



LABORATÓRIO NACIONAL  
DE ENGENHARIA CIVIL

## **MOSAIC.PT FIELD CAMPAIGNS**

**Cova-Gala, Vieira and São Pedro de Moel beaches,  
January-March 2019**

MOSAIC.pt – Multi-source flood risk analysis for safe coastal  
communities and sustainable development

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## Title

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## MOSAIC.PT FIELD CAMPAIGNS

Cova-Gala, Vieira and São Pedro de Moel beaches, January-March 2019

### Abstract

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The present report summarizes the field campaigns of the project MOSAIC.pt, performed between January and March 2019 in the Cova-Gala, Vieira and São Pedro de Moel beaches, located in the Portuguese west coast. The campaigns aimed to characterize the response of the beaches, with diverse typology, to the hydrodynamic forcing and included topographic surveys by GNSS-RTK, drone surveys, superficial sediment sampling and the report of the territorial elements affected.

Keywords: Topographic survey / Photogrammetric survey / Territorial elements / Sediment sampling

## CAMPANHAS MOSAIC.PT

Praias da Cova-Gala, Vieira e São Pedro de Moel, janeiro-março 2019

### Resumo

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O presente relatório sumariza as campanhas de campo do projeto MOSAIC.pt, realizadas entre janeiro e março de 2019 nas praias da Cova-Gala, Vieira e São Pedro de Moel situadas na costa ocidental portuguesa. As campanhas tiveram como objetivo caracterizar a resposta das praias, com tipologia diversa, ao forçamento hidrodinâmico e incluíram levantamentos topográficos com GNSS-RTK, levantamentos com *drone*, recolha de sedimentos superficiais e registo dos elementos do território afetados.

Palavras-chave: Levantamentos topográficos / Levantamento fotogramétrico / Elementos territoriais / Recolha de sedimentos





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# 1 | Introduction

This report describes the field campaigns of the project MOSAIC.pt - Multi-source flood risk analysis for safe coastal communities and sustainable development, funded by the *Fundação para a Ciência e a Tecnologia* (PTDC/CTA-AMB/28909/2017). The MOSAIC.pt project aims to develop an advanced flood risk management framework for coastal zones, integrating robust predictive tools and multi-source data with the different dimensions of the risk, to adequately contribute to emergency planning and response.

The objective of the field campaigns was to characterize the response of beaches with different typology to different oceanographic and meteorological conditions. Three beaches with diverse typology, located in the Portuguese central west coast, between Mondego river mouth and Nazaré cape were chosen: Cova - Gala, Vieira and São Pedro de Moel beaches. This coastal stretch is known by its history of sediment drift starvation (particularly in the north sector). The campaigns were performed between January and March 2019 and included topographic surveys by GNSS-RTK, drone surveys, superficial sediment sampling and the report of the territorial elements affected.

This report is divided into six sections, besides the present introduction. The description of the study areas and an overview of the field campaigns are presented, respectively, on chapters 2 | and 3 |. Chapter 4 | summarizes the oceanographic and meteorological conditions observed during the field campaigns. In the following chapters, from 5 | to 7 |, the campaigns performed in each beach are described. Finally, section 8 | presents a brief evaluation of the campaigns.

## 2 | Description of the study areas

The Cova - Gala, Vieira and São Pedro de Moel beaches are located in the Portuguese central west coast, between the Mondego river mouth and the Nazaré cape (Figure 2.1). The littoral stretch, which includes these three beaches, is constituted by two natural subsectors: since the Mondego river mouth until the vicinity of São Pedro de Moel, by a continuous beach - dune system followed, from São Pedro de Moel until Nazaré cape, by active cliffs carved in consolidated rocks. The northern sector, correspondent to the beach - dune system, is only interrupted by the coastal protection structures implemented in the seafronts of Cova - Gala, Costa de Lavos, Leirosa, and river Lis mouth, and by the rocky outcrop of Pedrogão. The southern sector, which includes São Pedro de Moel beach, is constituted by beaches with smaller width, frequently interrupted by mesozoic rocky outcrops forming active cliffs. The transition between the two sectors is done along an extension of about 2 km north of São Pedro de Moel.

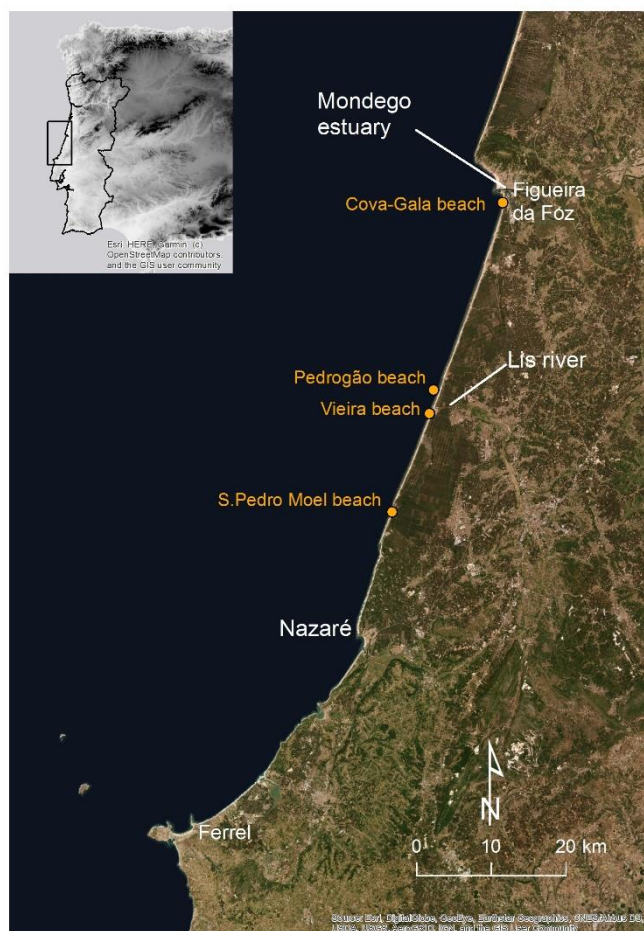


Figure 2.1 – Location of the study beaches



## 2.1 Cova – Gala beach

The coastal stretch of Cova-Gala is a sandy beach-dune system with a coastline length approximately 2 km and main alignment 5°N. It is located south of the south jetty of the Mondego river mouth and includes the seafront of Cova-Gala, part of São Pedro parish and village, in Figueira da Foz council (from Figure 2.2 to Figure 2.8). The stretch evolved, since the last mid-century, under the influence of diverse human interventions (Simões and Castanho, 1978; Simões, 1979; Vicente and Pereira, 1998; Dias *et al.*, 1994; Cunha *et al.*, 1997; INAG, 1999; Oliveira, 2015, Oliveira, 2016). Among those, the following stand out:

- the construction of the north and south jetties of the Mondego river mouth, with 900 and 950 m length, respectively, and distance between heads 325 m (1961-1965);
- the sand extraction from Figueira da Foz beach (1973-1996);
- the interventions of river regularization, for defence against floods, for irrigation and for hydropower production (dispersed in time);
- the interventions of port regularization, for improving the port operations (dispersed in time);
- the dredging of the port entrance to access the port (dispersed in time);
- the artificial nourishment, performed 50 m south of the land extreme of the south jetty and 2.25 m above the mean sea level (MSL) at the time, between 1973-1976, with about  $3 \times 10^5$  m<sup>3</sup> of sediment dredged from Coxim dock (50 110 m<sup>3</sup> in 1973, 69 830 m<sup>3</sup> in 1974, 88 640 m<sup>3</sup> in 1975 and 85 440 m<sup>3</sup> in 1976);
- the construction of the alongshore coastal defences of Cova-Gala (1975);
- the reinforcement (raise of 1 m) of the alongshore coastal defences of Cova-Gala (1978);
- the construction of the five groynes of Cova-Gala (1978-1979); and
- the extension (of about 400 m) of the north jetty of the Mondego river mouth (Jul/2008 - Aug/2010).

The study of Simões and Castanho (1978) is the first known that describes the coastal erosion south of the south jetty of the Mondego river mouth, observed since the beginning of the sixties, which became very serious in the seventies. The authors report that the situation was such that with the contribution of the maritime winters of 1971-1972, the safety of some buildings constructed on the dune south of the mouth was endangered, making it necessary to implement emergency protection measures, which were based on the construction of alongshore defence structures, subsequently raised and complemented by groynes.

Based on the comparison of three topo-hydrographic surveys, dated of 1975, 1978 and 2011, Oliveira (2015) concluded that, regarding the evolution of the Cova-Gala seafront, the coastal protection interventions executed in 1975 and 1978-2011, that is, the alongshore defences and the Cova-Gala groyne field (Figure 2.3), respectively, together with the artificial nourishment of  $174 \times 10^3$  m<sup>3</sup> of sediments, performed in 1975-1976, limited the progression of the erosive outbreak observed in the period 1975-1978 and promoted the beach recovery during the period 1978-2011. In fact, in 2011 the coastline was on average 25 m farther advanced than the coastline in 1975. In opposition, immediately south of the Cova-Gala groyne field, specifically, downdrift the last groyne of the Cova-Gala groyne field,

the erosive outbreak observed in the period 1975-1978 was intensively increased in the period 1978-2011.



Figure 2.2 – Oblique aerial view of the seafront of Cova-Gala beach



Figure 2.3 – Aerial photograph (18/6/2018; © Google Earth) of the Mondego river mouth and the coastal stretch of Cova-Gala, with its four alongshore defence structures (from DL1 to DL4) and five groynes (from E1 to E5)



Figure 2.4 – Photographs of Cova-Gala beach: view of the south jetty of the Mondego river mouth from the dune at the northern extreme of the beach (25/Feb/2019)



Figure 2.5 – Photographs of Cova-Gala beach: view, towards the north of the beach, of E2 and E3, from the sedimentological cell between E3 and E4 (19/Feb/2019)



Figure 2.6 – Photographs of Cova-Gala beach: view towards the north of the beach from the sedimentological cell between E3 and E4, at low and high tide (left and right, respectively) (21/Feb/2019)





Figure 2.7 – Photographs of Cova-Gala beach: view, towards the south of the beach, of E4 and E5, from the sedimentological cell between E3 and E4 (21/Feb/2019)

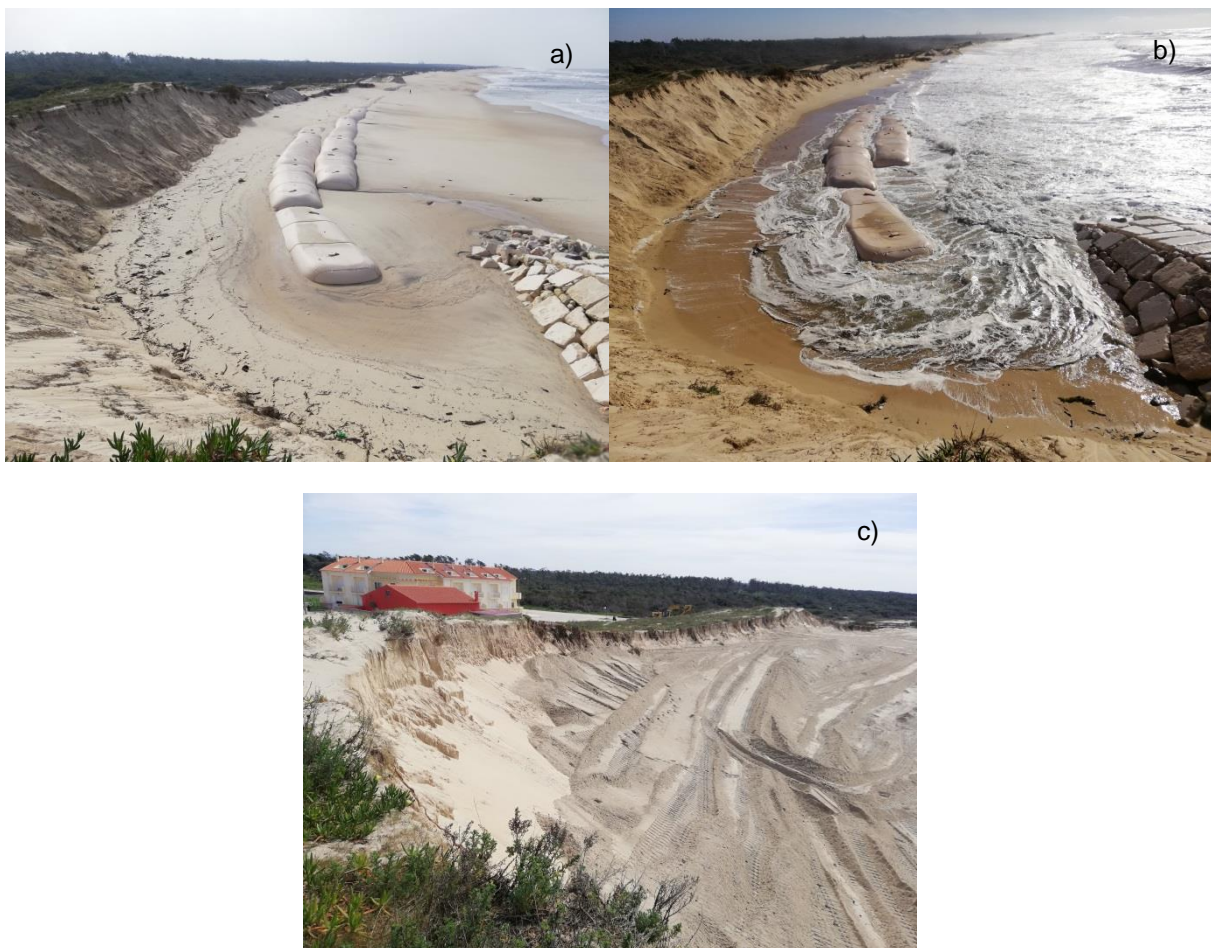


Figure 2.8 – Photographs of Cova-Gala beach: adjacent downdrift zone of the groyne further south, E5, during and after the implementation of geotextile tubes for coastal protection: a) 21/Feb/2019, b)19/Feb/2019 and c) 26/March/2019

## 2.2 Vieira beach

The coastal stretch of Vieira beach is a sandy beach - dune system with a coastline length of approximately 1 km and main alignment 19°N. It is located south of the south jetty of the Lis river mouth and includes the seafront of Vieira, part of Vieira de Leiria parish and city, in Marinha Grande council (from Figure 2.9 to Figure 2.12). The stretch evolved, since the last mid-century, under the influence of diverse human interventions (Cabral, 1986; Dias *et al.*, 1994; Cunha *et al.*, 1997; Oliveira *et al.*, 2004). Among those, the following stand out:

- the construction of the jetties, with 150 m length, of the Lis river mouth (1950);
- the construction of the alongshore coastal defence, with 600 m length, south of the Lis river mouth (1959);
- the reinforcement of the above alongshore coastal defence (seventies);
- the shortening, in about 80 m, of the jetties of the Lis river mouth (1978); and
- the sand extraction from Vieira beach (until 1978);



Figure 2.9 – Oblique aerial view of the seafront of Vieira beach



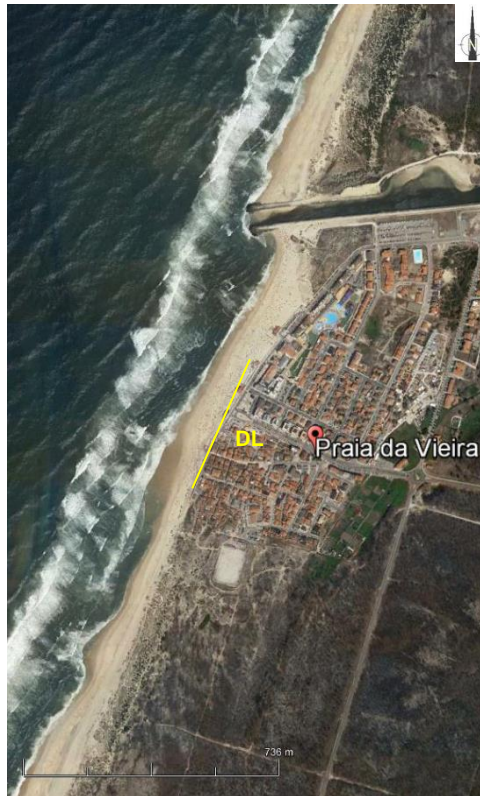


Figure 2.10 – Aerial photograph (dated of 18/6/2018; © Google Earth) of the Lis river mouth and the Vieira beach, with its the alongshore defence structure (DL)

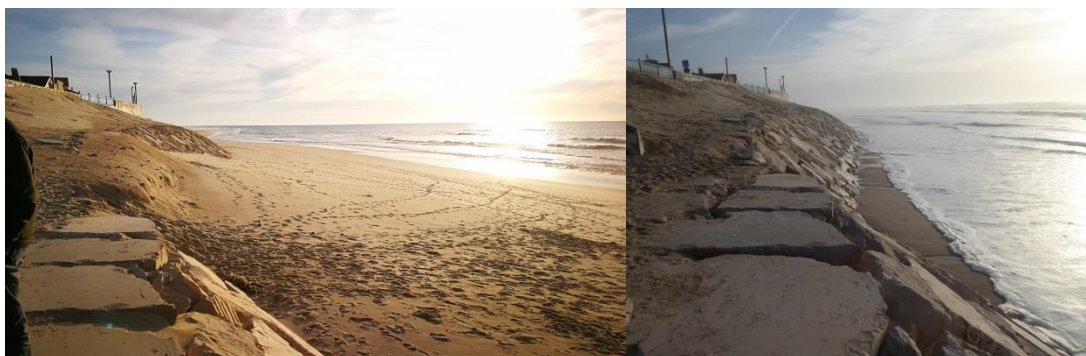


Figure 2.11 – Photographs of Vieira beach in the alongshore defence structure: towards the north sector (above, on the 19/Feb/2019) and towards the south sector (below, on the 4/Feb/2019, at left, and on the 25/Feb/2019, at right)



Figure 2.12 – Photographs of the extremes of Vieira beach: north (left) and south (right) (both on the 25/Feb/2019)

### 2.3 São Pedro de Moel beach

The São Pedro de Moel beach is an embedded narrow beach with a coastline length of approximately 400 m and main alignment 25°N. It is located south of a 2 km length active cliff carved in consolidated rocks and includes the part of the seafront of the São Pedro de Moel village, part of Marinha Grande parish, city and council (from Figure 2.13 to Figure 2.17). The beach backshore is limited by a seawall with varying height (with some infrastructures on the top), an alongshore defence structure and an active cliff carved in consolidated rocks at both extremes. The beach surface is dug in the cross-shore direction, in a channel shape, by the São Pedro stream, whose outlet, covered by blocks of concrete, is located at the base of the seawall (Figure 2.14). Both extremes of the beach are characterised by the presence of low rocky outcrops, which are alternately covered and uncovered by sand.



Figure 2.13 – Oblique aerial view of the seafront of São Pedro de Moel beach





Figure 2.14 – Aerial photograph (dated of 18/8/2018; © Google Earth) of São Pedro de Moel beach and location of the low rocky outcrops, the stream outlet and the alongshore defence structure (DL)



Figure 2.15 – Photographs of the São Pedro stream outlet and induced local erosion in São Pedro de Moel beach (Feb/2019)





Figure 2.16 – Photographs of the northern sector of São Pedro de Moel beach (11/Feb/2019), from the sea towards the backshore (left to right)



Figure 2.17 – Photographs of the central and southern sectors of São Pedro de Moel beach (left photo: 26/March/2019; right photo: 19/Feb/2019), from the backshore towards the sea

### 3 | Field campaigns overview

Nine field campaigns were performed between 08/Jan/2019 and 26/March/2019 (Table 3.1). The activities performed in each campaign on Cova-Gala, Vieira and São Pedro de Moel beaches are described in the following sections. Sediment samples were also collected in Pedrógrão beach (see Figure 2.1 for location) as complementary data that are described in 6.4.

Table 3.1 – Field campaigns overview: date and locations

Date	Beach
08/Jan/2019	Cova-Gala, Vieira, Pedrógrão and São Pedro de Moel
04/Feb/2019	Cova-Gala
11/Feb/2019	Cova-Gala
12/Feb/2019	São Pedro de Moel
19/Feb/2019	São Pedro de Moel and Vieira
21/Feb/2019	Cova-Gala
25/Feb/2019	Cova-Gala, Vieira and São Pedro de Moel
26/March/2019	Cova-Gala, Vieira and São Pedro de Moel
27/March/2019	Vieira

## 4 | Oceanographic and meteorological conditions

### 4.1 Water level conditions

The maximum water levels in the Figueira da Foz tide gauge during the field campaigns are presented in Table 4.1. The observed (data provided by the Hydrographic Institute) and predicted ([http://webpages.fc.ul.pt/~cmantunes/hidrografia/hidro\\_mares.html](http://webpages.fc.ul.pt/~cmantunes/hidrografia/hidro_mares.html)) levels are similar showing that no meteorological surge conditions were observed during the campaigns.

Table 4.1 – Tide and water level conditions during the field campaigns

Date	Highest water level observed (m)	Highest tidal level predicted (m)
08/Jan/2019	3.52	3.54
04/Feb/2019	3.40	3.45
11/Feb/2019	3.12	3.16
12/Feb/2019	3.00	3.01
19/Feb/2019	3.86	3.87
21/Feb/2019	4.16	4.07
25/Feb/2019	3.32	3.30
26/March/2019	3.29	3.21
27/March/2019	2.87	2.80

### 4.2 Wave conditions

With the exception of the first field campaign, the following ones took place after the winter storm Helena that impacted the Portuguese coast on the 1st of February, with high wind intensity and wave height (Figure 4.1). The atmospheric pressure reached 993.26 hPa.

The wave conditions, represented by the statistic parameters maximum wave height,  $H_{max}$ , significant wave height,  $H_s$ , peak period,  $T_p$ , and wave direction in the peak period,  $Dir$ , in the Leixões coastal wave buoy from the Hydrographic Institute (IH) (<http://www.hidrografico.pt/m.boias>) during the field campaigns are presented in Table 4.2. In Figure 4.2 the water surface elevation components, wave height and water level, observed in Figueira da Foz are presented.

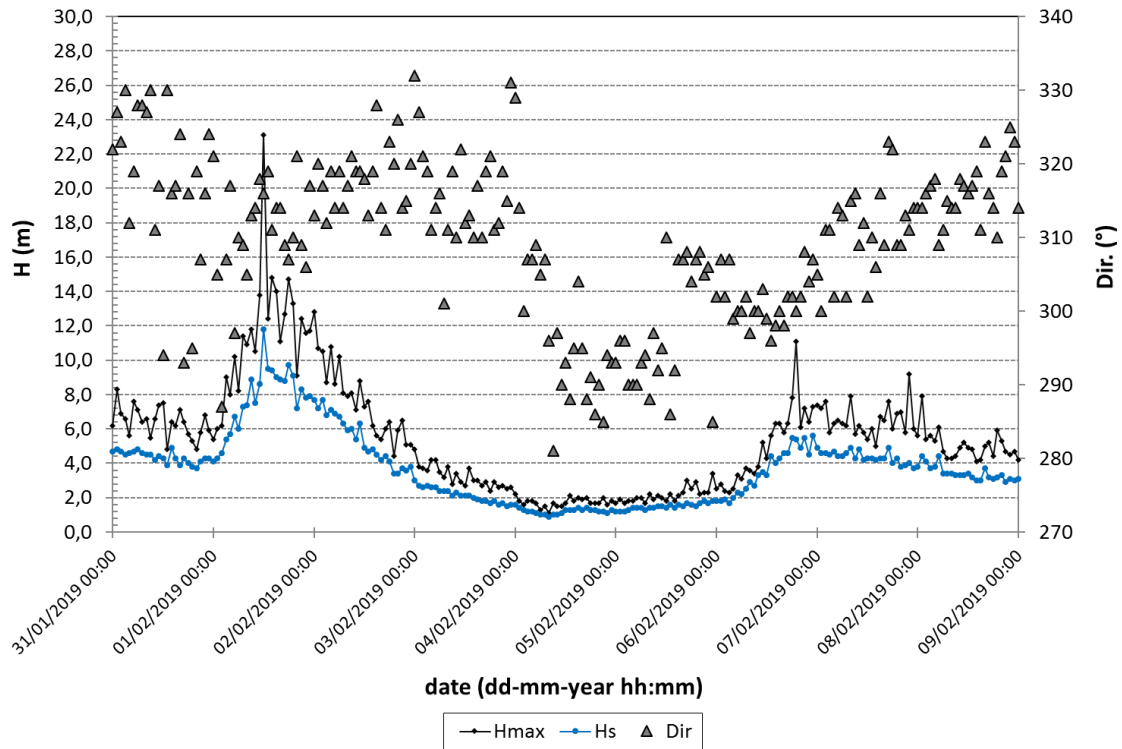


Figure 4.1 – Wave conditions between 31/Jan/2019 and 09/Feb/2019 at Leixões buoy

Table 4.2 – Wave conditions during the field campaigns. Data in the IH Leixões wave buoy

Date	Hmax (m)	Hs (m)	Tp (s)	Dir(°)
04/Feb/2019	2.2	1.6	8.7	329
11/Feb/2019	5.7	3.1	12.0	340
12/Feb/2019	4.0	2.4	13.4	338
19/Feb/2019	8.6	4.6	14.5	323
21/Feb/2019	7.6	5.6	17.3	282
25/Feb/2019	7.3	4.5	17.1	274
26/March/2019	4.4	2.5	13.6	328
27/March/2019	5.7	3.6	14.5	302

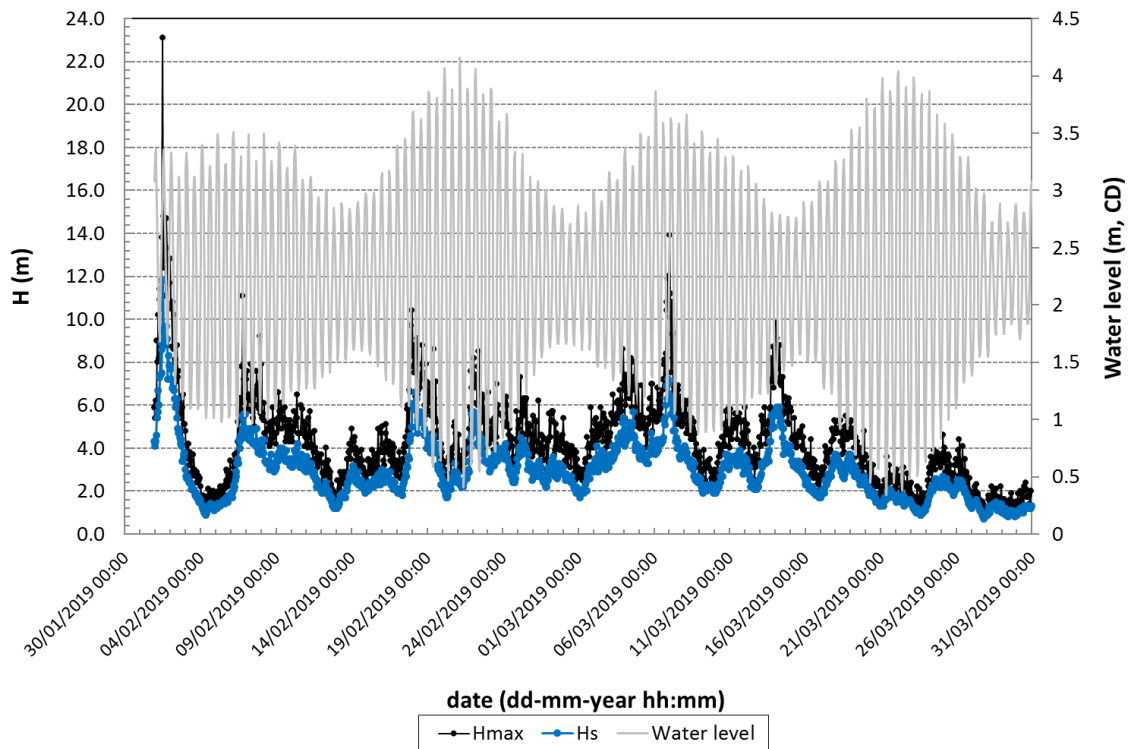


Figure 4.2 – Wave height (at Leixões) and tide (at Figueira da Foz) conditions during February and March 2019

### 4.3 Meteorological conditions

Wind and atmospheric data observed in the Ferrel meteorological station of the Hydrographic Institute (IH) (see Figure 1 for location) during the field campaigns are presented in Table 4.3.

Table 4.3 – Meteorological conditions during the field campaigns. Data in the IH Ferrel station

Date	Wind max. intensity (m/s)	Wind average intensity (m/s)	Wind average direction (°)	Minimum atmospheric pressure (hPa)
08/Jan/2019	7,20	2,63	78,47	1020,68
04/Feb/2019	6.27	3.64	115.31	1023.51
11/Feb/2019	9.69	5.10	76.17	1021.92
12/Feb/2019	10.00	3.07	92.49	1021.92
19/Feb/2019	13.74	4.95	108.92	1013.96
21/Feb/2019	13.43	4.31	143.19	1015.09
25/Feb/2019	8.76	3.63	107.56	1021.80
26/March/2019	11.87	4.13	76.57	1007.54
27/March/2019	7.51	3.87	217.39	1021.88

## 5 | Cova-Gala beach

### 5.1 Summary of the field campaigns

The field campaigns and activities performed in the Cova-Gala beach are described in Table 5.1.

Table 5.1 – Activities performed on the Cova-Gala beach field campaigns

Date	Topographic survey	Drone survey	Sediment sampling	Territorial elements report
03/01/2019			✓	
04/02/2019	✓			✓
11/02/2019		✓	✓	✓
21/02/2019	✓			✓
25/02/2019	✓			✓
26/03/2019	✓			✓

### 5.2 Topographic surveys

Four of the field campaigns included topographic surveys of the beach, specifically of the following elements: twelve cross-shore profiles, the base of the groynes, the base of the primary dune, the base of the alongshore defence, the waterline, the crest of the dune in the downdrift zone adjacent to the southernmost groyne (E5) and the limit of dune overwash events south of E5. The location of these topographic elements surveyed on the 04/Feb/2019, 21/Feb/2019, 25/Feb/2019 and 26/March/2019 is presented in Figure 5.1 and Figure 5.2.

The surveys were performed by RTK using a Topcon Hiper Pro GNSS receiver. The position of the fixed station was obtained by static processing and the corrections were applied to the points surveyed. The fixed station was positioned on the land extreme of E5 (coordinates in PT-TM06/ETRS89: X=-62317.13 m, Y=50866.98 m; and orthometric height: Z=6.95 m), in the four campaigns (Figure 5.3). The reference position of each of the twelve topographic profiles, from P1 to P12 (in Figure 5.1 and Figure 5.2), is identified in Table 5.2.





Figure 5.1 – Location of the topographic elements surveyed in Cova-Gala beach in the campaigns of 4/Feb/2019 and 21/Feb/2019, left and right, respectively. Image: ESRI Basemap







Figure 5.2 – Location of the topographic elements surveyed in Gala-Cova beach in the campaigns of 25/Feb/2019 and 26/March/2019, left and right, respectively. Image: ESRI Basemap









Figure 5.3 – Photograph of the positioning of the fixed station of the GNSS receiver on the campaign of 04Feb/2019: land extreme of E5; view towards south

Table 5.2 – Reference position of the topographic cross-shore profiles surveyed in Cova-Gala beach





Topographic profile designation	Coordinates of the reference position (PT-TM06/ETRS89)	Notes and photographs of the reference position
P1	X = -62135.06; Y = 52502.51	Last of the four wooden posts (when counting from north to south) located over the dune at the northern extreme of the beach, immediately adjacent to the south jetty of the Mondego river mouth.  
P2	X = -62133.35; Y = 52117.65	Left limit (when facing the sea) of the wooden footbridge in front of the left limit of the surf school cabin (which was later demolished).  

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<b>P3</b>	X = -62130.09; Y = 51768.73	First street tower lamp located at the beach side of the street after the parking place, towards north.	
<b>P4</b>	X = -62159.92; Y = 51668.54	Street tower lamp positioned in the corner of the pedestrian platform located in the middle of the street in front of a roundabout (with a blue wave sculpture) in front of the hospital.	
<b>P5</b>	X = -62194.71; Y = 51598.39	Left steel handrail (when facing the sea) of the concrete stair located at the north limit of the backshore of the sedimentological cell between E2 and E3 (the stair gives access to the parking place in front of the hospital).	
<b>P6</b>	X = -62186.49; Y = 51474.70	South limit of the northern stretch of the wall that that limits the pedestrian platform in front of the parking place, in front of the hospital.	

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<b>P7</b>	X = -62177.52; Y = 51361.37	Corner of the wooden footbridge at the south limit of the backshore of the sedimentological cell between E2 and E3.
		
<b>P8</b>	X = -62255.27; Y = 51198.50	Corner of the north limit of the wall that limits the pedestrian platform of the seafront of the sedimentological cell between E3 and E4.
		
<b>P9</b>	X = -62273.54; Y = 51125.43	Left corner of the wall (when facing the sea) of the backyard of the house located over the alongshore defence of the sedimentological cell between E3 and E4.
		
<b>P10</b>	X = -62292.75; Y = 50982.32	Left corner (when facing the sea) of the third picnic box (counting from south to north) in front of the sedimentological cell between E4 and E5.
		

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<b>P11</b>	X = -62298.48; Y = 50921.46	Corner of the south limit of the wall that limits the pedestrian platform and the parking place in front of the sedimentological cell between E4 and E5.	
<b>P12</b>	X = -62186.72; Y = 50782.59	Corner of the pedestrian platform, near the street tower lamp, in front of the yellow block of apartments.	

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### 5.3 Drone survey

The drone survey was made on 11/Feb/2019. The drone used the multicopter from LNEC, a DJI Inspire 1 V2 equipped with a camera Zenmuse X3, and a remote control with a tablet. The plans of the flights (see a flight plan in Figure 5.4) were programmed on this tablet: the flight altitude was set to 50 m; the overlap of the photos chosen was 80%, both longitudinal and transversal. To photo survey the 2 km of beach alongshore extension, six flights were made during the low tide. During these a total of 1437 photos were taken.

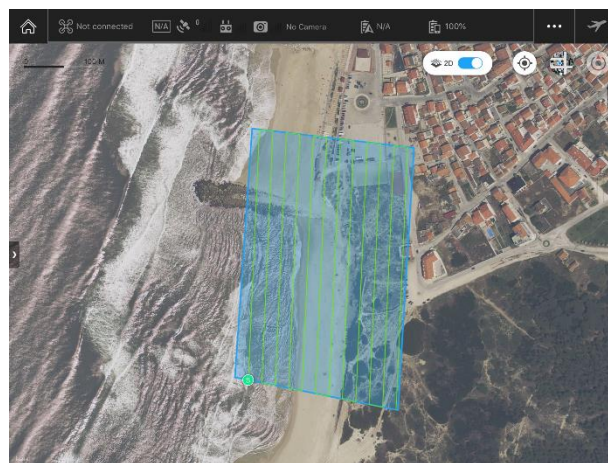


Figure 5.4 – Plan of the flight made over the southern area of the beach (includes part of groyne E5)

The flights were made with the authorization of the National Aeronautical Authority (NAA). In Portugal, obtaining this authorization is required to all flights, either to get aerial photos or to use a remote control that receives images from drones or other aerial platforms.

To reference the photo survey to the coordinate system of reference (PT-TM06/ETRS89, in planimetry, and Cascais Helmert 1938, in altimetry) and to perform quality check, a total of 78 points were coordinated by GNSS-RTK (in Figure 5.5 their location is marked on the numerical model of the surface). These points were divided in two groups. The first group of points (the ones used to reference the photo survey) are called ground control points (GCP), while the second group, used to perform the quality analysis, are called check points (CP).

The points were materialized by: i) targets, made with sheets of plastic (Figure 5.6a), placed on the sand; ii) triangular targets painted with red or white ink on the pedestrian platforms on the dunes area (Figure 5.6b) or on the surface of the blocks of the groynes (Figure 5.6c); iii) pre-existing local features (Figure 5.6d). All these points had to be visible on the aerial photos.

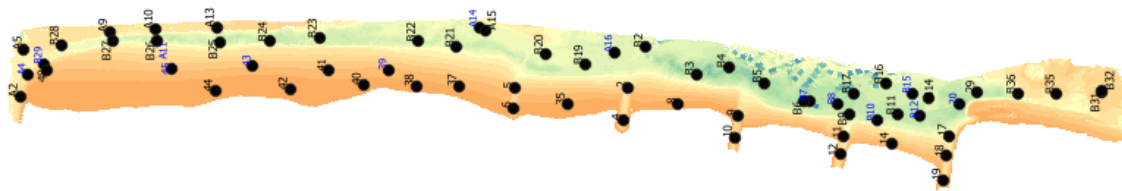


Figure 5.5 – Location of the points used to reference the photo survey and to perform quality check of the drone survey of Cova-Gala beach on 11/Feb/2019



Figure 5.6 – Points coordinated as seen on the aerial photographs on 11/Feb/2019

The points on the sand surface were coordinated before the flights. Between the coordination and the flights some were moved by the waves and, for this reason, they could not be used during the processing. Concerning the remaining points (points of type b, c and d), some were coordinated in the same day, others on the following day while others eight days after. Some of these points were coordinated twice, in different days, information that will be used to evaluate the quality of the GNSS coordinates.

To generate the point cloud (see a detail in Figure 5.7) and the orthomosaic (Figure 5.8) the software Agisoft Metashape was used. This generated a report with quality analysis and complementary

information. Figure 5.9 presents the locations of the camera and Figure 5.10 the photos overlap (photos used in the processing).



Figure 5.7 – Point cloud of the Cova-Gala beach, between E4 and E5, and the nearby area on 11/Feb/2019



Figure 5.8 – Orthomosaic of Cova-Gala beach on 11/Feb/2019

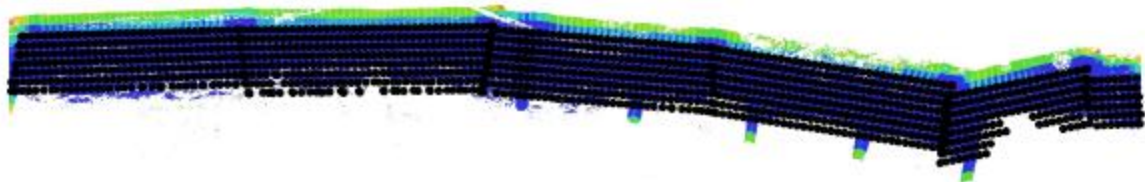


Figure 5.9 – Camera locations during the drone survey of Cova-Gala beach on 11/Feb/2019

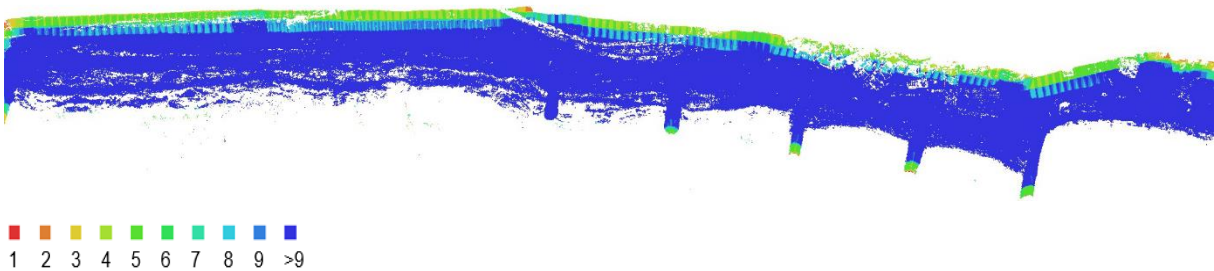


Figure 5.10 – Photos overlap during the drone survey of Cova-Gala beach on 11/Feb/2019



## 5.4 Sediment sampling

Superficial sediment samples were collected in Cova-Gala beach during two campaigns: 3 samples on 08/Jan/2019 and 45 samples on 11/Feb/2019.

The samples collected on 11/Feb/2019 were numbered following the criterion: Ci PX#, where i is the number of the sedimentary cell, between cross-shore protection structures, increasing from North to South and varying from 1 to 5. PX# is the cross-shore profile designation, where X is either N, C or S, for north, central or south, concerning the profile position in each cell, and # is 1, 2 or 3 concerning the cross-shore position of the sample in the profile (Figure 5.11). The location of the samples collected in both campaigns are presented in the following figures.

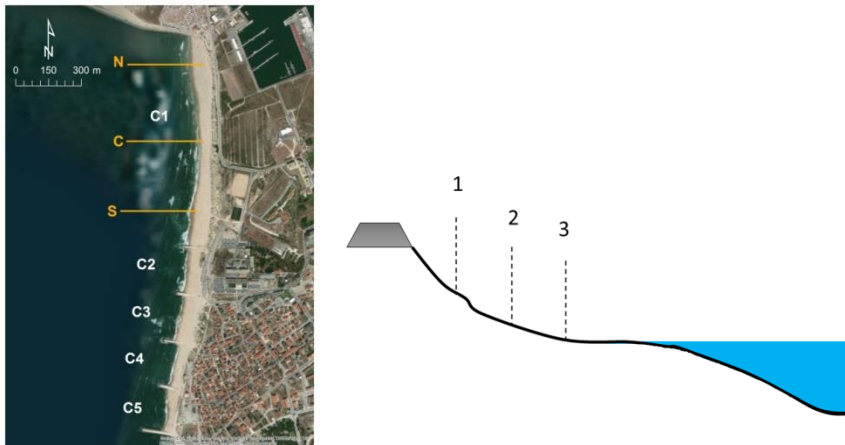


Figure 5.11 – Scheme of the sampling designation for the 11/Feb/2019 campaign (Image: ESRI Basemap)

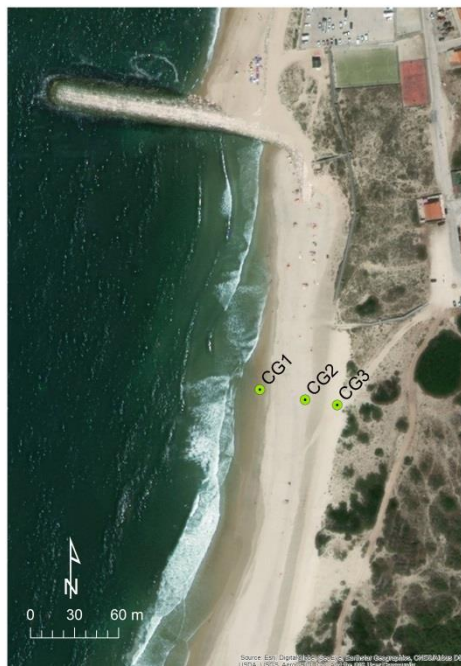


Figure 5.12 – Location of the sediment samples collected on 08/Jan/2019 south of the groyne E5. Image: ESRI Basemap








Figure 5.13 – Location of the sediment samples collected on 04/Fev/2019 from north to south for each sedimentological cell. Image: ESRI Basemap



## 5.5 Territorial elements affected

To characterize how the different coastal typologies presented in the Cova-Gala beach were affected by the forcing conditions observed during the field campaigns, information about territorial elements affected was acquired. The information includes the evidence of coastal defences overtopping and dune overtopping and overwash and is summarized in Table 5.3. The locations of the evidences are identified Figure 5.14.

Table 5.3 – Information of the territorial elements affected in Cova–Gala beach. Locations in Figure 5.14

Date	Elements	Description	Photos of the evidence	Location
04/Feb/2019	Alongshore coastal defence (DL4)	Evidence of overtopping		1
	Alongshore coastal defence (DL4)	Evidence of overtopping		1
19/Feb/2019	Alongshore coastal defence (DL4)	Evidence of overtopping		2
	Dune	Retreat and erosion		3
21/Feb/2019	Alongshore coastal defence (DL4)	Evidence of overtopping		1








	Alongshore coastal defence (DL4)	Evidence of overtopping		2
	Dune	Retreat and erosion		3
	Dune and inland natural area	Overwash and inland inundation		4
	Dune and inland natural area	Overwash and inland inundation		4
	Alongshore coastal defence (DL4)	Evidence of overtopping		1
<b>25/Feb/2019</b>	Alongshore coastal defence (DL4)	Evidence of overtopping		2
	Dune	Retreat and erosion		3



Figure 5.14 – Location of the territorial elements affected in Cova-Gala beach and described in Table 5.3

## 6 | Vieira beach

### 6.1 Summary of the campaigns

The field campaigns and activities performed on the Vieira beach are described in Table 6.1.

Table 6.1 – Activities performed on the Vieira beach field campaigns

Date	Topographic survey	Drone survey	Sediment sampling	Territorial elements report
03/01/2019			✓	
19/02/2019	✓			✓
25/02/2019	✓			✓
27/02/2019		✓		
26/03/2019	✓			✓

### 6.2 Topographic surveys by GNSS-RTK

Four of the field campaigns included topographic surveys of the beach, specifically of the following elements: seven cross-shore profiles and the base of the alongshore defence. The location of these topographic elements surveyed on 19/Feb/2019, 25/Feb/2019 and 26/March/2019 is presented in Figure 7.1.

The fixed station was positioned on the pedestrian platform in front of the roundabout with the boat sculpture, north of the Sun7 Bar (coordinates in PT-TM06/ETRS89: X=-71779.12 m, Y=23267.66 m; and orthometric height: Z=11.16 m) (Figure 6.2).

The reference position of each of the seven topographic profiles, from P1 to P9 (in Figure 6.1), is identified in Table 6.2.




Figure 6.1 – Location of the topographic elements surveyed in Vieira beach in the campaigns of 19/Feb/2019 and 25/Feb/2019 (left and right, above) and of 26/March/2019 (below). Image: ESRI Basemap



Figure 6.2 – Photograph (view towards north) of the positioning of the fixed station of the GNSS receiver on the campaign of 25/Feb/2019: pedestrian platform in front of the roundabout with the boat sculpture, north of the Sun7 Bar

Table 6.2 – Reference position of the topographic cross-shore profiles surveyed in Vieira beach

Topographic profile designation	Coordinates of the reference position (PT-TM06/ETRS89)	Notes on the reference position
P1	X = -71581.29; Y = 23563.58	Northern corner, at the beach side, of the public toilets. 



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**P2** X = -71657.77;  
Y = 23471.94 Corner of the fencing of the coffee shop on the top of the beach.



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**P3** X = -71779.74;  
Y = 23269.04 Cross-shore direction that intercepts the fixed station of the GNSS receiver.



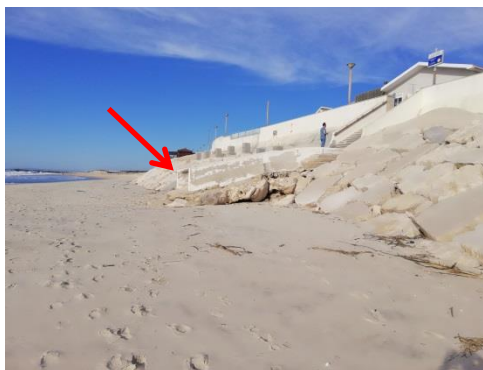
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**P4** X = -71807.84;  
Y = 23241.58 South corner of the coffee shop located further south.



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**P5** X = -71867.75;  
Y = 23140.99 Left corner of the concrete stair, which gives access from the pedestrian platform to the beach, located further north.



- 
- P6** X = -71868.71; Y = 23122.24 End of the concrete ramp which gives access from the pedestrian platform to the beach at the south sector the beach.



- 
- P7** X = -71879.41; Y = 23080.56 Left corner of the concrete stair, which gives access from the pedestrian platform to the beach, located further south.



- 
- P8** X = -71907.32; Y = 23003.56 Southern end of the alongshore defence structure.



- 
- P9** X = -71926.33; Y = 22933.52 End of the wooden footbridge located at the south extreme of the beach.





### 6.3 Drone survey

The drone survey was made on 27/Feb/2019. The drone and the flights parameters were the same as at Cova-Gala beach. To photo survey the 850 m of beach alongshore extension three flights were made during the low tide. During these a total of 767 photos were taken.

Besides the normal authorization to get the photos (described in 5.3), it was necessary to get, also from NAA, a special authorization to perform the flights over Vieira and São Pedro de Moel beaches, because both are located in a restricted area to flights, imposed by the vicinity of Air Force Military airbase located in Monte Real.



Figure 6.3 – Area with restrictions to flights due to the Air Force Military airbase of Monte Real

A total of 55 points were coordinated by GNSS-RTK (see in Figure 6.4 their location on the numerical model of the surface), the majority before the flights but all on the same day. The materialization was similar to the one used in Cova-Gala beach. Figure 6.5 shows the team during the coordination phase. A point cloud (see a detail in Figure 6.6 ) and an orthomosaic (Figure 6.7) were generated. The camera locations and photos overlap are presented in Figure 6.8.

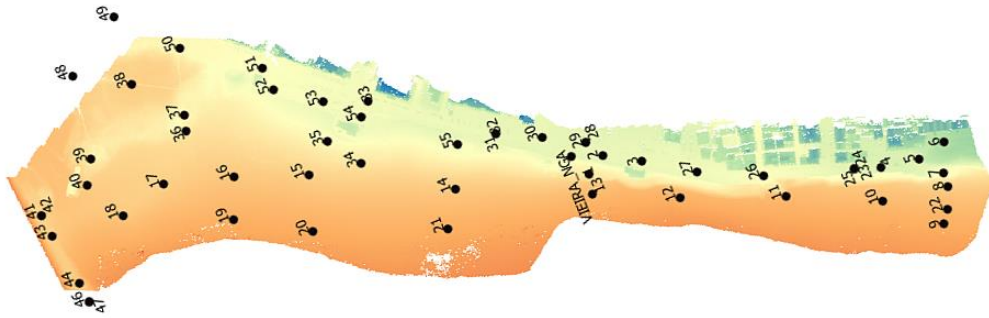


Figure 6.4 – Location of the points used to reference the photo survey and to perform quality check of the drone survey of Vieira beach on 27/Feb/2019



Figure 6.5 – Coordination of two points by GNSS-RTK in Vieira beach on 27/Feb/2019



Figure 6.6 – Point cloud of the south area of Vieira beach and the nearby area on 27/Feb/2019



Figure 6.7 – Orthomosaic of Vieira beach on 27/Feb/2019

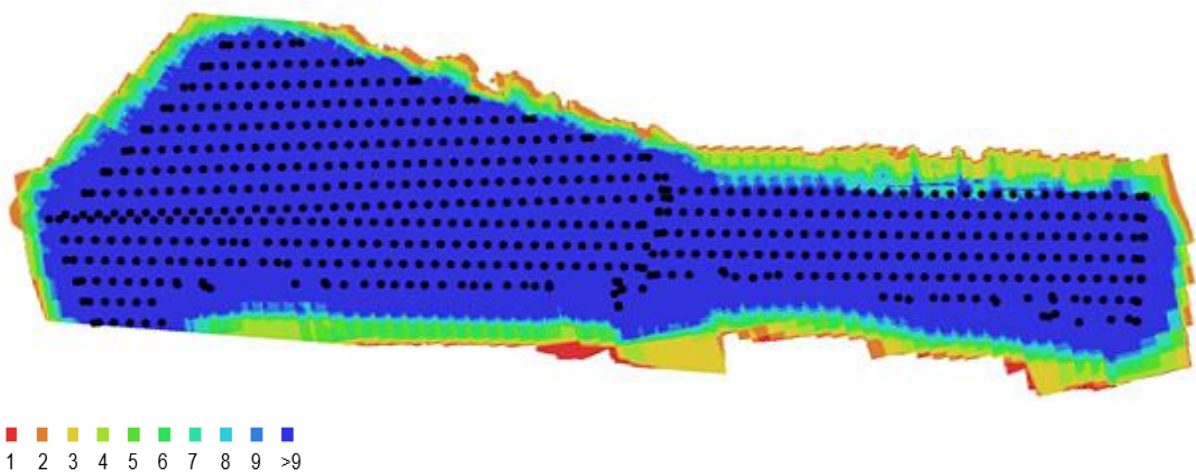


Figure 6.8 – Camera locations and photos overlap during the drone survey of Vieira beach on 27/Feb/2019

## 6.4 Sediment sampling

One superficial sediment sample was collected in the Vieira beach foreshore on 08/Jan/2019 (Figure 6.9). The location of the samples collected in the Pedrógão beach, about 5 km north, is presented in Figure 6.10.

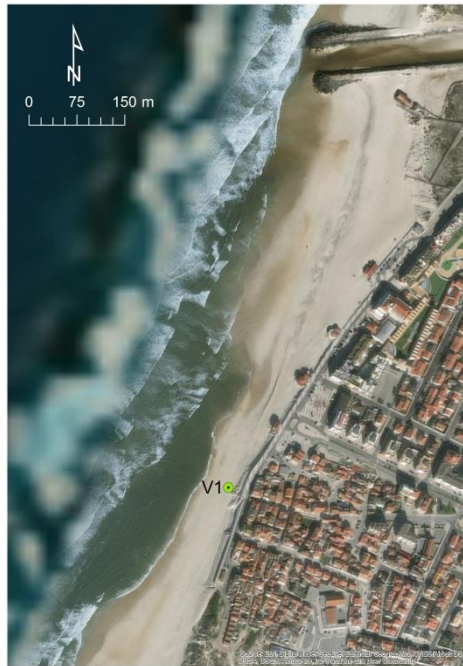


Figure 6.9 – Location of the sediment sample collected on 08/Jan/2019 in the Vieira beach, south the river Lis mouth. Image: ESRI Basemap

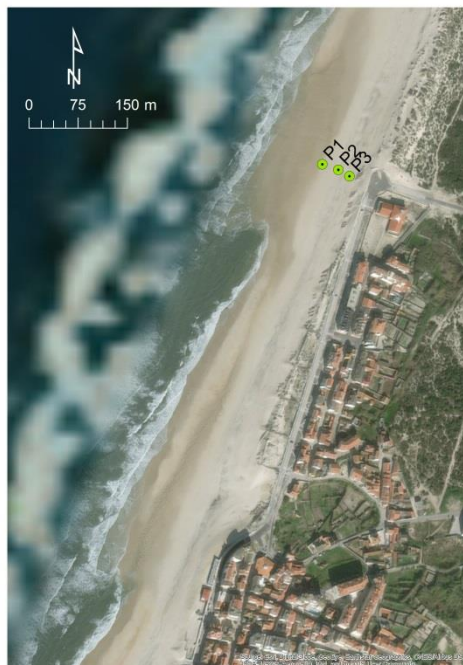


Figure 6.10 – Location of the sediment samples collected on 08/Jan/2019 in the Pedrógão beach. Image: ESRI Basemap



## 6.5 Territorial elements affected

The information about territorial elements in Vieira beach affected by the forcing conditions observed during the field campaigns is summarized in Table 6.3, and the evidences located in Figure 6.11.

Table 6.3 – Information of the territorial elements affected in Vieira beach. Locations in Figure 6.11




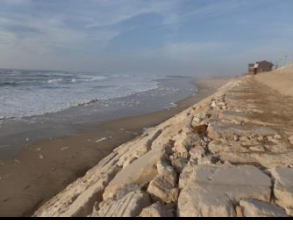
Date	Elements	Description	Photos of the evidence	Location
19/Feb/2019	Alongshore defence structure	Evidence of overtopping		1
21/Feb/2019	Alongshore defence structure	Evidence of overtopping		1
	Stairs in the defence structure	Evidence of overtopping		2
25/Feb/2019	Alongshore defence structure	Evidence of overtopping		1



Figure 6.11 – Location of the territorial elements affected in Vieira beach and described in Table 6.3

## 7 | São Pedro de Moel beach

### 7.1 Summary of the campaigns

The field campaigns and activities performed on the São Pedro de Moel beach are described in Table 7.1.

Table 7.1 – Activities performed on the São Pedro de Moel beach field campaigns

Date	Topographic survey	Drone survey	Sediment sampling	Territorial elements report
03/01/2019			✓	
12/02/2019	✓	✓		
19/02/2019	✓			✓
25/02/2019	✓			✓
26/03/2019	✓			✓

### 7.2 Topographic surveys by GNSS-RTK

Four of the field campaigns included topographic surveys of the beach, specifically of the following elements: three cross-shore profiles, the base of the cliffs on both extremes of the beach and the seawall along the beach backshore. The location of these topographic elements surveyed on 12/Feb/2019, 19/Feb/2019, 25/Feb/2019 and 26/March/2019 is presented in Figure 7.1 and Figure 7.2.

The fixed station of the GNSS receiver was positioned on the right corner (when facing the sea) of the balcony of the pedestrian platform in the central sector of the beach (coordinates in PT-TM06/ETRS89: X=-77052.79 m, Y=10074.19 m; and orthometric height: Z=8.56 m) (Figure 7.3).

The reference position of each of the three topographic profiles, from P1 to P3 (in Figure 7.1 and Figure 7.2), is identified in Table 7.2.



Figure 7.1 – Location of the topographic elements surveyed in São Pedro de Moel beach in the campaigns of 12/Feb/2019 and 19/Feb/2019, left and right, respectively. Image: ESRI Basemap



Figure 7.2 – Location of the topographic elements surveyed in São Pedro de Moel beach in the campaigns of 25/Feb/2019 and 26/March/2019, left and right, respectively. Image: ESRI Basemap



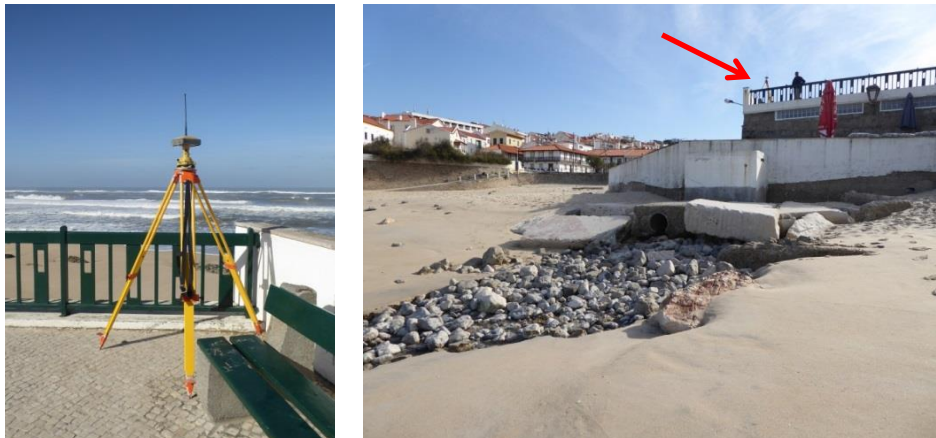




Figure 7.3 – Photographs of the position of the fixed station of the GNSS receiver on the campaign of 25/Feb/2019: right corner (when facing the sea) of the balcony of pedestrian platform in the central sector of the beach

Table 7.2 – Reference position of the topographic cross-shore profiles surveyed in São Pedro de Moel beach

Topographic profile designation	Coordinates of the reference position (PT-TM06/ETRS89)	Notes on the reference position
P1	X = -77008.84; Y = 10114.56	Rearmost position of the beach backshore at the north sector. Old water source with a stone shell on top located at the pedestrian platform elevation. The first point coordinated was on the top of the stone shell.

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<b>P2</b>	$X = -77079.21;$ $Y = 10017.58$	Column further north of the two columns of the alongshore defence structure implemented the beach backshore. The first point coordinated was on the top of a wall.
		
<b>P3</b>	$X = -77110.85;$ $Y = 9878.98$	First change in direction from north to south (slight rearward reversal) of the vertical concrete seawall located south of the alongshore defence structure in the beach backshore.
		

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### 7.3 Drone survey

The drone survey was made on 12/Feb/2019. The drone (Figure 7.4) and the flights parameters were the same as Cova-Gala and Vieira beaches. To photo survey the 200 m of beach alongshore extension, two flights were made all during the low tide. During these, a total of 262 photos were taken.



Figure 7.4 – Drone DJI Inspire 1 V2 take off in São Pedro de Moel beach on 12/Feb/2019

A total of 57 points were coordinated by GNSS-RTK (see in Figure 7.5 their location on the numerical model of the surface) before the flights. Figure 6.5 shows the team during the coordination phase. The team also coordinated three profiles (see section 7.2). The first point of each profile can be considered a stable point (a point with no displacements). A point cloud (Figure 6.6 ) and an orthomosaic (Figure 5.8) were generated.

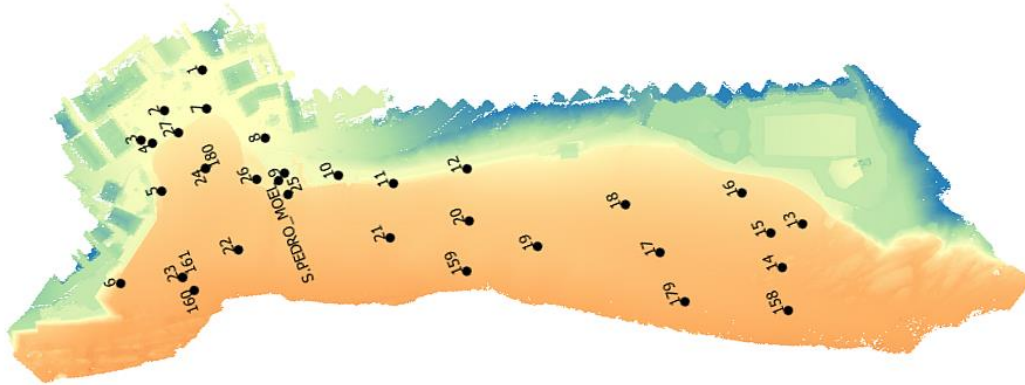


Figure 7.5 – Location of the points used to reference the photo survey and to perform quality check of the drone survey of São Pedro de Moel beach on 12/Feb/2019

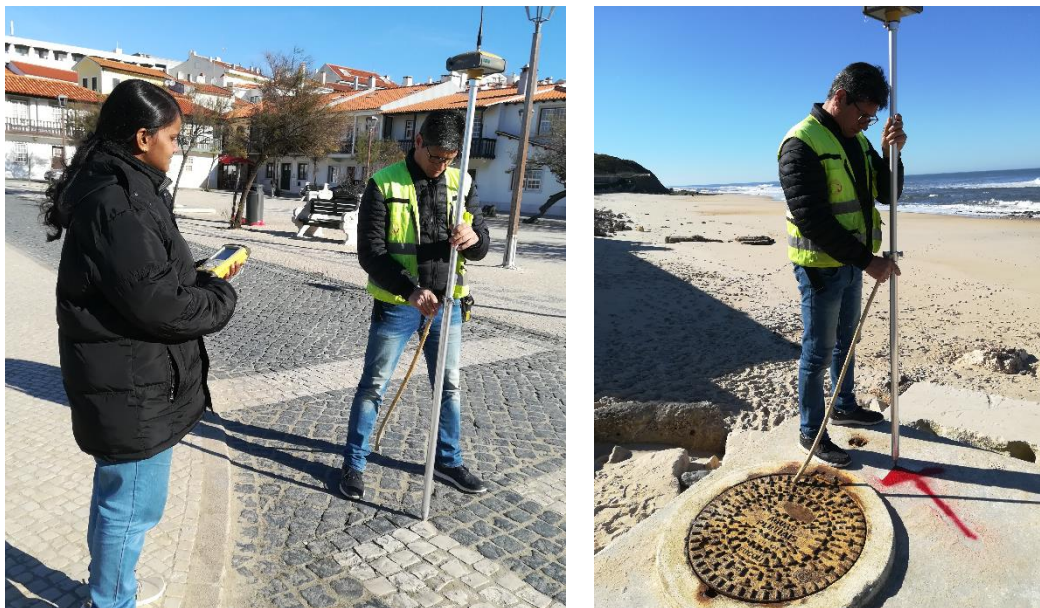


Figure 7.6 – Coordination of two points by GNSS-RTK in São Pedro de Moel beach on 12/Feb/2019





Figure 7.7 – Point cloud of the São Pedro de Moel beach on 12/Feb/2019



Figure 7.8 – Orthomosaic of São Pedro Moel beach on 12/Feb/2019

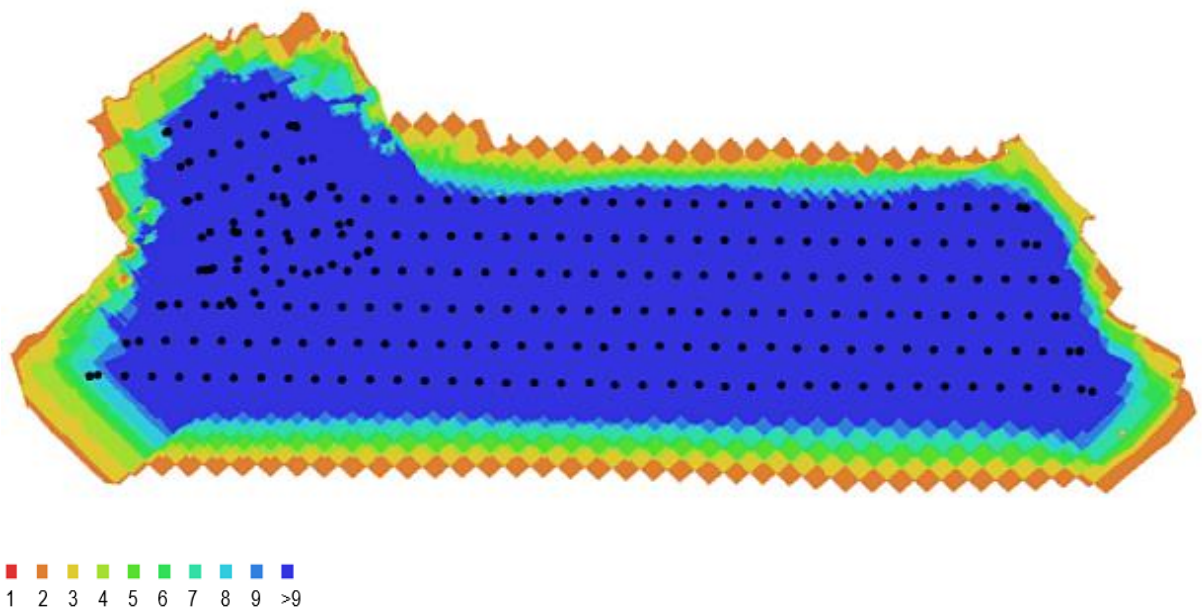


Figure 7.9 – Camera locations and photos overlap during the drone survey of São Pedro Moel beach on 12/Feb/2019



## 7.4 Sediment sampling

Two superficial sediment samples were collected on 08/Jan/2019 in the São Pedro de Moel beach foreshore (Figure 7.10).




Figure 7.10 – Location of the sediment samples collected on 08/Jan/2019 in the São Pedro de Moel beach. Image: ESRI Basemap

## 7.5 Territorial elements affected

The information about territorial elements in São Pedro de Moel beach affected by the forcing conditions observed during the field campaigns is summarized in Table 7.3, and the evidences located in Figure 7.11.

Table 7.3 – Information of the territorial elements affected in São Pedro de Moel beach. Locations in Figure 7.11

Date	Elements	Description	Photos of the evidence	Location
04/Feb/2019	Marginal promenade	Local testimonies indicate that the seawall has overflow		1



## 8 | Conclusions

This report describes the field campaigns of the project MOSAIC.pt that aim at characterizing the response of beaches with diverse typology to different oceanographic and meteorological conditions. Nine field campaigns took place between 08/Jan/2019 and 26/March/2019, including topographic and drone surveys, sediment sampling and identification of the territorial elements affected.

The objective of the campaigns was successfully accomplished and the results will help the planning of the next campaigns of the project.

## Acknowledgments

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The authors would like to thank the Instituto Hidrográfico (IH) for tidal and meteorological data availability.

Lisbon, LNEC, August 2019

APPROVED

Head of the Estuaries and Coastal Zone Unit



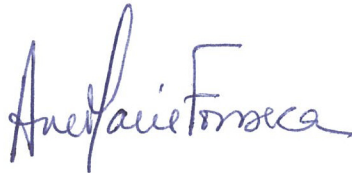
Luís Portela

Head of the Hydraulics and Environment  
Department



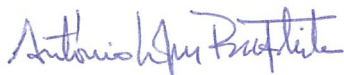
Helena Alegre

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Head of the Concrete Dams Department

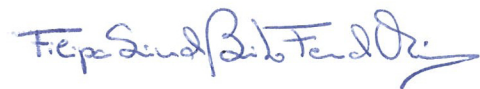


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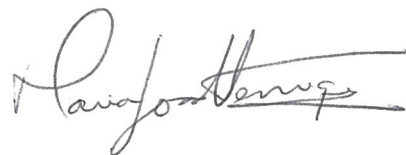
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