LABORATÓRIO NACIONAL
DE ENGENHARIA CIVIL

UBEST FIELD CAMPAIGNS

4th Campaign: Tagus Estuary, May 10, 2018

REPORT 280/**2018 – DHA/NEC**

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UBEST – Understanding the biogeochemical buffering capacity of estuaries relative to climate change and anthropogenic inputs

FCT – Fundação para a Ciência e a Tecnologia

Lisbon • July 2018

R&D HYDRAULICS AND ENVIRONMENT

REPORT 280/**2018 – DHA/NEC**

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FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Title

UBEST FIELD CAMPAIGNS
4th Campaign: Tagus Estuary, May 10, 2018

Authors

HYDRAULICS AND ENVIRONMENT DEPARTMENT

Daniela Santos
Research Fellow, Estuaries and Coastal Zone Unit

Paula Freire
Assistant Researcher, Estuaries and Coastal Zone Unit

André B. Fortunato
Senior Researcher with Habilitation, Estuaries and Coastal Zone Unit

UNIVERSIDADE DO ALGARVE

Alexandra Cravo
Assistant Professor

AV DO BRASIL 101 • 1700-066 LISBOA
e-mail: lnec@lnec.pt
www.lnec.pt

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UBEST FIELD CAMPAIGNS

4th Campaign: Tagus Estuary, May 10, 2018

Abstract

The present report summarizes the 4th field campaign of the project UBEST, performed in the Tagus estuary on May 10, 2018. This campaign was the first in the Tagus estuary and was representative of spring conditions. Seven stations were chosen along the estuary where *in situ* measurements of temperature, salinity, pH and dissolved oxygen (% and mg/L) were carried out and water samples were collected to determine in laboratory the concentration of nutrients, chlorophyll *a*, total suspended solids, and confirm dissolved oxygen and pH on samples where pH sensors were not available.

The data acquired will contribute to better understanding the biogeochemical functioning of the Tagus estuary and to calibrate and validate numerical models (hydrodynamic and biogeochemical), that will attempt to predict the response of the estuary to future scenarios of climate change and anthropogenic inputs.

Keywords: Tagus estuary / Field campaign / Water samples / Physico-chemical parameters

CAMPANHAS UBEST

4ª Campanha: Estuário do Tejo, 10 de Maio de 2018

Resumo

O presente relatório sumariza a quarta campanha do projecto UBEST, realizada a 10 de Maio de 2018 no estuário do Tejo. Esta campanha foi a primeira ser realizada neste estuário e é representativa das condições de primavera. Foram selecionadas sete estações ao longo do estuário, onde se realizaram medições *in situ* de temperatura, salinidade, pH e oxigénio dissolvido (% e mg/L) e a recolha de amostras de água, que foram posteriormente tratadas em laboratório para determinar a concentração de nutrientes, clorofila *a*, sólidos suspensos totais, e confirmar os valores de oxigénio dissolvido e pH em amostras de estações onde os sensores de pH não se encontravam funcionais.

Os resultados obtidos irão contribuir para a melhor compreensão do funcionamento biogeoquímico do estuário do Tejo e para calibrar e validar modelos numéricos (hidrodinâmico e biogeoquímico), que tentarão prever a resposta do estuário a futuros cenários relacionados com o aquecimento global e pressões antropogénicas.

Palavras-chave: Estuário do Tejo / Campanha / Amostras de água / Parâmetros físico-químicos

List of contents

List of figures

List of tables

List of Acronyms

APA – Agência Portuguesa do Ambiente

CWB – Coastal Water Body

DO – Dissolved Oxygen

FCT – Fundação para a Ciência e a Tecnologia

HMWB – Heavily Modified Water Bodies

LNEC – Laboratório Nacional de Engenharia Civil

MARE – Marine and Environmental Sciences Centre

UAlg – University of Algarve

UBEST – Understanding the biogeochemical buffering capacity of estuaries relative to climate change and anthropogenic inputs

WB – Water Body

1 | Introduction

This report describes the 4th field campaign of the project UBEST- Understanding the biogeochemical buffering capacity of estuaries relative to climate change and anthropogenic inputs (PTDC/AAG-MAA/6899/2014), performed in the Tagus estuary. The project UBEST is funded by the *Fundação para a Ciência e a Tecnologia (FCT)* and aims at improving the understanding of the biogeochemical buffering capacity of the estuaries and their susceptibility to future scenarios of anthropogenic inputs and climate change, that will support the short and long term management of these systems. This goal will be achieved by the deploying of «observatories» in two Portuguese coastal systems, the Ria Formosa lagoon and the Tagus estuary. These two systems were chosen due to their distinct characteristics, allowing a generalization of the project conclusions.

This campaign was the first campaign in the Tagus estuary, UBEST 4, and was performed on May 10, 2018, aiming to be representative of the spring conditions. To assure the coverage of the entire estuary, seven stations throughout the system were chosen. In each station physico-chemical and biological data were collected during one semidiurnal tidal cycle (~12.5 hours). In order to better understand the functioning of the estuary, two more field campaigns in the Tagus estuary are planned, representative of summer and autumn conditions.

This report is divided in two sections, besides the introduction. Chapter 2 presents the location of the sampling stations and the weather conditions, and describes the field and laboratorial work. On the chapter 3 a brief evaluation of the campaign is presented.

2 | Description of the field campaign

2.1 Objective of the field campaign

This campaign aimed to characterise the spring biogeochemical conditions of the Tagus estuary, through the collection of water samples and *in-situ* measurements of physico-chemical parameters. This data will also support the modelling of the estuary, through hydrodynamic and biogeochemical models.

2.2 Sampling stations

The seven sampling stations were chosen to allow the best coverage of the entire estuary, including the different water bodies (WB) described by *APA (Agência Portuguesa do Ambiente)* (Figure 2.1). Table 2.1 presents the coordinates of each station and Figure 2.2 presents the satellite image of each station, referring the water body where each station is situated. P1 is situated in the water body Tagus river (HMWB – *Jusante Bs. Castelo do Bode e Belver*).

The sampling stations P1 (*Muge/Valada*) and P7 (*Cascais*) are representative of the river and oceanic boundary conditions, respectively. The other five stations are distributed longitudinally through the estuary. P2 is situated in *Vila Franca de Xira*, in the south margin of the estuary, and the water samples were collected from a floating platform. P3 is located in *Santa Iria* at a fixed platform of the VALORSUL facilities, situated on the north margin. The two next stations (P4 and P5) are located in channels of the estuary, near the *Vasco da Gama* Bridge and *Barreiro*, respectively. The sampling at these two stations was performed by boat, supported by the *Sacavém* firefighters. P6 is located near the mouth of the estuary, in *Algés*.

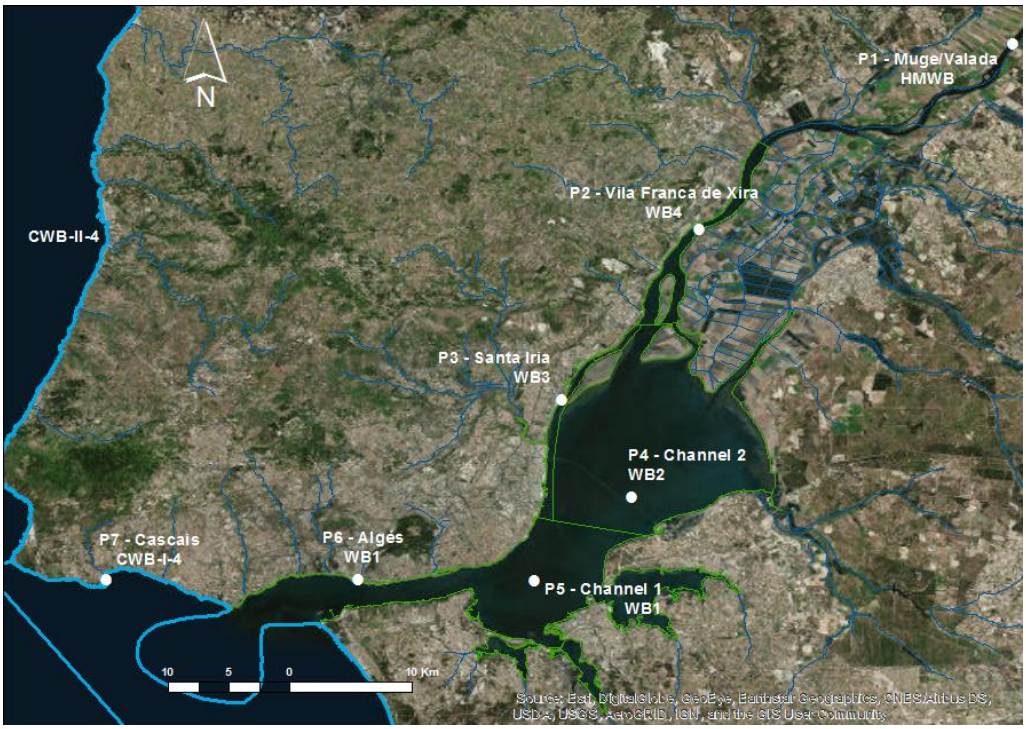

Figure 2.1 - Location of the sampling stations (source: ArcMap). Legend: Green - Tagus water bodies (WB); Light Blue - Coastal water bodies (CWB); Dark Blue - Heavily modified water bodies (HMWB)

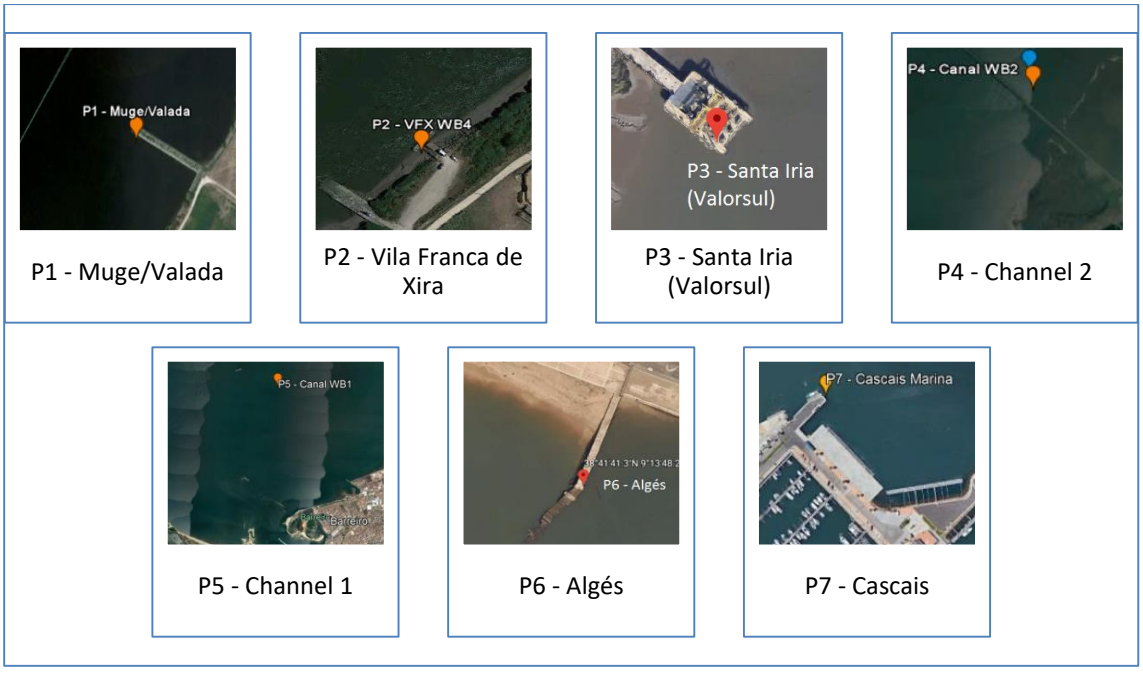

Figure 2.2 - Satellite image of each station (source: Google Earth)

Table 2.1 - Coordinates of the sampling stations

Station	Location	Latitude	Longitude
P1	Muge/Valada	39°5'27.66" N	8°44'46.17" W
P2	Vila Franca de Xira	38°57'13.97" N	8°58'41.55" W
P3	Santa Iria	38°49'40.00" N	9°4'45.64" W
P4	Channel 2	38°45'19.52" N *	9°1'42.09" W *
P5	Channel 1	38°41'39.43" N *	9°6'0.10" W *
P6	Algés	38°41'40.78" N	9°13'49.21" W
P7	Cascais	38°41'40.77" N	9°24'59.56" W

Obs: *Expected coordinates, real coordinates in Appendix I

2.3 Tide and weather conditions

The tide prediction in each station for the day of the campaign is presented in Figure 2.3.

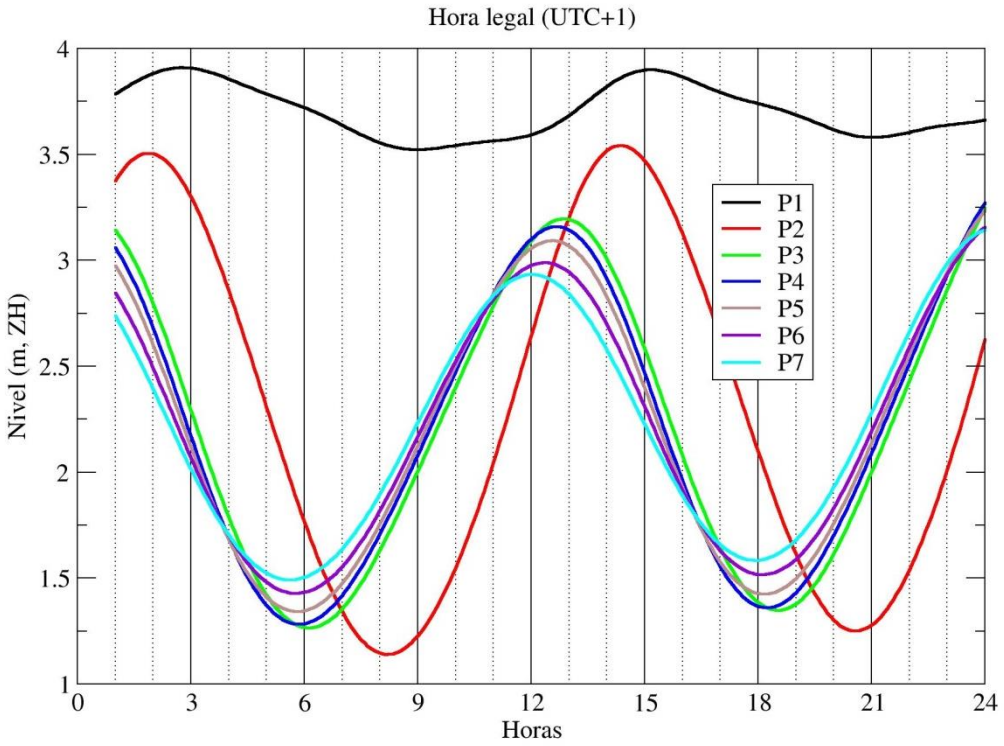

Figure 2.3 – Tidal prediction in Tagus for 2018/05/10 (Legend: X – Hour of the day; Y – Level (meters))

Table 2.2 presents the wind direction, the range and mean values of the wind speed and air temperature in locations near the UBEST stations. The data were obtained from the *Windguru* site (source: https://www.windguru.cz, May 22, 2018) corresponding to the period between 7 am and 10 pm in the campaign day, and are the forecast of the day. In terms of cloud cover, *Cascais* was the only station

with no cloud cover forecast during the time of the campaign. All the other stations had the expectation of cloud cover, only during the 7 am to 10 am period with the percentage of: *Belém* - 13%; *Alcochete* - 32%; *Barreiro* and *Ponta dos Corvos* - 23%.

In terms of data obtained in the day, Table 2.3 presents the minimum, maximum and average of air pressure, air and water temperatures and sea level acquired during all day in May 10, 2018. This data was recorded in *Marégrafo de Cascais*, and the raw data was accessible in their site (source: ftp://ftp.dgterritorio.pt/Maregrafos/Cascais/2018/C_2018-05/, June 10, 2018).

Table 2.2 - Wind Speed and temperature prediction for May 10, 2018 (source: Windguru)

Location	Wind Speed (m/s)		Wind Direction	Temperature (°C)	
	Range	Mean		Range	Mean
Lisboa - Belém	4.12 to 6.69	5.85	Northwest to Southeast	13 to 20	16.5
Alcochete	3.09 to 5.14	4.24	Northwest to Southeast	12 to 24	18.8
Barreiro	3.60 to 5.66	4.02	Northwest to Southeast	13 to 22	17.7
Cascais	6.17 to 10.80	8.68	Northwest to Southeast	14 to 15	14.5
Ponta dos Corvos (Tejo)	3.60 to 5.66	5.02	Northwest to Southeast	13 to 22	17.7

Table 2.3 – Minimum, maximum and average Air Pressure (mbar), Air Temperature (°C), Water Temperature (°C) and Sea Level (mm) for Cascais in May 10, 2018 (source: Marégrafo Cascais)

	Air Pressure (mbar)	Air Temperature (ºC)	Water Temperature (ºC)	Sea Level (mm)
Min	1018	13,9	16,1	-617
Max	1020	20,7	17,9	1046
Average	1018,71	16,48	17,38	112,68

Obs: The orthometric height of the benchmark is 3.562 m and the Chart datum is 2.080 m

No rainfall occurred during the day of the campaign, which eased the collection of samples. The Appendix II presents graphs of temperature, relative humidity, pressure at sea level and wind velocity from the campaign day (data from 12 am to 11.30 pm). These data were obtained in *tempo.pt* website (source: https://www.tempo.pt/lisboa.htm, May 22, 2018) and were recorded in Lisbon Airport.

2.4 Field work

The field campaign UBEST 4 was performed on May 10, 2018, during one entire semidiurnal tidal cycle (~12.5 hours). The sampling was supported by three cars and one van with a driver from LNEC, and one car from the University of Algarve. The teams in each vehicle were responsible for the transport of the team members and all the material and equipment. During the day the teams from P1, P7 and the van were responsible for the delivery of the samples to the laboratory located in LNEC.

The *in situ* measurements of temperature, salinity, pH and dissolved oxygen (DO) (concentration in mg/L and saturation %) were performed by YSI multiparameter probes, one in each station. Their calibration was executed previously to the field survey with the adequate calibration solution. In Table 2.4 the distribution of the equipment in each station is presented. Each station also had a Niskin bottle, a Van Dorn bottle or a sampling cup to perform the collection of the water for the determination of dissolved oxygen, nutrients and total suspended solids compounds (1 L), chlorophyll *a* (2 L) and 5 L to quantify photosynthetic pigments[1]. The stations with the Niskin bottles collected water at the surface and at the bottom, and in the P4 and P5 stations vertical profiles were also conducted. In order to preserve the quality of the water samples, these were preserved in thermal containers until the laboratory treatment started.

Table 2.4 - Multiparameter probes and samplers distribution

Station	Location	Multiparameter Probe	Parameters	Samplers
P1	Muge/Valada	YSI	Cond, T,	Sampling Cup
P2	Vila Franca de Xira	YSI 660 XL	Cond, T, DO, pH	Sampling Cup and Pressure Sensor
P3	Santa Iria	YSI 556 MPS	T, DO, pH	Van Dorn Bottle
P4	Channel WB2	YSI 556 MPS	T, DO, pH	Niskin Bottle
P5	Channel WB1			
P6	Algés	YSI 8620	T, DO, pH	Van Dorn Bottle
P7	Cascais	YSI 556 MPS	T, DO, pH	Niskin Bottle

The sampling was, normally, performed with intervals of two hours along the semidiurnal tidal cycle, with the exception in the P1 and P7 stations. All the information related to the sampling is presented in Table 2.5. A pressure sensor was installed at P2 to record the pressure during the entire semidiurnal tidal cycle. Aspects of the sampling stations are presented in the Figure 2.4 to Figure 2.10.

[1] The list of the photosynthetic pigments is presented in the Appendix. This quantification is for the work of Rui Cereja, which is not included in the UBEST program.

Table 2.5 - Sampling specifications (parameters, depths and hours). Legend: T- temperature; DO – Dissolved Oxygen; Cond – Conductivity; Sal – Salinity. Winkler – Water collection for laboratorial confirmation of dissolved oxygen concentration acquired by the probes.

Station	Intervals of Sampling	Depths	Measurements	Sampling	Observations
P1	8 am, 12 am , 6pm	Surface	T , Sal, pH, Cond	Water, Winkler	
P2	7.30am, 9.30am, 12am, 2pm, 4pm, 6pm, 8pm	Surface	T, Sal, pH, Dissolved Oxygen(DO)	Water, Winkler*	Levels (Pressure Sensor)
P3	7.30am, 9.30am, 12am, 2pm, 4pm, 6pm, 8pm	Surface and Bottom	T, Sal, pH, Dissolved Oxygen(DO)	Water, Winkler*	
P4	7.30am, 9.30am, 12am, 2pm, 4pm, 6pm, 8pm	Surface and Bottom	T, Sal, pH, Dissolved Oxygen(DO)	Water, Winkler*	Vertical Profile (12am and 6pm)
P5	7.30am, 9.30am, 12am, 2pm, 4pm, 6pm, 8pm	Surface and Bottom	T, Sal, pH, Dissolved Oxygen(DO)	Water, Winkler*	Vertical Profile (12am and 6pm)
P6	7.30am, 9.30am, 12am, 2pm, 4pm, 6pm, 8pm	Surface and Bottom	T, Sal, pH, Dissolved Oxygen(DO)	Water, Winkler*	
P7	12am, 6pm	Surface and Bottom	T, Sal, pH, Dissolved Oxygen(DO)	Water, Winkler	

Obs: * 7.30am, 12am, 6pm, 8 pm

Figure 2.4 - Sampling Station P1: Muge/Valada

Figure 2.5 - Sampling Station P2: Vila Franca de Xira

Figure 2.6 - Sampling Station P3: Santa Iria

Figure 2.7 - Boat of Sampling Station P4/P5: Channels

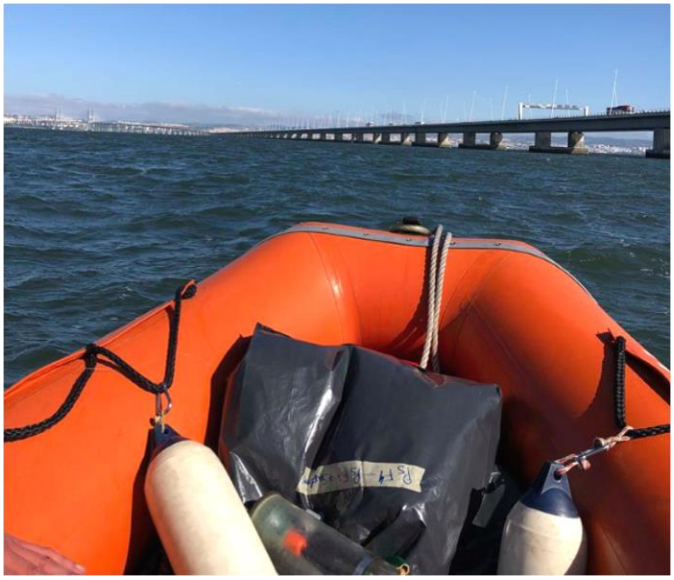

Figure 2.8 - Boat of Sampling Station P4/P5: Channels

Figure 2.9 - Sampling Station P6: Algés

Figure 2.10 - Sampling Station P7: Cascais

2.5 Team

Table 2.6 presents the team that participated in the campaign, both in the sampling stations and in the laboratory. The team included persons from the *Laboratório Nacional de Engenharia Civil* (LNEC), the University of Algarve (UAlg) and Marine and Environmental Sciences Centre (MARE).

Table 2.6 –Team of the field campaign UBEST 4

Station/Laboratory work/ Car	Name	Institution
Co-coordination of the campaign and delivery of samples to the laboratory (Car 3)	Paula Freire	LNEC
P1 and delivery of samples to the laboratory (Car 1)	Américo Louro	LNEC
	Simões Pedro	LNEC
P2 (Car 2)	André Fortunato	LNEC
	Daniela Santos	LNEC
	Ricardo Martins	LNEC
P3 (Car 2)	Alexandra Rosa	UAlg
	Ana Rilo	LNEC
	Anabela Oliveira	LNEC
	Fernando Brito	LNEC
P4/P5 (Car 3)	Ana Rita Teresa	FCUL
	Diogo Mendes	LNEC
	Matilde Almodôvar	FCUL
	Rui Cereja	MARE
P6 (Car UAlg)	João Cunha	UAlg
	José Jacob	UAlg
P7 and delivery of samples to the laboratory (Car 4)	Alberto Azevedo	LNEC
	Joana Teixeira	LNEC
Co-coordination of the campaign and laboratory work	Alexandra Cravo	UAlg
Laboratory work	Cátia Correia	UAlg
	Alexandra Rosa	UAlg

2.6 Laboratorial procedures

The processing of the water samples was performed in the laboratory of the *Estação Experimental de Sedimentos Coesivos* of LNEC by the team members of the University of Algarve. The water samples

were filtered according specific protocol and type of filters: for suspended solids, Gellman-Pall filters of cellulose acetate with 0.45 µm porosity, and for chlorophyll *a* filters Whatman GF/F with 0.7 µm porosity.

The filtered water samples through 0.45 µm filters were used to subsequent determination of the nutrients concentration (nitrate, nitrite, ammonium, phosphate and silicate), through specific spectrophotometric methods described in Grasshoff *et al*. (1983).The filters Whatman GF/F, 0.7 µm filters were used to determine the chlorophyll *a*, through the spectrophotometric method described by Lorenzen (1967). To determine the total suspended solids concentrations the gravimetric method described in APHA (1992) was used. The chemical analyses for the determination of the nutrients and chlorophyll *a* concentration will be performed at the University of Algarve, by the UALG team of the UBEST project.

In order to confirm the value of the dissolved oxygen concentration measured *in situ*, the Winkler method was performed in the laboratory at LNEC. Figure 2.11 shows the processing of the water samples in the laboratory.

Figure 2.11 - Laboratorial analysis

3 | Conclusions

The general objective of the campaign was successfully accomplished. The results acquired in this campaign will also help the planning of the next two campaigns, through the knowledge acquired.

However, some aspects were less positive and should be improved in the future:

- The P1 team members had difficulties during the low tide to access the water for sampling collection;

- Malfunction of some equipment occurred. In P2 the pressure sensor did not record the pressures during the tidal cycle and the multiparameter probe that was designated to P4 and P5 stations had to be replaced by another from MARE (EXO2 of YSI) which delayed the sampling. In the P3 station the support of the van Dorn bottle broke and had to be temporarily fixed.

- In the P2 station, the strong currents prevented the vertical characterization of the water column as the weights placed in the probe were not sufficiently strong to have the sensor descending vertically;

- The team in the boat had difficulties to accomplish the collection schedule in stations P4 and P5. The maritime conditions, mainly due to the strong wind during the afternoon, made it harder to travel between the two stations. In addition, the time needed to perform surface and bottom samplings and measurements in vertical profiles is too long for the same team to move between two stations;

- In P6 the salinity was lower than was expected (<31). This can be related to the presence of an external source of freshwater since the salinity measured at the discharge outlet in the vicinity of the station was *ca*. 12 at 16:25.

Acknowledgments

This work was funded by *Fundação para a Ciência e a Tecnologia* project UBEST - Understanding the biogeochemical buffering capacity of estuaries relative to climate change and anthropogenic inputs (PTDC/AAG-MAA/6899/2014). This project also funds the grants of Daniela Santos (LNEC) and Alexandra Rosa (UALG).

The authors would like to thank the volunteers from the Faculdade de Ciências da Universidade de Lisboa, Ana Rita Teresa and Matilde Almodôvar, the PhD students from LNEC Ana Rilo and Diogo Mendes, and Rui Cereja[2] (*Instituto Dom Luiz* (IDL – FCUL) and Marine and Environmental Science Centre (MARE – FCUL)), Cátia Correia and João Cunha from CIMA – University of Algarve, for their support in the campaign and on the laboratorial work, Marine and Environmental Science Centre (MARE – FCUL) for equipment availability, VALORSUL and Marina de Cascais for the authorization to use their facilities for sampling.

[2] PhD research grant (PD/BD/135064/2017) attributed by *Fundação para a Ciência e Tecnologia* (FCT) with financing from *Programa Operacional Capital Humano* (POCH) by the Portugal2020 program.

Lisbon, LNEC, July 2018

APPROVED

The Head of the Estuaries and Coastal Zone Unit

Luís Ivens Portela

The Head of the Hydraulics and Environment Department

Helena Alegre

AUTHORS

Daniela Santos
Research Fellow

Paula Freire
Assistant Researcher

André Fortunato
Senior Researcher with Habilitation

Alexandra Cravo
Assistant Professor

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Annexes

ANNEX I
Coordinates of P4 and P5

Table I.1 - Coordinates of P4 during the hours of the campaign

Time	Depths (m)	Latitude	Longitude
09:38	0.00	38°45'19"N	9°1'39"W
09:55	6.00		
12:48	0.23	38°45'20"N	9°1'40"W
12:48	3.00		
12:48	6.00	38°45'16"N	9°01'34"W
16:37	0.13	38°45'16"N	9°1'43"W
16:46	4.00	38°45'10"N	9°1'45"W
18:10	0.00	38°45'20"N	9°1'39"W
18:10	5.00		

Table I.2 - Coordinates of P4 during the vertical profiles

Time	Depths (m)	Latitude	Longitude
12:48	0.23	38°45'20"N	9°1'40"W
	1.00	38°45'20"N	9°1'40"W
	2.00	38°45'20"N	9°1'40"W
	3.00	38°45'20"N	9°1'40"W
	4.00	38°45'20"N	9°1'40"W
	5.00	38°45'16"N	9°01'34"W
	6.00	38°45'16"N	9°01'34"W
18:10	0.00	38°45'20"N	9°1'39"W
	1.00	38°45'20"N	9°1'39"W
	2.00	38°45'20"N	9°1'39"W
	3.00	38°45'20"N	9°1'39"W
	4.00	38°45'20"N	9°1'39"W
	5.00	38°45'20"N	9°1'39"W

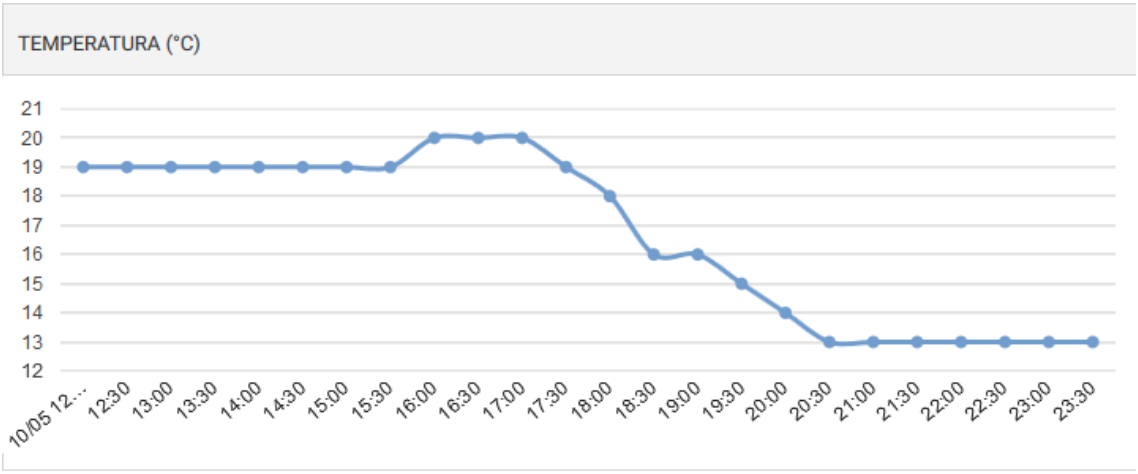
Table I.3 - Coordinates of P5 during the hours of the campaign

Time	Depths (m)	Latitude	Longitude
07:53	0.00	38°41'39"N	9°06'0.73"W
08:32	8.00	38°41'39"N	9°06'0.73"W
10:37	0.00	38°41'38"N	9°6'1.19"W
10:55	10.00	38°41'38"N	9°6'1.19"W
14:25	0.30	38°41'37"N	9°06'06"W
14:25	4.00	38°41'37"N	9°06'06"W
14:25	6.00	38°41'37"N	9°06'06"W
17:25	0.00	38°41'37"N	9°6'09"W
17:32	6.00	38°41'37"N	9°6'09"W
19:23	0.00	38°41'34"N	9°6'0.8"W
19:23	3.00	38°41'34"N	9°6'0.8"W
19:23	6.00		

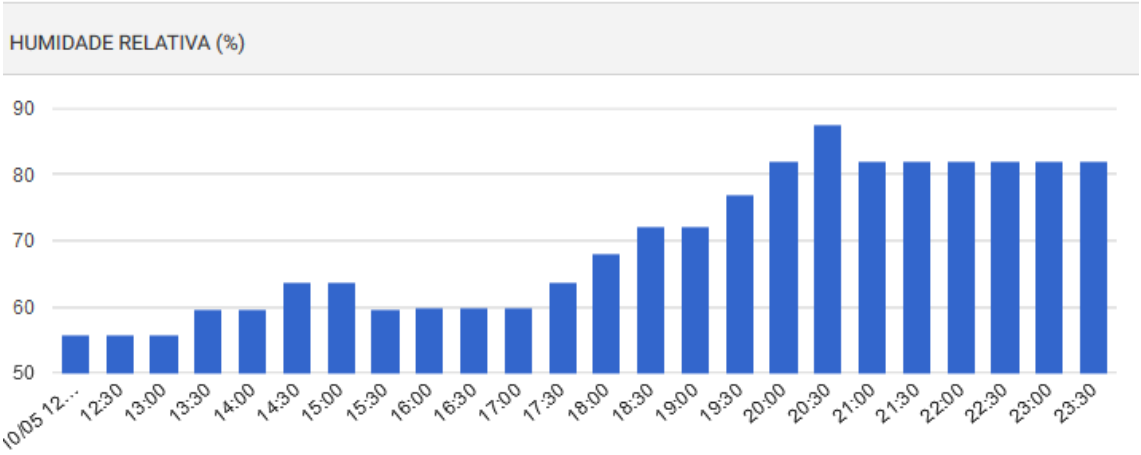
Table I.4 - Coordinates of P5 during the vertical profiles

Time	Depths (m)	Latitude	Longitude
14:25	0.30	38°41'37"N	9°06'06"W
	1.00	38°41'37"N	9°06'06"W
	2.00	38°41'37"N	9°06'06"W
	3.00	38°41'37"N	9°06'06"W
	4.00	38°41'37"N	9°06'06"W
	5.00	38°41'37"N	9°06'06"W
	6.00	38°41'37"N	9°06'06"W
19:23	0.00	38°41'34"N	9°6'0.8"W
	1.00	38°41'34"N	9°6'0.8"W
	2.00	38°41'34"N	9°6'0.8"W
	3.00	38°41'34"N	9°6'0.8"W
	4.00	38°41'34"N	9°6'0.8"W
	5.00	38°41'34"N	9°6'0.8"W
	6.00	38°41'34"N	9°6'0.8"W

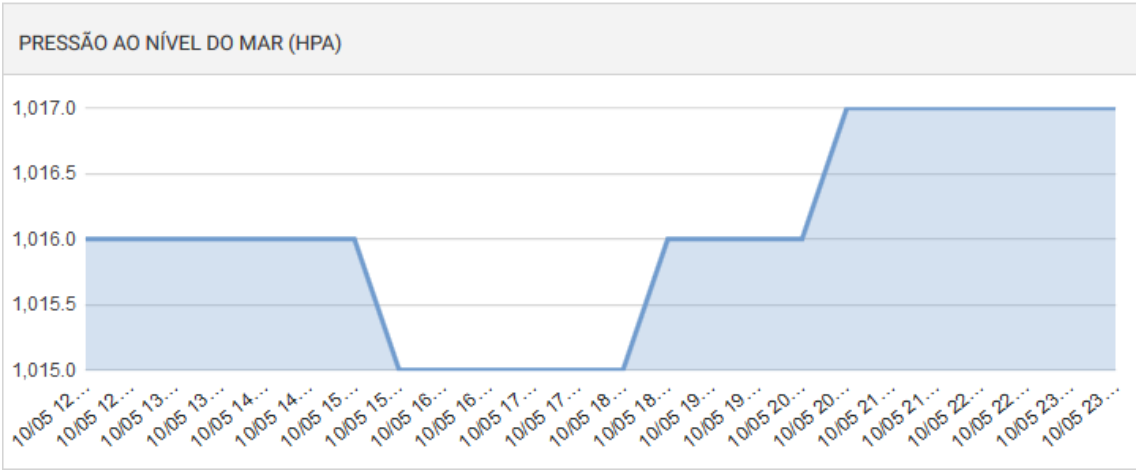
ANNEX II
Weather Conditions



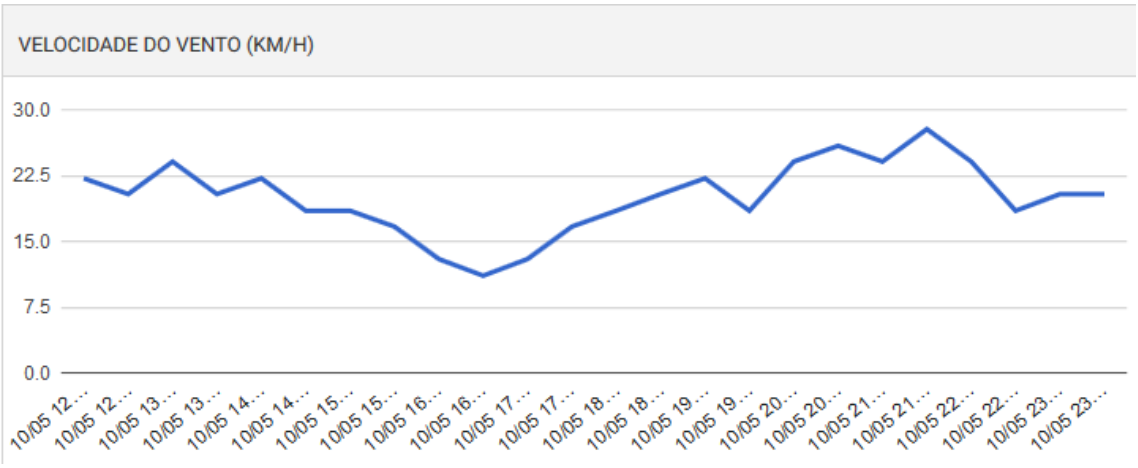
Graph II.1 - Temperature (°C) variation during May 10, 2018 (source: tempo.pt, May 22, 2018)



Graph II.2 - Relative humidity (%) variation during May 10, 2018 (source: tempo.pt, May 22, 2018)



Graph II.3 - Pressure at sea level (HPA) variation during May 10, 2018 (source: tempo.pt, May 22, 2018)



Graph II.4 - Wind velocity (km/h) variation during May 10, 2018 (source: tempo.pt, May 22, 2018)

ANNEX III
Photosynthetic Pigments list

Photosynthetic pigments read by HPLC:

- Zeaxanthin
- Prasinoxanthin
- Violaxanthin
- Feofitin a
- Feoforbide a
- Peridinin
- Neoxanthin
- Lutein
- Fucoxanthin
- Mg DVP
- Divinil chl a
- Diatoxanthin
- Diadinoxanthin
- Chlorophyll a
- Chlorophyll c3
- Chlorophyll c1 + c2 (does not separate)
- Chlorophyll b
- Chlorophyll a
- β-carotene
- Anteraxanthin
- Aloxanthin
- α-carotene
- 19-hexa-fucoxanthine
- 19-buta-fucoxanthin

AV DO BRASIL 101 • 1700-066 LISBOA • PORTUGAL
tel. (+351) 21 844 30 00 • fax (+351) 21 844 30 11
lnec@lnec.pt • www.lnec.pt