New tools for seabed monitoring using multi-sensors data fusion

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Abstract. SEMANTIC TS, an acoustics & oceanography engineering consulting company, uses sound to infer aquatic environment : water column, vegetation, bottom (nature and topography), sub bottom. SEMANTIC TS is able to operate, simultaneously or not, one or several acoustic systems, from very light survey units and to develop its own software suite devoted to data acquisition, processing, fusion and operational map production

Keywords. Bottom monitoring. Seabed. Acoustics. Side scan sonar. Multibeam bathymetry. Multi-sensors data fusion.

1 Introduction

Setting up a process to build accurate seabed maps is indeed challenging, but to ensure its reproducibility is even more complex. Now, this is a required condition since only evolution between two maps can provide us with relevant information to qualify occurring changes for monitoring purpose.

This paper details the methods used by Semantic TS since 2001 to set up affordable seabed monitoring techniques using multi-sensors data fusion. Costs of such methods are now affordable for both military and civil organisms, the latter facing an increasing number of norms about environmental monitoring.

This approach is aimed at designing light survey units to merge data from various sensors, at different frequencies and to set up an acoustics classification method for seabed nature using a dedicated software framework.

2 Principle of shallow water bottom monitoring

To enable us to build maps and to monitor shallow water seabeds and vegetation, we propose to use the following tools:

- Small dedicated oceanographic survey ship
- Side scan sonar and hull interferometer to get multi-beam and Side scan imagery at the same time
- Detection and monitoring methods, Vertical Acoustic monitoring, CLASS (CLassification des Sédiments Superficiels) and FISH (Halieutique) improved since 2003 and using signals from a scientific echo sounder (SIMRAD ES60)
- Additional sensors: acoustic camera, sediments sounder, magnetometer,...

These systems, working at different frequencies, provide us with complementary information about the marine medium.

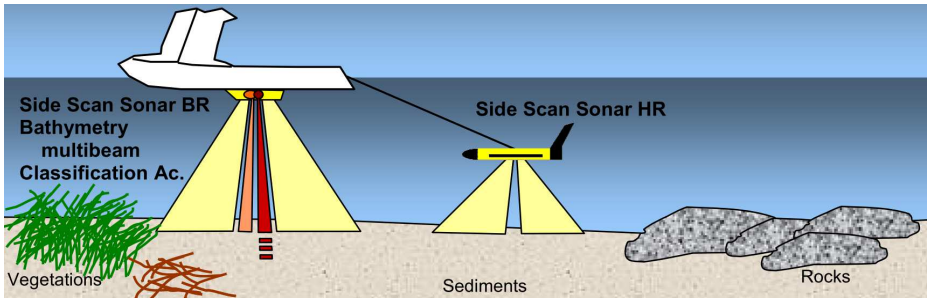

Fig. 1. Principle of multi-sensors data acquisition from SEMANTIC oceanographic survey vessel

3 Development of new tools devoted to bottom monitoring

3.1 Light survey units

We have developed small new survey units to be deployed in littoral sea areas, rivers, ponds, lakes.

Small size survey units offer high level of technology, both for platform positioning systems and for acoustic sensors. Boats are equipped with motion central and high speed internet is available through 3G used for D-GPS RTK corrections, from land reference D-GPS station, in real time. Survey units are able to produce energy to process simultaneously all the instrumentation (24/7 for the SEMANTIC unit).

Fig. 2. SEMANTIC (6.5 m) and MINO (4.3 m) mini oceanographic survey vessels

3.2 Implementing seabed acoustics classification methods

Since 2004, we conduct studies on acoustics classification of vegetation and underwater sediments, which led us to release an innovative automatic seabed acoustics classification system (SACLAF), inferring the reflected signal in water column and seabed named SIVA (Système d'Inspection Verticale Acoustique).

3.3 Implementing multi-sensors data fusion

We are working on acoustic data fusion from the following sensors since 2007 :

- 3D Bathymetry (underwater topography of the location)
- Bathymetric roughness, providing information about the vegetation
- Side Scan Sonar imagery, where gray level gives information about bottom reflectivity and consequently on the vegetal (or non-vegetal) nature of the seabed

- Whether dense vegetation is present or not can be found out by the DIVA method [1]
- Sediment classification information provided by CLASS [2]
- Geo referencing of fishery resources provided by the FISH method

The uniqueness of our work lies in the various acoustics devices we can integrate simultaneously along with the specially developed software framework for the seabed monitoring.

This software acts as a scheduler, driving all devices and sensors, handling their synchronization, timestamping, conflicts, geo-referencing, the communication with the data acquisition station as well as the raw data storage.

This software also includes a scientific database featuring signal processing functions dedicated to acoustic classification, generating secondary data (process data : bathymetry, side scan sonar mosaic, results from SIVA classification method...).

These systems, working at different frequencies, provide us with complementary information about the marine medium. Data gathered from the various instruments is accurately georeferenced and time stamped (synchronized on the same time base) by the same DGPS RTK/Motion sensor (centimetric precision) positioning system. This common Space-Time reference basis, easing the data fusion process, significantly improves our knowledge of the marine medium and the performance and reliability of the monitoring process.

4 Results

Initially developed for Posidonia detection, the multi-sensor data fusion method is now regularly used in operation for various kinds of seagrass meadow… as well as bottom colonizing species: mussels, slipper limpet (*Crepidula Fornicata*)…[3].

These methods have been successfully applied in Corsica and French Riviera vegetation (on Mediterranean *Posidonia Oceanica and Cymodocea Nodosa* meadows and sediments), in Guyana (high turbidity), in French Brittany (*Laminaria Hyperborea*), in Arcachon basin (*Zostera Marina*). Following picture shows an example of data fusion results obtained near Sanary s/Mer (Riviera), on posidonia meadow.

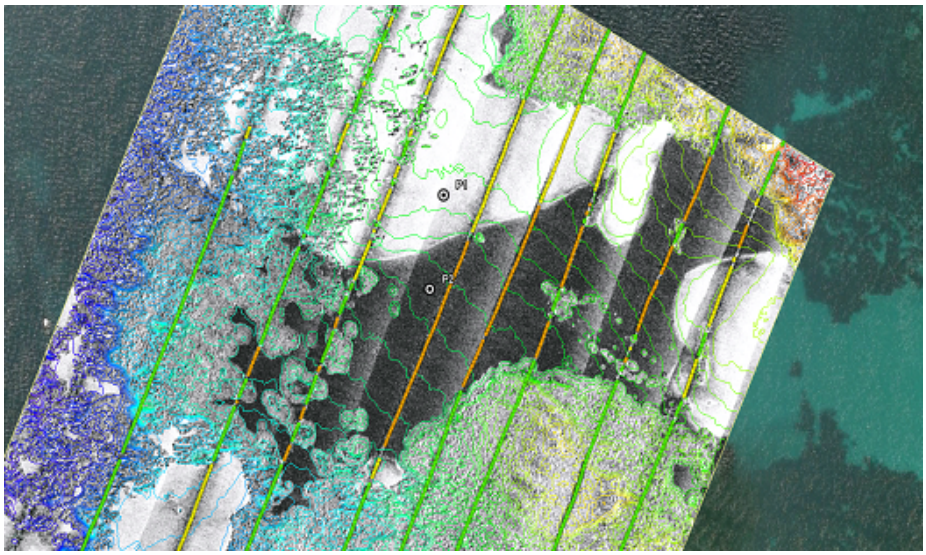

Fig. 3. Bathymetric micro-rugosity & Acoustic classification. (vegetation (green), fine sediment (yellow) et coarse (orange)) On side scan sonar mosaic and aerial view

Fig. 4. Left : Isobaths - Right : Corresponding side scan sonar imagery. Black area are full of cymodocea. Dark gray areas contain posidonia.

5 Conclusions & Perspectives

Data fusion concept is innovative and powerful. It allows producing like in medical applications, very accurate 3D scan pictures of seabed derived from different sources (side-scan, multi-beams, echo sounder) and information (aerial pictures, classification methods results, divers/video observations …). Power of data fusion concept remains

on the quality of the data and on their complementarities. In this context such mini-survey units, able to operate and synchronize several complementary high resolution acoustic sensors simultaneously, and to precisely process motion and geo-positioning, appears as a very efficient tool in the crucial data collection first step of the data fusion process.

SEMANTIC TS is currently working on extending the SIVA method to acoustic detection of coralligenous and to the characterization o^f posidonia dead matte.

Please note that the previously described methods, applicable for shallow water monitoring, can be transposed to deep sea (embedded on drones), as illustrated in the picture below. We are currently actively driving this technology transfer.

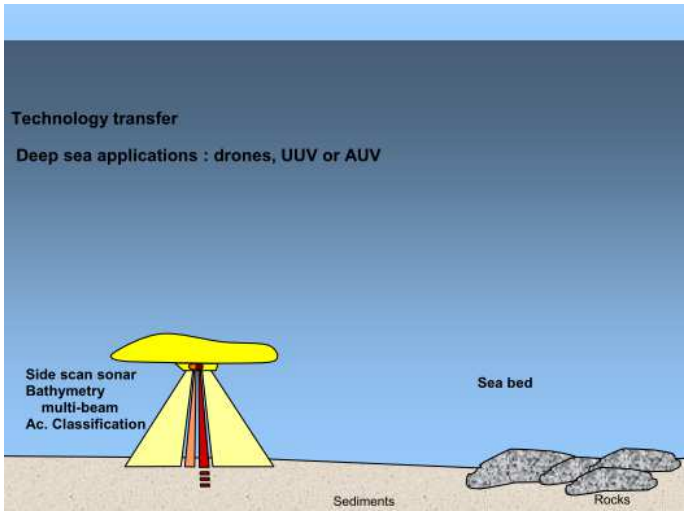

Fig. 5. Technology transfer to deep sea application

The authors thank the D4S/MRIS from DGA as well as Agence de l'Eau RMC which supports financially this work.

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