CINTAL - Centro de Investigação Tecnológica do Algarve

Universidade do Algarve

RIA'17

July 2017 experiment

Data report

P. Felisberto, J. P. Silva

Rep 5/17 - SiPLAB
August/2017

University of Algarve
Campus de Gambelas
8005-139 Faro,
Portugal

tel: +351-289800131
fax: +351-289864258
cintal@ualg.pt
www.cintal.ualg.pt

Work requested by	CINTAL Universidade do Algarve, FCT - Campus de Gambelas 8005-139 Faro, Portugal Tel/Fax: +351-289864258, cintal@ualg.pt, www.cintal.ualg.pt
Laboratory performing the work	SiPLAB - Signal Processing Laboratory Universidade do Algarve, Campus de Gambelas, 8005-139 Faro, Portugal tel: +351-289800949, info@siplab.fct.ualg.pt, www.siplab.fct.ualg.pt
Projects	SEAOX (PTDC/EEIPRO/2598/2014)
Title	RIA'17
	July 2017 experiment
Authors	P. Felisberto, J. P. Silva
Date	August, 2017
Reference	5/17 - SiPLAB
Number of pages	31 (thirty one)
Abstract	This report describes the data gathered from 24th to 28th July, by 2 SR-1 hydrophones installed in a *Cymodocea nodosa* and in a *Caulerpa* bottom covered sites in Ria Formosa, close to the Culatra island. The hydrophones recorded ambient noise. Simultaneously, dissolved O2 data was acquired by optodes. CTD measurements were also performed in the *Caulerpa* site.
Clearance level	UNCLASSIFIED
Distribution list	SiPLAB, CINTAL
Total number of copies	2 (two)
Acknowledgements	This work was funded by National Funds through FCT- Foundation for Science and Technology under project SEAOX (PTDC/EEIPRO/2598/2014). FCT Fundação para a Ciência e a Tecnologia MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

Contents

List of Figures

Abstract

This report describes the acoustic and other complementary data gathered during an experiment carried from 24th to 28th July 2017 in the Culatra Island area inside the Ria Formosa. The experiment was conducted in the framework of the SEAOX project (PTDC/EEIPRO/2598/2014). The objective was to gather ambient noise in two closely located sites, about 150 m apart, where the bottom was covered by different vegetation, *Cymodocea nodosa* seagrass and *Caulerpa* algae. Both sites are very shallow water (order 1 m) and subject to tidal peak to peak amplitude of about 3 m during this period of the year. Intense yachting and boating activity is observed in the area during the summer season with important contribution for the ambient noise during the daylight periods. Dissolved O2 data was acquired by optodes at both sites simultaneously with acoustic data. In addition CTD measurements (temperature, salinity, sound speed, depth) were also performed in the Caulerpa site. This report presents the experimental setup, the acoustic and complementary environmental data and discusses preliminary results.

Acknowledgments

The authors thank Marsensing for the loan of the self-recording hydrophones, and CC-MAR colleagues for the logistics, at sea operations and dissolved O2 measurements.

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 main objective of this experiment was to determine, if any, the strength of O2 supersaturation in open waters of the Ria Formosa covered by marine plants, and its correlation with local ambient noise. Experiments conducted during last year in a pond of EPPO station covered by *Cymodocea nodosa* have shown large O2 supersaturation in summer and late spring conditions with large impact in active acoustic signals and ambient noise [1, 2]. However, the pond is a relatively controlled environment, the meadow is dense and currents are weak. So, the data acquired in the present experiment may indicate the similarities and differences of O2 release and its impact on acoustic signal between the two environments. This information will help on the design of acoustic based measurement methods for open waters.

This report is organized as follows: in the next chapter the experimental setup is presented. The 3rd chapter is devoted to present environmental data (CTD and optode data). The ambient noise is discussed in chapter 4. The conclusions are drawn in a final chapter.

Chapter 2

Experiment location and setup

The experiment was conducted from 24th to 28th July in the Ria Formosa close to the Culatra island. During the period, ambient noise data were acquired at two different sites where the bottom was covered by the seagrass *Cymodocea nodosa* and by the algae *Caulerpa*. The sites were about 125 m distant, both in a very shallow water area. In low tide the water depth was about 1 m. During the period of the experiment the difference of amplitude between low and high tide was on the order of 3 m (see Tab. 2.1). In addition to acoustic data, dissolved O2 data by optodes was acquired at both sites and CTD data was acquired at the *Caulerpa* site.

Figure 2.1(a) shows the area of the experiment and the location of the *Cymodocea* and *Caulerpa* sites, represented by the red and yellow icon, respectively. During the summer a large number of sailboats are anchored in the area, which is crossed by small motor boats of various types. It is expected that the noise produced by the motor boats has a large contribution for the acoustic noise of the area.

(a) (b)

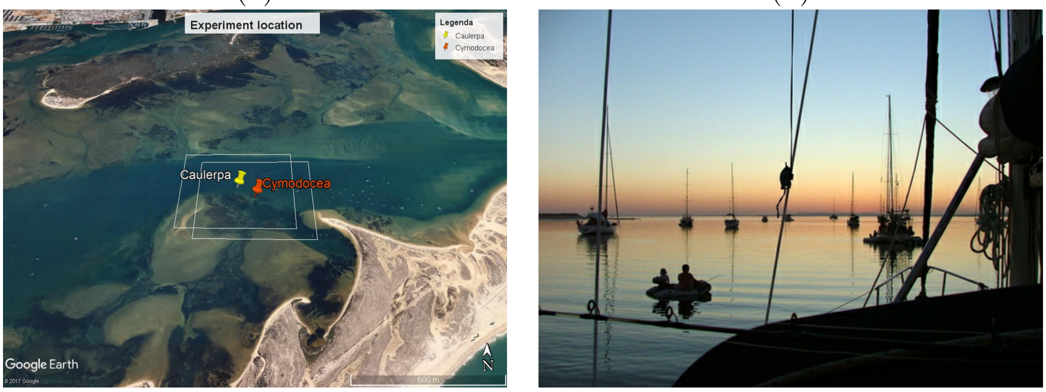


Figure 2.1: Experimental area: location of the *Cymodocea* and *Caulerpa* sites (a), view of the area showing a large number of anchored sailboats and small motor boats cruising around. ©Google Earth

Figure 2.2 shows samples of seagrass *Cymodocea nodosa* and algae *Caulerpa* gathered in the area. The seagrass *Cymodocea nodosa* is a native specie in Ria Formaosa, whereas the algae *Caulerpa* is an invasive specie, rapidly spreading in the area. The experiment reported herein was performed in the framework of a larger experiment conducted by

Table 2.1: Tide forecast, local time (source IH). Time offset is expected for the actual area of the experiment.

Data: **2017-07-24**	Porto: **Faro - Barra de Faro-Olhão**	
Hora Legal de **Verão** (UTC +1)	Altura(m)	
Dom, 2017-07-23 21:33	0.37	Baixa-mar
Seg, 2017-07-24 03:56	3.41	Preia-mar
Seg, 2017-07-24 09:47	0.47	Baixa-mar
Seg, 2017-07-24 16:18	3.63	Preia-mar
Seg, 2017-07-24 22:18	0.35	Baixa-mar
Ter, 2017-07-25 04:42	3.39	Preia-mar
Ter, 2017-07-25 10:31	0.49	Baixa-mar
Ter, 2017-07-25 17:04	3.61	Preia-mar
Ter, 2017-07-25 23:02	0.41	Baixa-mar
Qua, 2017-07-26 05:27	3.31	Preia-mar
Qua, 2017-07-26 11:12	0.57	Baixa-mar
Qua, 2017-07-26 17:48	3.51	Preia-mar
Qua, 2017-07-26 23:43	0.55	Baixa-mar
Qui, 2017-07-27 06:10	3.19	Preia-mar
Qui, 2017-07-27 11:53	0.72	Baixa-mar
Qui, 2017-07-27 18:32	3.34	Preia-mar
Sex, 2017-07-28 00:25	0.74	Baixa-mar
Sex, 2017-07-28 06:54	3.03	Preia-mar
Data no Servidor de Dados: 2017-08-03 20:26 +0100		

(a) (b)

Figure 2.2: Samples of *Cymodocea nodosa* (a) and *Caulerpa* (b) gathered in the area

the Algae group of CCMAR[1] to characterize the local *Cymodocea nodosa* and *Caulerpa* meadows, their coverage and dynamics. The results will be documented elsewhere.

The acoustic data was gathered by 2 digital SR-1 hydrophones provided by Marsensing in two separate moorings. Each mooring was composed by a rope secured by 2x20kg iron disks, a subsurface float and a surface signaling buoy. The hydrophone was fixed at approximately 0.5 m from the bottom. The CCMAR optode was fixed to the hydrophone. The CTD RBRconcerto, that in addition to temperature, conductivity and pressure/depth, also measures oxygen concentration was fixed to the rope at approximately 1 m from the bottom in the *Caulerpa* mooring. The active part of the CTD optode (sensor) was mounted pointing to the surface, in order to minimize bubbles sticking on the sensor surface, which may give rise to erroneous measurements of dissolved O2.

Figure 2.3 shows the moorings before deployment at sea on Wednesday 26th July at $\sim$ 12h30, and the *Caulerpa* mooring before recovery, Friday 28th July 2017 at $\sim$12h30, both at low tide. A first deployment only at the *Cymdocea* area took place from Monday 24th July, midday to Wednesday 26th July, midday. Acoustic data and CCMAR optode data were gathered during this deployment.

[1]Centro de Ciências do Mar da Universidade do Algarve

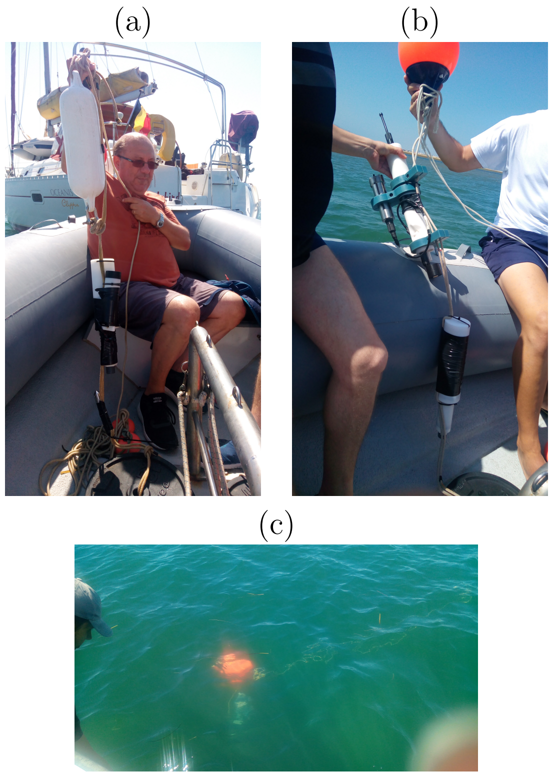


Figure 2.3: *Cymodocea* before deployment (a) and *Caulerpa* mooring before deployment (b) and ebefore recovery (c).

Chapter 3

Environmental data

This chapter presents the CTD data and CCMAR optode data gathered during the experiment period. It is also included a comparison between dissolved O2 data acquired by the CTD optode and the CCMAR optode acquired in the *Caulerpa* mooring, for control of the CTD optode measurements.

3.1 CTD profile

A CTD profile was collected Monday 24th July at 15h30 (GMT) from a sailor boat anchored nearby of the moorings, but at a deeper location. Figure 3.1 shows the temperature, salinity and dissolved O2 profiles measured by the CTD and CCMAR optodes and derived quantities, sound speed and concentration of dissolved O2.

The temperature and salinity are almost constant along the water column (22.5 °, 36.4 ppm) with a small increase (0.5 °, 0.1 ppm) close to the surface ($<$ 2 m depth) typical for summer profiles gathered in the afternoon. The dissolved O2 is slightly above 100% along the water column, with the highest values close to the bottom and the surface, most likely due to photosynthesis. At the bottom due to release of O2 by the plants and at the surface because of O2 trapped at the surface or due to release of O2 by microalgae. Nevertheless, the dissolved O2 variability along the water column is less than 2% or 0.1 ml/l.

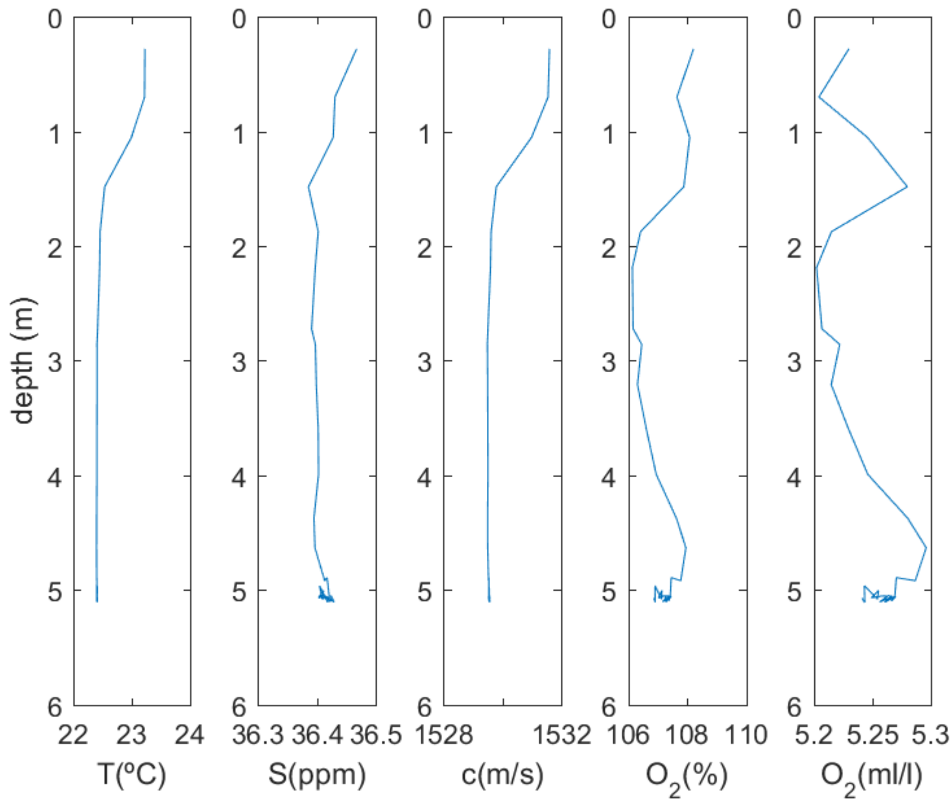


Figure 3.1: CTD data gathered Monday 24th July at 15h30 (GMT) from a sailor boat anchored nearby of the moorings.

3.2 Temperature and dissolved O2

The water temperature and the dissolved O2 measured by the CCMAR optodes and CTD installed in the moorings are presented in Fig 3.2, respectively on the left and on the right.

The green curves are related to data gathered by the CCMAR optode installed in the *Cymodocea* mooring from midday of Monday 24th July to midday of Friday 28th July. The spike in the temperature curve is due to the recovery and redeployment of the *Cymdocea* mooring at midday of Wednesday 26th July. The blue curve represents the data acquired by the CTD installed in the *Caulerpa* mooring. An additional CCMAR optode was installed in this mooring during the last day, from midday of Thursday to midday of Friday. These data is represented by the cyan curve. It can be seen that the temperature follows a similar pattern in both moorings. Surprisingly, the variability pattern of temperature shows peak values around midnight (also during the day) around the low tide. The dissolved O2 curves show values above 100% during the day, but the curves are very peaky along the diurnal cycles. It may indicate the importance of tidal flows in the variability patterns of temperature and dissolved O2.

It should be noticed that the dissolved O2 measured by the CTD and by the CCMAR optodes show a similar pattern, but with a positive offset of about %10 given by the CTD.

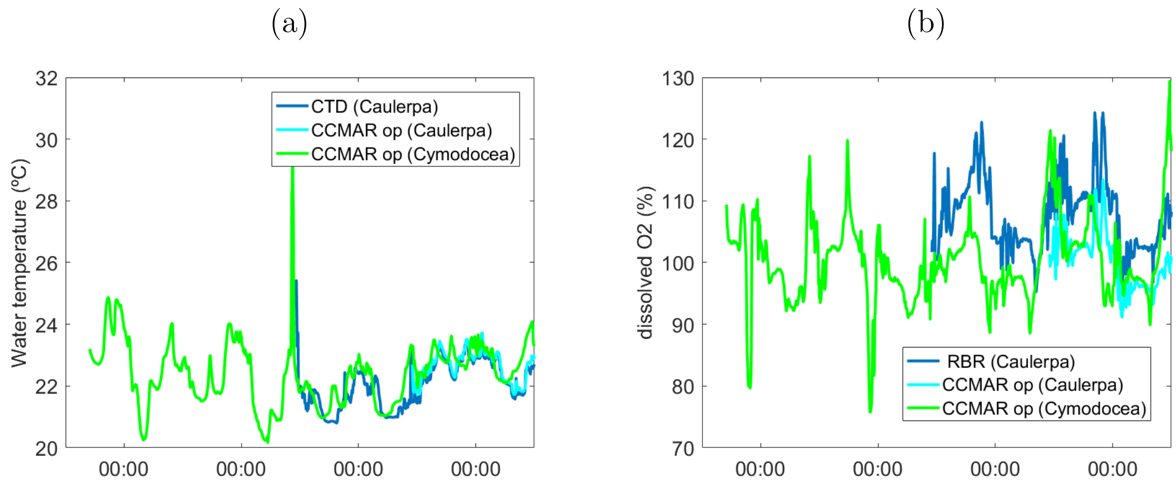


Figure 3.2: Temperature (a) and dissolved O2 (b) measured by the CCMAR optodes in the *Cymodocea* mooring (green) and *Caulerpa* mooring (cyan) and by the CTD (blue). The period represented is from midday of Monday 24th July to midday of Friday 28th July for the *Cymodocea* mooring, from midday of Wednesday 26th of July to midday of Friday 28th July for the CTD in the *Caulerpa* mooring and from midday of Thursday 27th July to midday of Friday 28th July for the CCMAR optode, also in the *Caulerpa* mooring.

3.3 Water depth

Figure 3.3 shows the water depth at the *Caulerpa* mooring (red curve), estimated from the depth readings of the CTD (blue curve). As stated above the *Caulerpa* mooring was deployed at midday on Wednesday 26th July and recovered at midday on Friday 28th July. The spike at the middle of the period is due to an intermediate recovery of the mooring to install the CCMAR optode.

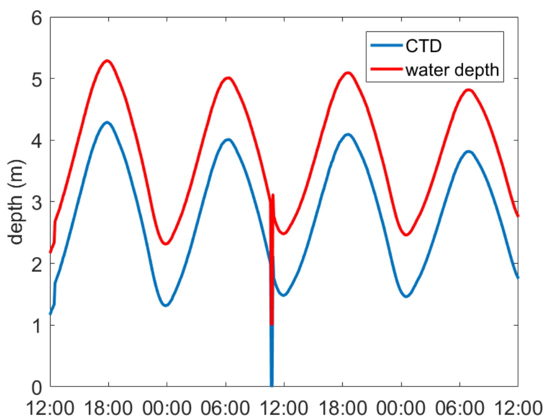


Figure 3.3: Water depth at the *Caulerpa* mooring (red) estimated from CTD measurements (blue) from midday on Wednesday 26th July to midday on Friday 28th July.

It can be seen that the *Caulerpa* site is very shallow, with 2 m water depth at the low tide and 5 m water depth at high tide. Although, no water depth measurement is available at the *Cymodocea* mooring, the water depth at this site is even lower (order of 0.5 m). It should be also noted that in-situ observations of the water depth in low tide indicates that the minimum water depth is below (1 m), thus the mooring should bend under these conditions and the water depth may be overestimated under low tide situation.

3.4 Sound speed

Figure 3.4 shows the CTD measurements of temperature (a) and salinity (b) at the *Caulerpa* mooring and the corresponding sound speed estimates (c), covering the period from midday on Wednesday 26th July to midday on Friday 28th July. As stated above, the spike at the middle of the period is due to an intermediate recovery of the mooring to install the CCMAR optode.

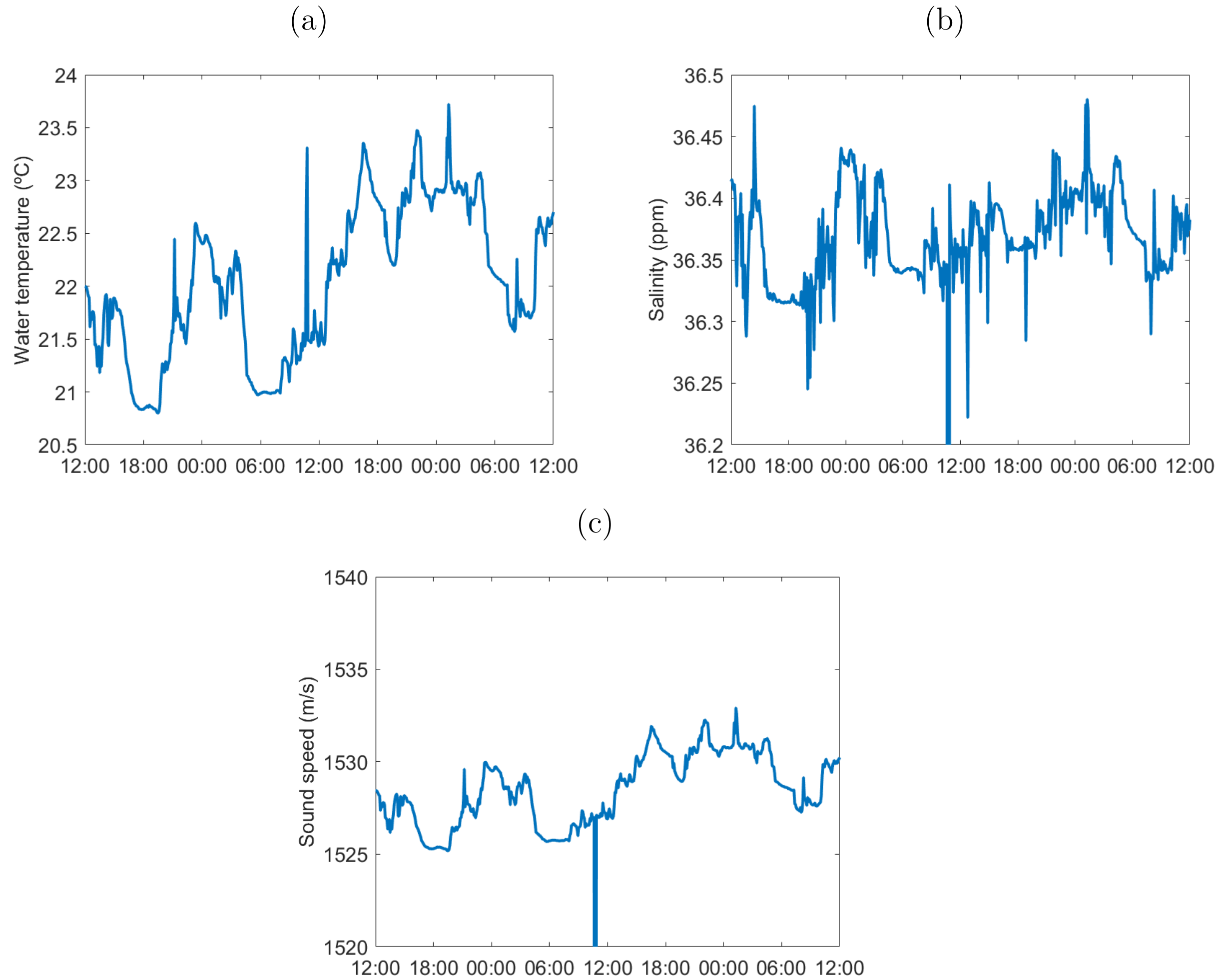


Figure 3.4: Temperature (a) and salinity (b) measured by the CTD at the *Caulerpa* mooring (red), and calculated sound speed (c) from the midday of Wednesday 26th July to the midday of Friday 28th July.

The temperature variability is less than 2.5° and the salinity variability is less than 0.2 ppm giving rise to a sound speed variability less than 8 m/s during the period. As already discussed in Sec. 3.2 the tidal forcing may be a relevant drive of this variability, since one can notice an increase of those physical values during the night.

Chapter 4

Acoustic noise measurements

The ambient noise was recorded by 2 SR-1 hydrophones. From midday on Monday 24th July to midday on Wednesday 26th July the ambient noise was gathered only at the *Cymodocea* mooring, where 90 s snapshots of data at sampling frequency of 52734 Hz were recorded every 10 minutes. During this period the PGA gain of SR-1 was set to 64. In the second part of the experiment, from midday on Wednesday 26th July to midday on Friday 26th July the ambient noise was recorded in both *Cymodocea* and *Caulerpa* moorings. Again, 90 s snapshots of data at sampling frequency of 52734 Hz were recorded periodically, every 5 minutes at the *Cymodocea* mooring and every 10 minutes at the *Caulerpa* mooring. The acquisition at both hydrophones overlap every 10 minutes. Note that the acquisition systems does not allow for fine synchronization (at sample level) and time offsets between hydrophones of few seconds are expected. Each 90 s snapshot of data was stored in a "WAV" file.

4.1 Data samples

Figures 4.1, 4.2 and 4.3 show 90 s snapshot of data (1 file) acquired in the 2nd deployment, simultaneously at both sites July 26th around midday and midnight during low tide, and July 27th at dawn (∼5am) during high tide. In these figures panel (a) shows the snapshots acquired in the *Cymodocea* (blue) and the *Caulerpa* (red) sites, and respective spectrograms. Then, panel (b) shows the power spectral density of snapshots in panel (a), and panel (c) shows examples of impulsive waveforms present in data snapshots.

In all snapshots one can see impulsive waveform that may be related to biological activity in the sites. During the summer period Ria Formosa and this region in particular is crossed by large number of boats. Motor boats cruising close to the moorings have typical broadband figures of interference, what can be seen in the spectrograms of Fig. 4.1. The boating activity is mainly during the day, but occurs also during the night, as seen in the spectrogram of Fig. 4.4 from data acquired around 5am (GMT). Power spectral density estimates presented in panel (b) (and the spectrograms) of the various figures show a notch around 2 kHz, what may be ascribed to environmental conditions (water depth, bottom structure) of the area. It can be also noticed a band of increased power (3-6 kHz). The noise power in this band may be related to biological activity as been seen in other littoral marine ecosystems. Above this band the power spectral density decreases almost linearly with frequency. In the low frequency band, below the notch (0-2 kHz), the noise power reach high values in snapshots containing motor boats signatures (Fig. 4.1 and Fig. 4.4). It is expected that the main contribution for the noise in this low frequency band is due to boat and other anthropogenic activity. The variability of the noise during the overall period will be discussed in the next Section, however analyzing these few data snapshots, one should remark that the curves of power spectral density estimates have a similar shape in both sites, the noise power is almost equal when motor boats are present (Fig. 4.1 and Fig. 4.4), but is lower at *Cymodocea* site when motor boat signatures are absent. This behavior may be ascribed to the fact that the water depth at *Cymodocea* site is lower than at *Caulerpa* site.

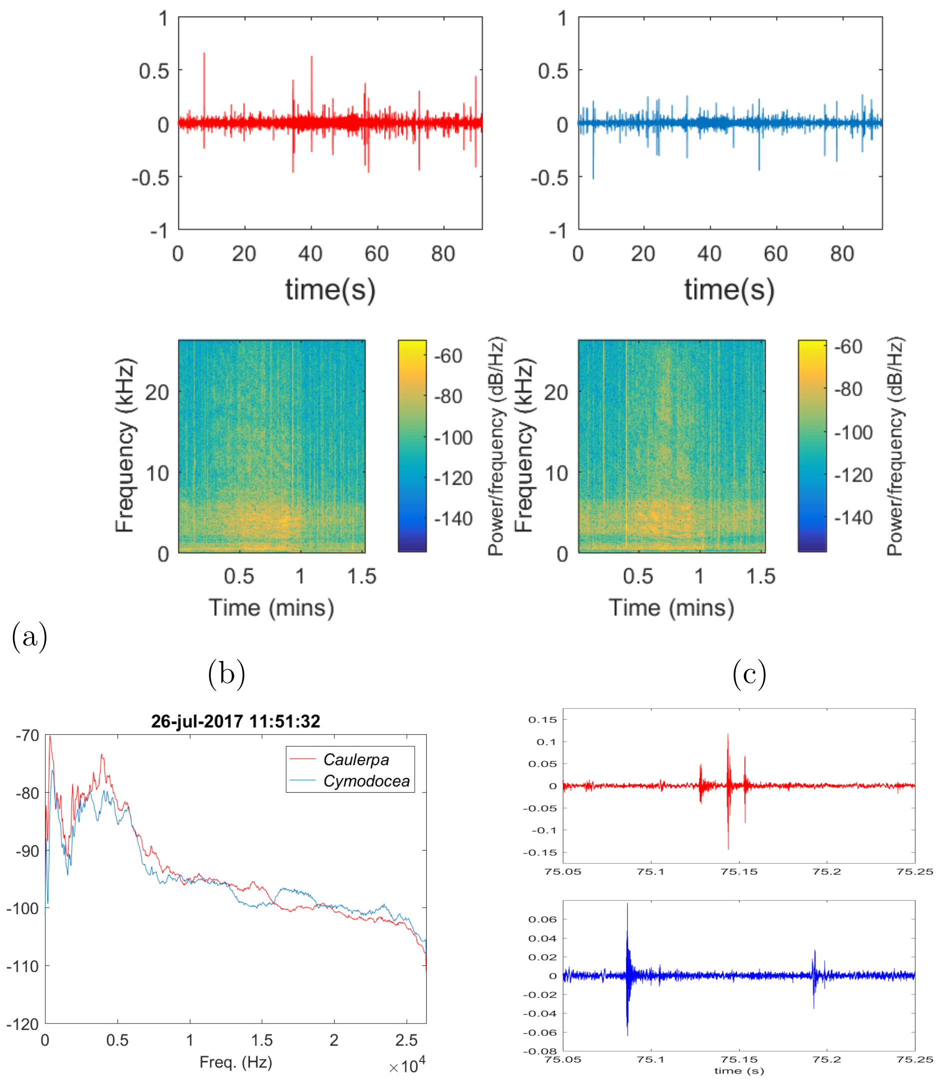


Figure 4.1: Files recorded in July 26th, 11h50 (low tide) in both sites:time samples and respective spectrograms, *Caulerpa* left, *Cymodocea* right, (a); power spectral estimate (b), samples of impulsive waveforms (c). Red and blue lines represent *Caulerpa* and *Cymodocea* data, respectively.

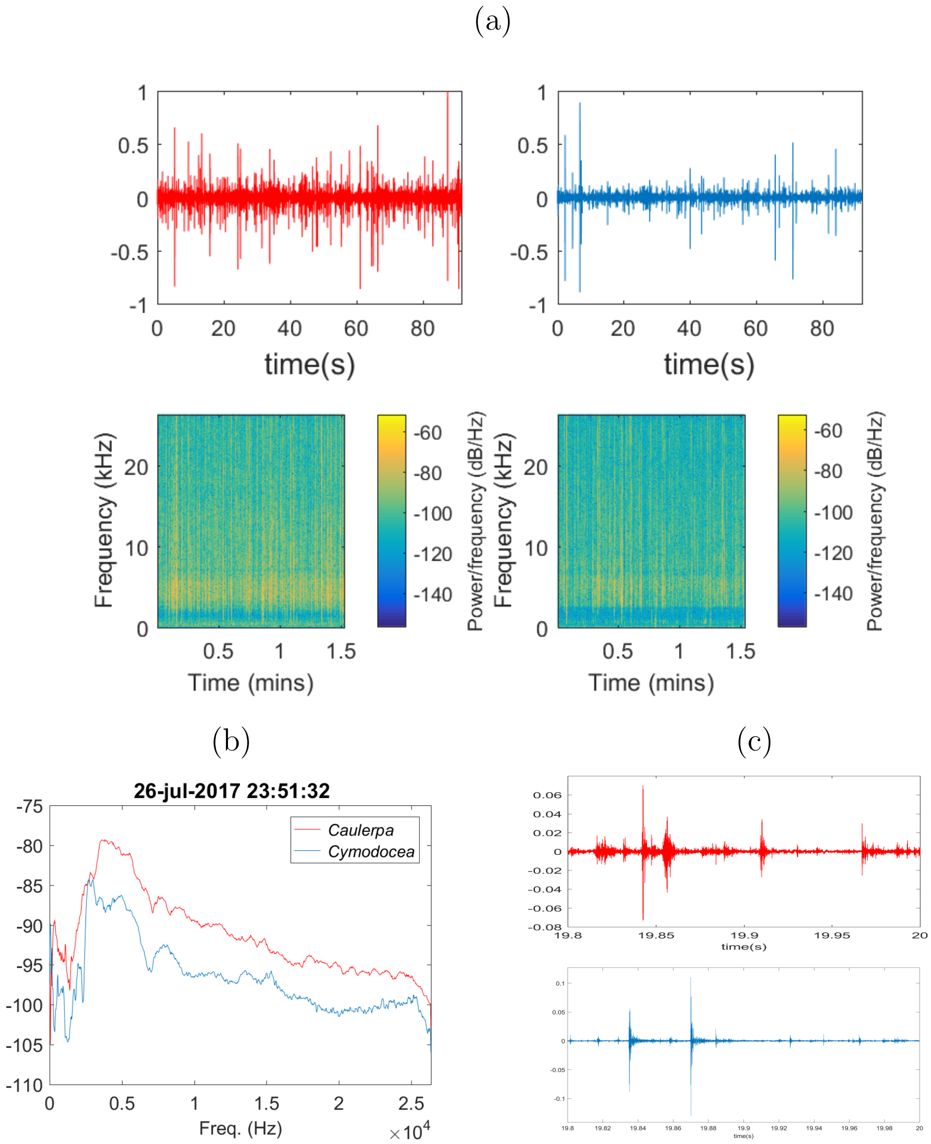


Figure 4.2: Files recorded in July 26th, 23h50 (low tide) in both sites: time samples and respective spectrograms, *Caulerpa* left, *Cymodocea* right, (a); power spectral estimate (b), samples of impulsive waveforms (c). Red and blue lines represent *Caulerpa* and *Cymodocea* data, respectively.

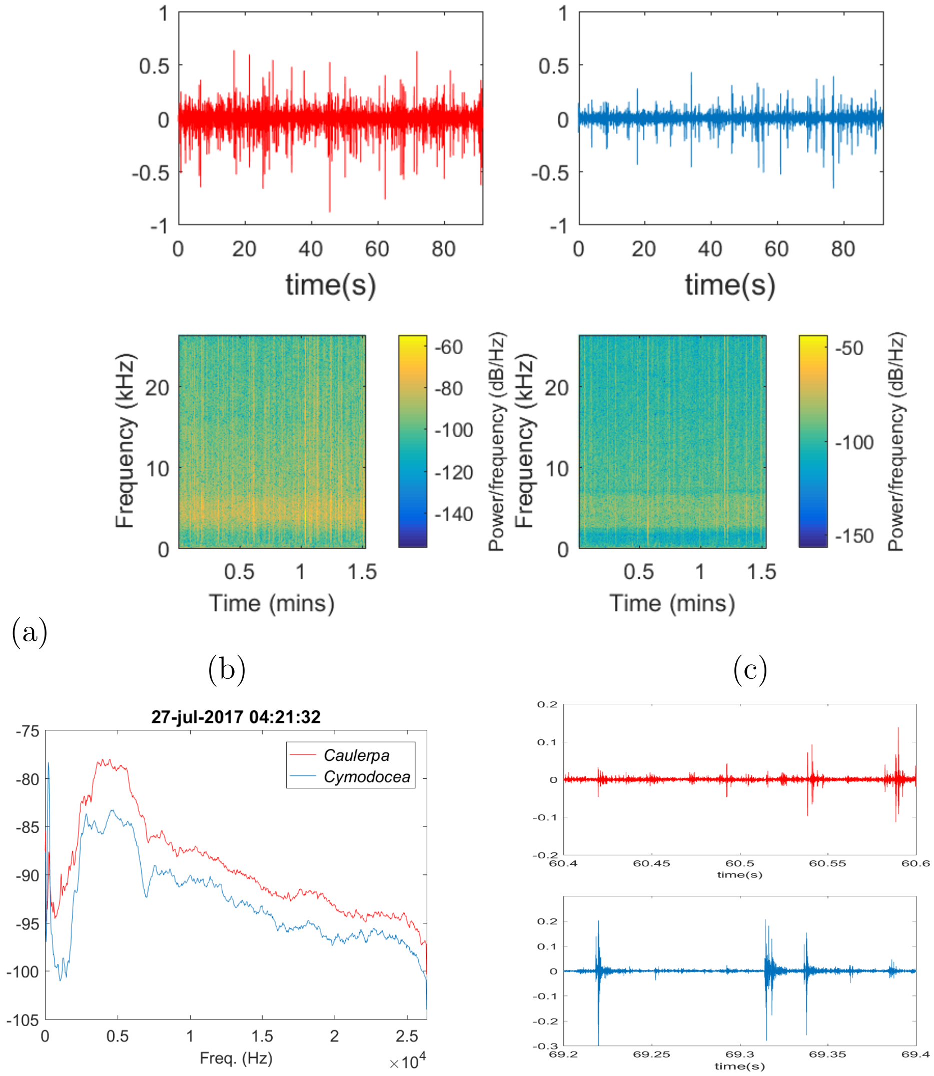
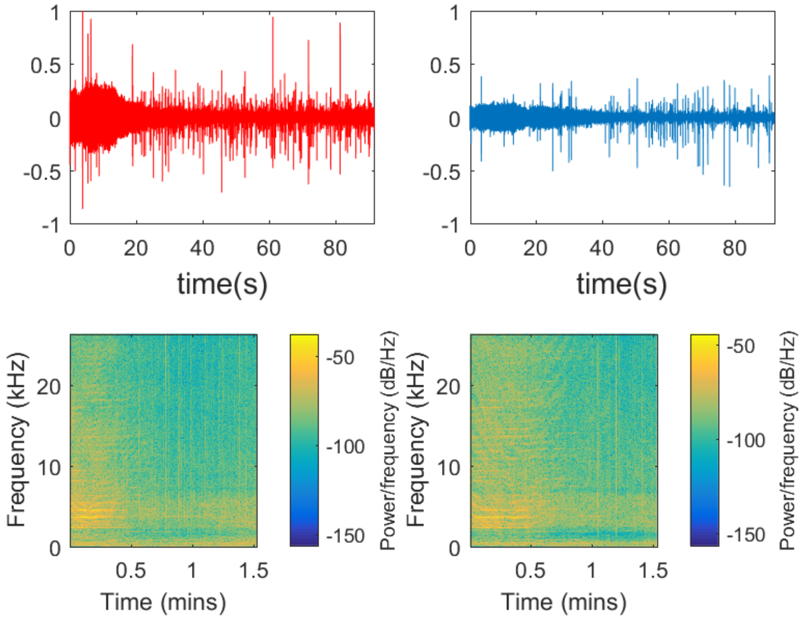


Figure 4.3: Files recorded in July 27th, 4h20 (∼ high tide) in both sites: time samples and respective spectrograms, *Caulerpa* left, *Cymodocea* right, (a); power spectral estimate (b), samples of impulsive waveforms (c). Red and blue lines represent *Caulerpa* and *Cymodocea* data, respectively.

(a)



(b)

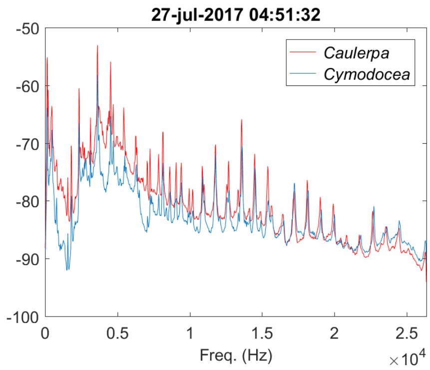


Figure 4.4: Files recorded in July 27th, 4h50 (∼ high tide) in both sites: time samples and respective spectrograms, *Caulerpa* left, *Cymodocea* right, (a); power spectral estimate (b). Red and blue lines represent *Caulerpa* and *Cymodocea* data, respectively.

4.2 Diurnal noise variability

To show the variability of ambient noise along time the power spectral density of acoustic noise was computed using the Welch method using a 2048 points FFT with 512 samples overlapping. The results are presented next.

4.2.1 *Cymodocea*, 1st deployment

Figure. 4.5 shows the power spectral density in the 0–25 kHz band and 0–2 kHz, 2–7.5 kHz, 7.5–25 kHz sub-bands of the ambient noise gathered over the *Cymodocea* meadow along 2 diurnal periods, from midday of Monday 24th July to midday of Wednesday 26th July. The integrated values of the noise power in the various sub-bands are shown in Fig. 4.6. In both figures the O2 saturation level and water temperature are plotted as black and green lines respectively. It should be also noted that low tides occur around midday and midnight.

The noise power presented in Fig. 4.5 shows a persistent background noise in the band 3– 6kHz, and a number of spikes. The ambient noise is largely affected by ship noise due to boat traffic in the area, which give rise to spikes in the various bands clearly shown in Fig. 4.6. Only during night periods from 10 pm to next day 6 am , when the boat activity is expected reduced, the frequency and strength of spikes is small. During these periods the noise power varies smoothly in the various sub-bands, increasing from 10 pm to 3 am and then decreasing. During the day, due to spikes it is difficult to find a general trend, the curves suggest that after 3 am, the power in the band 2–7.5 kHz and particularly in the band 7.25–25 kHz decreases until 11 am, after that increases until 3 pm. This behavior may be related to water depth change with tide. For the low frequency band, no particular trend is visible during the day, but this may be ascribed to the large power in this band due to ship noise. It should be also noticed the large spikes in the various bands when the dissolved O2 decreases to a minimum in a relative short period around 9 pm. Others correlations between dissolved O2 and noise power are not obvious from the figures.

4.2.2 *Cymodocea* 2nd deployment

Figure. 4.7 shows the power spectral density in the 0–25 kHz band and 0–2 kHz, 2–7.5 kHz, 7.5–25 kHz sub-bands of the ambient noise gathered over the *Cymodocea* meadow along 2 diurnal periods, from midday of Wednesday 24th July to midday of Friday 26th July (2nd deployment). The integrated values of the noise power in the various sub-bands are shown in Fig. 4.8. In both figures the O2 saturation level and water depth are plotted as black and green lines respectively. Note that water depth is given by the CTD installed in the nearby *Caulerpa* mooring.

Like for the period discussed above one can notice a persistent background noise in the band 3–6 kHz and numerous spikes due to boats crossing the area. However, the behavior during the night period when the boat activity is small and the curves changes smoothly is different from the described before, now showing minima in low tide. The 2nd deployment was in a different place of that of the first deployment (but not so far), what may explain the different behavior.

4.2.3 *Caulerpa* deployment

Figure. 4.9 shows the power spectral density in the 0–25 kHz band and 0–2 kHz, 2–7.5 kHz, 7.5–25 kHz sub-bands of the ambient noise gathered over the *Caulerpa* meadow along 2 diurnal periods, from midday of Wednesday 24th July to midday of Friday 26th July. The integrated values of the noise power in the various sub-bands are shown in Fig. 4.10. In both figures the O2 saturation level and water depth are plotted as black and green lines respectively. Note that water depth is an estimate from the CTD installed in the mooring.

Also in this site, spikes in noise power due to boats crossing the area which spread over the overall band are evident. Looking in the band integrated values shown in Fig. 4.10, one can see that during the night, when the boat activity is reduced (few spikes), the noise power in the lower frequency band (0–2 kHz) follows the water depth pattern, having a minimum at low tide. This behavior is similar to that observed in the 2nd *Cymodocea* deployment, and may be ascribed to the change of the cut-off frequency of the waveguide due to tide. However, for the two higher frequency bands, on can see in Fig. 4.10 an increase of the noise power during the same period (night), therefore distinct of that observed in the *Cymodocea* site during the same period.

4.2.4 Variability of background noise

It was seen that the noise produced by boats crossing the experimental area represent a major contribution for the noise power, particularly during the day. The contribution of boats passing close to the moorings are discrete events leading to an instantaneous increase of the noise power, that can last for several minutes. In order to estimate the background noise level, which is partially due to biological activity, meteorological phenomena or diffuse anthropogenic noise from faraway sources, a nonlinear sliding window minimum filter was applied to the noise power estimates in the various band along time during the deplyments starting midday Wednesday 26 July (red, blue and magenta curves in Fig 4.8 and Fig 4.10. The results are shown Fig 4.11 for the low frequency band (<2500 Hz) red line (a), medium frequency band (2500–7500 Hz) blue line (b) and high frequency band (≥7500 Hz) magnta (c), where the solid line represents the *Cymodocea* site and the dash-dotted line represents the *Caulerpa* site. The green and black lines represent the water depth and the dissolved O2, respectively.

The variability of background noise power in the lower frequency band has a similar behavior at both sites, having a minimum around midnight, simultaneously with low tide. Although, during the day the noise power is of same order at both sites with a maximum at afternoon, during the night, and particularly at the minimum, a difference of more than 10 dB is noticed, where the noise power is higher at the *Caulerpa* site than at *Cymodocea* site. At these low frequencies the water depth has an important impact on propagation, because of the cut-off frequency of the waveguide. During the night, when the local boat activity is small, the contribution of for this band is expected from faraway sources. Since, visual inspection showed that the *Cymodocea* site is shallower than the *Caulerpa* site, the attenuation is expected higher at the *Cymodocea* site. During the day due, to the large boat activity, the low frequency background noise is high, even at low tide. Please not that the applied filter only discards discrete sources passing very close to the moorings).

The overall behavior of the variability of noise power at medium and high frequency bands are similar, and also among sites, as can be seen in Fig. 4.11 (b), (c) and particularly (d). They show an increased noise power during the night, with two peaks (at dusk and dawn). Such behavior as been observed in other seagrass and coral reef ecosystems and is related to an increase of biological activity. For both frequency bands the background noise power is lower at the *Cymodocea* site than at the*Caulerpa* site, what may be due to the different water depth at the de sites as discussed above. Due to the limited period of the experiment, only two diurnal cycles, it is difficult to conclude about the environmental variability and the background noise power variability.

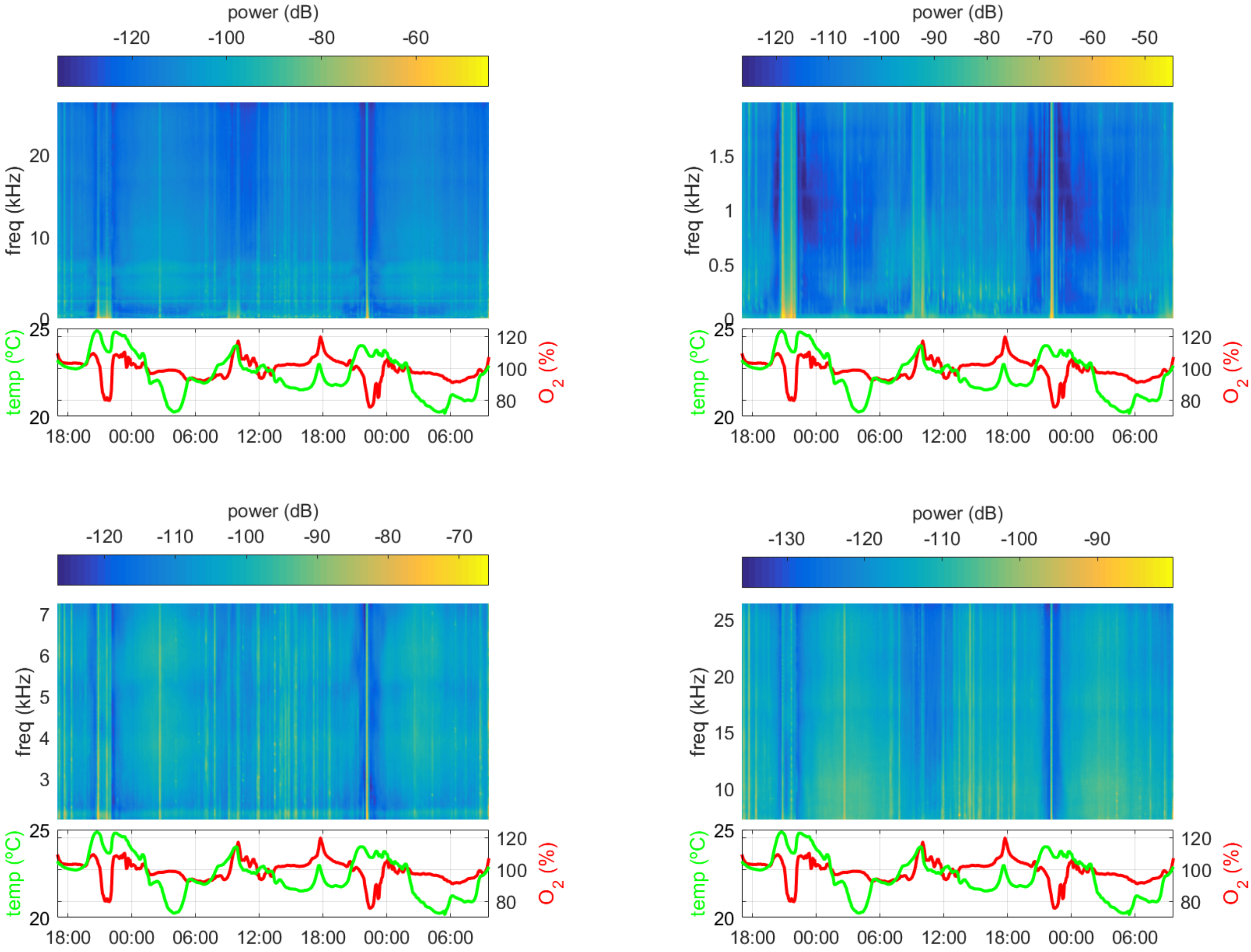


Figure 4.5: Power spectral density of the ambient noise over the *Cymodocea* meadow, estimated every 10 min from midday 24th July to midday 26th July: full 0–25 kHz band (upper-left), and zoom of 0–2 kHz (upper-right), 2–7.25 kHz (bottom-left) and 7.25–25 kHz (bottom-right) bands. The red and green curves represent the O2 saturation and water temperature, respectively.

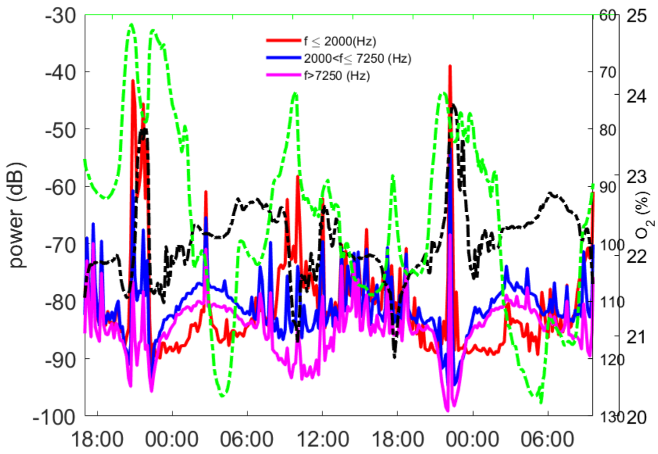


Figure 4.6: Comparison between the variability of the noise power shown in Fig. 4.5, integrated in the bands 0–2 kHz (red), 2–7.25 kHz (blue) and 7.25–25 kHz (magenta), and the variability of O2 saturation level (black). The green curve represent the water temperature, respectively.

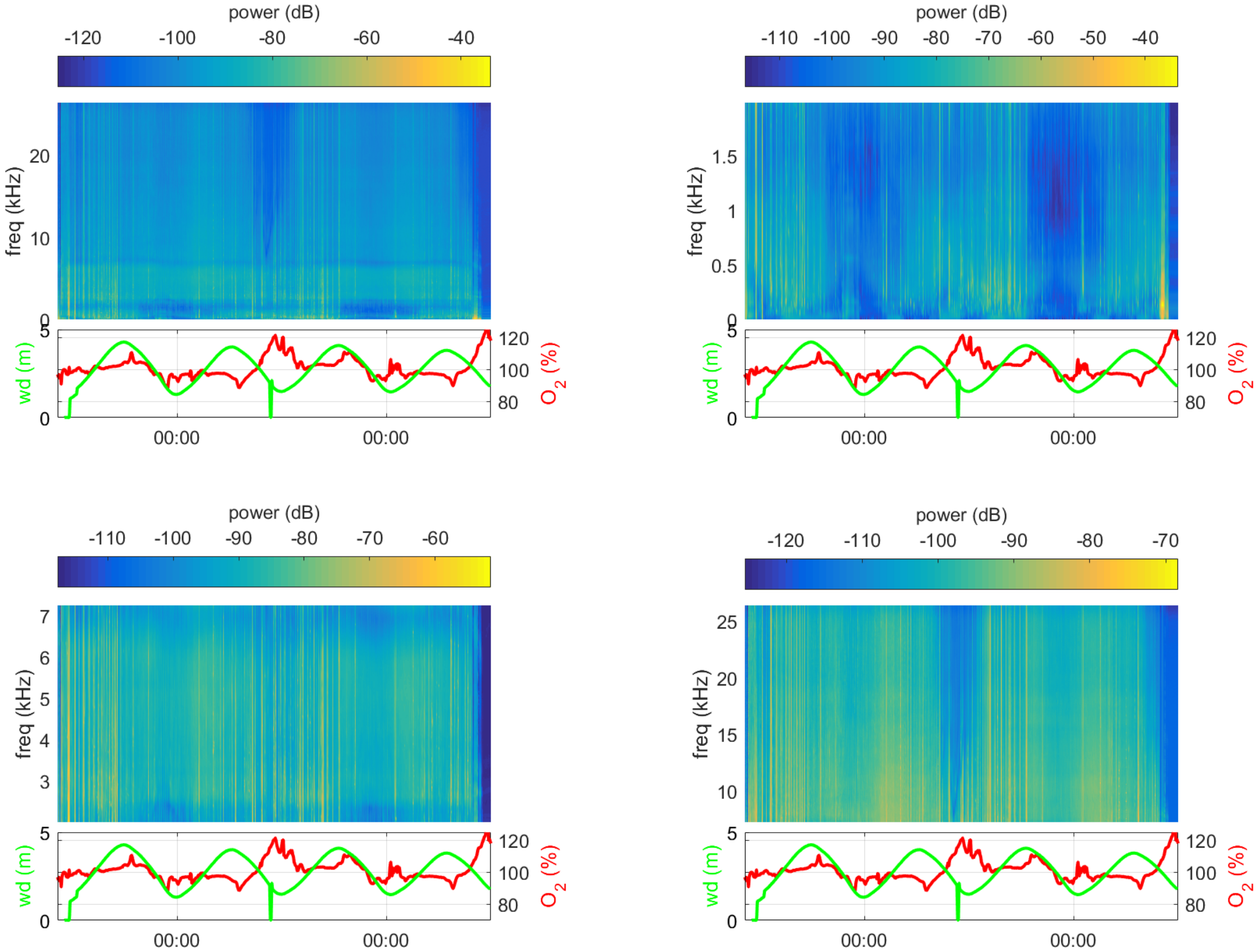


Figure 4.7: Power spectral density of the ambient noise over the *Cymodocea* meadow, estimated every 5 min from midday 26th July to midday 28th July: full 0–25 kHz band (upper-left), and zoom of 0–2 kHz (upper-right), 2–7.25 kHz (bottom-left) and 7.25–25 kHz (bottom-right) bands. The red and green curves represent the O2 saturation and water temperature, respectively.

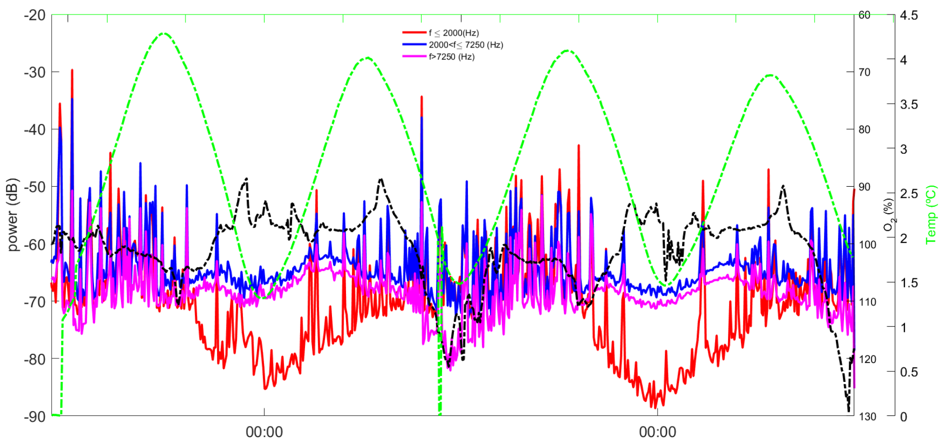


Figure 4.8: Comparison between the variability of the noise power shown in Fig. 4.7, integrated in the bands 0–2 kHz (red), 2–7.25 kHz (blue) and 7.25–25 kHz (magenta), and the variability of O2 saturation level (black). The green curve represent the water temperature, respectively.

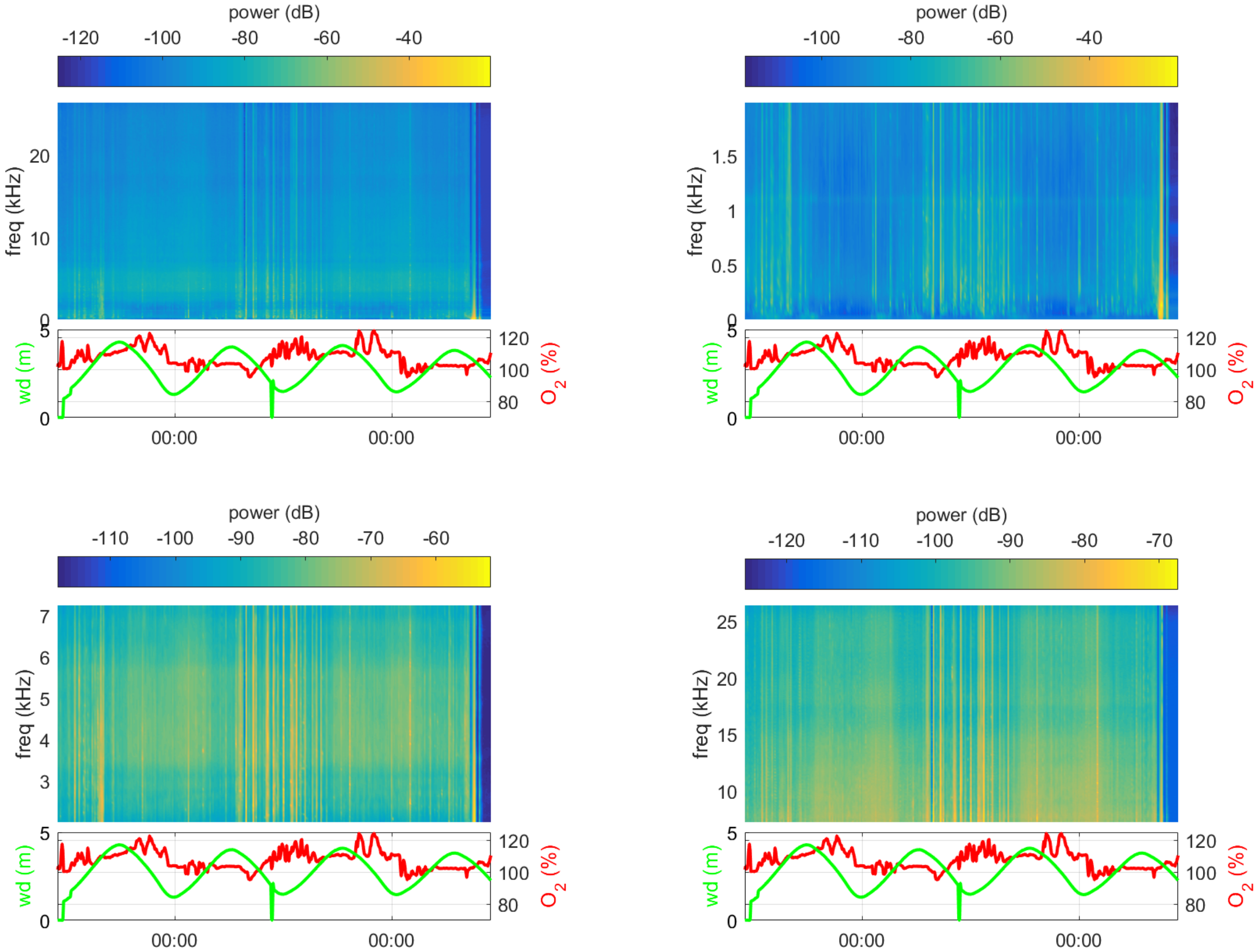


Figure 4.9: Power spectral density of the ambient noise over the *Caulerpa* meadow, estimated every 10 min from midday 26th July to midday 28th July: full 0–25 kHz band (upper-left), and zoom of 0–2 kHz (upper-right), 2–7.25 kHz (bottom-left) and 7.25–25 kHz (bottom-right) bands. The red and green curves represent the O2 saturation and water temperature, respectively.

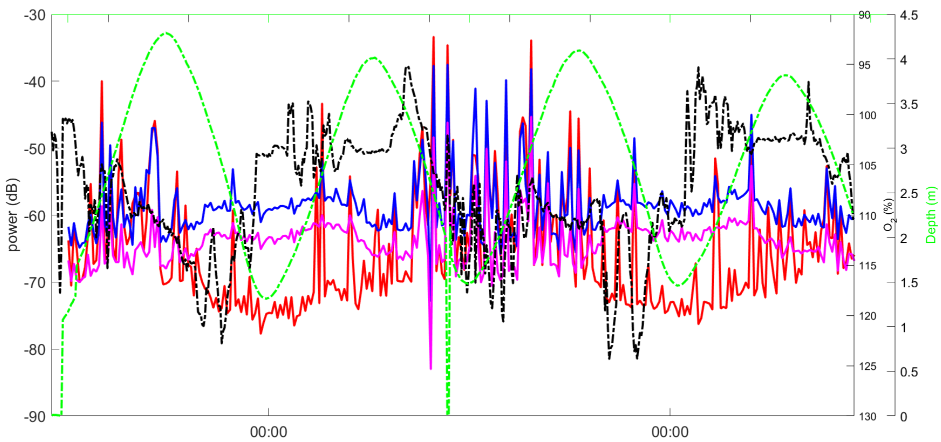


Figure 4.10: Comparison between the variability of the noise power shown in Fig. 4.9, integrated in the bands 0–2 kHz (red), 2–7.25 kHz (blue) and 7.25–25 kHz (magenta), and the variability of O2 saturation level (black). The green curve represent the water temperature, respectively.

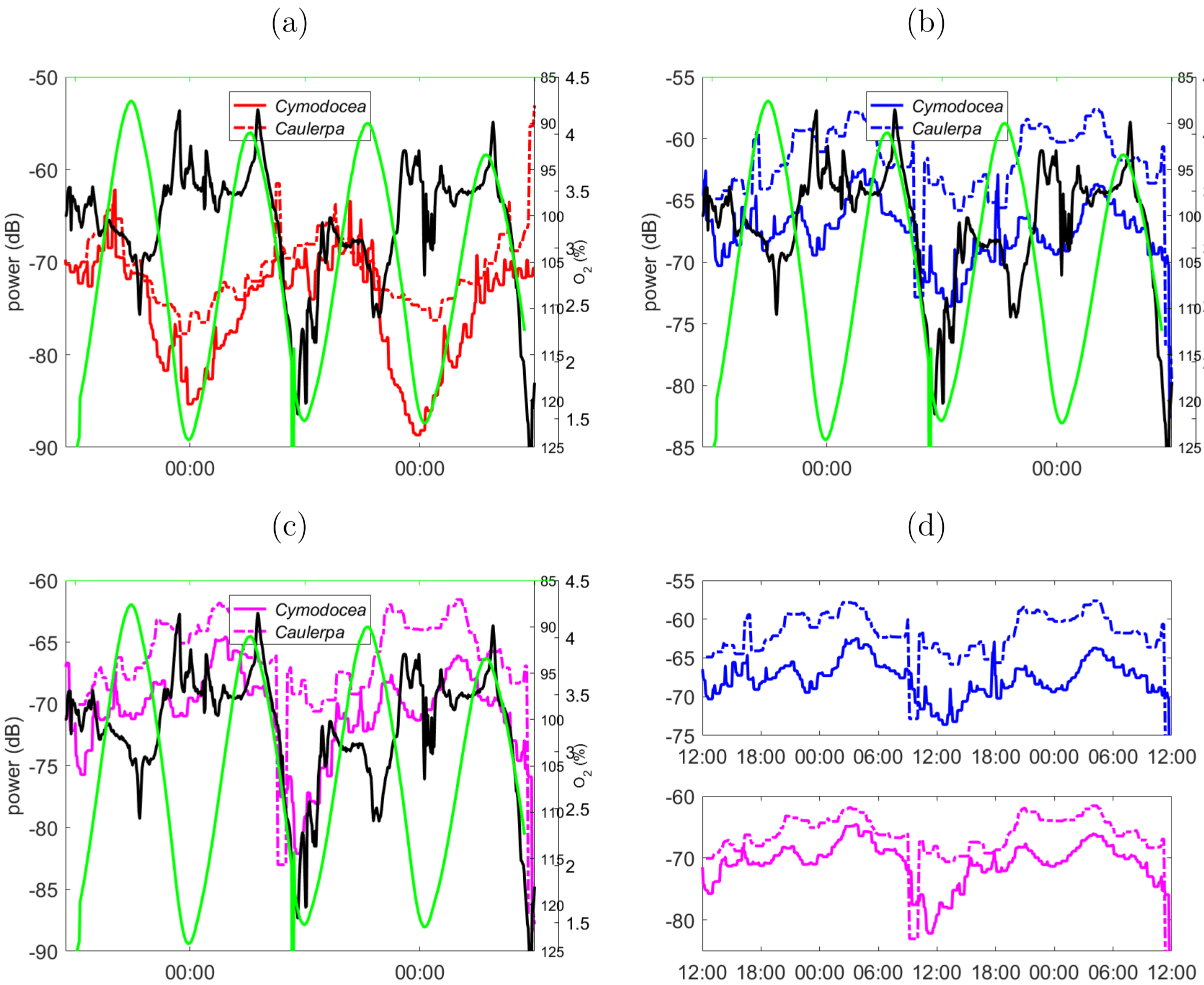


Figure 4.11: Comparison of the background noise power at the various frequency bands and the environmental parameters. water depth (green) and dissolved O2 (black): 0-2500 Hz, red (a), 2500–75000 Hz blue (b) and >7500 Hz magenta (c) (solid line *Cymodocea* site, dash-dotted *Caulerpa* site). Comparison detail of noise power only (d) for 2500–75000 Hz (upper) and $> 7500\,Hz$ (bottom).

Chapter 5

Conclusion

This experiment shows that the variability of the noise power in these very shallow water sites is very complex, the overall characteristics did not change significantly among sites, and observed differences can not be ascribed to the different bottom characteristics. During the day a large number of boats cross the area and dominates the noise power in all bands. The variability of the dissolved O2 is also similar among sites, and no correlation with noise power was found. The tidal forcing may have influence on environmental parameters (water temperature, dissolved O2) and noise power, for the latter particularly at low frequencies. There is a persistent background noise in the 3–6 kHz that may linked with biological activity. The background noise in this band have two peaks at dawn and dusk, similar to patterns observed in other littoral environments due to biological activity. From the preliminary results it is clear that longer lasting experiments are needed to support the development of methods to use noise as a proxy of the health of the seagrass ecosystem

Bibliography

[1] P. Felisberto, J. P. Silva, A. Silva, EPPO preliminary tank experiment: data report, Rep. 03/16, SiPLAB - University of Algarve, August 2016.

[2] P. Felisberto, J. P. Silva, EPPO preliminary tank experiment: October experiment data report, Rep. /16, SiPLAB - University of Algarve, October 2016.