Assessing the role of Posidonia banquettes in coastline protection against erosion, through UAV technology and granulometric analysis: Preliminary results from the case of Schinias-Marathon National Park, Attica, Greece.

Vandarakis D.[1]*, Salomidi M.[1], Gerakaris V.[1], Issaris Y[1], Ioannis Kourliaftis I[1], Agaoglou C.[2], Kapsimalis V.[1], and Panagiotopoulos I.[1]

[1] Institute of Oceanography, Hellenic Centre for Marine Research (HCMR), 19013 Anavyssos P.C., Greece;

[2] Department of European Projects Hellenic Society for the Protection of Nature, Nikis 20, 105 57 Athens, Greece,

*corresponding author: Vandarakis Dimitrios

e-mail: divandarakis@hcmr.gr

Abstract Coastal environments and in particular beaches are valuable natural assets, offering a wide array of ecosystem services and economic benefits. In this study UAV technology with RTK-GPS is used in order to map in detail, the beach morphological characteristics, aiming to the impact of the presence of *Posidonia oceanica* beach-cast deposits. The principal aim of this research is to evaluate the relation between the banquettes and the sediments, as well as the banquette's significance concerning the beach protection. Particularly, the distinctive goals are: a) to identify the differences in volume, shape and area covered by the banquettes, and b) to analyze the relationship between banquette deposition and the changes of the sedimentary budget. The presence of the fine-grained sediments and the calculation of the sediment budget enclosed in the total volume of the banquette (692.57±8.3m^3 (Mission 2)) will re-evaluate their role concerning the coastline protection.

Keywords: *Posidonia oceanica* banquettes, UAV survey, volume-area-sediment calculation, coastal protection

1. Introduction

Coastal environments and, in particular, beaches are rapidly evolving systems, driven by the continuous interaction of the topography and transport processes with wind, wave and tidal forcing. In order to understand and quantify coastal morphodynamics, it is necessary to acquire high-resolution data on beach topographic changes (Casella et al., 2020). During the recent years, the use of Unmanned Aerial Vehicles (UAVs) has been increased significantly, in order to deal with physical geography, geomorphology, biogeography, geology etc. In this study UAV technology with RTK-GPS is used in order to map in detail, the beach morphological characteristics, aiming to assess the impact of beach-cast accumulations of the Mediterranean endemic and protected seagrass *Posidonia oceanica*; also called Posidonia "banquettes", these deposits are known to offer important ecosystem services, among which beach protection and nourishment, dune formation and stabilization, and coastal and marine biodiversity enhancement (Simeone et al., 2013; Otero et al. 2018).

The principal aim of this research is to evaluate the relation between the banquettes and the sediments included, as well as their significance as a natural protection of the beach (De Falco et al., 2003). In particular, the distinctive goals are: a) to identify the differences in volume, shape and area covered of the banquettes and b) to analyze the relationship between banquette deposition and morphological changes of the sedimentary composition of the beach. Five missions were planned (Mission 1 July 2020, Mission 2 September 2020, Mission 3 December 2020, Mission 4 March 2021 and Mission 5 July 2021) but only two have already been executed and studied completely, the third (Mission 3 Feb 2021) is in the phase of the laboratory analysis, due to the pandemic. The research is still ongoing it will end July 2021, thus the results till now are limited. The study area is located at the coastal plain of Marathon and particularly at Schinias coastal front, located in the northeast region of Attica Prefecture, with an orientation of NE to SW (Fig. 1). The coastal area of Schinias, is characterized by smooth slope, relatively low wave energy and sandy sediments.

2. Methods

In order to investigate the differences of the extension and volume of the banquettes, UAV flights were designed and executed. Due to the smoothness of the terrain (almost flat) the flights were horizontal parallel to the ground at a certain height AGL (Above Ground Level) (Trajkovski et al., 2020). The sensor of the UAV is pointed in 80 degrees (nadir). The images were taken in a specific overlap (80% front, 80% side), in order to achieve very high resolution of 3D reconstruction of the relief, and therefore to acquire as accurate measurements as possible. Pix4D capture (v.4.12.1) software was used to make the flight plans and to select the necessary criteria for the optimum representation.

Also, the contribution of Ground Control Points (GCPs) to such a survey is fundamental, because they increase the accuracy of the UAV imagery to centimeter level (Fallati et al., 2020; Lu et al., 2020). At least 5 to 10 GCPs,

depending to the extension of the banquette, were used for each mission of this study. They also improve the results from the Structure from Motion (SfM) interpretation of the photogrammetry process (Windle et al., 2019). The GCPs also improved the absolute altitude of each point. Prior to the flight, they were surveyed with RTK-GPS.

Sediment samples were collected during the UAV Missions (July 2020, September 2020). The sites where the samples were acquired are in general, on the shoreline and on the coastline area of the banquettes, forming three transects, spaced approximately 50m apart each other. That was planned in order to have a holistic approach to the relation between the presence of the banquettes and the granulometry of the sediments.

The production of the Orthomosaic, the DSM, the DTM and the contours of the area was made through Pix4D mapper, after the processing of all the collected images.

The calculations of the different volumes were made through Pix4D mapper by digitizing the area of the banquettes and by using specific modules provided by the software. The base of the calculation was considered according to the elevation and the extent of the banquette lying on the beach in each Mission.

Additionally, the granulometric-sedimentological analyses were conducted at the Bio-Geo-Chemical Laboratory (ISO 17025) of HCMR. The samples were dried and they were sieved (sieves from 4mm to <63μm) in order each sediment class to be separated and thus to identify the dynamic of the deposition environment in each specific part.

Finally, the results were interpreted statistically through the Gradistat v. 8.0 (Blott et al., 2001), in order to define the quality and the quantity of the distinctive sediment classes and therefore to identify the contribution of the presence of the banquette onshore, in the coastline protection.

3. Results

Results from the Mission 1 (July 2020) (Fig. 1) and Mission 2 (September 2020) (Fig 1) showed that the maximum volume of the Banquettes concentrated on the beach is 692.57±8.3m^3 (Mission 2) with an outspread about 2617.43m^2, after four days of high velocity eastern winds. The dominant sediment class is "fine sand" with a percentage over 55%, in approximately every sample taken from both Missions (1 & 2). Especially, the granulometry for **Mission 1** is showing that the samples Schinias 1 up July 2020, Schinias 1 down July 2020, Schinias 2 up July 2020 and Schinias 2 down July 2020 present very high percentage of fine sand 61.5% to 74.9%. The class of very fine sand is limited between 9% (Schinias 1 up July 2020) to 37% (Schinias 2 down July 2020). The class of coarse sand is ranging between 2.1% (Schinias 2 up July 2020) to 14.6% (Schinias 1 up July 2020). These three classes are the most significant during this mission. There are four more classes and the results are presented as follows. For the medium sand the percentage ranges from 2.3% (Schinias 2 down July 2020) to 17.3% (Schinias 3 down July 2020). very coarse sand ranges from 1.2% (Schinias 2 down July 2020) to 12.4% (Schinias 3 up July 2020). For the very fine gravel the percentage ranges from 0.8% (Schinias 2 down July 2020) to 10.9% (Schinias 3 up July 2020). Finally, the class with the lowest percentage is that of very coarse silt which ranges from 0.3% (Schinias 1up July 2020 and Schinias 1 down July 2020) to 1% (Schinias 2 down July 2020). Similarly, for **Mission 2** the sediment classes are mostly in agreement with those from Mission 1. The dominated sediment is sand and specifically the class of fine sand with a percentage of approximately 49.57% (Schinias 1 down September 2020) to 62.92% (Schinias 3 up September 2020). Especially, the samples Schinias 2 up September 2020, Schinias 2 down September 2020, Schinias 1 down September 2020 and Schinias 3 up September 2020 present very high percentage of fine sand from 54.41% to 62.92%. The class of medium sand is limited between 9.45% (Schinias 3 up September 2020) to 18.58% (Schinias 1 up September 2020). The class of coarse sand is ranging between 7.56% (Schinias 3 up September 2020) to 20.10% (Schinias 1 up September 2020). These three classes are the most significant during this mission. There are four more classes and the results presented as follows. For the very fine sand the percentage ranges from 6.80% (Schinias 1 up September 2020) to 8.65% (Schinias 3 up September 2020). Very coarse sand ranges from 1.56% (Schinias 2 up September 2020) to 7.09% (Schinias 2 down September 2020). For the very fine gravel the percentage ranges from 0.77% (Schinias 2 down September 2020) to 5.97% (Schinias 3 up September 2020). Finally, the class with the lowest percentage is that of very coarse silt which ranges from 0.3% (Schinias 1 down September 2020) to 2.57% (Schinias 3 up September 2020). Generally, the "Fine sand" prevails in both Missions, but the samples in Mission 2 seem to have lower percentages of "Fine sand" and higher percentages of coarser classes, than those of Mission 1 (finer classes dominate).

4. Discussion-Conclusion

The presence of fine sediments indicates the low energy deposition environment, thus the protective trend of the banquette to the coastal zone, in combination with the location of the test site, the morphology-geomorphology of the littoral area, the climatic conditions prevailing and the relative low wave activity in specific wind directions (mainly northern winds), that favors the concentration of the beach cast sea-grass litter. The total volume of the sand in relation to the total volume of the banquette will be measured also, in order to determine its use as sediment reservoir. This research is still in progress, more results will be published in the near future.

Acknowledgements

The study is carried out in the scope of the international InterregMED project "POSBEMED2: GOVERNANCE AND MANAGEMENT OF POSIDONIA BEACH-DUNE SYSTEMS ACROSS THE MEDITERRANEAN

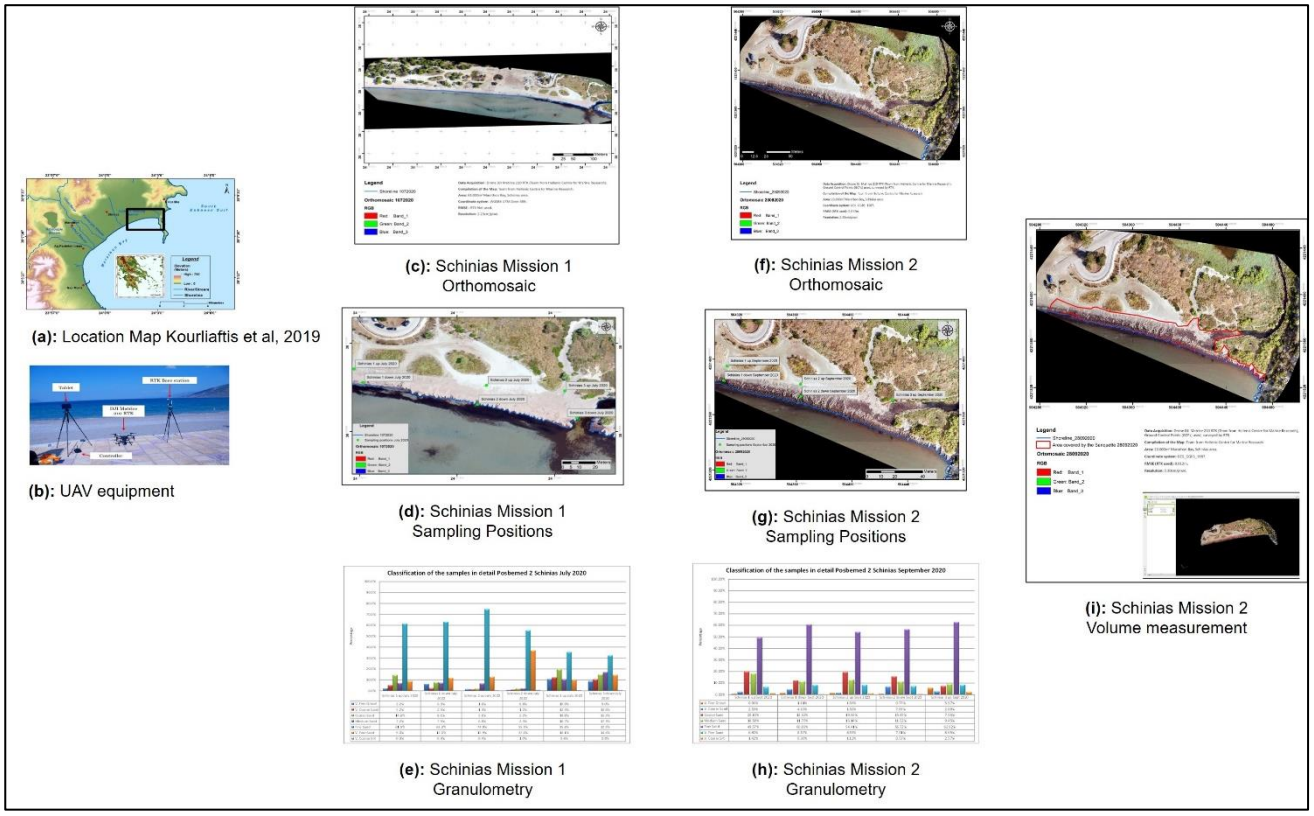

Figure 1: Location of the study area along with the physiographic settings of the coastal plain of Marathon (after Kourliaftis et al., 2019). The black rectangle indicates the selected test site (a). UAV equipment (b). The orthomosaics of the area resulted from images of Mission 1 & 2 (July 2020 & September 2020) (c & f). The sampling sites of Mission 1 & 2 (July 2020 & September 2020) (d & g). The statistical-granulometric analysis of Mission 1 & 2 (July 2020 & September 2020) (e & h). Finally, the volume calculation from Mission 2 (surveyed by RTK-GPS) (i).

References

1. Blott, S. J., Pye, K. (2001). GRADISTAT: a grain size distribution and statistics package for the analysis of unconsolidated sediments. Earth surface processes and Landforms, 26(11), 1237-1248.
2. Casella, E., Drechsel, J., Winter, C., Benninghoff, M., Rovere, A. (2020). Accuracy of sand beach topography surveying by drones and photogrammetry. Geo-Marine Letters, 1-14.
3. De Falco, G., Molinaroli, E., Baroli, M., Bellaciccob, S. (2003). Grain size and compositional trends of sediments from Posidonia oceanica meadows to beach shore, Sardinia, western Mediterranean. Estuarine, Coastal and Shelf Science, 58(2), 299-309.
4. Fallati, L., Saponari, L., Savini, A., Marchese, F., Corselli, C., Galli, P. (2020). Multi-temporal UAV data and bject-based image analysis (OBIA) for estimation of substrate changes in a post-bleaching scenario on a Maldivian reef. Remote Sensing, 12(13). doi: 10.3390/rs12132093
5. Kourliaftis, G., Vassilakis, E., Kapsimalis, V., Poulos, S., Vandarakis, D. (2019). Evolution of the Coastal Environment of the Marathon Bay Based on the Shoreline Displacement Rate for the Last 80 Years. In 15th International Congress of the Geological Society of Greece.
6. Lu, C.-H., Chyi, S.-J. (2020). Using UAV-SfM to monitor the dynamic evolution of a beach on Penghu Islands. Terrestrial, Atmospheric and Oceanic Sciences, 31(3), 283–293. doi: 10.3319/tao.2019.09.25.01
7. Otero, M.M., Simeone, S., Aljinovic, B., Salomidi, M., Mossone, P., Giunta Fornasin, M.E., Gerakaris, V., Guala, I., Milano, P., Heurtefeux, H., Issaris, Y., Guido, M., Adamopoulou, M. (2018). Governance and management of Posidonia beach-dune system. POSBEMED Interreg Med Project. 66pp+ Annexes
8. Simeone, S., De Muro, S., De Falco, G. (2013). Seagrass berm deposition on a Mediterranean embayed beach, Estuarine, Coastal and Shelf Science, 135: 171-181
9. Trajkovski, K. K., Grigillo, D., Petrovič, D. (2020). Optimization of UAV flight missions in steep terrain. Remote Sensing, 12(8), 1–20. doi: 10.3390/RS12081293
10. Windle, A. E., Poulin, S. K., Johnston, D. W., Ridge, J. T. (2019). Rapid and accurate monitoring of intertidal Oyster Reef Habitat using unoccupied aircraft systems and structure from motion. Remote Sensing, 11(20). doi: 10.3390/rs11202394New York.