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Universidade do Algarve

EPPO tank experiments

May, June and July 2017 experiment

Data report

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Abstract	This report describes the data gathered in summer of 2017 by a SR-1 hydrophone in the water pumps tank at the Estação Piloto de Piscicultura de Olhão (EPPO) during a period of 7 weeks. This data set, covering a longer period (7weeks), complements the data set described in [1] and [2].
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Abstract

This report describes the acoustic and other complementary data gathered during an experiment carried from May 23rd to July 13th in the water tank at the IPMA-EPPO (Estação Piloto de Piscicultura de Olhão), Olhão, in the framework of the SEAOX project (PTDC/EEIPRO/2598/2014). The tank bottom is covered by seagrasses, particularly *Cymodocea nodosa* and *Zostera marina*. The objective of this experiment was to complement that dataset gathered in July 2016[1] and October 2016[2]. The recorded acoustic data is ambient noise generated by the water pumps. Simultaneously with acoustic data, temperature, salinity and dissolved O2 data were measured by a multiparameter sonde (CTD). This report also includes data recorded by the atmospheric station installed at the EPPO and dissolved O2 optode data measured by the EPPO team at two times per day. The report presents the experimental setup, the acoustic and complementary environmental data.

Acknowledgments

The authors thank technical and scientific staff at IPMA-EPPO for the logistics, atmospheric and O2 dissolved data, *João Pereira* and *João Duarte* for their help and support during the experiment and *Marsensing* for the loan of the self-recording hydrophone.

This work was funded by National Funds through FCT-Foundation for Science and Technology under project SEAOX (PTDC/EEIPRO/2598/2014).

Chapter 1

Introduction

The experiments conducted in July 2016 and October 2016 in the EPPO station have shown that in high productive seagrasses (*Cymodocea nodosa* and *Zostera marina*) releases large amounts of O2 as bubbles[1]. The acoustic signature of bubbles was clear seen in the acoustic backscatter during daylight when the dissolved O2 measurements by opodes have shown high O2 oversaturation (saturation levels above 200% were measured). The acoustic signature of bubbles was also clear seen in low frequency signals transmitted at short ranges and in ambient noise generated by the water pumps. The attenuation of the low frequency signals and noise was high during the photosynthetic active period (daylight). It was also observed striation patterns that might be related to the change in the effective sound speed of the water due to bubbles release during photosynthesis. However, it was also clear shown that in such very shallow water environments, the water depth variability due to tide has an important acoustic signature that superimposes in acoustic variability due to bubbles.

In order to simplify the setup, only the SR-1 self-recording hydrophone and the multi-parameter sonde have been used. The noise produced by the water pumps was used as acoustic source. Such a setup allowed to gather data during a longer period (6 weeks), when the environmental conditions, tide heights and atmospheric, might significantly vary.

This experiment supports the task T1 (Tank experiments) and task T2 (Measurement systems) of the SEAOX project and the main objectives are:

- to test measurement setup,
- to measure the diurnal variability of ambient noise,
- to measure environmental parameters to support acoustic signal analysis.

This report is organized as follows: in the next chapter the experimental setup is presented. The 3rd chapter is devoted to present the CTD, meteo and EPPO dissolved O2 data. The ambient noise is discussed in chapter 4. The conclusions are drawn in a final chapter.

Chapter 2

Experimental setup

The experiment was carried out from midday of May 23rd until morning of July 13th in a water pumps tank of the Aquaculture Research Station (IPMA-EPPO) of Portuguese Institute for the Sea and Atmosphere, Olhão, southern Portugal. The tank used is an open water tank covered by seagrasses and has conditions very similar to the conditions in *Ria Formosa*. The weather conditions during this experiment were favourable for bubbles production by photosynthesis process.

Figure 2.1 shows the location of various tanks and the depth at tank (C), the tank used in this experiment. The bottom of the tank is densely covered by marine plants, particularly *Cymodocea nodosa* and *Zostera marina*, however, *C. nodosa* covers almost completely the tank with few uncovered patches. The water depth is about 1.8 m and varies with tide, ranging from 1.4 m to 2.1 m.

Since the tanks are connected with the Ria Formosa lagoon by a tide gate, the water depth change in the tank does not show a sinusoidal shape, but rather a ramp (sawtooth) like shape. The main contributions for the acoustic noise of the tank are from the water pumps. Aeration pumps are installed close to the water pumps. When working aeration pumps produce bubbles, which influences the acoustic signature of water pumps, as been seen in [1] and [2].

The equipment used in this experiment was:

- the multiparameter CTD RBRconcerto, that in addition to temperature, conductivity and pressure, also measures oxygen concentration;
- the digitalHyd SR-1 hydrophone to record ambient noise;

both deployed in separate moorings around the same location of the July and October 2016 experiment (20–30 m from the water pumps). The CTD and the hydrophone were fixed at 70 cm from the bottom (see figure 2.2).

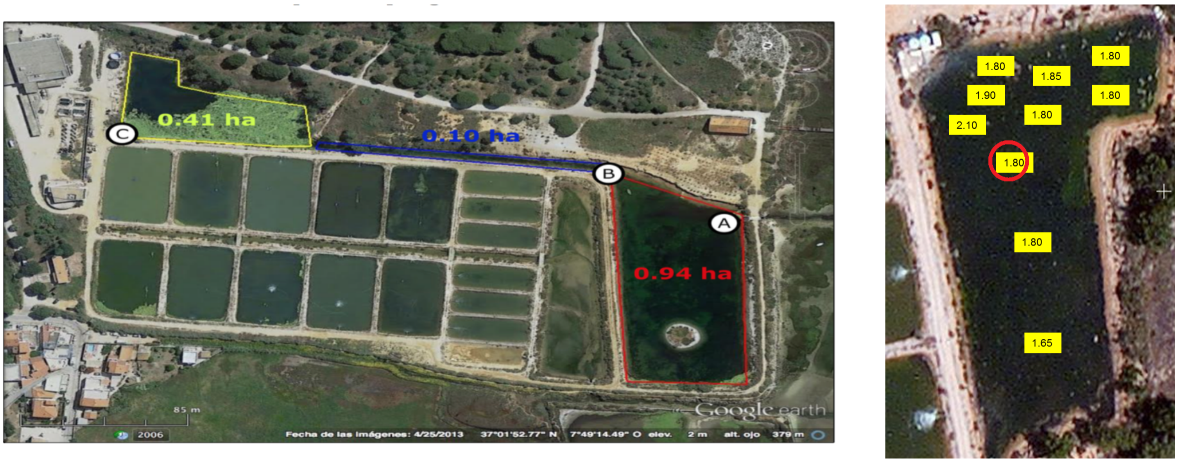


Figure 2.1: Experimental area: EPPO areas with seagrasses *Cymodocea nodosa* and *Zostera marina* (on the left), water depths at the tank labeled (C) with area of moored equipment marked with a red circle (on the right).

Figure 2.2: The CTD (left mooring) and SR-1 (right mooring) moorings before deployment.

Chapter 3

Environmental data

This chapter presents the meteorological data and CTD data gathered during the period of the acoustic experiment. It is also included a section with O2 optode data acquired by the EPPO team during the same period.

3.1 Meteorological data

The meteorological data, provided by EPPO colleagues, were recorded by a meteo station installed in top of a station building. The mean values of wind speed, atmospheric pressure, air temperature, relative humidity, precipitation and solar irradiance collected every 10 minute are presented in the figures below.

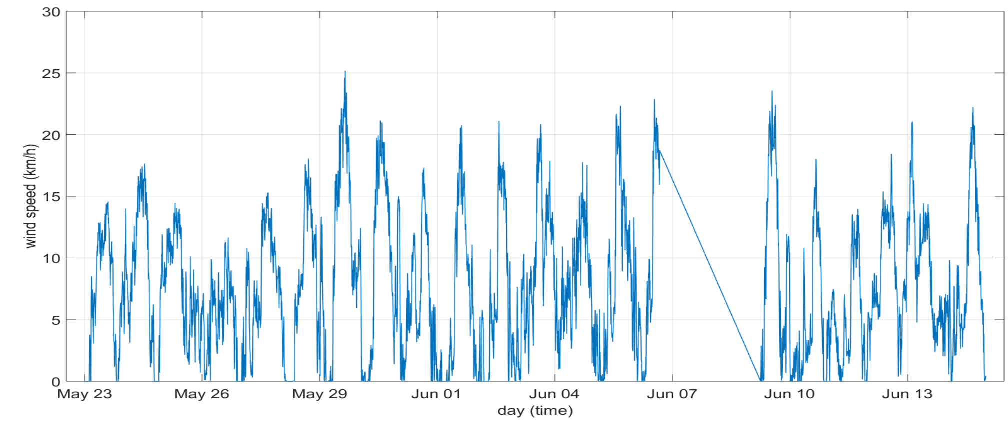
The data are separated into two parts, the first part from the beginning of the experiment (May 23) until June 14 and the second part from June 15 to July 5.

The meteo station didn't record the meteorological data in the period from June 6 until June 9, as it is possible to verify in graphs of the 1^{st} part (see Fig.3.1 and 3.2).

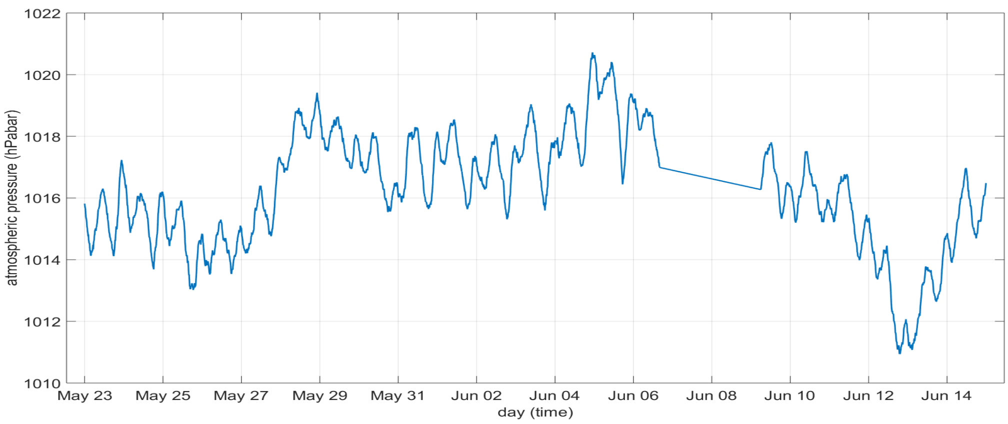
The data measured by the station are typical values for the time of the year in which the experiment was performed. Usually this season, the days are quite sunny, a few days of rain and the maximum air temperature around 30°C and the minimum around 18°C, as shown in figures below.

Maybe the solar irradiance is the most relevant parameter for the photosynthetic activity of the plants because it measures light availability, however, the wavelength is not known. The solar irradiance has practically the same peak values during the days of the experiment, and these daily peaks values (around 600 kW/m^2) occured around 2 p.m (3 p.m. local time), as shown in Fig. 3.2(f) and 3.4(f).

(a)



(b)



(c)

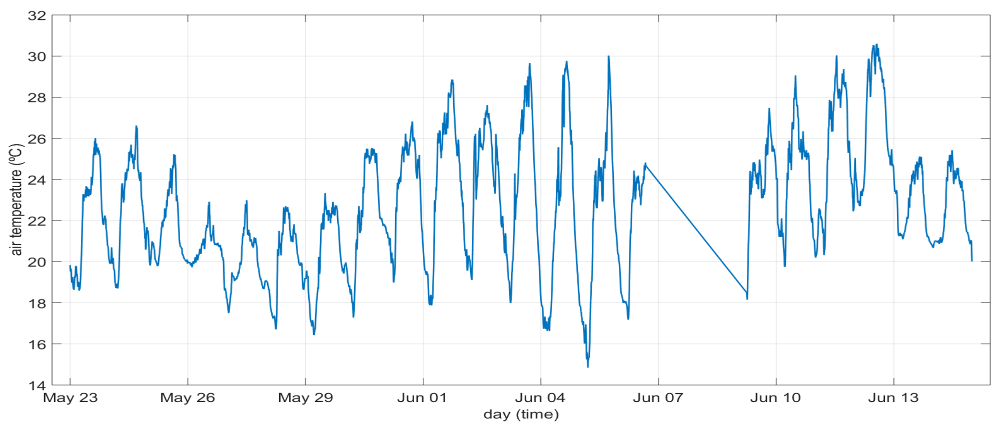
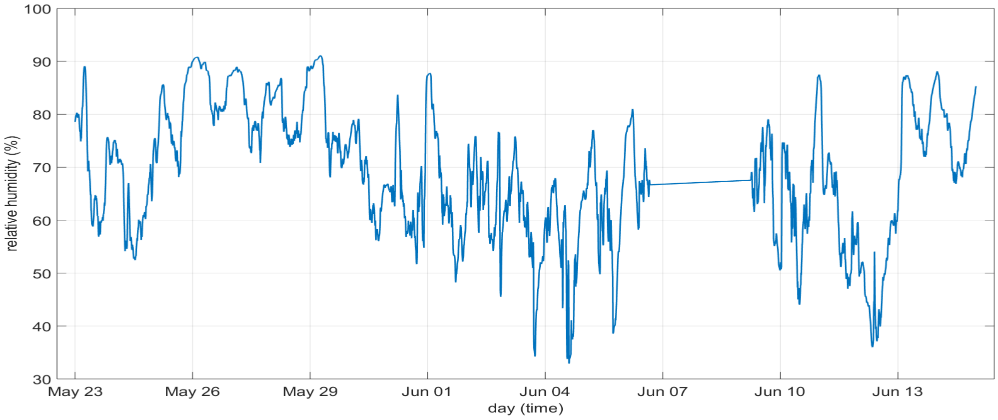
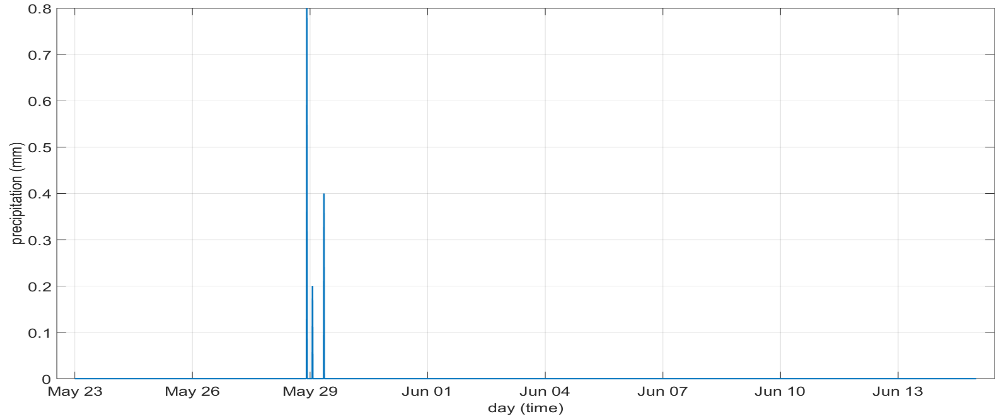


Figure 3.1: Meteorological data of 1st part: wind speed (a), atmospheric pressure (b), air temperature (c). Note: Missing data from June 6 to June 9.

(d)



(e)



(f)

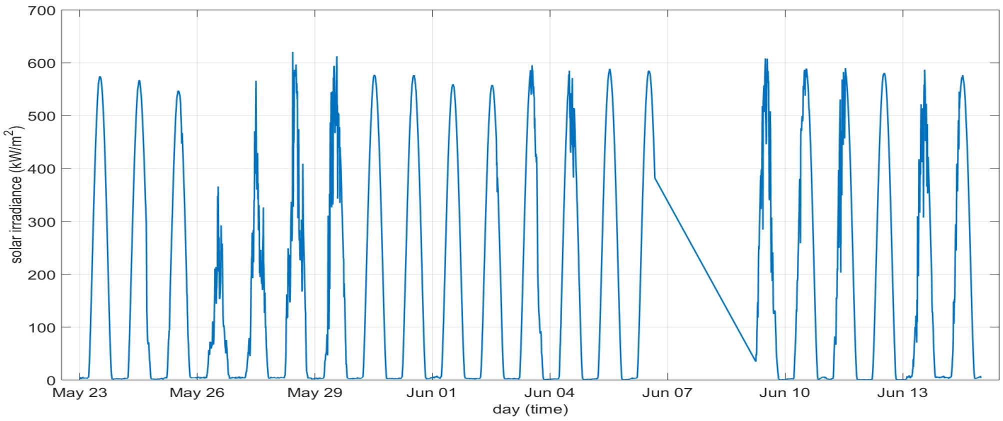


Figure 3.2: Meteorological data of 1st part: solar irradiance (d), relative humidity (e), and precipitation (f). Note: Missing data from June 6 to June 9.

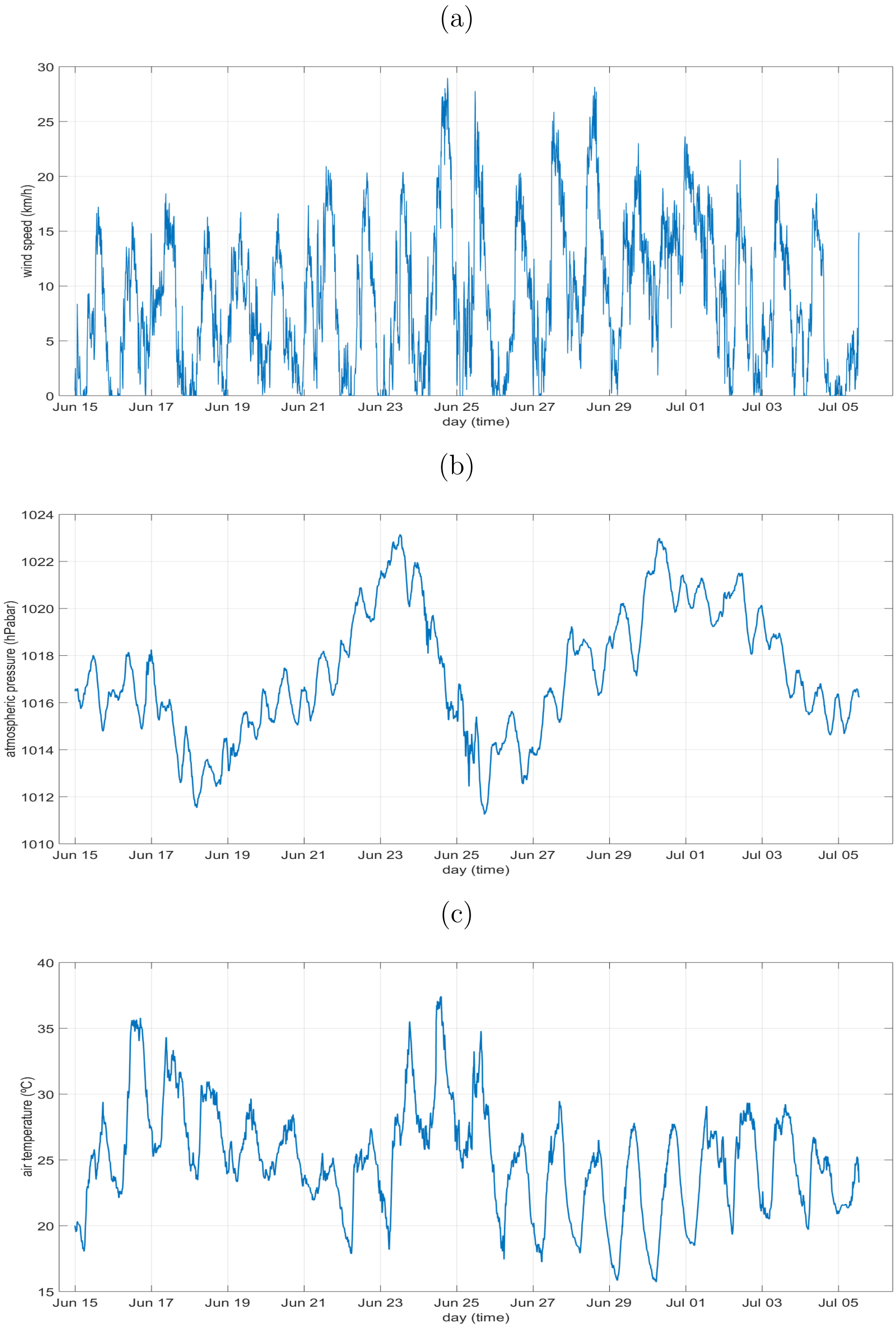
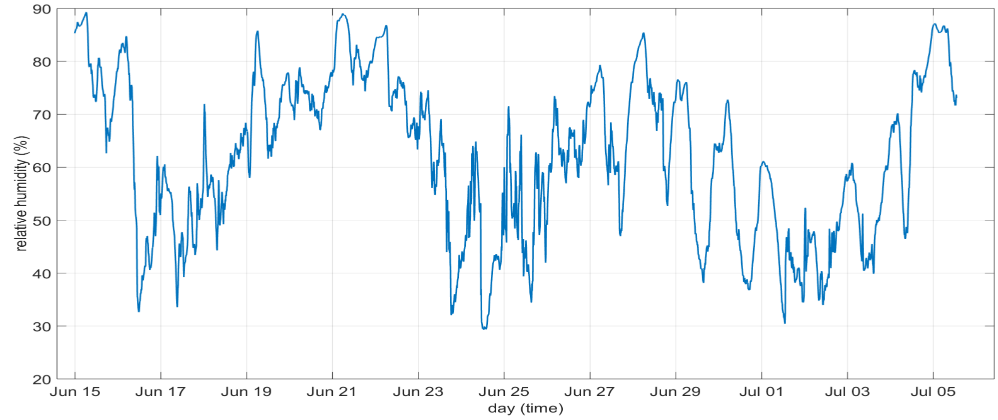
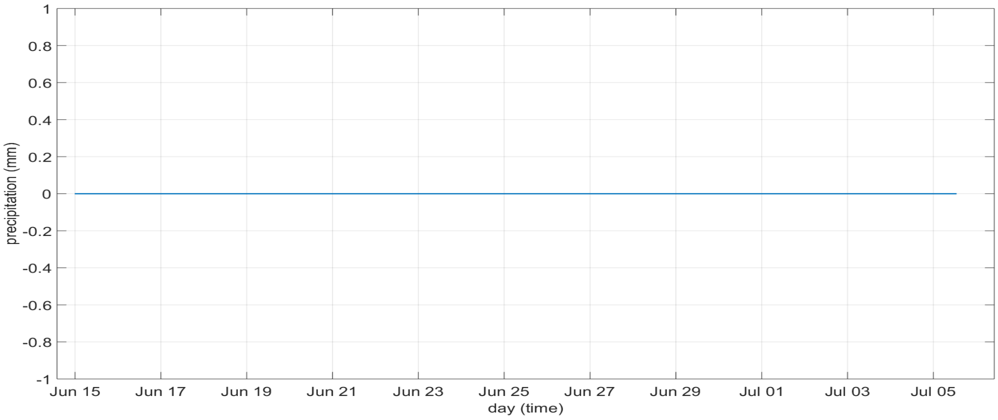


Figure 3.3: Meteorological data of 2nd part: wind speed (a), atmospheric pressure (b), air temperature (c).

(d)



(e)



(f)

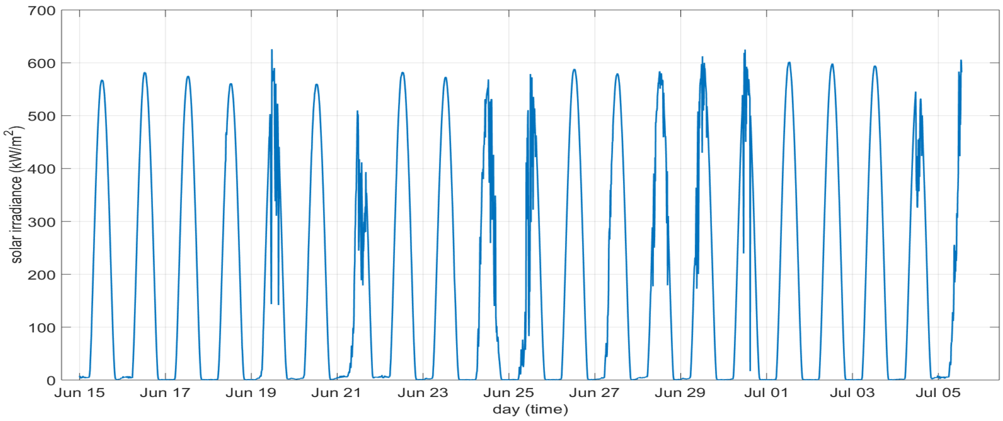


Figure 3.4: Meteorological data of 2$^{\text{nd}}$ part: solar irradiance (d), relative humidity (e), and precipitation (f).

3.2 CTD data

The CTD collected pressure (depth), conductivity, temperature and dissolved O2 data at sampling frequency of 2 sample per minute from May 23rd to July 6th. Data were downloaded during the experiment on 3 different days. On those days, the equipment was removed from the water, the data was downloaded and the sensors were cleaned, and then the CTD was put back into the water. This process took about 1 hour. The data was stored in the instrument during the acquisition and downloaded using the RBR-Ruskin software. The downloaded data was converted to Matlab mat-file format using RBRRuskin software. The data acquired on the last periods (after June 26 noon) was discarded, because of possible malfunction of the CTD due to discharged batteries. The data are separated by two periods, the 1st period from May 23rd to June 14th and the 2nd period from June 15th to June 26th.

The water temperature, salinity, sound speed and depth are presented in Fig. 3.5 and 3.7. The water temperature varied about 6°C between 22 and 28°C during the 1st period and about 4°C between 25 and 29°C during the 2nd period. The variability shows a diurnal pattern

The salinity varies between 36ppm and 37ppm along the two periods. At the begin of the 1st period the value was 36ppm and increased to 37ppm. In the second period, the value is practically constant at 36.5ppm. Apart of the variation, the salinity plots show some spikes (short time decrease of salinity).

The sound speed in the first period varies between 1530 and 1545 m/s, and in the second period varies between 1536 and 1546 m/s. As expected, follows a pattern similar to the water temperature. Several authors correlate the two parameters, concluding that the 1°C increase in temperature increases the sound speed in 3 m/s, approximately, which is in accordance with the data measured by the multiparameter CTD (see Fig. 3.5 and 3.7).

The sensor depth and the estimated water depth varies with the tide inside of the tank, however, instead of a (quasi) sinusoidal pattern, the water depth increase and decreases almost linearly with a higher slope (faster) during the inflow, due to the water flux control system (floodgate). There is a period when the water depth does not vary, due to the fact that the tides in the Ria Formosa lagoon are large or small tides.

The dissolved O2 are presented in Fig. 3.6 and 3.8, showing a diurnal pattern with the lowest values just before sunrise, and the highest values afternoon. The maximal value of dissolved O2 is about 700% measured in four days (June 1, June 9, June 16 and June 17). The value might be biased because the sensor is not calibrated.

The aeration pumps might be working during the period, but there are no time records.

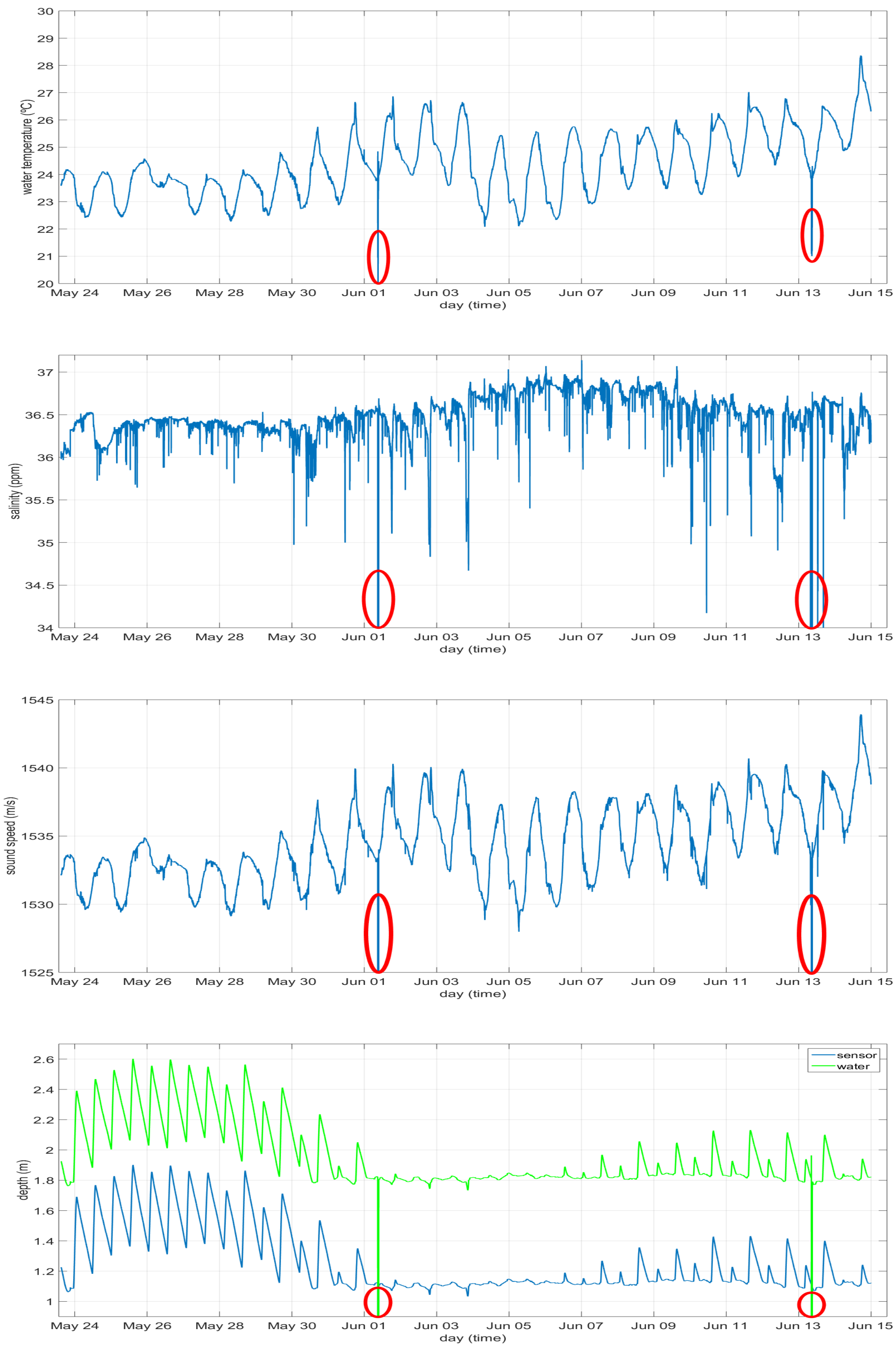


Figure 3.5: CTD data: water temperature, salinity, bubbles free sound speed and depth (blue line) and estimated water depth (green line) during the 1st period (23rd May to 14th June). The red ellipses represent the moment of replacement of the equipment batteries.

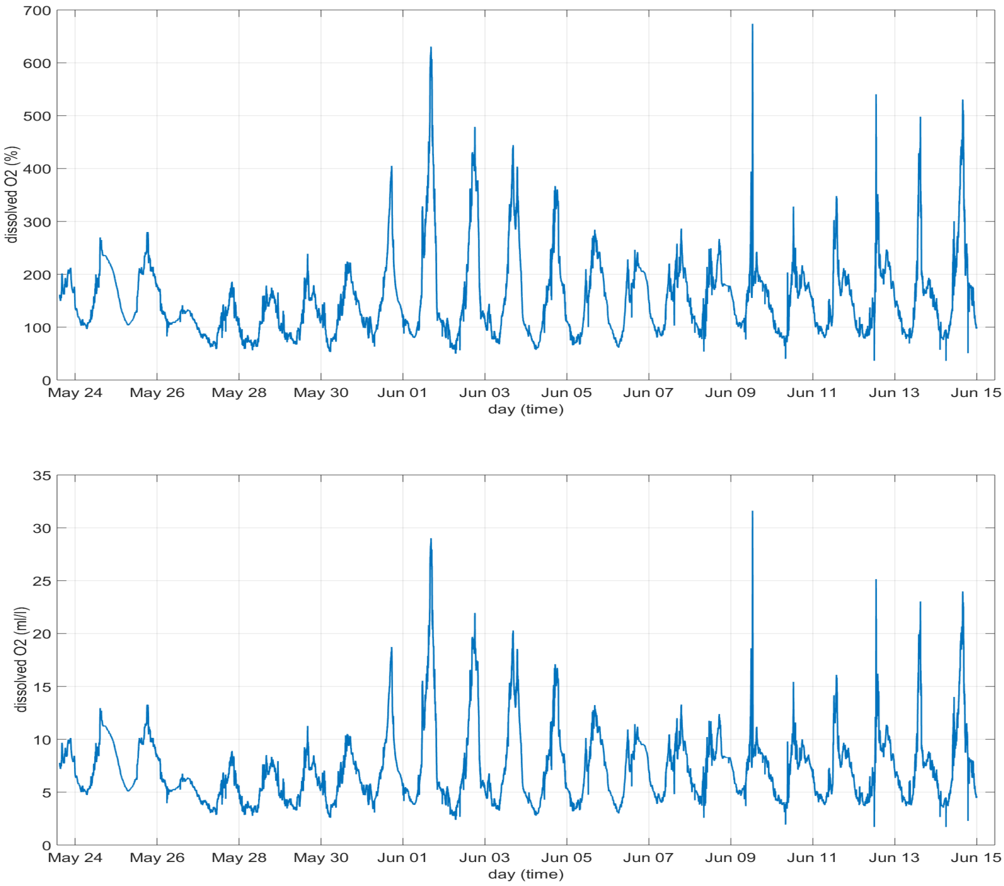


Figure 3.6: Dissolved O2 data from CTD optode: percentage of saturation (left) and concentration (right) during the 1st period (23rd May to 14th June).

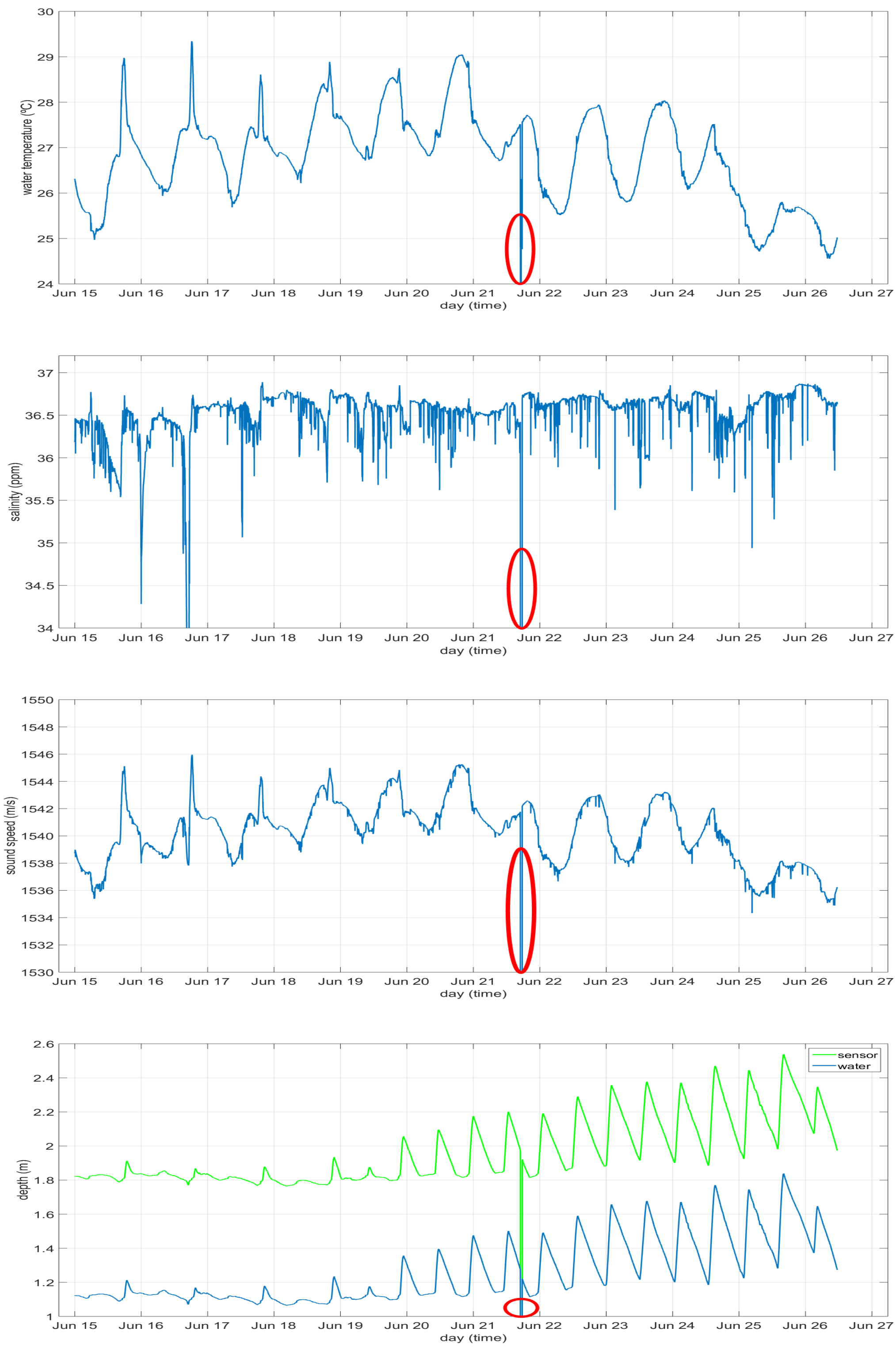


Figure 3.7: CTD data: water temperature, salinity, bubbles free sound speed and depth (blue line) and estimated water depth (green line) during the 2nd period (15th June to 26th June). The red ellipse represents the moment of replacement of the equipment batteries.

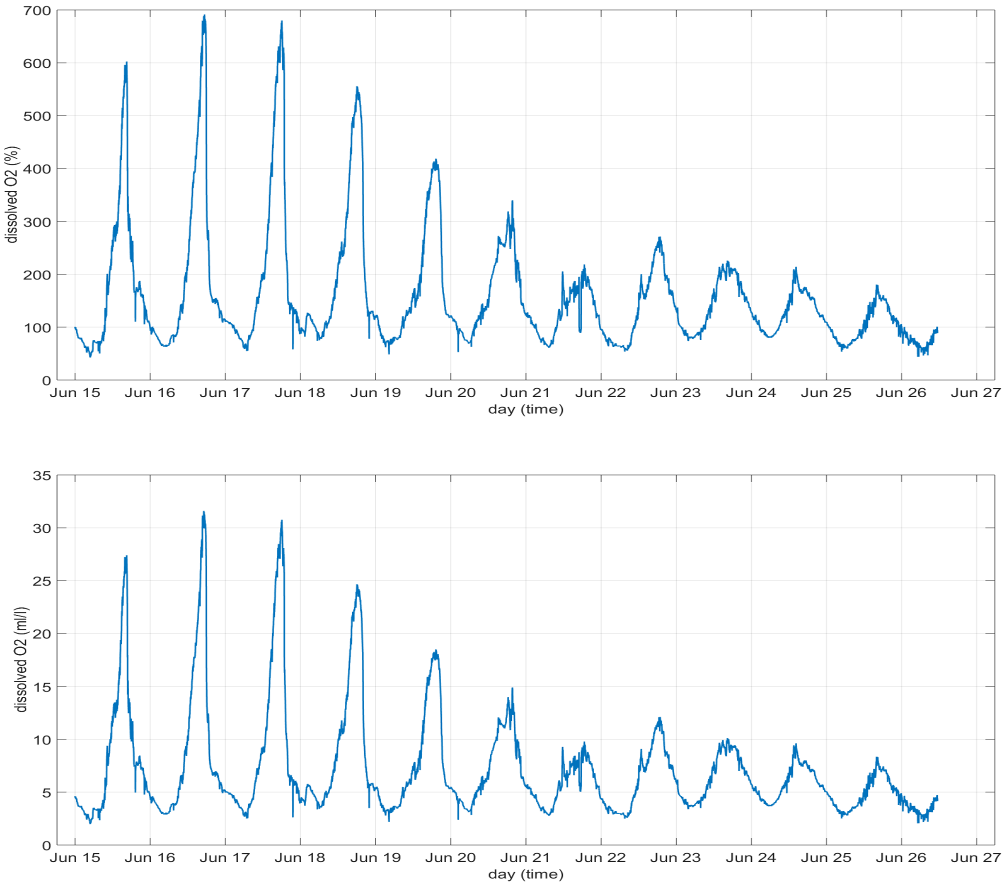


Figure 3.8: Dissolved O2 data from CTD optode: percentage of saturation (left) and concentration (right) during the 2nd period (15th June to 26th June).

3.3 EPPO dissolved O2 measurements

EPPO team carried dissolved O2 measurements using optodes, at the water pumps tank (C), during all period of the experiment. Measurements were performed in the morning and afternoon, however, there were 3 days where the measurement was not performed during the afternoon (June 9, June 10 and June 21). The measurements were performed at the middle of water column, close to the water pumps (no plants in the area), the sensor is immersed in the water column through a cable and the measurement is made.

The dissolved O2 in percentage of saturation and concentration are presented in Fig.3.9 and the water temperature is presented in Fig.3.10.

It can be noticed outstanding oversaturation conditions during this experiment, particularly in afternoon period. In Fig.3.9 it is possible to verify that in the afternoon an oxygen concentration is higher than the morning value. This figure shows that the oxygen concentration value during the afternoon is always greater than 100%, unlike the morning value where it is almost always less than 100%, which suggests that there is supersaturation of the water column during the afternoon and release of oxygen bubbles.

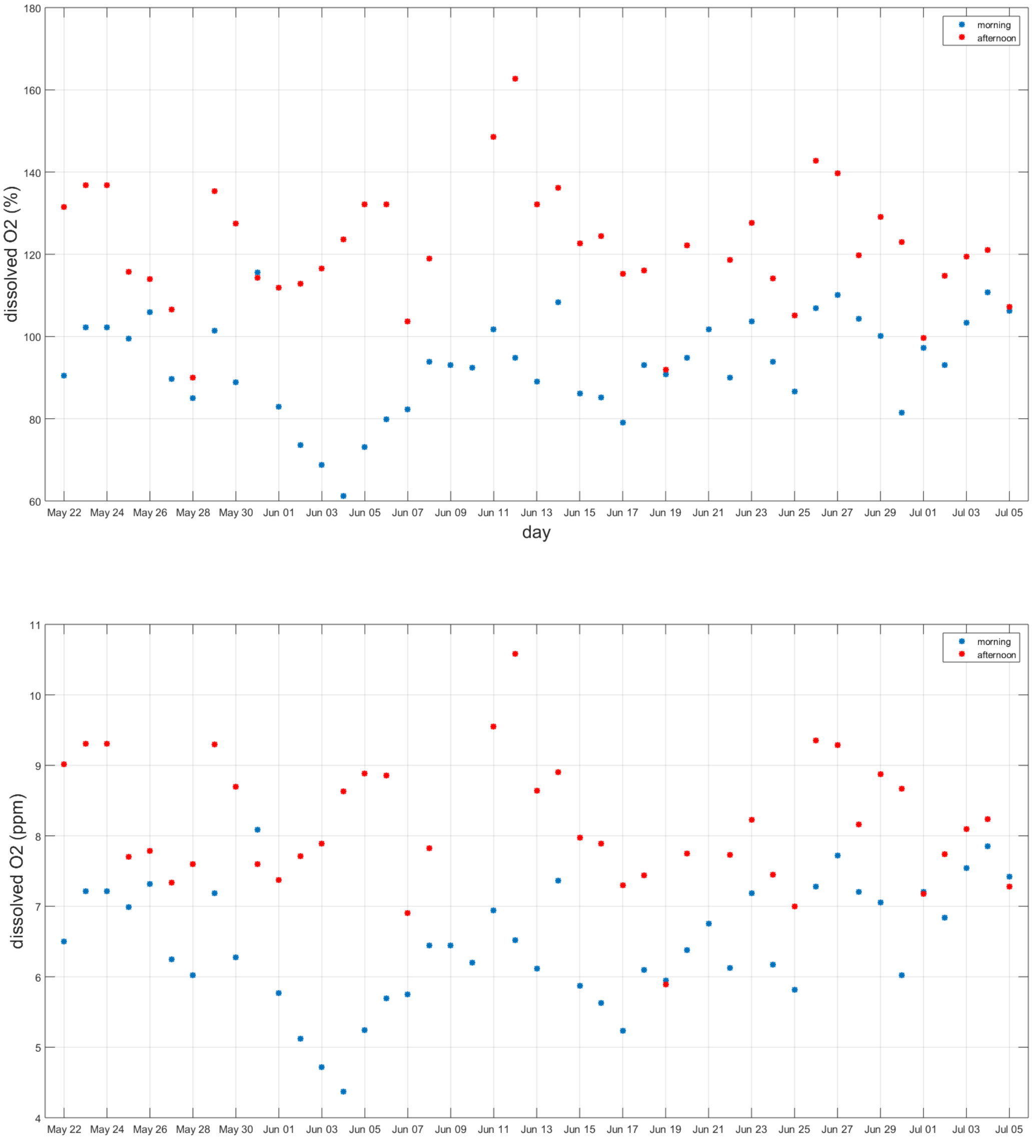


Figure 3.9: Dissolved O2 measurements by optodes carried out by EPPO team during this experiment. O2 dissolved in percentage (upper) and o2 dissolved in ppm (bottom). The figure shows values of the morning (blue) and values of the afternoon (red). On 9th, 10th and 21st of June, no measurements were taken during the afternoon.

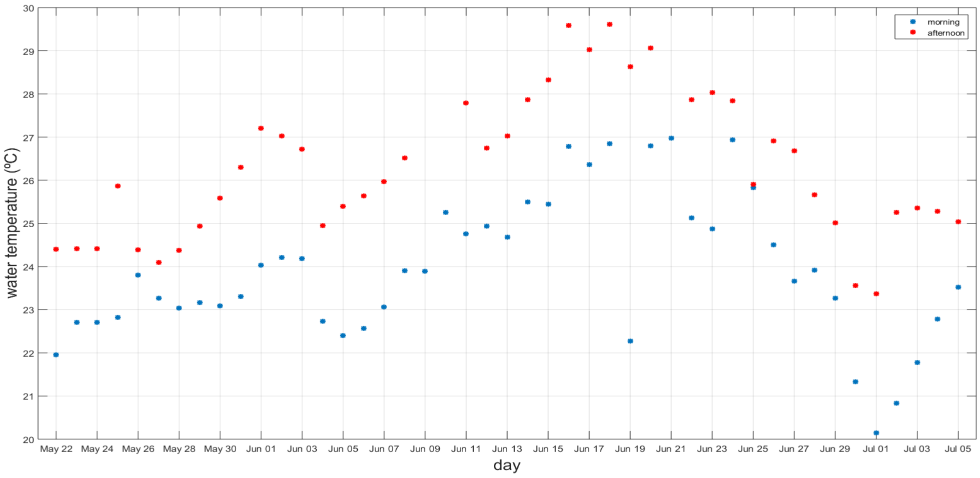


Figure 3.10: Water temperature measurements carried out by EPPO team during this experiment. The figure shows values of the morning (blue) and values of the afternoon (red). On 9th, 10th and 21st of June, no measurements were taken during the afternoon.

Chapter 4

Noise measurements

The ambient noise is dominated by the water pumps noise and bubbles generated by the aeration pumps. The SR-1 hydrophone was deployed around the location of the October 2016 experiment [2]. 90 s snapshots of data at sampling frequency of 52734 Hz were recorded every 10 minutes. Like in previous experiment the power spectral density of noise was computed using the Welch method from 30 s snapshots (last 30 s of the .wav files) using a 2048 points FFT with 512 samples overlapping.

The data were separated by parts, according to the days when the data was downloaded and the batteries of the hydrophones were replaced:

- **Week 1** - from May 23 to June 1;
- **Week 2** - from June 1 to June 5;
- **Week 3** - from June 5 to June 13;
- **Week 4** - from June 13 to June 21;
- **Week 5** - from June 21 to June 30;
- **Week 6** - from June 30 to July 13;

4.1 Week 1

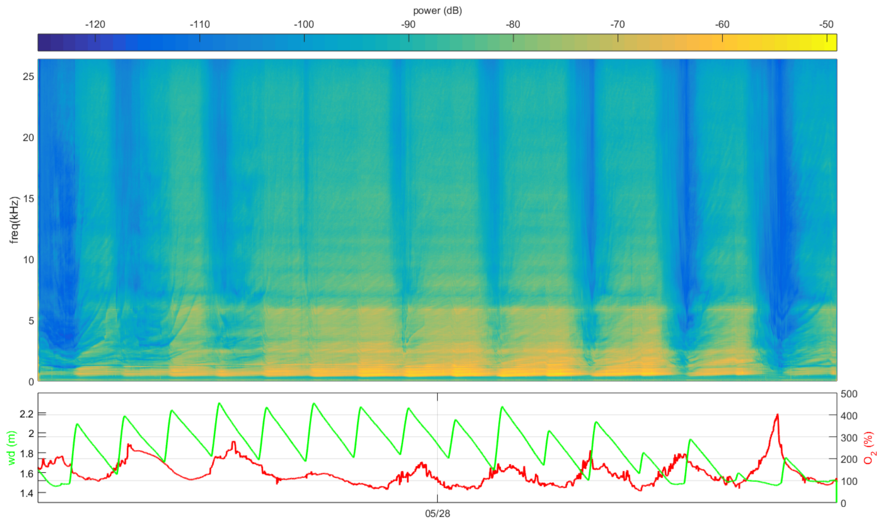


Figure 4.1: Power spectral density of the ambient 5noise in the bands 0-25 kHz, estimated every 10 min during the Week 1. The red and green curves represent the O2 saturation level and water depth, respectively.

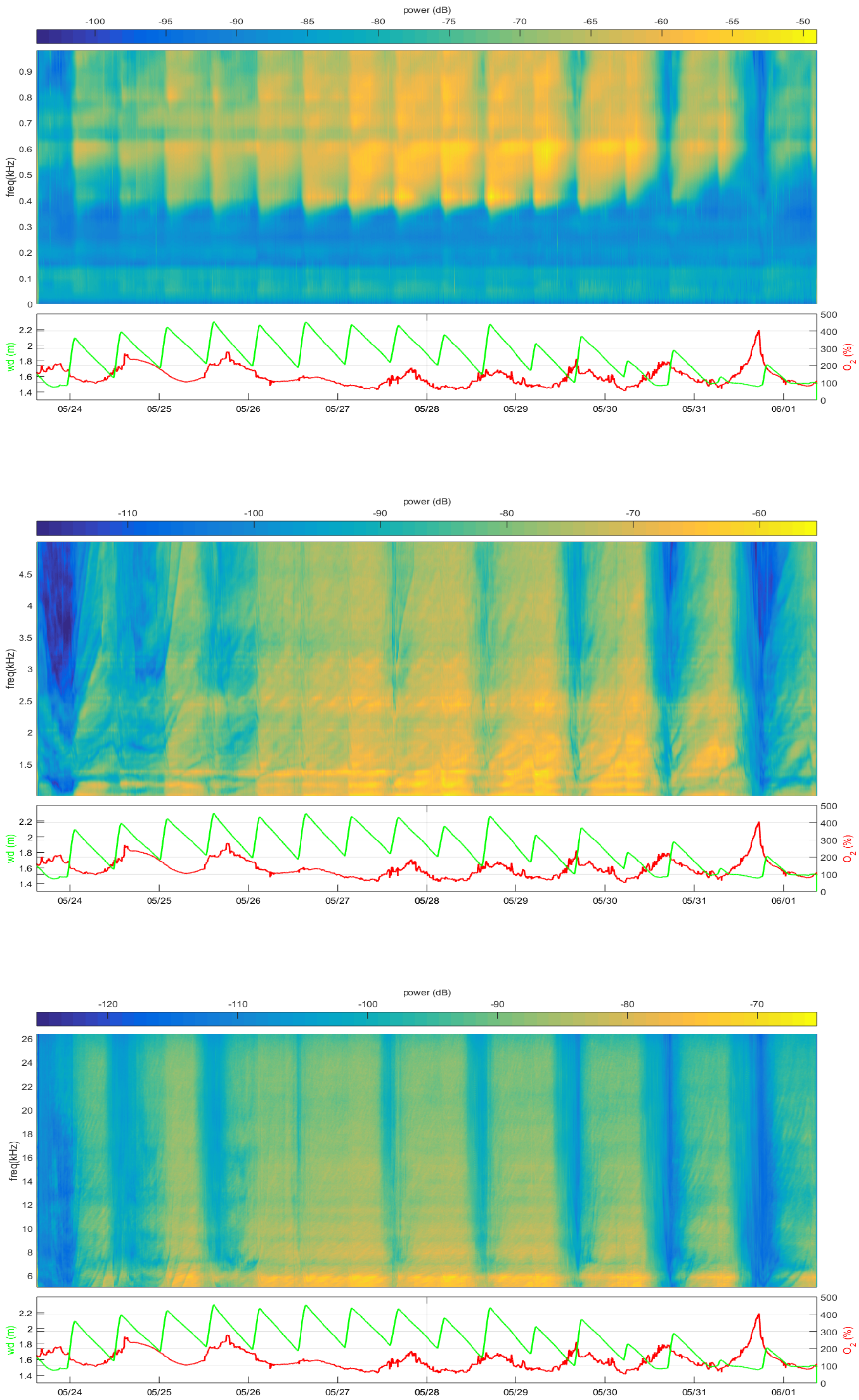


Figure 4.2: Power spectral density of the ambient noise in the bands: 0-1 kHz (top), 1-5 kHz (middle) and 5-25 kHz (bottom), during the Week 1. The red and green curves represent the O2 saturation level and water depth, respectively.

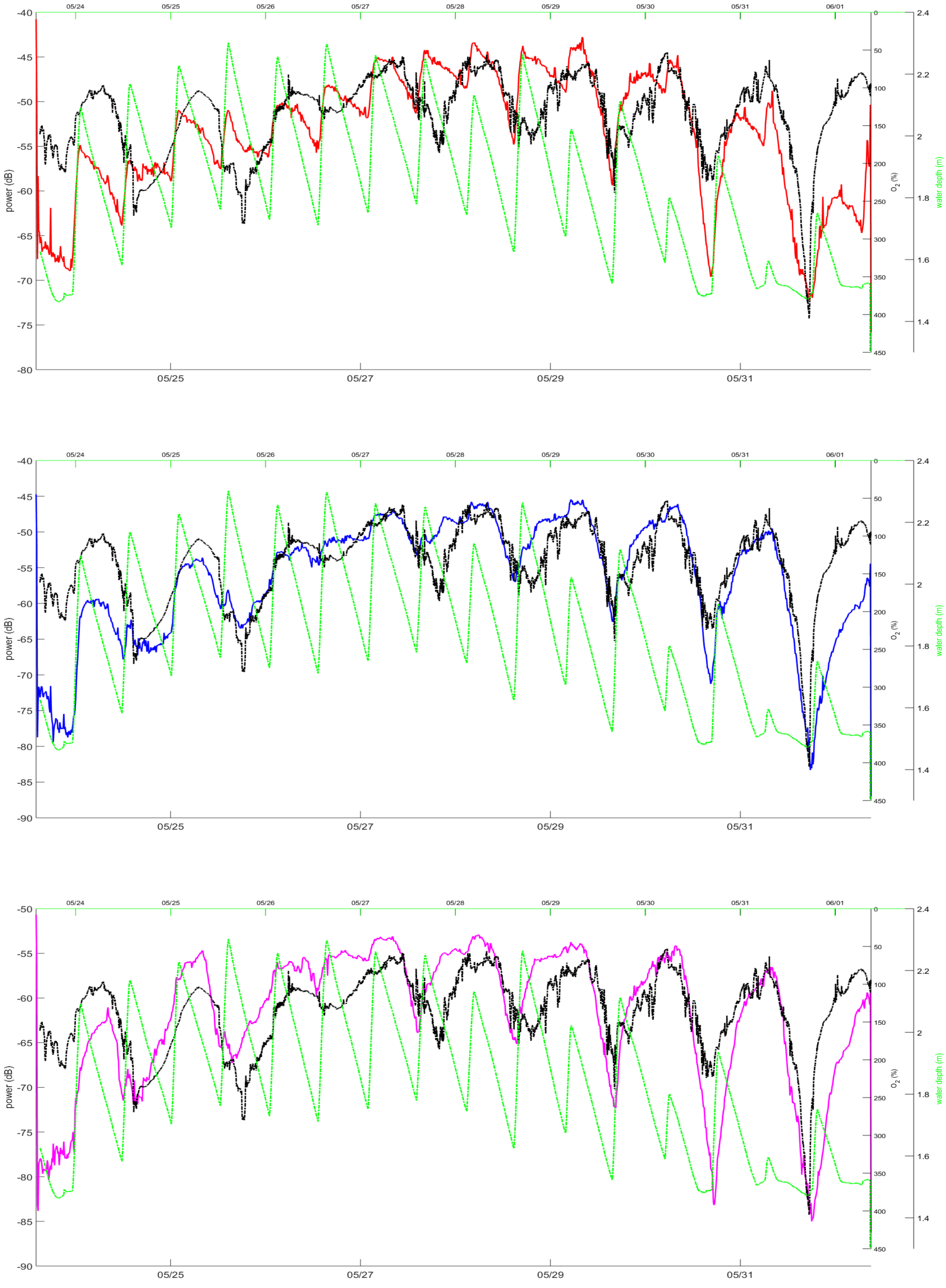


Figure 4.3: The variability of the ambient noise power in the bands: 0-1 kHz (first figure in red), 1-5 kHz (second figure in blue) and 5-25 kHz (third figure in magenta), during the Week 1. The red and green curves represent the O2 saturation level and water depth, respectively.

4.2 Week 2

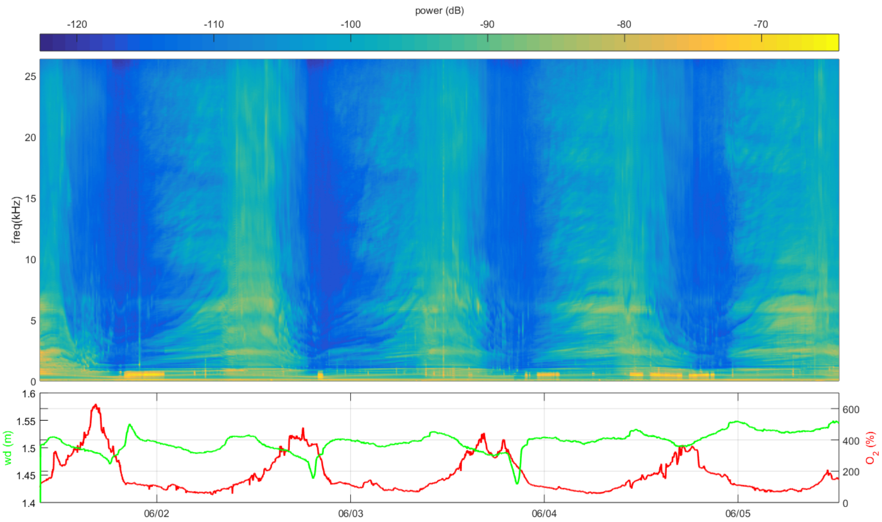


Figure 4.4: Power spectral density of the ambient noise in the bands 0-25 kHz, estimated every 10 min during the Week 2. The red and green curves represent the O2 saturation level and water depth, respectively.

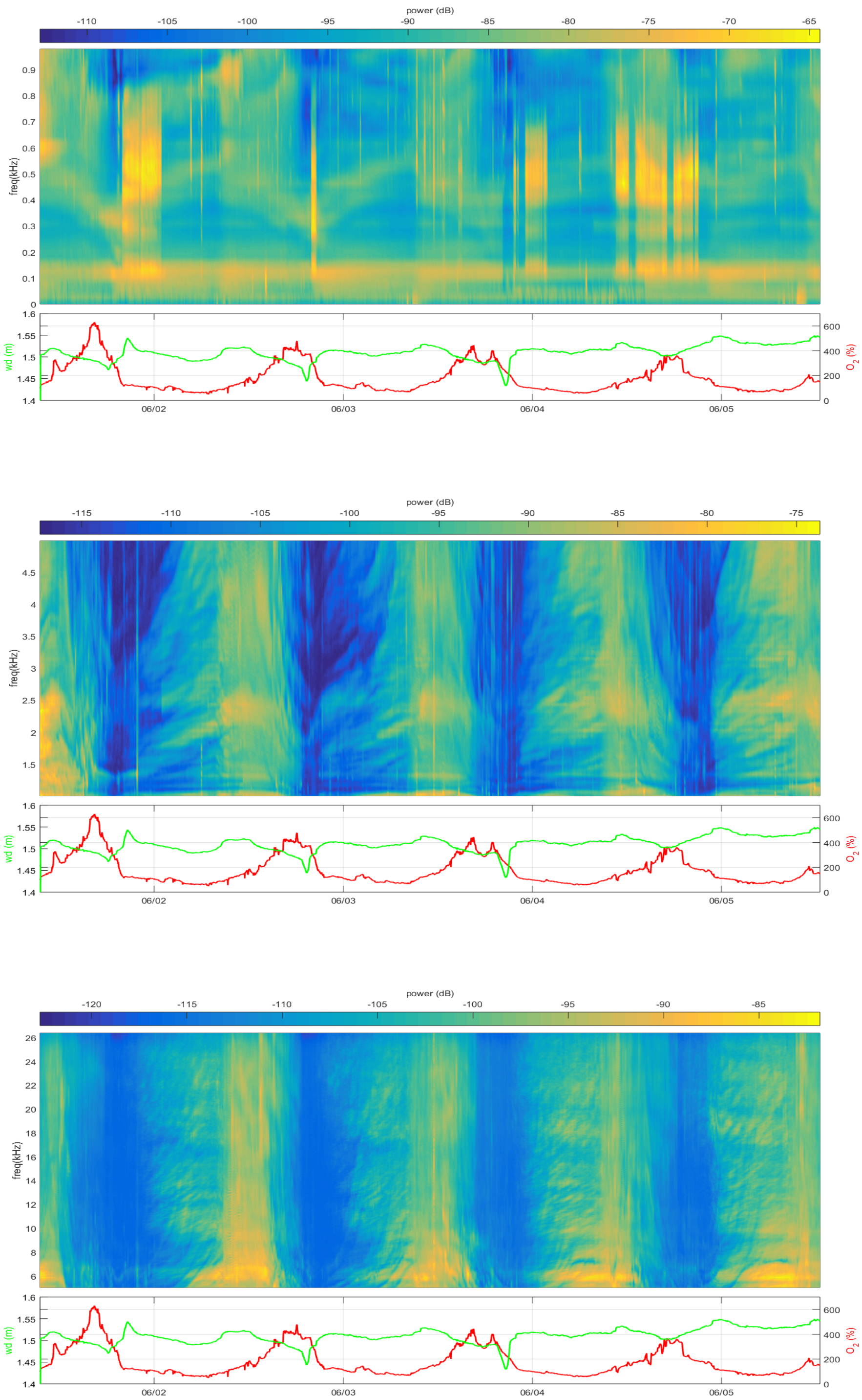


Figure 4.5: Power spectral density of the ambient noise in the bands: 0-1 kHz (top), 1-5 kHz (middle) and 5-25 kHz (bottom), during the Week 2. The red and green curves represent the O2 saturation level and water depth, respectively.

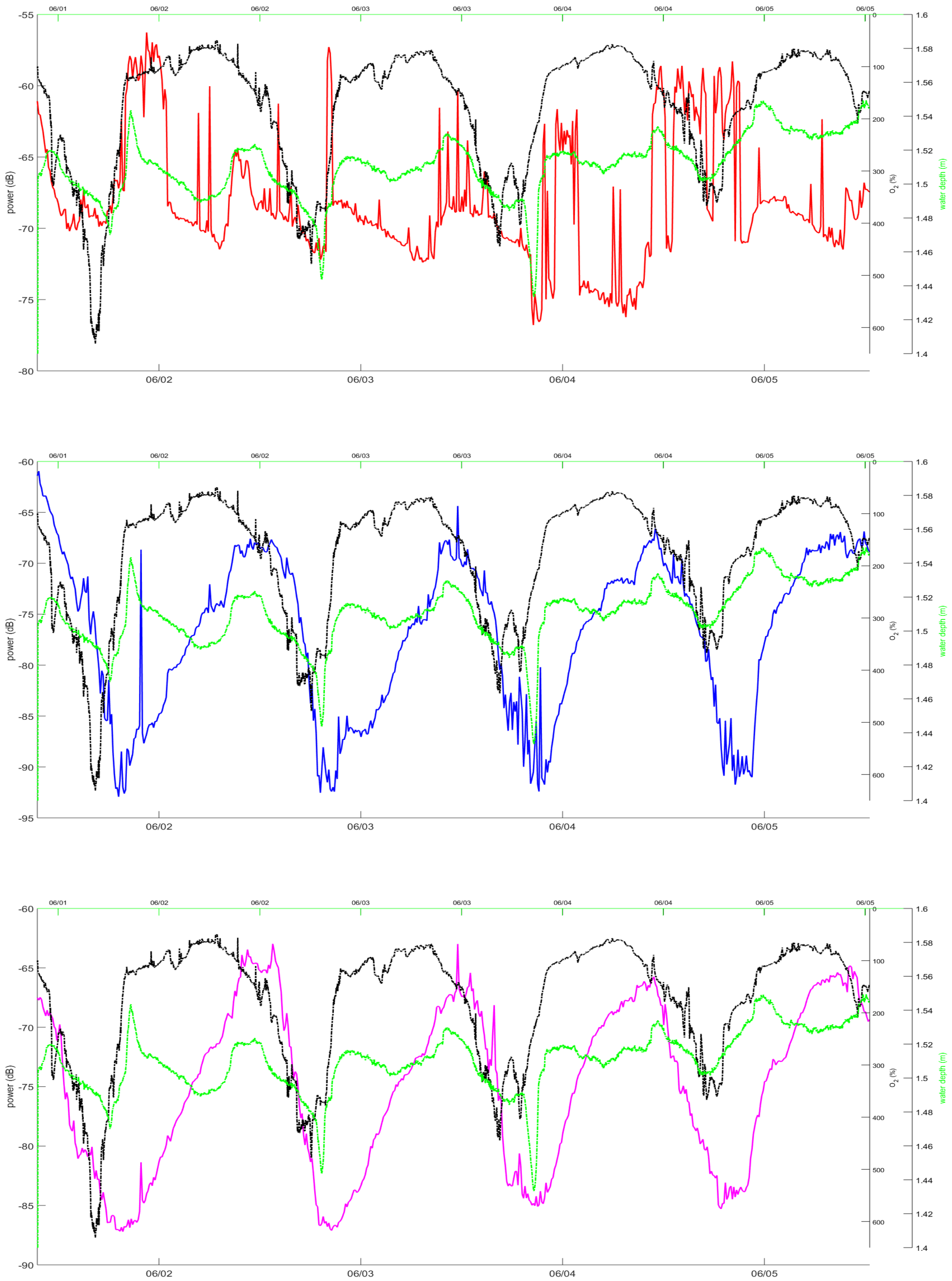


Figure 4.6: The variability of the ambient noise power in the bands: 0-1 kHz (first figure in red), 1-5 kHz (second figure in blue) and 5-25 kHz (third figure in magenta), during the Week 2. The red and green curves represent the O2 saturation level and water depth, respectively.

4.3 Week 3

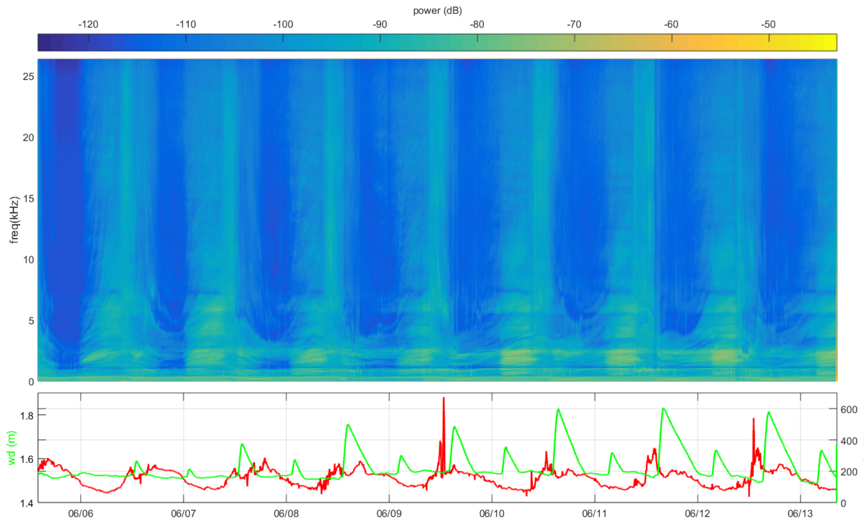


Figure 4.7: Power spectral density of the ambient noise in the bands 0-25 kHz, estimated every 10 min during the Week 3. The red and green curves represent the O2 saturation level and water depth, respectively.

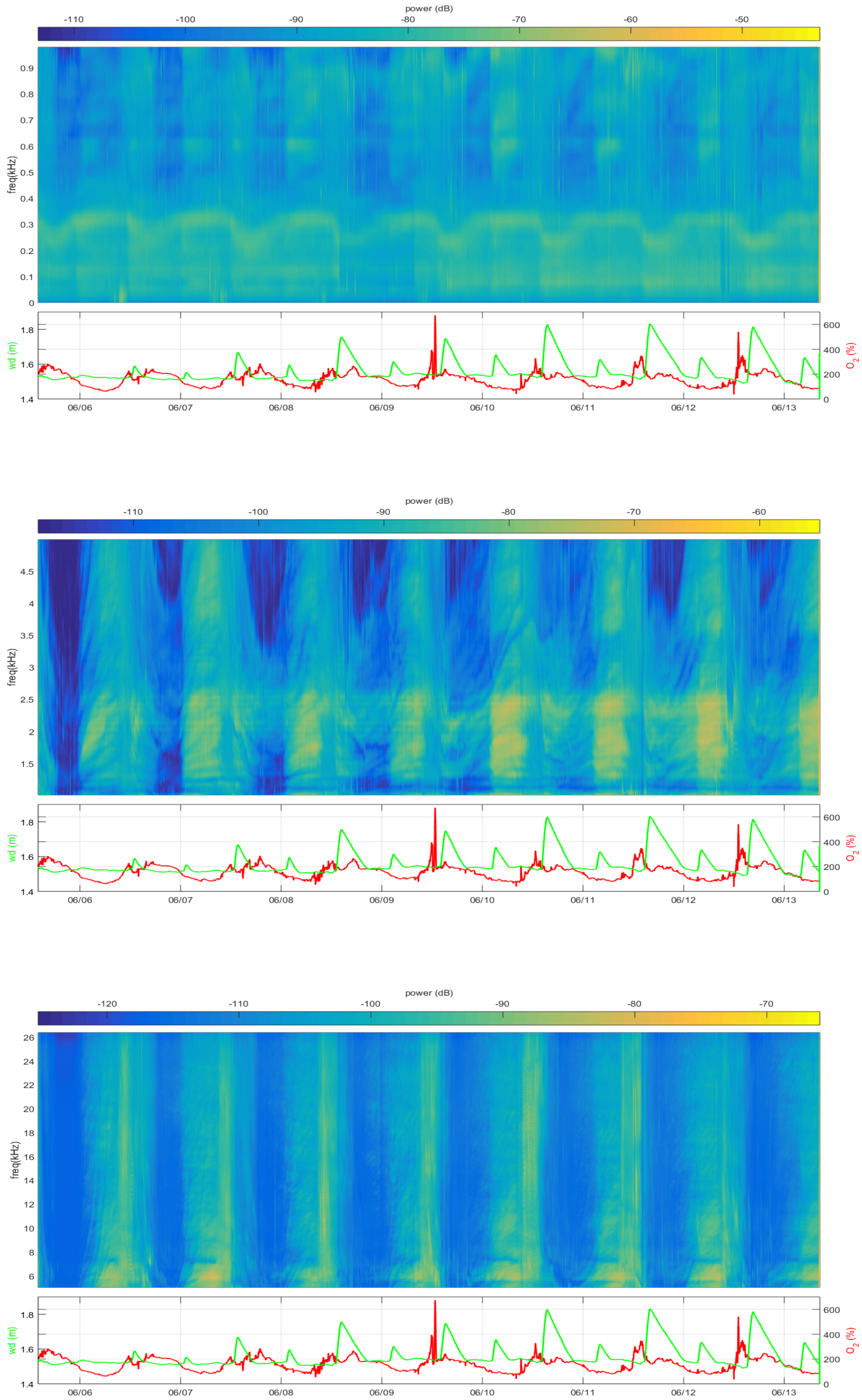


Figure 4.8: Power spectral density of the ambient noise in the bands: 0-1 kHz (top), 1-5 kHz (middle) and 5-25 kHz (bottom), during the Week 3. The red and green curves represent the O2 saturation level and water depth, respectively.

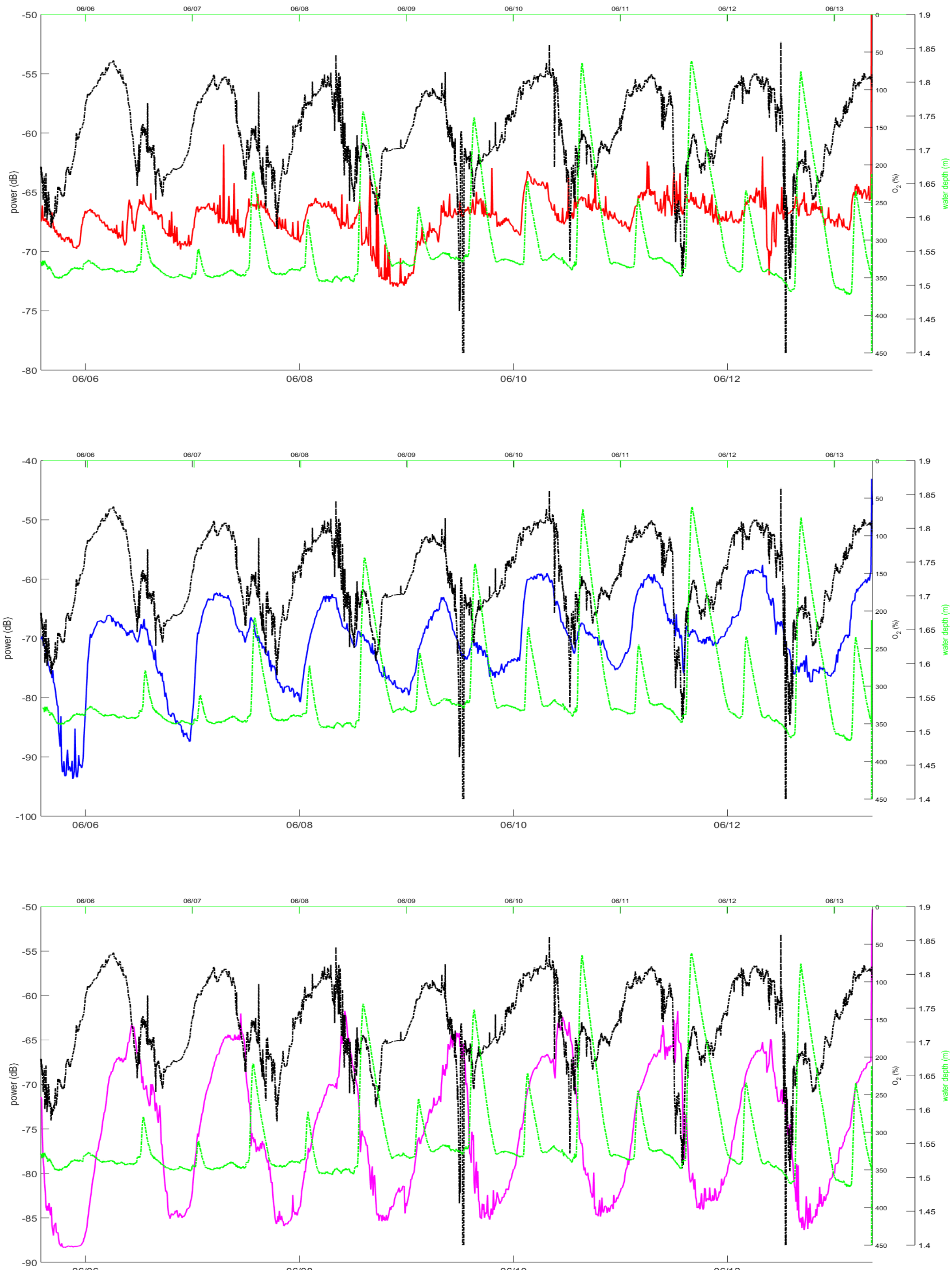


Figure 4.9: The variability of the ambient noise power in the bands: 0-1 kHz (first figure in red), 1-5 kHz (second figure in blue) and 5-25 kHz (third figure in magenta), during the Week 3. The red and green curves represent the O2 saturation level and water depth, respectively.

4.4 Week 4

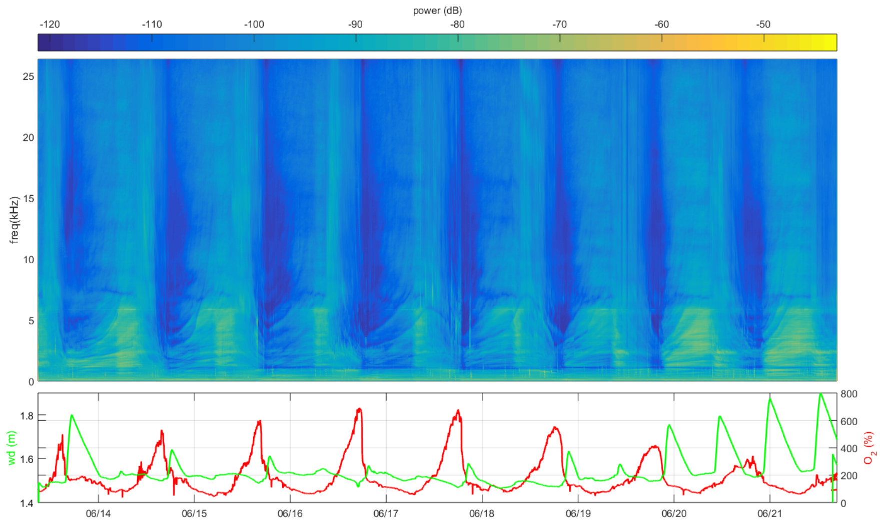


Figure 4.10: Power spectral density of the ambient noise in the bands 0-25 kHz, estimated every 10 min during the Week 4. The red and green curves represent the O2 saturation level and water depth, respectively.

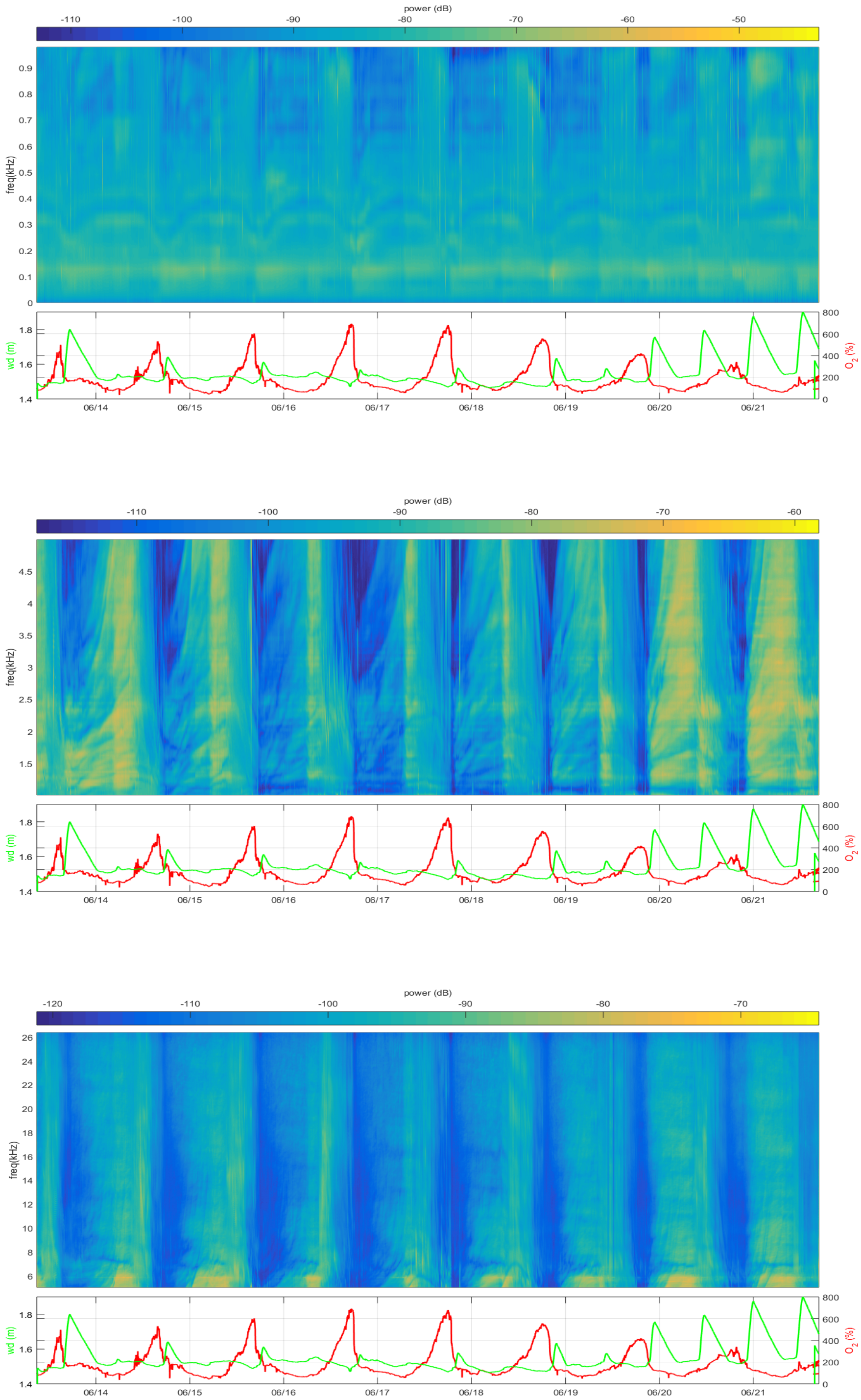


Figure 4.11: Power spectral density of the ambient noise in the bands: 0-1 kHz (top), 1-5 kHz (middle) and 5-25 kHz (bottom), during the Week 4. The red and green curves represent the O2 saturation level and water depth, respectively.

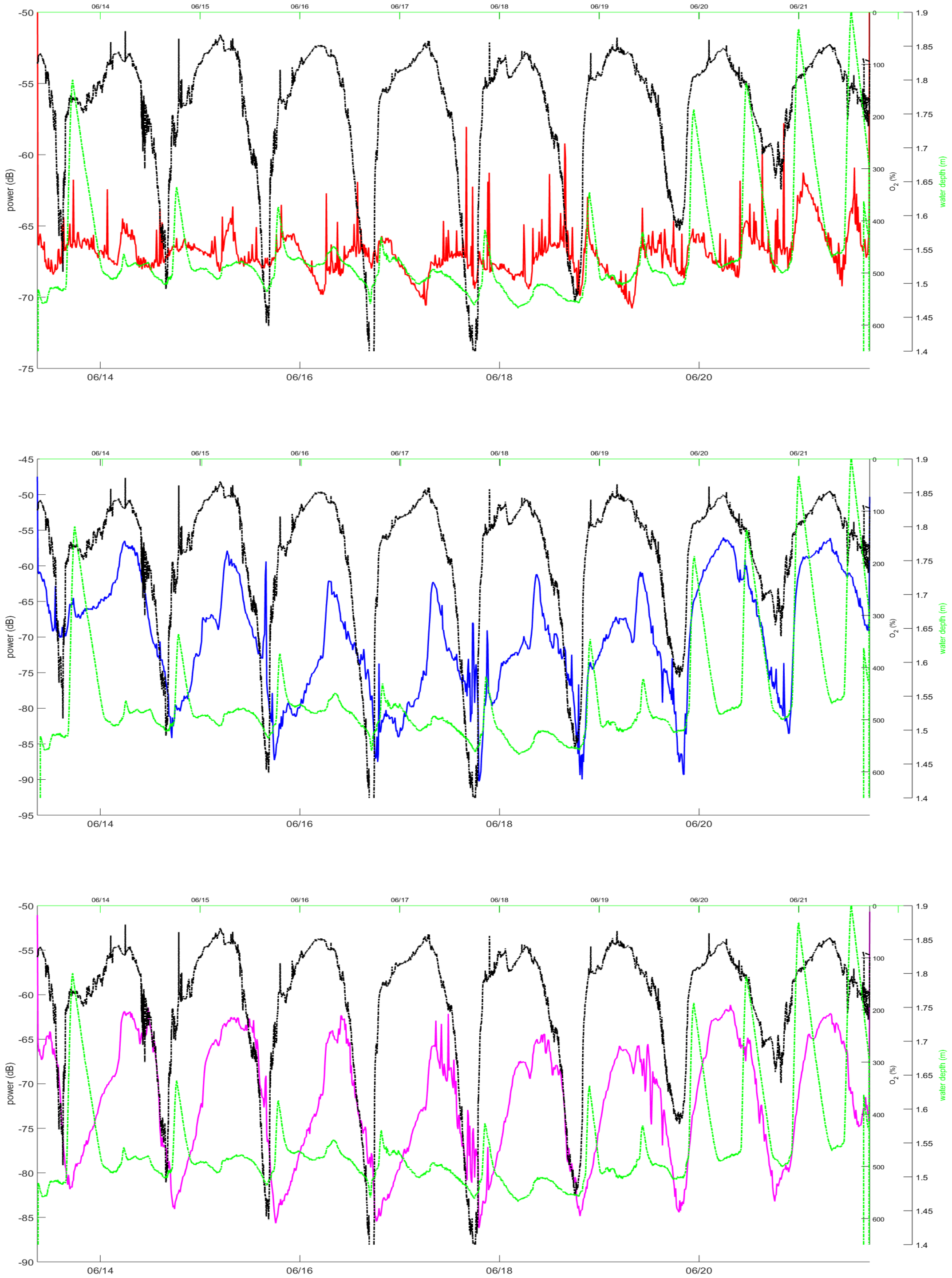


Figure 4.12: The variability of the ambient noise power in the bands: 0-1 kHz (first figure in red), 1-5 kHz (second figure in blue) and 5-25 kHz (third figure in magenta), during the Week 4. The red and green curves represent the O2 saturation level and water depth, respectively.

4.5 Week 5

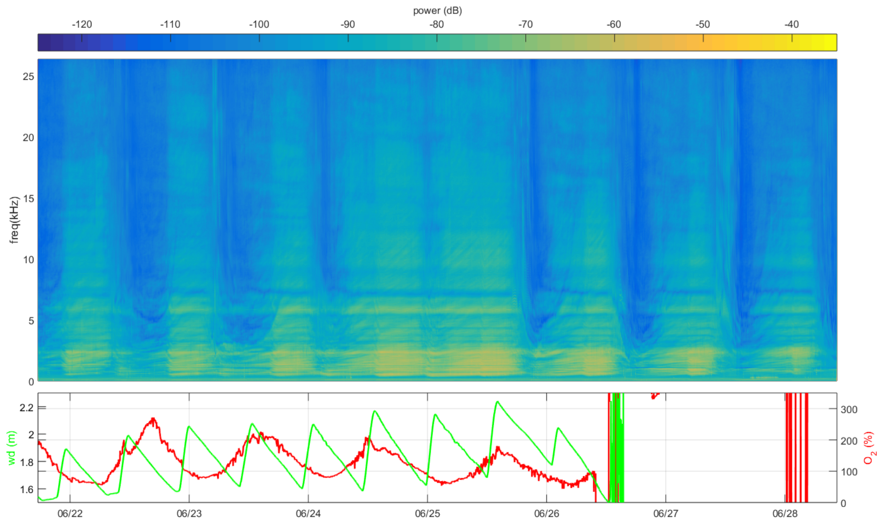


Figure 4.13: Power spectral density of the ambient noise in the bands 0-25 kHz, estimated every 10 min during the Week 5. The red and green curves represent the O2 saturation level and water depth, respectively. However, CTD data are only available up to June 26 afternoon.

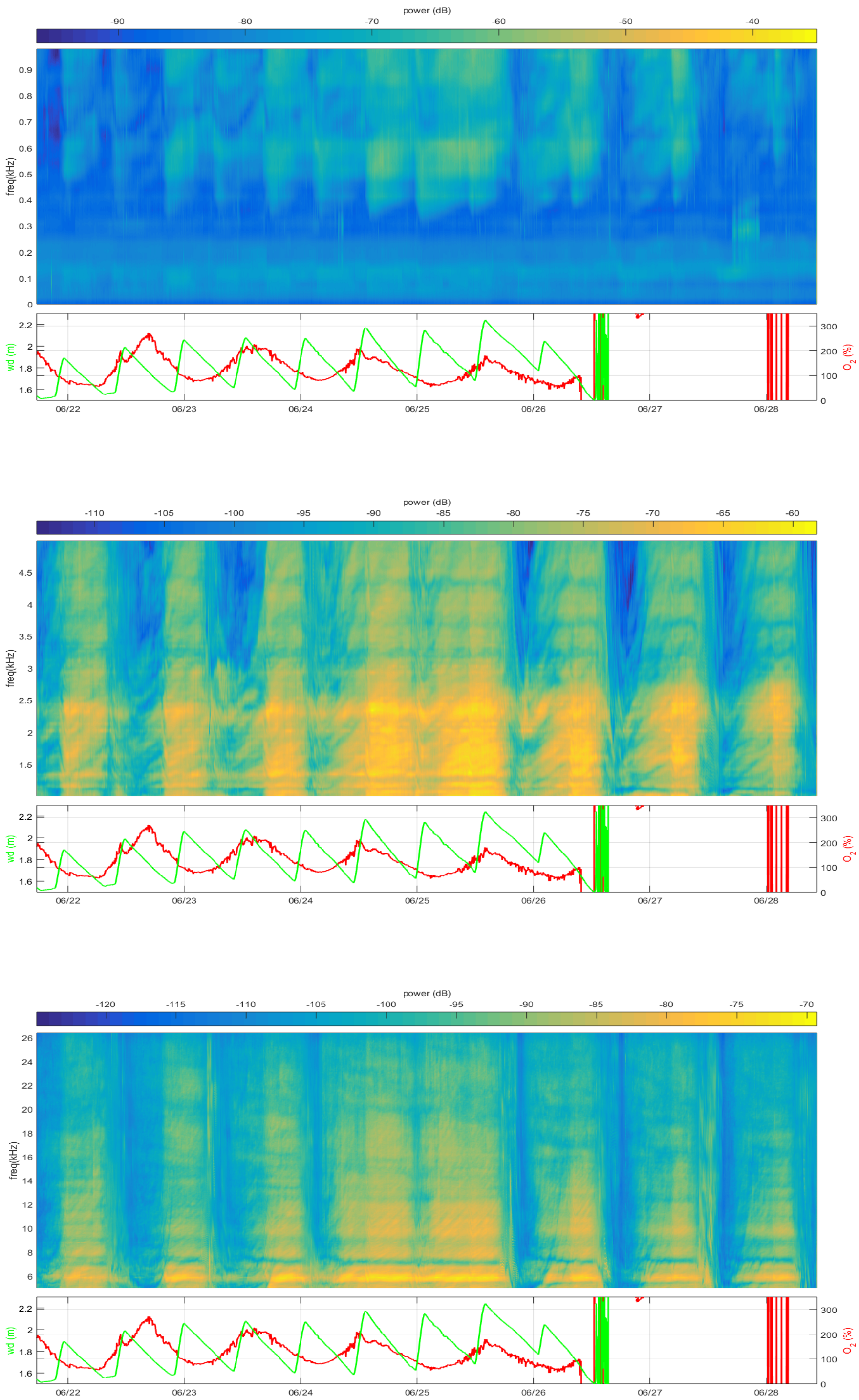


Figure 4.14: Power spectral density of the ambient noise in the bands: 0-1 kHz (top), 1-5 kHz (middle) and 5-25 kHz (bottom), during the Week 5. The red and green curves represent the O2 saturation level and water depth, respectively.

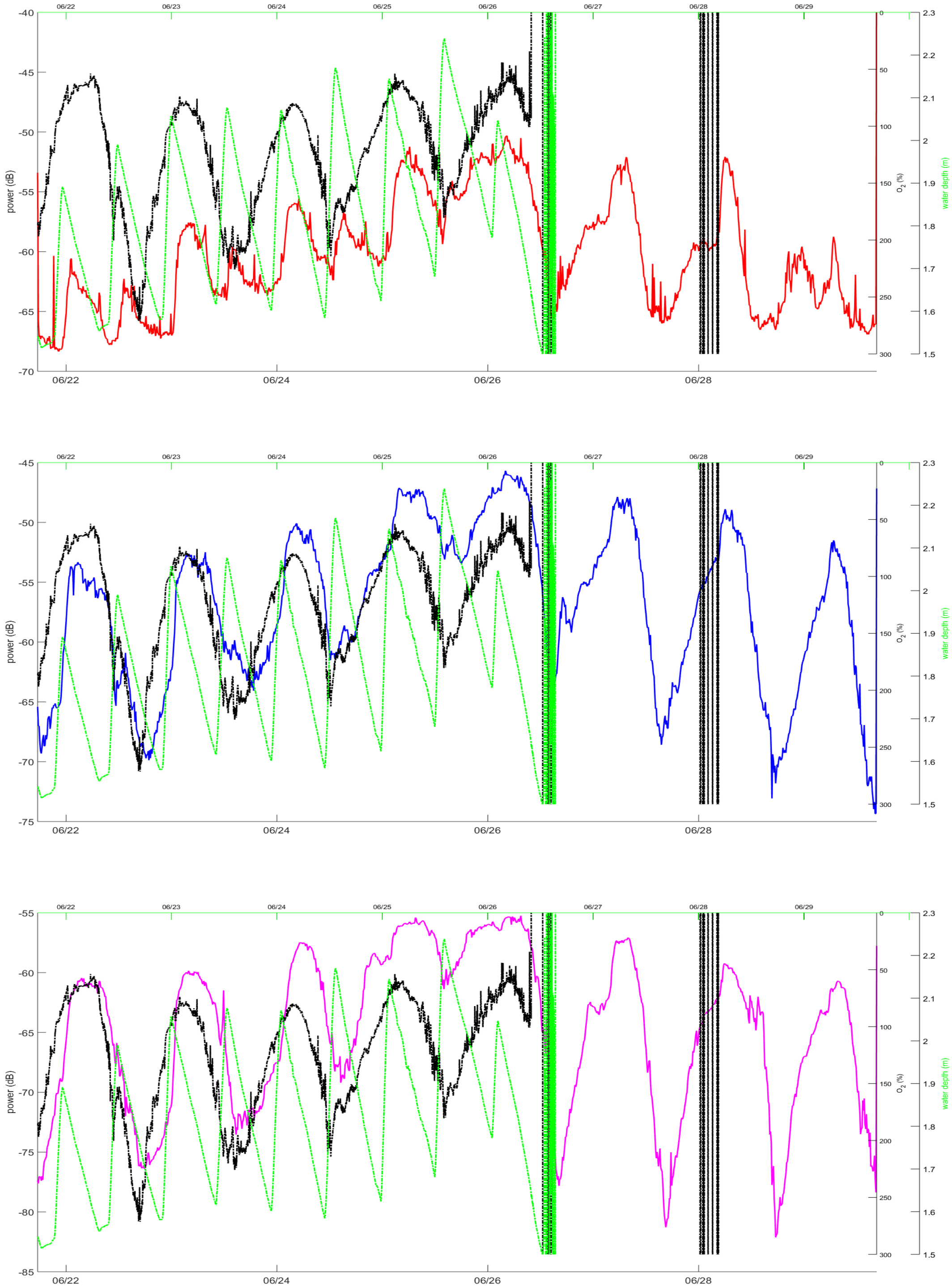


Figure 4.15: The variability of the ambient noise power in the bands: 0-1 kHz (first figure in red), 1-5 kHz (second figure in blue) and 5-25 kHz (third figure in magenta), during the Week 5. The red and green curves represent the O2 saturation level and water depth, respectively.

4.6 Week 6

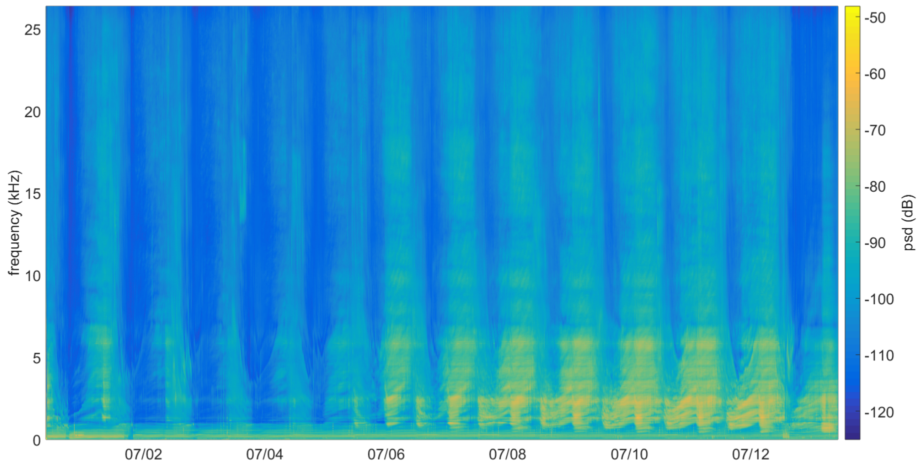


Figure 4.16: Power spectral density of the ambient noise estimated every 10 min of the Week 6. The O2 saturation level and water depth are not available in this period.

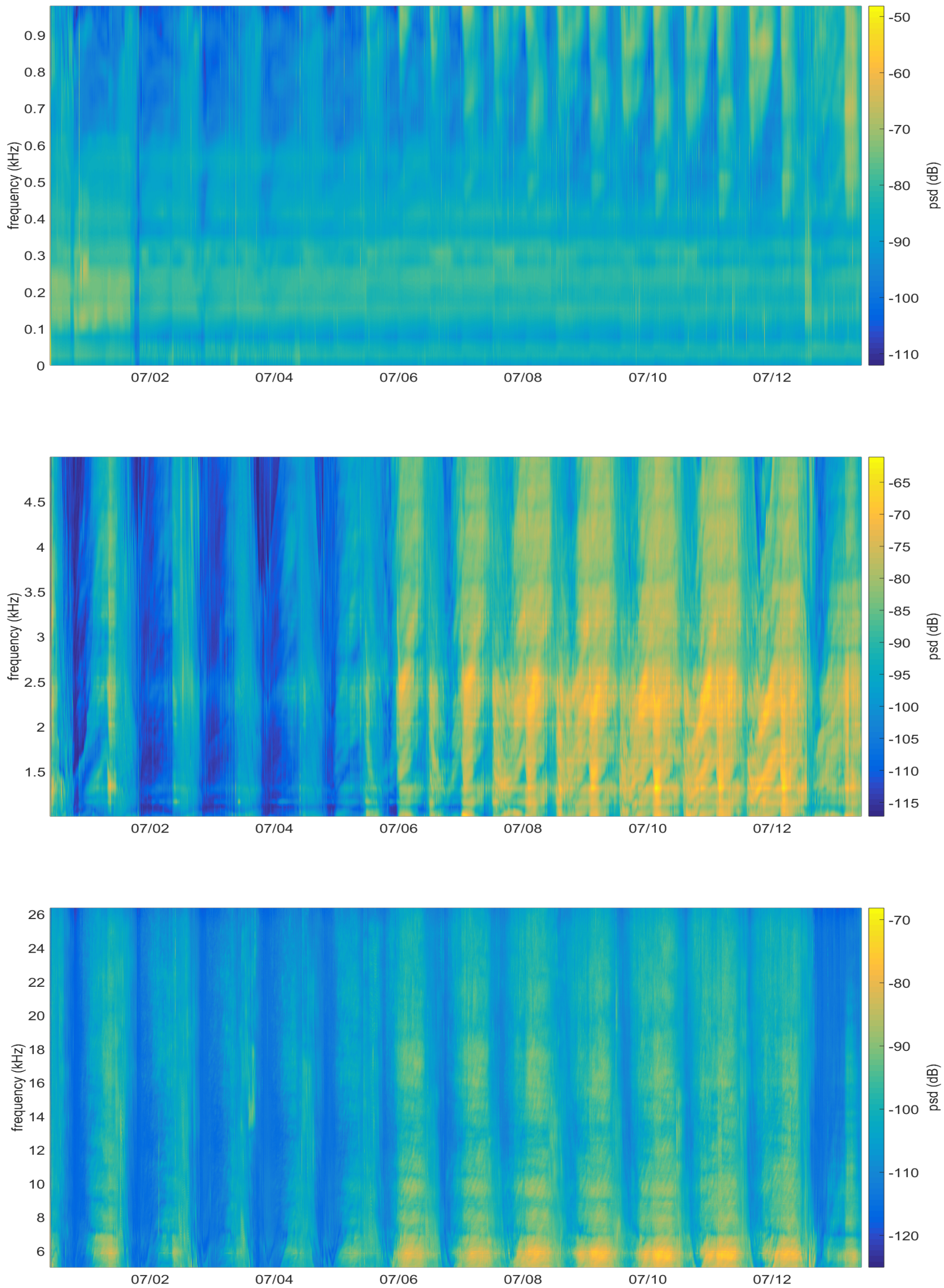


Figure 4.17: Power spectral density of the ambient noise in the bands: 0-1 kHz (top), 1-5 kHz (middle) and 5-25 kHz (bottom), during the Week 5. The O2 saturation level and water depth are not available in this period.

Chapter 5

Conclusion

This report presents the environmental and acoustic data acquired at the IPMA-EPPO and is a complement to previous experiments [1] and [2]. The objective of this experiment was to assess the acoustic signature of photosynthesis in seagrass meadows at frequencies below 25 kHz. The high O2 saturation levels measured during daylight periods suggests that part of the O2 is released as bubbles.

This experiment was conducted in a tank where water pumps were permanently working giving rise to acoustic noise. It was shown that during high O2 saturation level the acoustic noise is highly attenuated, particularly in medium (1-5 kHz) and high (5-25 kHz) frequencies. This correlation is also shown in the amplitude, i.e., a higher O2 saturation level causes a greater attenuation of the ambient noise. At low frequencies (0-1 kHz) there is a strong correlation with the variation of water depth. The water depth causes the cut effect at high frequencies.

Bibliography

[1] P. Felisberto and J. Silva, "Eppo preliminary tank experiments: data report," CINTAL, 3, Aug. 2016.

[2] ——, "Eppo preliminary tank experiments: October 2016 experiment data report," CINTAL, 3, Oct. 2016.