Acoustic characterization of underwater vegetations

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SHORT ABSTRACT: *This paper presents research tasks conducted by SEMANTIC-TS, in collaboration with GESMA, aimed to develop a method for detecting and characterizing vegetation on the seabed using the acoustic response from a conventional single beam echo sounder. First, this study is limited to posidonia, which plays a key role in Mediterranean's echosystem. Then, further extension of the method will be investigated to address other types or species (laminar, crepidula...) which can significantly affect the performance of acoustic sensors used for sea-mines detection.*
Keywords:*Underwater acoustic, classification, detection, vegetation, echo sounder.*

RÉSUMÉ COURT: *Cet article présente les travaux de recherche réalisés par la société SEMANTIC-TS, en collaboration avec le GESMA, aboutissant à une méthode de détection de la biocénose présente sur le fond marin à partir de signaux réels de sondeur mono faisceau. Dans un premier temps, l'étude se limite aux herbiers de posidonie, écosystème pivot de la Méditerranée. La méthode développée pourra ensuite être étendue à d'autres types ou espèces (laminaires, crépidules ...) qui engendrent du bruit sur les images sonar et perturbent la détection des mines.*
Mots-clés: *Acoustique sous-marine, classification, détection, végétation, echosondeur.*

1 IN-SITU ACOUSTIC AND VIDEO MEASUREMENTS

An experimentation phase was carried out in order to acquire signals reverberated by various types of bottom (sand with and without vegetation, rock), for various depths and various parameter settings of the echo sounder (emission power and impulse duration).

Fig. 1: Acoustic instrumentation and survey vessel

Hydroacoustic surveys were carried out using a mono beam SIMRAD EQ60 sounder emitting at frequencies of 38 and 200 kHz; they were accompanied by divings and pictures in order to have a truth of the bottom.

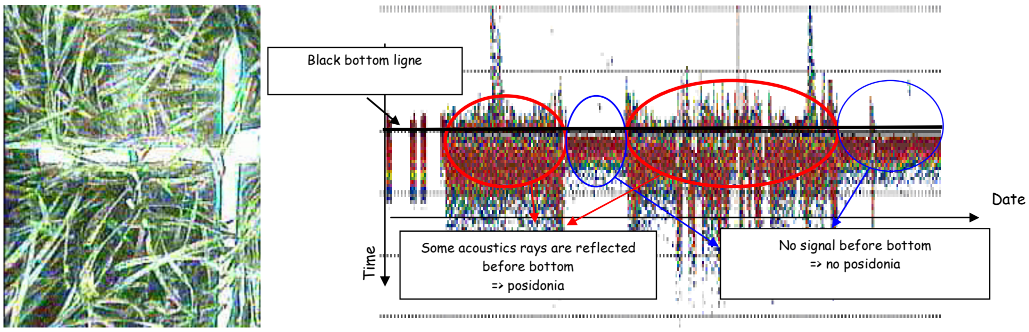


Fig. 2: Image of a bottom covered with Posidonia from a video sequence
Example of SIMRAD EQ60 sequence - Zoom of the first bottom echo.

Processing and analysis of these signals highlight the presence of reverberation peaks before the bottom echo in the case of bottom covered with posidonia. This specificity allows acoustic signatures differentiation among the bottom types and offers feasibility of the acoustic detection of the posidonia land. In addition, comparison between depth of the canopy echo, and depth of bottom interface echo, allows to estimate plants height.

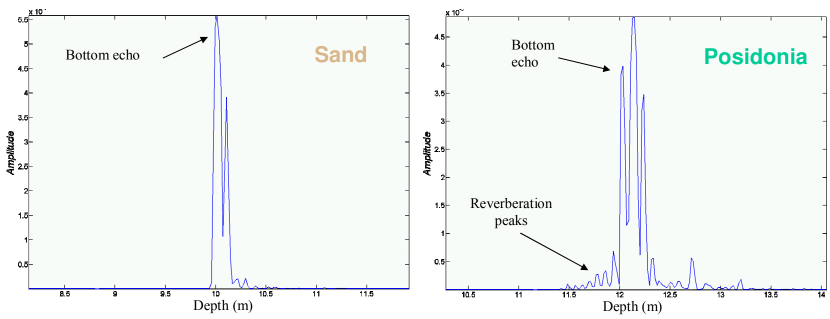


Fig. 3: Example of measured impulse responses on sand (left) and posidonia (right).

2 BOTTOM CHARACTERIZATION METHODS

2.1 Performance estimation

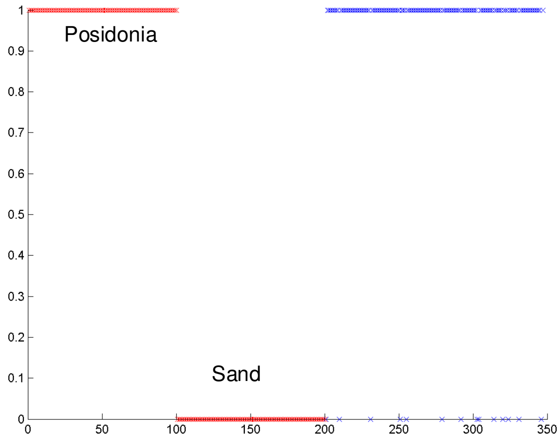
Probabilities of detection (pd) and of false alarm (pfa) are used in order to test and compare efficiency of the developed methods. If H0 is true (the bottom is not covered with posidonia) and that H1 is chosen, an error is made called "false alarm" or error of first species. If, on the other hand, H1 is true and H0 is selected, the made error is known as of " not detection "or error of second species. Traditional methods resulting from the decisional theory (or probabilistic methods) tend to maximize the probability of detection with probability of fixed false alarm. Other methods, known as geometrical methods, try to minimize the rate of "badly-classified". These last allow moreover to consider the case of a number of classes higher than 2.

2.2 Methods based on energy analysis of the retrodiffused signal

A state of the art has outlighted several promising methods usually used in the field of acoustic recognition of sea-beds [1] to [5]. These methods were estimated for the detection of the posidonia on sand bottom. These methods are not well adapted to vegetation detection, mainly because they exploit the signal after the bottom. A method based on calculation of energy present before the bottom gives better results (pd = 91 %, pfa = 9 %) but shows some disadvantages: threshold of detection empirically fixed, important sensitivity to the noise, important errors in case of moving sequences.2.3 Method based on the discriminant analysis

2.2 Methods based on the discriminant analysis

These results lead us to explore other kinds of methods, especially those based on multidimensional data analysis and form recognition. Discriminant analysis [6] has proved to be particularly interesting.
The following picture shows an example of linear discriminant analysis results:



In red: training phase
In blue: discriminant phase on a reference bottom covered with posidonia

Method efficiency is :
- sand/posidonia discrimination: pd = 96 % and pfa = 5 %,
- rock/posidonia discrimination: pd = 79 % and pfa = 20 %.

Fig. 4: Results example of the discriminant analysis

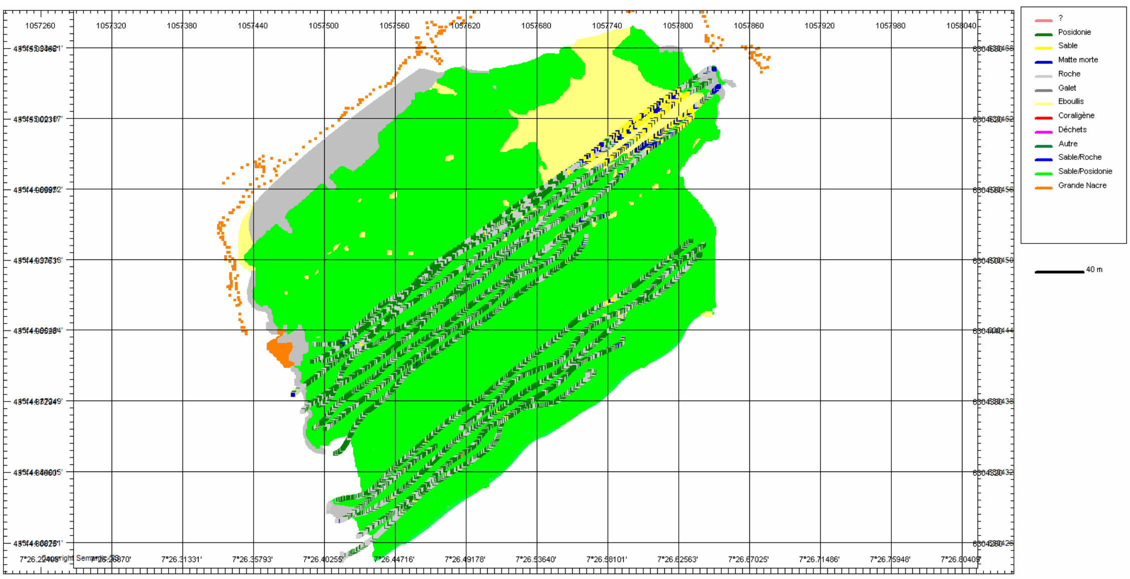


Fig. 5: Classification results obtained in Roquebrune beach, placed on in-situ observation map realized by divers and underwater camera.

Method offers advantage of not requiring any adjustment of threshold. Results for distinction sand/posidonia are encouraging, and enable correct processing of moving acquisition sequence.
The taking into account, in this method, of rock type, highlights a problem of confusion between the signals reflected on rock bottom and those coming from posidonia bottom. This phenomenon can be explained by the very similar characteristics of both echoes. However an intelligent and hierarchical algorithm, coupling methods derived from energy analysis and discriminant analysis would allow overcoming this problem.

3 CONCLUSIONS - PERSPECTIVES

Discriminant analysis method presented here realizes automated acoustic detection of the posidonia presence with satisfactory operational performances in case of station. This method is nowadays to the processing of the moving acquisition sequence (displacement of the ship). This work is a first stage of a global method, which aims in the long term to define a powerful system of automated classification, while merging nadir acoustic information with the side sonar one.

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