hidrográfico
marinha · portugal

ACTAS

5.as JORNADAS DE ENGENHARIA HIDROGRÁFICA

19, 20 E 21 DE JUNHO DE 2018


ACTAS
5.as JORNADAS
DE ENGENHARIA
HIDROGRÁFICA
19, 20 E 21 DE JUNHO DE 2018

Lisboa

Título – Actas das 5.as Jornadas de Engenharia Hidrográfica
Autor – Instituto Hidrográfico
Tiragem – 70 exemplares
Edição e paginação – Instituto Hidrográfico, 2018
Impressão e acabamento – ACDPRINT, S.A.
ISBN – 978-989-705-128-9
Depósito Legal – 441477/18

One Year Monitoring of Water Characteristics Inside Ria Formosa

J. Jacob (1), A. Cravo (1), A. Rosa (1), M. Rodrigues (2) and J. Rogeiro (2)

(1) Universidade do Algarve, CIMA, Campus de Gambelas, 8005-139 Faro, Portugal, jjacob@ualg.pt.

(2) Laboratório Nacional de Engenharia Civil, Av. do Brasil 101, 1700-066 Lisboa, Portugal.

Abstract: Estuaries and coastal lagoons are among the most productive ecosystems on Earth and provide multiple ecosystem services. However, the predicted increase of human activities, together with climate change, may increase the hazards in these systems and change their dynamics. The goal of the project UBEST is to improve the global understanding of the biogeochemical buffering capacity of Ria Formosa and Tagus River and their susceptibility to future scenarios of anthropogenic inputs and climate change. For that "observatories" will be deployed which are emerging tools that integrate process-based numerical models and *in-situ* observations. In this work we analyse the variability of water characteristics (temperature, salinity, pH, dissolved oxygen, turbidity and chlorophyll *a*) acquired over almost one year, every 15 min on a real-time monitoring station installed in the Port of Faro. The high frequency of data acquisition enables the understanding of both seasonal variability and occurrence of short-term events inside Ria Formosa.

Key words: Coastal lagoon, Ria Formosa, coastal ecosystem, physical-chemical properties of water

1. INTRODUCTION

Ria Formosa is a coastal lagoon located in the south coast of Portugal (Fig.1), delimited by 5 islands, 2 peninsulas and 6 inlets. These inlets are interconnected by a complex network of channels, allowing the permanent water exchange with the ocean and the water recirculation within the lagoon. Considering the hydrodynamics, this system can be divided in three different sectors: eastern, central and western sectors (Salles *et al.*, 2005).

An online water quality monitoring station was installed in the Ria Formosa by the Laboratório Nacional de Engenharia Civil (LNEC) and the Universidade do Algarve under the scope of the project UBEST - Understanding the biogeochemical buffering capacity of estuaries relative to climate change and anthropogenic inputs (PTDC/AAG-MAA/6899/2014). This project aims at improving the global understanding of the biogeochemical buffering capacity of estuaries and its susceptibility to future scenarios of anthropogenic inputs and climate change, to effectively support the short and long-term management of these systems. UBEST scientific goals will be achieved by the deployment of "observatories" in two Portuguese case studies: the Tagus estuary and the Ria Formosa coastal lagoon.

The online water quality monitoring station is one of the components of the Ria Formosa observatory and was installed on May 2017 in the port of Faro (Fig.1). Data from the UBEST case study of Ria Formosa lagoon will be presented, considering the continuous real-time observation at this station along almost one year (11 months), covering different seasonal conditions.

Fig. 1. The Ria Formosa coastal lagoon with the location of the real-time observatory (RTO).

2. DESCRIPTION OF THE MONITORING STATION

2.1 Location

The water quality monitoring station is located in the Ria Formosa, in the Cais do Combustível of the Port of Faro (37º 00' 9.92'' N, 7º 55' 16.28'' W; Figure 1), which is an old and disabled fuel dock under the administration of the APS - Ports of Sines and the Algarve Authority.

The Port of Faro is located in one of the main channels of the western sector of the Ria Formosa, the Faro channel. Since about 90% of the water volume is exchanged in the western sector of the lagoon (Pacheco *et al.*, 2010), this location was selected aiming to be representative of the water quality in one of the main channels of the Ria

Formosa. The selection of this site took also into consideration other criteria, namely access to essential infrastructures (e.g., GSM/GPRS connectivity), ability to obtain permission to install the equipment and protection from vandalism.

2.2 Description of the equipment and structures

The water quality online monitoring station is equipped with an YSI EXO 2 multiparameter probe (Fig. 2) which includes sensors to measure water temperature, conductivity/salinity, pH, dissolved oxygen, turbidity and chlorophyll *a*. The probe is also equipped with copper-alloy sensor guard and an anti-fouling wiper to reduce the biofouling in the sensors.

Fig. 2. YSI EXO 2 multiparameter probe and general overview of the Ria Formosa monitoring station.

Data acquisition and transmission is performed using an OBSERMET OMC-045-III data logger which includes a GSM/GPRS modem. Data is transferred through the internet, from the remote site to LNEC's premises, using the FTP protocol. The transmission procedure happens each hour, producing a new csv formatted file encompassing the data sampled/acquired in that period.

The probe is supported and protected by a PVC tube, while the data logger is protected by an environmental shelter. The power supply to the operation of the multiparameter probe and of the data logger is provided by solar panels.

The multiparameter probe is under operation since 26th May, 2017, while the online data transmission system is under operation since 29th June, 2017. Data are measured continuously at the monitoring station with 15 minutes' intervals. Measured data, transmitted hourly, is stored in a data repository developed for the UBEST project, and will be accessible in the web platform.

2.3 Description of the equipment and structures

Maintenance procedures were established and implemented to guarantee the continuous acquisition of the data, the safety of the multiparameter probe and the quality of the data. At the Ria Formosa station, these procedures are performed by the members of UAlg's team with the support of APS - Port of Faro, which provides the access to the place where the probe is installed.

Two levels of maintenance procedures are considered:

- Periodic cleaning, verification and inspection – procedures of visual inspection and manual cleaning of the probe, verification and/or calibration of sensors. These procedures were performed with a periodicity of two weeks during the first two months of operation of the probes to ensure the quality of the acquired data. After this period these procedures were performed with the periodicity of one month. For safety reasons at least two technicians were required;
- Out-of-schedule inspection – supplementary procedures for inspecting the probe may be undertaken when needed (e.g., lack of communication from the probe, observation of out of the range measurements) but have not yet been needed.

During the first month of operation of the probe five maintenance visits were performed on June 2017, on the following days: 7, 13, 20, 23 and 29. During these visits, the visual inspection of the probes and supporting structures was performed. Measured conductivity, pH and turbidity were checked using several calibration solutions. Conductivity was calibrated against a standard solution (1-point) of 50000 S/cm, pH by 3 different standard solutions (3-point calibration: pH 4, 7, 10) and turbidity by 2 standard solutions (2-point calibration): distilled water (0 NTU) and 12.7 NTU. Dissolved oxygen was calibrated at 100% air saturation every visit (1-point calibration). Chlorophyll *a* was calibrated during the first day of deployment, at 1-point (0 μg/L) based on distilled water, while on the June 23 a 2-point calibration was performed using distilled water (0 μg/L) and the results of a laboratorial analysis of *in situ* water sample collection. The results of calibrations, as expected, suggest a good performance of the sensors.

3. RESULTS AND DISCUSSION

This real-time observational station is continuously measuring a series of variables, ranging from physical (temperature and salinity) to chemical (pH, dissolved oxygen and turbidity) and biological processes on a 24/7 basis. Regarding temperature (Fig. 3, top), the seasonal cycle is well marked. The highest values (>20 ºC) are observed in Summer and the lowest values (around 10 ºC) in Winter, with intermediate values observed in Spring and Autumn. Upwelling events have also been recorded at some periods in the Summer (e.g., in August and September 2017, as confirmed by the wind velocity records, not shown). These events were responsible for a decrease in water temperature, pH and

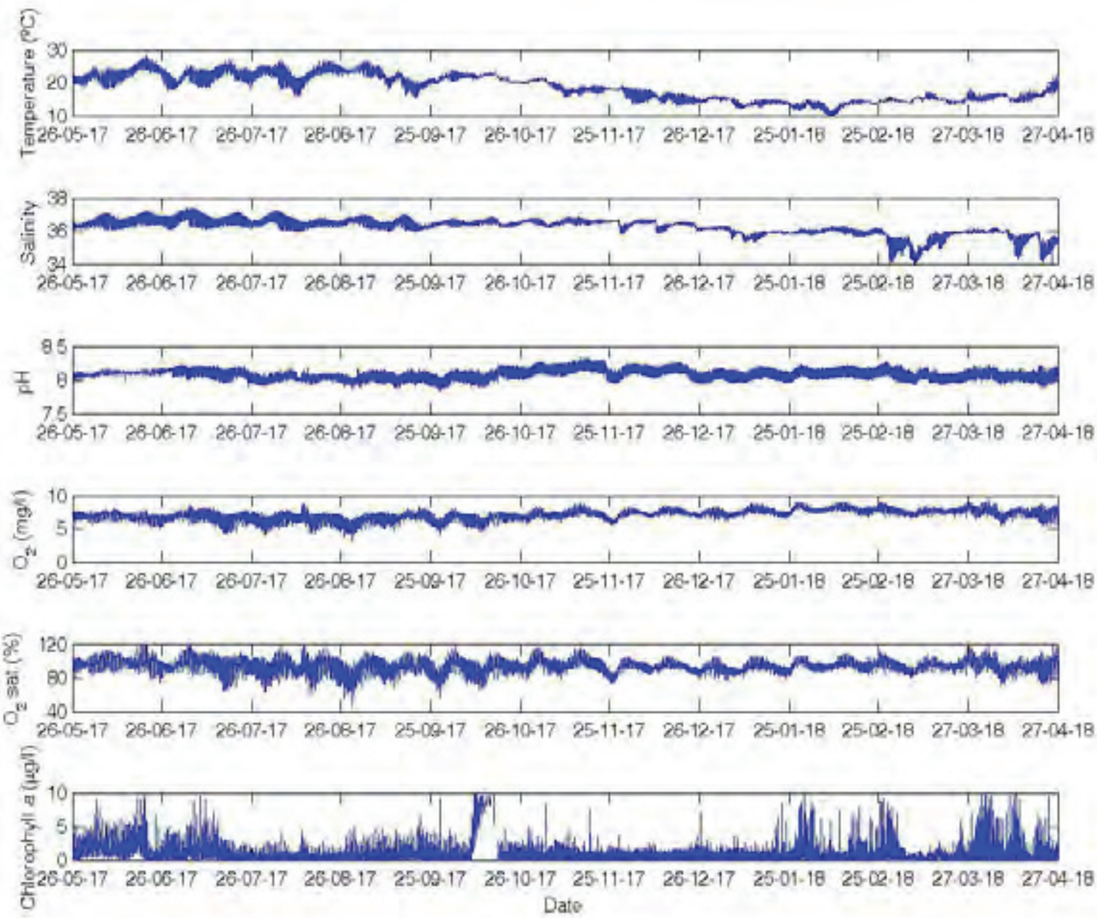


Fig. 3. Time series of data acquired with the YSI EXO 2 multiparameter probe along almost one year, from 26-5-2017 to 27-4-2018: temperature, salinity, pH, dissolved oxygen in concentration and in % of saturation and chlorophyll a.

dissolved oxygen, particularly during the night period when very low values of % of saturation of dissolved oxygen were attained, below the minimum allowable value (70%), corresponding to values < 5 mg/L. Salinity was also maximum in Summer (*ca.* 37) and minimum in Winter, less than 36 in January 2018 and within the range 34-35.5 in March-April 2018, after episodic rainfall and storm events. Regardless those extreme values, most of them were within the narrow range 36-36.5. The values of pH and dissolved oxygen depict a similar temporal variability, with higher values in Winter and lower values in Summer. The pH values varied within a small range, typical of coastal water (7.84-8.33). The range of dissolved oxygen was 3-10 mg/L, however most of the values were between 6 to 8 mg/L, which corresponds to well-oxygenated waters, globally within the range 80-110%.

The chlorophyll *a* and turbidity sensors are optical whose signal easily suffers interference and contamination from particles in the water and sometimes part of the values are not accurate and can be considered as outliers, as in Fig 3, bottom, and Fig. 4, respectively for chlorophyll *a* and turbidity that must be discarded during Quality Control Analysis. Nevertheless, chlorophyll *a* globally was < 5 μg/L, with most values < 3 μg/L, despite maximum during the Spring-Summer period followed by Autumn. The high values > 5 μg/L recorded from January to March 2018, after rainfall events, could result from interference of suspended solids that could also emit fluorescence. For turbidity (Fig. 4), most of the data is < 15 NTU, majorly < 5 NTU typical of clear coastal waters. The rainfall and storm events of March-April 2018 were also captured in this parameter depicting values > 20 NTU.

Concerning the variability and influence of semi-diurnal tides, globally for the described parameters, it was more evident during spring tides than in neap tides.

In summary, using this innovative approach, this real time observational fixed station allows high-resolution temporal details and insights into different time variability scales, crossing from short to long term. It is possible to capture seasonal fingerprints along with semi-diurnal tidal, diurnal signals and ultimately episodic/extreme events that usually cannot be captured by using conventional sampling/monitoring strategies.

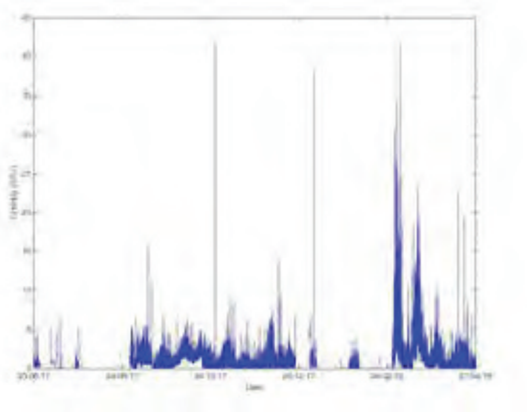


Fig. 4. Time series of turbidity data acquired with the YSI EXO 2 multiparameter probe along almost one year, from 23-6-2017 to 27-4-2018.

4. CONCLUSIONS

The data presented provide observations to support the numerical model calibration and continuous validation used in the observatory implemented for the Ria Formosa study area.

An integrative approach was applied, linking data from continuous real time observations, discrete *in-situ* field campaigns and hydrodynamic-biogeochemical mechanistic models for the Ria Formosa. The project will further contribute to the development of a customizable and integrative WebSIG platform that will provide access to observations, real-time forecasts and future scenarios to stakeholders and other end-users.

The recorded high resolution data applied in a skill-assessed modelling system with targeted simulations of processes or scenarios offer multiple representations of processes, variability and change playing a key role to predict future scenarios of global changes.

These important observational data coupled with modelling can be translated into useful information for end-users and decision makers. This facilitates a better understanding of the functioning of this ecosystem and contributes to its short and long-term management and protection, imperative to building knowledge-based societies.

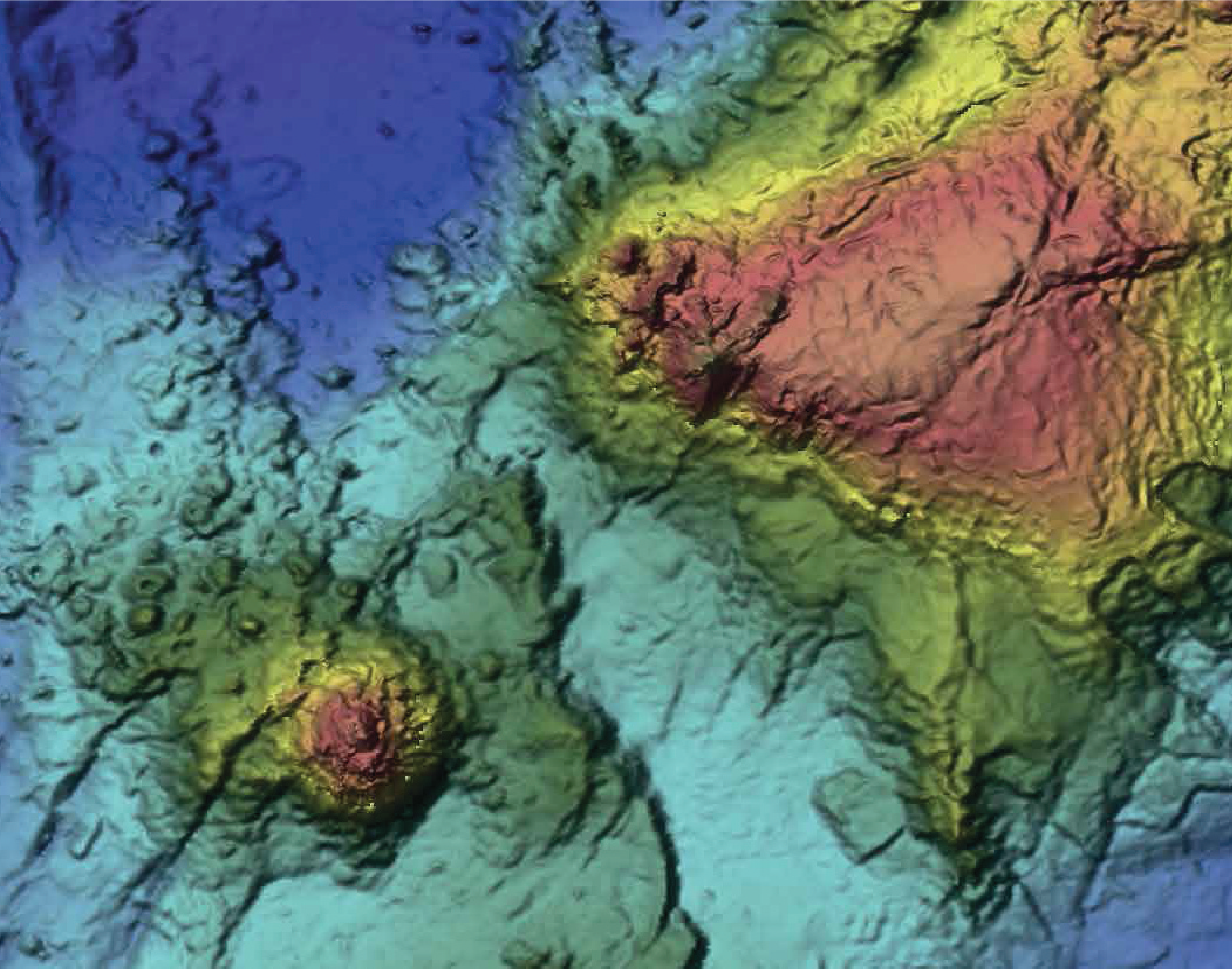
Acknowledgements

This work was funded by Fundação para a Ciência e a Tecnologia under the project UBEST – Understanding the biogeochemical buffering capacity of estuaries relative to climate change and anthropogenic inputs (PTDC/AAG-MAA/6899/2014).
The third author is funded by Fundação para a Ciência e a Tecnologia in the scope of the project UBEST (PTDC/AAG-MAA/6899/2014).
The fourth author is co-funded by Fundação para a Ciência e Tecnologia grant SFRH/BPD/87512/2012.
The authors would like to thank the APS - Ports of Sines and the Algarve Authority for the permission for the installation of the probe in the Port of Faro and all the support provided by their technicians during the installation and maintenances. The authors also thank the technicians of OilWater.

REFERENCES

Pacheco, A., Ferreira, Ó.,Williams, J.J., Garel, E., Vila-Concejo, A., and Dias, J.A., (2010). Hydrodynamics and equilibrium of a multiple inlet system. *Marine. Geology*, 274, 32–42.

Salles, P., Voulgaris, G., and Aubrey, D. (2005). Contribution of nonlinear mechanisms in the persistence of multiple tidal inlet systems. *Estuarine, Coastal and Shelf Sciences*, 65, 475–491.



hidrográfico
marinha·portugal

Instituto Hidrográfico
Rua das Trinas, 49
1249-093 Lisboa – Portugal
Tel.: +351 210 943 000
mail@hidrografico.pt
www.hidrografico.pt

PATROCINADORES

KONGSBERG

MRA GRUPO ÁLAVA

WonderStatus SOLUÇÕES DE LAB. INVESTIGAÇÃO E INDUSTRIA

TELEDYNE CARIS Everywhereyoulook™

qualitas instruments

Interreg Atlantic Area

MyCoast

Imagem: Modelo batimétrico de alta resolução entre o Banco Leão e a Planície Abissal da Ferradura, a norte do Arquipélago da Madeira