Acoustics'08 Paris
June 29-July 4, 2008
www.acoustics08-paris.org

Acoustic data fusion devoted to underwater vegetation mapping

C. Noel[a], C. Viala[a], M. Coquet[a], B. Zerr[b] and T. Perrot[c]

[a]Semantic TS, 39 Ch Buge, 83110 Sanary, France
[b]DGA/GESMA, BP42, 29240 Brest Armées, France
[c]CEVA, Presqu'île de Pen Lan BP3, 22710 Pleubian, France
noel@semantic-ts.fr

This paper presents results of research tasks conducted by SEMANTIC TS, in collaboration with GESMA, aimed to develop a mapping method for underwater vegetation lying on seabed. First stage is to develop a method for detecting and characterizing vegetation on the seabed using the acoustic response from a conventional single beam echo sounder. This new method is then operated simultaneously with multibeam sonar producing micro-relief information and side scan sonar providing gray scale levels associated with bottom reflectivity. Then fusion of these three data is processed. We show efficiency of these multisensor data fusion concept to get very precise seabed vegetation mapping in a way reducing truth control (video and diving investigations). Sensors and method accuracy allow obtaining, like in biomedical field, real 3D scan pictures of seabed vegetation. This study is first applied to posidonia and cymodocea, which play a key role in Mediterranean's ecosystem. Then, extension of the method is investigated to address laminaria which may significantly affect the performance of acoustic and optical sensors used for sea-mines detection. This paper presents results of data fusion mapping on an Atlantic sea area covered by laminaria, studied and well known by the CEVA.

1 Introduction

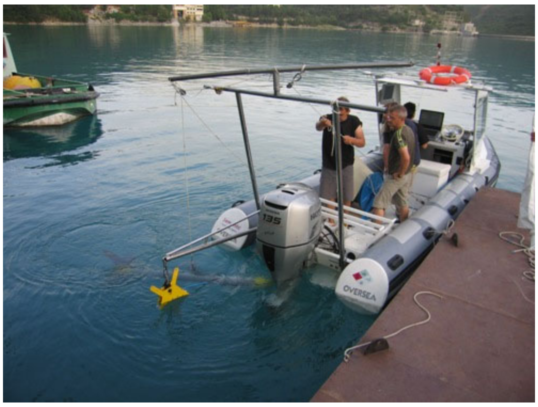
Research tasks presented here referred to a global project relative to development of an operational bottom mapping method devoted to underwater vegetations [1]. This project comes out observation of similar mapping needs in civil and military environments, because vegetation may hide bottom mines and can significantly affect the performance of acoustic sensors used for sea-mines detection. First stage was to develop an echo sounding method to detect vegetation, then side scan sonar data and bathymetry data are combined to product very precise maps, with reduced needs of truth observations.

2 Instrumentation means used

Experimentation phases were carried out using SEMANTIC survey vessel devoted to bottom inferring, 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).

Several systems were used:

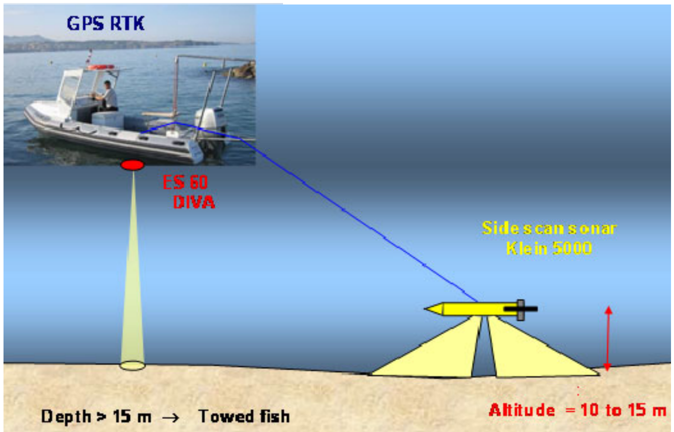
- GESMA Sonar Klein 5000: high resolution side scan sonar, frequency 455 kHz, resolution 20 cm at 75 meters ; range max : 150 meters.



.Fig.1: Side scan Klein 5000 sonar on the SEMANTIC survey vessel.

- Geoswath interferometric system able to deliver bathymetry and, in very shallow water (less than 15 m) side scan sonar mosaic picture; frequency : 250 kHz.
- Echo sounding system Simrad ES60 high precision (scientific system) devoted to SEMANTIC TS DIVA method for acoustic bottom vegetation detection
- D-GPS differential RTK Leica GX1230 centimetric: one base and one receiver
- Acquisition and processing data devices, and automatic navigation system.
- Professional divers. Video camera

Fig.2 and Fig.3 show respectively principles of multisensor acquisition in deep and shallow water.



.Fig.2: Principle of multisensor acquisition in deep water (>15m)

Fig.3: in shallow water (< 15m).

3 DIVA method

Principle of DIVA method is given on Fig. 4. The shape of acoustic bottom impulse response from a scientific echo sounder is recorded simultaneously with centimetric GPS position. As sand and vegetation have different acoustic signature shapes, we have developed a signal processing algorithm based on discriminant analysis and energy level of the bottom reflected impulse response. Fig 5 shows samples of sand and posidonia acoustic signature.

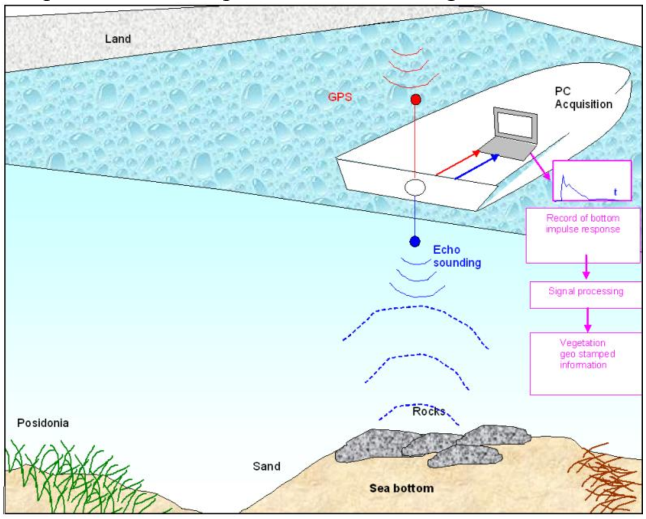


Fig.4 : Principle of DIVA method.

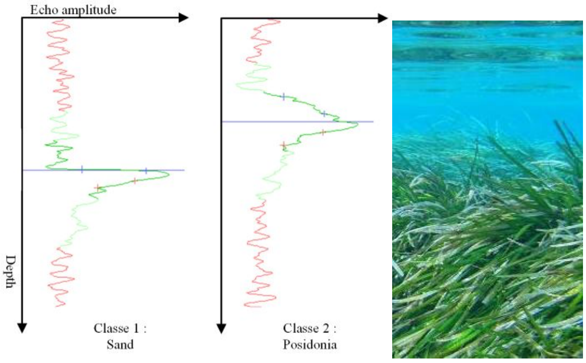


Fig.5 : Left : typical acoustic signature of sand and posidonia. Right : posidonia.

After a calibration phase DIVA is able to give reliable information about presence or absence of vegetation. It constitutes a useful tool to help side scan sonar mosaic picture interpretation. It allows easily determining contour of a vegetation meadow.

4 Fusion method and results

In order to produce precise 3D vegetation mapping, we have develop on a second stage a method based on the fusion of data provided by :

- Geoswath bathymetric system
- Side san sonar systems (Geoswath or Klein)
- DIVA method

Methods are operated simultaneously, and data fusion is realized by combining:

- 3D bathymetric data producing micro relief information of the vegetation
- Side scan sonar imagery in gray levels, producing information about reflectivity, and so about bottom nature.
- DIVA information about presence and absence of vegetation.

This method has been implemented and works quasi automatically. It has been successfully applied in several areas in Mediterranean sea on posidonia (see Fig. 6 and 7) and in Atlantic area on laminaria (See Fig 9 and 10).

Fig.9 illustrates good results of multisensor data fusion method in laminaria case, where it allows finding biomass spatial repartition mapped by CEVA using a specific digital sonar mapping method to detect and quantify the density of seaweeds (methods using a Simrad EK60 echosounder and scuba diving observations) [4].

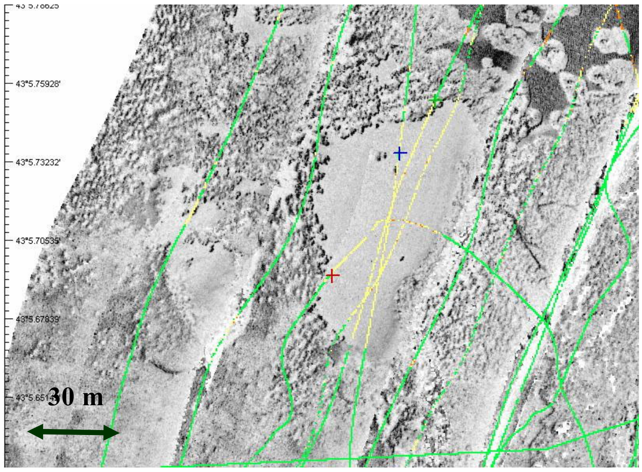


Fig.6 : Results of DIVA method in Mediterranean area (in green : posidonia, in yellow: sand) superposed to gray scale side scan sonar mosaic from Geoswath system.

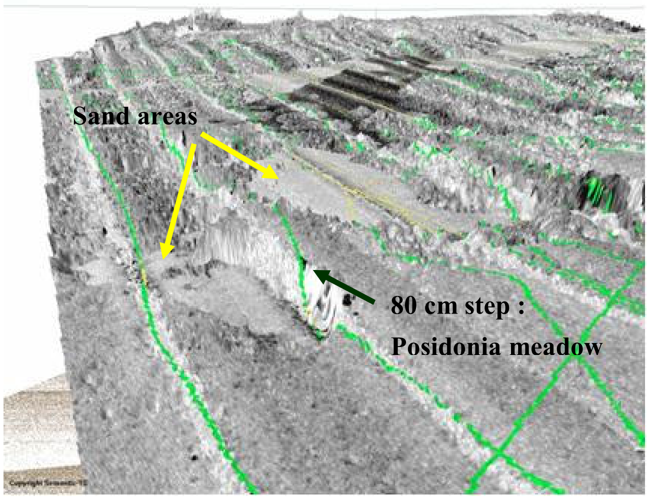


Fig.7 : 3D scan picture of posidonia meadow: micro relief (from Geoswath bathymetric system) fusioned with DIVA results and side scan sonar mosaic.

Fig.8 : Laminaria

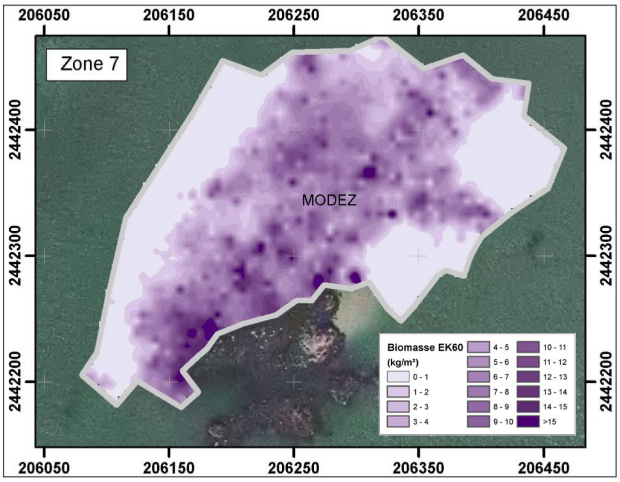


Fig.9: Kelp density map (coupling acoustic data interpolation and scuba diving observations) made by CEVA in the study area of Modez (Atlantic)

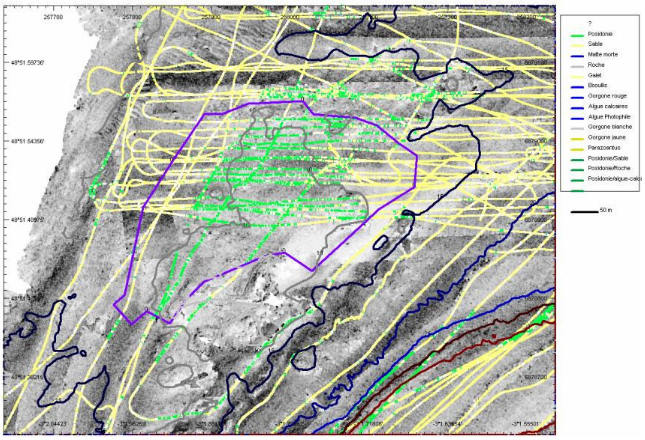


Fig.10 : Results of DIVA method in Atlantic area (in green : laminaria, in yellow: sand) superposed to gray scale side scan sonar mosaic from Geoswath system. In purple: CEVA study area. Results are to compared with Fig 9 CEVA biomass repartition.

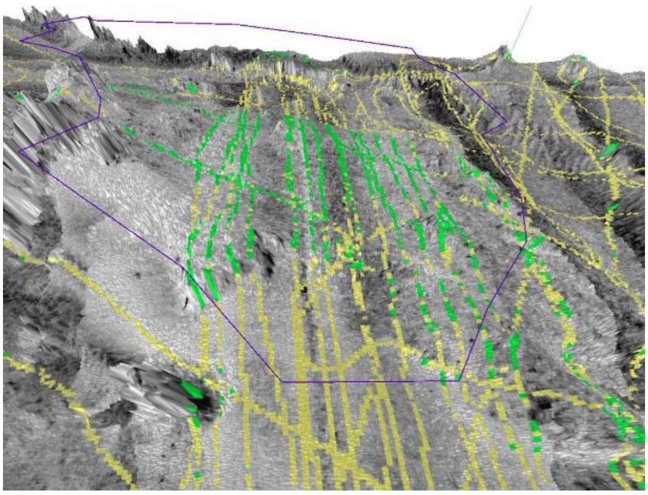


Fig.11 : 3D scan picture of laminaria meadow: micro relief (from Geoswath bathymetric system) fused with DIVA results and side scan sonar mosaic. In purple: CEVA study area

5 Conclusion

Data fusion concept is innovative and powerful. It allows producing like in medical applications, very accurate 3D scan pictures of seabed vegetations.

Such precise 3D scan pictures of vegetation could only be obtained with very high accuracy at each step of data acquisition and processing. For this we had to develop a specific GIS software inside which, we have incorporated processing algorithms.

If it quite works in smooth areas, which constitute 80 % of the applications, there remain difficulties in case of more relief. They are typically due to some confusion between rocks and vegetation acoustic signatures, and are still on study.

Acknowledgments

The authors thank the D4S/MRIS from DGA which supports financially this work under contract N° 05.34.011.00.470.75.65.

They also thank dynamic sea data acquisition team: S. Le Goanvic, C. Genty, G. Kerampran, B Le Breton from GESMA and E. Bauer, S Marchetti, S. Hernandez from Semantic TS.

References

[1] C. Viala, C. Noël, M. Coquet, B. Zerr, P. Lelong, JL Bonnefont, "Pertinence de la méthode DIVA pour l'interprétation des mosaïques sonar latéral". *Third Mediterranean Symposium on Marine Vegetation. Marseille, March 2007*

[2] C. Noël, C. Viala, E. Lehn, C. Jauffret, "Développement d'une méthode acoustique de détection des herbiers de posidonies". *Colloque : Sciences et technologies marines du futur - Un enjeu pour la Méditerranée. Marseille Hotel de Région -19-20 Mai 2005*

[3] C. Noël, C. Viala, B. Zerr, "Acoustic characterization of underwater vegetations". *Colloque Caractérisation du Milieu Marin, Brest 16-19 oct 2006*

[4] CEVA (2006), "Mise en place d'un coefficient de proportionnalité liant l'index de réverbération volumique à la biomasse en place". Rapport final de contrat pour l'Ifremer dans le cadre du projet REBENT.