Using active and passive acoustics to assess O_2 production of a Posidonia oceanica meadow

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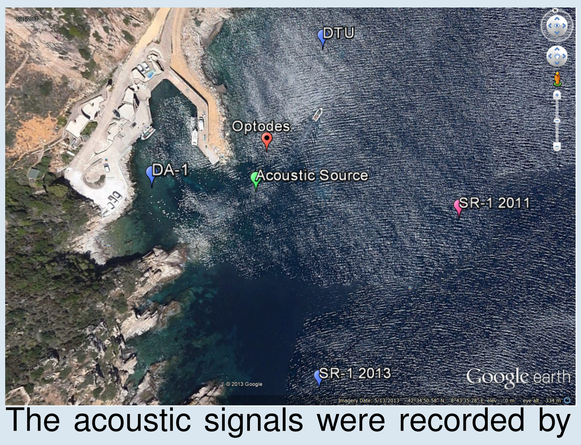
Abstract

This work discusses the data acquired during two experiments conducted in October 2011 and May 2013 in the Bay of la Revellata, Calvi, Corsica for the purpose of developing an acoustic system for monitoring the oxygen production of a seagrass meadow. During two periods of one week, acoustic signals transmitted from a sound source (active acoustics) and environmental acoustic noise (passive acoustics) were recorded at various locations over Posidonia oceanica. The changes of both the acoustic power of the transmitted signal and of the acoustic noise at the various locations were highly correlated with dissolved oxygen measurements by optodes conducted in the same area, i.e. with the diel cycle of photosynthesis. The changes of the acoustic signal are ascribed to the formation of O_2 bubbles both in the water column and within plant aerenchymas. Since the amount of O_2 bubbles are not assessed by conventional chemical methods, combining the acoustic method with those methods will allow to obtain more robust, and accurate in situ estimates of the productivity of seagrass meadows. This work is a contribution for the development of a low cost, non-intrusive system to continuously monitor coastal ecosystems dominated by macrophytes at high spatial scales.

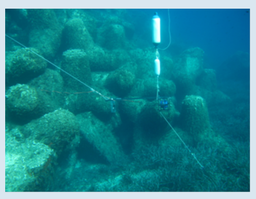
Objectives

- to develop a simple (passive) acoustic system to monitor the O2-based productivity of a seagrass meadow at the ecosystem level with high time resolution
- to estimate the production of O2 as bubbles, which is difficult to asses by other methods

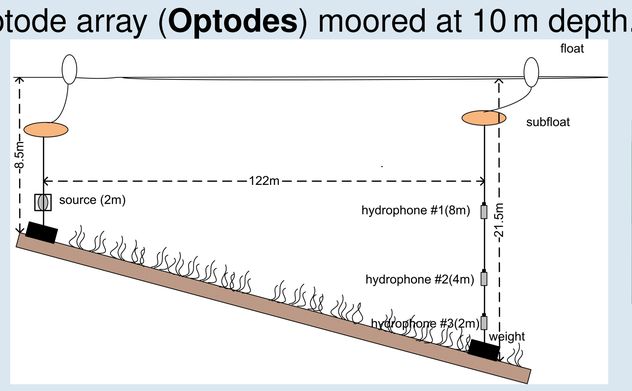
The experiment



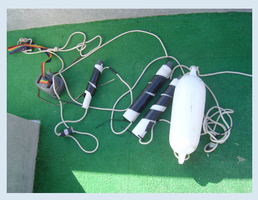
The data were gathered in front of the Station de Recherches Sous-marine et Oceanographiques (STARESO) Calvi, Corsica, over a *Posidonia oceanica* (L.) Delile meadow from October 10 to 19, 2011, and from May 9 to 15, 2013.
In both periods, a sound source (**Acoustic Source**) transmitted every 5 min, 2 min long sequences of low frequency signals.
The acoustic signals were recorded by SR1-1 self-recording hydrophones 100 m distant from the source: 3 hydrophones in October 2011 (**SR1-1 2011**) and 2 hydrophones in May 2013 (**SR-1 2013**). Additionally, in May 2013, the acoustic signals were recorded continually (transmissions and environmental noise) by the single-hydrophone (**DA1**) and the 8 hydrophone short array (**DTU**) moored at approximately 50 m from the source.
Dissolved O2 data was acquired hourly at 4.5, 7.0 and 9.5 m depth above the meadow by a 3-optode array (**Optodes**) moored at 10 m depth.



source mooring

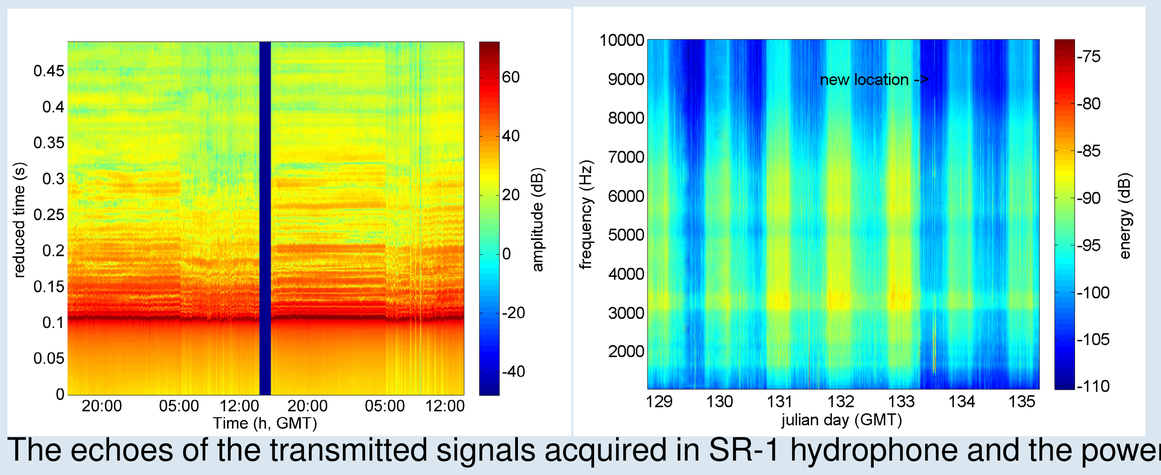


schematic of the moorings

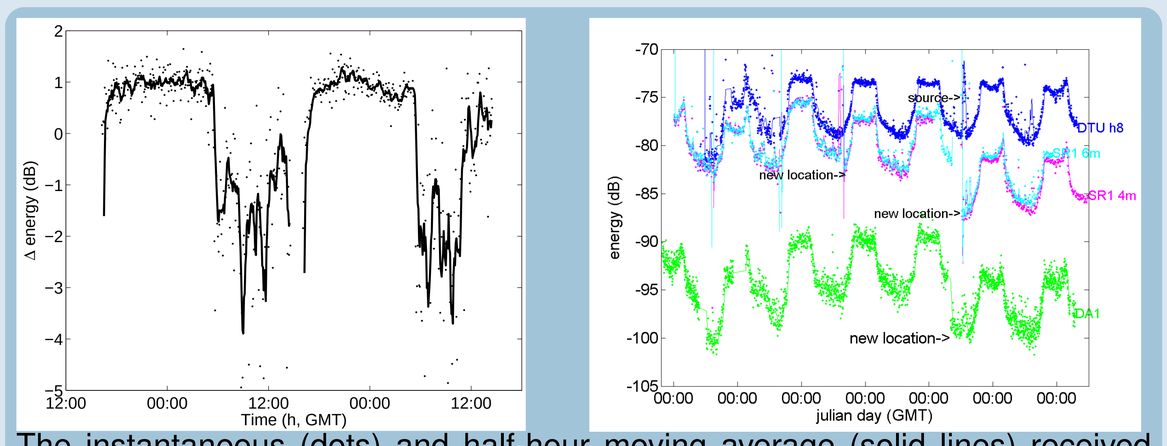


SR-1 hydrophones

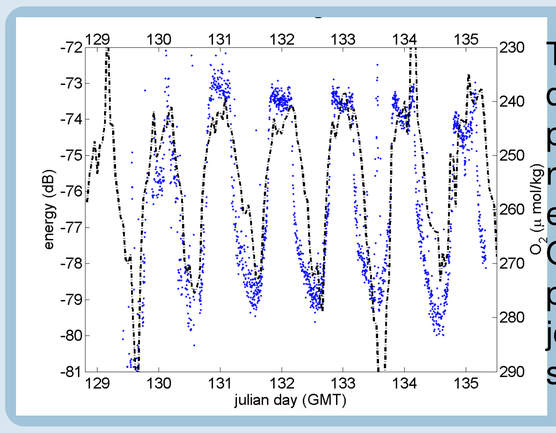
Experimental results



The echoes of the transmitted signals acquired in SR-1 hydrophone and the power spectral density of the environmental noise acquired in DA1 hydrophone were highly attenuated during the daylight period.

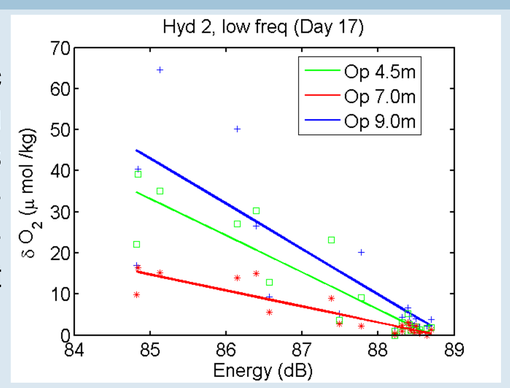


The instantaneous (dots) and half-hour moving average (solid lines) received energy from the transmitted signals (left panel) or environmental noise (right panel) show a diurnal pattern, where the energy sudden decreases at sunrise and increases at sunset.
The magnitude of the variability observed during the period of one week was similar at the various receivers/locations.
Due to different system gains and location of the receivers the absolute values changed among hydrophones and/or periods.



The comparison between the changes in dissolved O2 and the changes in noise power shows a high correlation. At sunrise the high gradient of change occurs earlier in acoustic data than in dissolved O2, what could suggest that the air in plant tissues (aerenchymas) plays a major role in the acoustic signature of photosynthetic activity.

The relation between changes in acoustic energy and dissolved O2 was fitted using a linear model. The model parameters were estimated by least square regression at 5% confidence level. The statistical values, P<0.001 and r^2>0.6, suggest that the linear model can be accepted.



Conclusions

- O2 production of a seagrasses give rise to a visible acoustic signature in
  - low frequency signals ($< 10\,kHz$) transmitted trough the meadow
  - environmental noise
- changes in acoustic energy were highly correlated with dissolved O2 measurements
  - the sudden change of acoustic energy at sunrise occurs earlier than the change of dissolved O2, what can be ascribed to the formation of O_2 bubbles within plant aerenchymas.

Acknowledgments

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