expected outcome:** Reducing negative pressures on habitats and community in Posidonia beds.

**Associated partners:** expert associates, associations

#### A.4.2. Improvement of the boat anchoring system in Sakarun Bay

**Types of activities:** Active

**Area of activity:** Habitats of Posidonia beds and sandy bottoms of protected bays in Sakarun Bay

**Current status:** Traditional anchoring system (block with chain) in the area of the concession zone not covering the entire bay.

**Goal of the activity:** Introducing environmentally friendly boat anchoring systems taking into account the presence of Posidonia beds.

**Proposed technique:** Providing support to Zadar County in a gradual transition from a traditional to an environmentally friendly boat anchoring system in Sakarun Bay.

**Technical description:**

Cooperate with the county of Zadar to address the issues concerning anchorage area and concession domain in Sakarun Bay.

Develop a model of transition onto a more environmentally friendly anchorage system - define conditions, volume, location and possible phases of investment.

Displace current blocks from Posidonia beds onto sedimentary seafloor.

Expand concession domain, which is conditional on establishment of environmentally friendly anchorage.

Assist the county of Zadar in setting up a payment model for buoy mooring, which would generate part of the funds for maintenance and research operations as well as for the monitoring of ecosystems in Sakarun Bay.

Impose a year-round ban on anchoring on the entire area of Sakarun Bay.

Replace blocks with environmentally friendly anchoring system (such as "sand screw", "steel coil" and similar, depending on the habitat type subject to Project activities).

**Proposed methodology:** Activities minimising adverse impact on Posidonia beds.

**Description of the method:**

Diving activities and preparation of accompanying documentation for the project.

**Priority and implementation period:** Medium, spring.

**Frequency of the activity:** Annually (certain portion of the investment)

**Funding for implementation:** Funds provided by the county of Zadar, income from mooring fees.

**Environmental benefits:** Minimal damage to Posidonia beds, improved quality of habitats. Conservation of functional habitats. Added value in terms of protection of the area.

**Indicator of activity implementation:** A model has been developed. The model to be incorporated into future management plan for Natura 2000 habitats. The number of displaced blocks. Document amending concession domain.

**Desired outcome:** Eco-friendly anchorage in Sakarun Bay, to be set up within a period of 5 years.

**Expected outcome:** Eco-friendly anchorage in Sakarun Bay, to be set up within a period of 10 years.

**Associated partners:** The county of Zadar, concessionaire

## 5. BUILDING CAPACITY, RAISING AWARENESS AND PROVIDING EDUCATIONAL ACTIVITIES

### A.5.1. Building capacities of local stakeholders

**Types of activities:** Active

**Area of activity:** Dugi Otok, the county of Zadar

**Current status:** Local stakeholders aware of the issue.

**Activity goal:** To strengthen capacities of local stakeholders, enabling them to safeguard and protect natural condition of Sakarun Bay.

**Proposed technique:** Non-formal educational activities.

**Technical description:**

Prepare and implement activities aimed at strengthening capacities of local stakeholders, enabling them to conserve Posidonia banquettes and related habitats.

Organise regular trainings designed to strengthen capacities of stakeholders' staff managing the area.

Prepare and implement activities to strengthen capacities of local stakeholders (concessionaires, renters and similar) showing them how to educate their users and customers.

**Proposed methodology:** Public workshops, round tables, public consultations, targeted trainings for employees of local stakeholders.

**Description of the method:** It is essential to raise awareness and understanding of the condition of Sakarun beach and to strengthen capacities of local stakeholders, enabling them to educate their users and customers.

**Priority and implementation period:** High, winter and spring

**Frequency of the activity:** Annually

**Funding for implementation:** Funds provided by the Public Institution in partnership with tourist boards.

**Environmental benefits:** Providing a basis for a model of eco-friendly beach, which would also indirectly protect and prevent any disruptions of terrestrial habitats, Posidonia seagrass deposits and marine habitats (Posidonia beds).

**Indicator of activity implementation:** Number of workshops. Number of participants. Prepared educational materials for users.

**Desired outcome:** Raising awareness among local stakeholders of the need to support implementation of eco-friendly beach model on Sakarun.

**Expected outcome:** Raising awareness among some local stakeholders of the need to support implementation of eco-friendly beach model on Sakarun.

**Associated partners:** Local associations, tourist boards (Tourist Board of Dugi Otok, Tourist Board of Božava)

### A.5.2. Raising awareness among beachgoers to Sakarun beach

**Types of activities:** Active

**Area of activity:** Dugi Otok

**Current status:** Beach visitors with different expectations and different levels of awareness of the actual condition and appearance of Sakarun beach.

**Activity goal:** Beach visitors who perceive Sakarun beach as a place of relaxation and preserved nature.

**Proposed technique:** Non-formal educational activities.

**Technical description:**

Prepare and distribute educational materials and tools.

Emphasis placed on digital distribution of educational tools - QR codes on information signs, ships, tourist trains, information boards.

Maintenance of information boards which promote Sakarun beach, emphasizing the importance of *Posidonia oceanica* in the sea and of *Posidonia* seagrass deposits

Preparation of multi-lingual educational brochures/ leaflets for digital distribution.

Maintenance (appropriate replacement in case of wear and tear) of information boards

**Proposed methodology:** Prepare and distribute educational materials and tools. Emphasis placed on digital distribution of educational tools - QR codes on information signs, ships, tourist trains, information boards.

**Description of the method:** Prepare educational materials which are informative and visually appealing, presenting interesting scientific aspects of the research carried out on Sakarun beach and emphasizing its relevance in terms of preservation of nature, environment and biodiversity.

**Priority and implementation period:** High, summer

**Frequency of the activity:** Daily

**Funding for implementation:** Funds provided by the Public Institution.

**Environmental benefits:** Providing a basis for a model of eco-friendly beach, which would also indirectly protect and prevent any disruption of dune habitats, *Posidonia* seagrass deposits and underwater marine habitats (*Posidonia* beds).

**Indicator of activity implementation:** Prepared educational materials for users. Results of evaluations and survey.

**Desired outcome:** Raising awareness among beach visitors of the need to support implementation of eco-friendly beach model on Sakarun.

**Expected outcome:** Raising awareness among beach visitors of the need to support implementation of eco-friendly beach model on Sakarun.

**Associated partners:** associations, tourism boards (Tourism Board of Dugi Otok, Tourism Board of Božava)

### A.5.3. Educational workshops

**Types of activities:** Active

**Area of activity:** Dugi Otok, the county of Zadar

**Current status:** Beach visitors with different expectations and different levels of awareness of the actual condition and appearance of Sakarun beach.

**Activity goal:** Beach visitors who perceive Sakarun beach as a place of relaxation and preserved nature.

**Proposed technique:** Non-formal educational activities.

**Technical description:**

Non-formal educational workshops designed for children, young people and adults, held on Sakarun beach. Non-formal workshops for children and young people in the county of Zadar, organised within the framework of the educational system. Setting up a model of "eco-friendly beach" - seasonal educational displays and play area, showcasing *Posidonia oceanica*

**Proposed methodology:** Non-formal educational workshops.

**Description of the method:** Educational and practical workshops are used to raise awareness among visitors and local residents, in particular children and young people, about *Posidonia oceanica* and its banquettes, about habitats they build and the manner in which they can be protected through eco-friendly beach model.

**Priority and implementation period:** High, spring and summer.

**Frequency of the activity:** Daily

**Funding for implementation:** provided by the Public Institution and associated partners (associations).

**Environmental benefits:** Setting up a model of eco-friendly beach indirectly protects dune habitats, *Posidonia* seagrass deposits and underwater marine habitats (*Posidonia* beds) against any disruptions and threats caused by anthropogenic activities.

**Indicator of activity implementation:** Prepared educational materials for users. Results of evaluations and survey.

**Desired outcome:** Raising awareness among beach visitors who support and participate in activities included in the eco-friendly beach model on Sakarun.

**Expected outcome:** Raising awareness among beach visitors who support and participate in activities included in the eco-friendly beach model on Sakarun.

**Associated partners:** associations, tourist boards (Tourist Board of Dugi Otok, Tourist Board of Božava)

#### A.5.4. Rebranding of the beach in Sakarun Bay

**Types of activities:** Active

**Area of activity:** Croatia

**Current status:** Sakarun Bay is equated with Sakarun beach and they are both branded as “sandy beach”, however, sand can be found primarily in the bay whereas the beach is a pebble beach covered with *Posidonia banquettes*.

**Activity goal:** Branding of Sakarun beach as rural pebble beach, boasting exceptional biodiversity and sandy bay.

**Proposed technique:** Non-formal educational activities

**Technical description:**

Prepare communication strategy “Sakarun - sandy bay” intended for all tourist boards promoting Sakarun beach.

**Proposed methodology:** Develop communication and educational tools.

**Description of the method:** Bringing together interested parties promoting the area, with an aim of presenting and rebranding Sakarun beach and bay as an example of modern rural beach, designed to safeguard and protect the environment and offer a relaxing sandy bay and clean seawater.

**Priority and implementation period:** High, spring and summer

**Frequency of activity:** intensive during the first year of implementation.

**Funding for implementation:** Municipality of Sali and tourist boards set up by the municipality (Tourist Board of Dugi Otok and Tourist Board of Božava), funds provided by the Public Institution in partnership with the Croatian National Tourist Board

**Environmental benefits:** Visitors who know what to expect indirectly protect dune habitats, *Posidonia* seagrass deposits and underwater marine habitats (*Posidonia* beds) and prevent any disruption and threats posed by anthropogenic activity, thus raising awareness of the specific nature of the area.

**Indicator of activity implementation:** Results of evaluations and survey.

**Desired outcome:** Rebranding accepted by visitors

**Expected outcome:** Rebranding accepted by foreign visitors.

**Associated partners:** Municipality of Sali, tourist boards (Croatian National Tourist Board, Tourist Board of Zadar County, Tourist Board of Dugi Otok, Tourist Board of Božava), tourist operators

## 8. Preparation and implementation of monitoring plan

Description of monitoring activities	Methodology	Implementation indicator	Implementation frequency
<b>Monitoring beach morphology (A.2.1.1d)</b>	Collect geomorphological data through field work and digital images of the area (in line with: Monitoring Manual: Monitoring methods for the sustainable management of Mediterranean beaches with <i>Posidonia oceanica</i> )	Monitoring beach geomorphology and developments along the coastline. Variability of coast profile, volume of changed sediment, volume of accumulated deposits, variability of deposit volume throughout the year.	Year-round monitoring - a minimum of four times a year (seasonal).
<b>Monitoring accumulated deposits (A.2.1.1.c)</b>	Collect data through field work, focusing on morphology of accumulated deposits, developments and changes (in line with: Monitoring Manual: Monitoring methods for the sustainable management of Mediterranean beaches with <i>Posidonia oceanica</i> ).	Composition of accumulated deposits, quantity of litter, removed biomass or biomass of deposits on the intervention area, impact on sediment quantity.	Year-round monitoring - a minimum of four times a year (seasonal).
<b>Monitoring habitat ecosystems of accumulated deposits (A.2.3.1b)</b>	Collect geomorphological and biological data through field work.	Monitor composition and size of ecosystems and the effect which displacement of accumulated deposits has on the ecosystem.	A minimum of two times a year
<b>Monitoring ecosystems in the inland area behind beach (A.3.2.2b)</b>	Collect geomorphological and biological data through field work.	Monitor composition and size of ecosystems, as well as the ways in which the use of the area impacts these ecosystems.	A minimum of two times a year
<b>Monitoring <i>Posidonia</i> beds (A.4.1.1a)</b>	Collect biological data through field work (in line with: Prvan M, Jakl Z, Guala I (2014): Field manual for monitoring of <i>Posidonia oceanica</i> seagrass meadows ( <i>Posidonia</i> meadows), Project MedMPAnet)	Conservation index and density	Every three years



## 9. Evaluation of the project and tools used under the Action Plan

Implementation of the Action Plan is monitored, i.e., project and tools are evaluated in order to determine whether the plan is being implemented effectively and whether the defined goals have been achieved. The aim of monitoring is also to identify impacts and gather experience and if necessary, adjust activities accordingly.

Evaluation of the project and of Action Plan tools could, to a larger extent, be carried out, as part of internal evaluation, by the employees of Natura Jadera public institution and if necessary, by external experts. In order to implement any activity under the Action Plan, it is necessary to employ new people (clarification provided in chapter 11). In line with the activities specified in the Plan, the Public Institution may designate persons responsible for monitoring the implementation of various parts of the Plan - with special emphasis on newly employed persons. All employees, involved in any shape or form in the implementation of the Plan, must be aware of the need to monitor the effects of the Plan and must gather evidence and information indicating whether or not the goals of the Plan have been achieved. Based on the findings obtained by monitoring the effects of the Plan, implementation monitoring plan will be subject to regular annual revision.

Consequently, activities for the following year may be modified taking into account last year's results, different circumstances or new information. When preparing annual reports, based on the evaluation provided by users, all activities will be subject to brief annual evaluation (if applicable). Evaluation is, for most activities, provided by the users, and in turn, employees of the Public Institution evaluate the activities based on the findings of evaluation provided by the users.

The main part of the evaluation activities is used to check whether results align with annual plans, once all activities have been implemented in a given year. It is necessary to follow whether implementation indicators have been successfully met and to monitor pace at which the desired outcome and goals are being achieved. Monitoring schemes should primarily include reports containing evaluations and re-evaluations for the future period, and this should be taken into account when evaluating or reevaluating activities.

If there is a discrepancy between plans and actual activities, it is necessary to determine underlying reasons for the discrepancy - lack of user interest, poor planning, insufficient resources and similar, and to conduct a reevaluation accordingly, the aim of which is to modify activity and improve its implementation.

All implemented activities should, after five years, be re-evaluated in order to determine whether any modifications are necessary, for example, new methodology of teaching and learning, different communication tools, extreme situations, if initial research revealed shortcomings which need to be addressed and similar. Based on a systematic reevaluation, it is internally decided to change and/or modify activities.

During the final year of implementation, it is necessary to carry out a comprehensive analysis of achievements, goals and vision. Findings of the analysis will be incorporated in the plan for the next period.

**(Potential) activities designed to monitor implementation of the Action Plan**

Ensure that research and monitoring reports and expert studies are prepared by experts under contractual obligation or by personnel of the Public Institution and that reports are submitted in a timely manner.

Keep records of workshops, programmes, presentations and number of participants.

Make sure that regulations and acts are prepared by the employees of the Public Institution within defined time limits, and that acts necessary for regular daily operations of the Public Institution are regularly updated.

Make sure that all collected data on key species, habitats and studies as well as data on boundaries between management authorities and zones within the protected area, have been recorded and incorporated in the GIS data base.

Hold two annual internal meetings to make sure that the Public Institution develops and implements key plans, projects, strategic programmes specified under Action Plan activities, or resulting from such activities. For all activities to be implemented in the current year.

Conduct a survey, before and after completing 50 % of educational activities, in order to assess the level of knowledge and awareness among targeted groups and local residents.

Keep records of trainings attended by the employees of the Public Institution.

Keep records of number and type of prepared and distributed information materials.

Ensure that the Public Institution has access to all external plans, strategies and regulations, developed by offices and authorities relevant for the area, and also ensure that Public Institution takes an active part in their preparation and provides written recommendations.

Ensure that supervisors and other relevant field workers prepare reports on activities related to control and monitoring of endangered species and habitats and that they have access to vulnerable areas.

Ensure trainings and strengthen employee capacities.

Prepare a comprehensive assessment of Action Plan activities during the fifth year of implementation and prepare a revised version.

All Action Plan activities initiated within the first 5 years of Plan implementation

## 10. Partnerships during implementation of Action Plan

- Shipowners (educational activities)
- Croatian National Tourist Board (promotional and educational activities)
- Environmental protection inspection (activities and strategies related to legal matters)
- Nature protection inspection (activities and strategies related to legal matters)
- Institutions (research activities)
- Ruđer Bošković Institute (research activities)
- Institute of Oceanography and Fisheries (research activities)
- Port Authority (strategies, rulebooks and concession-related matters)
- Media (promotional and educational activities)
- The Ministry of Economy and Sustainable Development (promotional and educational activities)
- The Ministry of Culture and Media (promotional and educational activities)
- Ministry of the Sea, Transport and Infrastructure (activities and strategies related to legal matters, concessions)
- Ministry of Agriculture (promotional and educational activities)
- Ministry of Physical Planning, Construction and State Assets (activities and strategies related to legal matters, concessions)
- Ministry of Regional Development and EU Funds (providing funding)
- Ministry of Tourism and Sports (promotional and educational activities)
- Mulić d.o.o. (maintenance)
- Crafts business (technical assistance and works)
- Sali municipality (organisational activities, activities and strategies related to legal matters, concessions)
- Experts (research activities)
- Universities and Faculties (research activities)
- Tourist Board of Božava (promotional and educational activities)
- Tourist Board of Dugi Otok (promotional and educational activities)
- Associations (educational and research activities)
  - o 20 000 leagues - marine explorers society
  - o Croatian Biological Society
  - o Aurelia, Biodiversity Conservation Association
  - o Since - Association for Nature, Environment and Sustainable Development
  - o HYL Association
  - o Bioteka Association
  - o Others
- Volunteers (maintenance)
- The county of Zadar activities and strategies related to legal matters, concessions)

## 11. Estimated human and financial resources

Public Institution "Natura Jadera" has only 5 permanent employees. As only one person works in the Specialist Service and three persons work in Nature Conservation Service, it is advisable that two more persons be employed. One person should be employed throughout the year to carry out on-site maintenance and supervision and conduct cleaning operations. It is recommended that this person be employed to work 25 % of regular working hours (or similar regime) throughout the year, and that he or she live on Dugi Otok to be closer to work and to be more efficient. The second person should be employed throughout the year to work part-time and to work full time during summer season. Their task would be to monitor implementation of activities set out in the Action Plan, prepare and develop relevant strategic documents, meet with other stakeholders and external associates and to carry out educational activities in summer period. Two new hires would ensure a sufficient number of employees necessary to implement activities under the Action Plan, which would also be facilitated because of good cooperation with other employees of the Public Institution and continuous cooperation with key partners such as Sali municipality, Mulić d.o.o. and support of volunteers.

It is advisable that Sakarun beach area be included, as part of the protected area, into the programme "Volunteering in the Croatian Parks". The programme could meet an increasing demand for workers during tourist season, and also before and after the season for the activities such as cleaning, displacement of deposits and carrying out educational activities, surveys and similar.

Many activities will require that external associates and experts be subcontracted, consequently, it is necessary to specify the volume of work and efficiency level in order to coordinate project tasks in cases where multiple subcontractors work on the same area and need to cooperate. The role of the Public Institution in such activities is to deal with subcontracting, supervision and assessment (role to be performed by planned new hires).

The funding necessary to implement planned activities is provided from own funds and from project activities. Implementation of long-term activities requires that resources be invested through project activities, particularly in the case of major infrastructure investments such as change of anchoring system. When it comes to such projects, it is necessary to seek support from other public bodies operating in this area and to jointly apply for public calls.

Development goals of the Public Institution and of the area of interest must include an educational / training program for employees and local stakeholders and the program should: be aligned with the mission and goals of the Institution, contain specific and achievable goals for employees, focus on helping employees to improve their performance, be designed to prepare an employee to take on a new role with greater responsibility and determine responsibility for planning, implementing and evaluating trainings. The programmes should be regularly implemented. This will, consequently, improve efficiency and quality of work, employee motivation and morale and also improve satisfaction of visitors to Sakarun beach.

## References

1. Bell J. D. i Harmelin-Vivien M. I. (1982) Fish fauna of French Mediterranean *Posidonia oceanica* seagrass meadows. *Tethys* 10, 337-347.
2. Borg J.A., Rowden A.A., Attrill M.J., Schembri P.J., Jones M.B. (2006) Wanted dead or alive: high diversity of macroinvertebrates associated with living and dead *P. oceanica* matte. *Mar. Biol.* 146, 667 – 677.
3. Boudouresque, C.F., Pergent, G., PergentMartini, C., Ruitton S., Thibaut T., Verlaque M. (2016). The necromass of the *Posidonia oceanica* seagrass meadow: fate, role, ecosystem services and vulnerability. *Hydrobiologia* 781:1, 25-42.
4. Boudouresque, Ch., Ponel, P., Astruch, P., Barcelo, A., Blanfune, A., Geoffroy, D., Thibaut, T. (2017). The high heritage value of the Mediterranean sandy beaches, with a particular focus on the *Posidonia oceanica* "banquettes": a review. *Scientific Reports of Port-Cros National Park.* 31. 23-70.
5. Buia M.C., Gambi M.C., Dappiano M (2004) Seagrass systems. *Biol. Mar. Mediterr.* 11 (suppl. 1), 133-183.
6. *Climate Change (2013): The Physical Science Basis.* Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley(eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp
7. Colombini, I., Mateo, M.A., Serrano, O., Fallaci, M., Gagnarli, E. et al. (2009). On the role of *Posidonia oceanica* beach wrack for macroinvertebrates of a Tyrrhenian sandy shore. *Acta Oecologica International Journal of Ecology* 35, 32–44.
8. Francour P., Ganteaume A., Poulain M. (1999). Effects of boat anchoring in *Posidonia oceanica* seagrass beds in the Port-Cros National park (NW Mediterranean Sea *Aquat Conserv* 9, 391 – 400.
9. Guidetti P. 2000. Differences among fish assemblages associated with nearshore *Posidonia oceanica* seagrass beds, rocky-algal reefs and unvegetated sand habitats in the Adriatic Sea. *Estuarine, Coastal and Shelf Science* 50, 515–529.
10. Hemminga M. A. and Duarte C. M. (2000). *Seagrass Ecology.* Cambridge University Press, Cambridge.
11. Istraživanje naselja morskih cvjetnica (*Posidonia oceanica*) u uvali Sakarun (eng. *Exploration of seagrass meadows (Posidonia oceanica) in Sakarun bay*), Zadar county, Expert report, Marine Explorers Society - 20.000 leagues, 2017
12. Milović, M., Pandža, M. (2016) Florističke i vegetacijske vrijednosti zaštićenog krajobraza sjeverozapadni dio Dugog otoka s posebnim osvrtom na uvalu Saharun. (eng. *The value of flora and vegetation of protected landscape in the northwest part of Dugi otok, with special emphasis on Sakarun Bay*) Expert report.
13. Morska bioraznolikosti akvatorija uz značajni krajobraz na sjeverozapadnom djelu Dugog otoka (eng. *Marine biodiversity of the waters along the significant landscape in the NW part of Dugi otok*), Expert study, "Sunce" Association, Split, 2009.
14. Pergent, G., Gerakaris, V., Sghaier, Y.R., Zakhama-Sraier, R., Fernández Torquemada, Y. & Pergent-Martini, C. (2016). *Posidonia oceanica*. The IUCN Red List of Threatened Species 2016.
15. Pergent-Martini, C., Leoni, V., Pasqualini, V., Ardizzone, G. D., Balestri, E., Bedini, R., & Boumaza, S. (2005). Descriptors of *Posidonia oceanica* meadows: Use and application. *Ecol. Indic.* 5(3), 213-230.

16. Pikelj, K. (2021): Geomorphological analysis of Sakarun beach. Second preliminary report. POSBEMED2 Interreg med project. p. 39
17. Pikelj, K., Godec, P. (2021): Geomorphological analysis of Sakarun beach. First preliminary report. POSBEMED2 Interreg med project. p. 40
18. Plan upravljanja Značajnim krajobrazom Sjeverozapadni dio Dugog otoka (eng. *Management Plan for the Northwestern part of Dugi Otok Significant Landscape*), Natura Jadera, 2013.
19. Praćenje stanja staništa i naselja morskih cvjetnica (*Posidonia oceanica*) u odabranim područjima ekološke mreže Zadarske županije, (eng. *Monitoring the condition of seagrass habitats and meadows (Posidonia oceanica) in selected areas of ecological network in Zadar county*), Expert report, Marine Explorers Society - 20.000 leagues, 2020.
20. Prvan M., Jakl Z., Guala I. (2014) Terenski vodič za praćenje stanja livada morske cvjetnice *Posidonia oceanica* (livade posidonije) (eng. *Field Manual for Monitoring of Posidonia oceanica Seagrass Meadows (Posidonia Meadows)*), Project MedMPAnet.
21. Rezultati klimatskog modeliranja za potrebe izrade nacrtu Strategije prilagodbe klimatskim promjenama Republike Hrvatske do 2040. s pogledom na 2070. i Akcijskog plana (EPTISA, March 2017) (eng. *Results of climate modelling for the draft Climate Change Adaptation Strategy in the Republic of Croatia for the period to 2040 with a view to 2070 and Action Plan*)
22. Strategija prilagodbe klimatskim promjenama u Republici Hrvatskoj za razdoblje do 2040. s pogledom na 2070. (eng. *Climate Change Adaptation Strategy in the Republic of Croatia for the period to 2040 with a view to 2070*) (OG 46/20)
23. Vacchi, M., De Falco, G., Simeone, S., Montefalcone, M., Morri, C., Ferrari, M., and Bianchi, C. N. (2017) Biogeomorphology of the Mediterranean *Posidonia oceanica* seagrass meadows. *Earth Surf. Process. Landforms*, 42: 42–54. doi: 10.1002/esp.3932.
24. Zubak I, Čižmek H, Mokos M (2020) *Posidonia oceanica* lower depth limits along a latitudinal gradient in the eastern Adriatic Sea. *Botanica Marina* 10.1515/bot-2019-0097.
25. <https://www.dugiotok.hr/o-otoku>
26. <https://natura-jadera.com/prirodne-vrijednosti/znacajni-krajobrazi/sjeverozapadni-dio-dugog-otoka/>
27. <http://www.bioportal.hr/gis/>