L'indice BATCLAS : une nouvelle technique d'identification et de cartographie à haute résolution des structures naturelles et artificielles sur les sites d'implantation marins d'éoliennes

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Résumé

Avant chaque implantation d'un parc éolien en mer il est nécessaire de réaliser des cartes bathymétriques et biocénotiques précises afin d'identifier d'éventuels obstacles et de limiter l'impact des installations sur le milieu marin. Afin de répondre à ces obligations, Subsea Tech et Seaviews ont développé une nouvelle méthode acoustique permettant de cartographier et de positionner avec une grande précision les irrégularités du fond marin dans le cadre du projet SACLAF-SMF. Dans un premier temps, une bathymétrie de haute précision est réalisée à partir d'un sondeur multifaisceau. Les données acoustiques de la colonne d'eau sont également échantillonnées. Nous utilisons ensuite un indice de discrimination, que nous avons nommé BATCLAS (Bathymetric Automated Treatment for Classification of the Seafloor), afin de détecter des structures bathymétriques de l'ordre du décimètre affleurant le substrat (p. ex. objets, épaves) et de classifier les habitats marins difficilement identifiables à l'aide des méthodes traditionnelles (p. ex. herbiers sous-marins de faible densité, petits récifs rocheux, récifs de moules peu denses).

Ainsi, l'utilisation d'un sondeur multifaisceau couplé à l'indice BATCLAS fournit :

- une identification accrue des structures artificielles et naturelles de petite taille
- une excellente précision
- une réduction des coûts d'acquisition des données
- une réduction du temps d'échantillonnage

Abstract

Prior to wind farms establishment, it is compulsory to obtain bathymetric data and maps of marine habitats with a high precision to identify possible obstacles and to limit their impact on marine biodiversity during their installation and use periods. In order to meet these requirements, Subsea Tech and Seaviews developed a new acoustic method allowing to map and position with high precision seafloor irregularities in the framework of the SACLAF-SMF project. At first, a high resolution bathymetry is produced with a multibeam echosounder and the water column data are sampled too. In a second time, we use a discrimination index, that we named BATCLAS (Bathymetric Automated Treatment for Classification of the Seafloor), to detect bathymetric structures flushing with the substrate surface in the range of a decimetre (e.g. objects, wrecks) and to classify marine habitats mapped with difficulty using traditional methods (e.g. sparse seagrass meadows, small rocky reefs, sparse mussel reefs).

The use of a multibeam echosounder coupled with the BATCLAS index thus provides:

- A more accurate identification of small size natural and artificial structures
- An excellent precision
- A reduction of data acquisition costs
- A decrease of the sampling time

Motivation – Purpose

Offshore wind farms has proved to be a good alternative to onshore wind turbines, the latter requiring space that is not always available. Offshore installations benefit from stronger winds which lead to a higher productivity despite their increased installation and operation costs (Breton and Moe, 2009). Although the economic and energy producing advantages of offshore wind turbines are clearly visible, it is also clear that the installation of such structures will affect marine environment. On the one hand, several impacts has been identified on various compartments of marine trophic webs such as birds, marine mammals and fish as well as on the seabeds and benthos (Snyder and Kaiser, 2009; Vaissière *et al.*, 2014). On the other hand, wind turbines are expected to constitute artificial reefs and shelter marine species in a no-take area, thus leading to a possible pill-over effect (Punt *et al.*, 2009). In any case, a careful spatial planning in compulsory prior to any wind farm installation in order to meet both high energy productivity and environmental protection. To achieve this aim, maps of marine habitats with a high precision allow to identify key habitats and artificial structures thus limiting fish farms' impact on marine biodiversity during their installation and use periods.

The SACLAF-SMF (Système Acoustique de CLassification Automatique des Fonds – Sondeur Multifaisceau) project aims to create an innovative solution to automatically classify marine biotopes. More specifically, it targets to drastically increase the precision and productivity when compared with the other mapping methods (Noël *et al.*, 2012). The main method of automated seabed acoustic classification (ASAC) relies on the use of a singlebeam echo sounder (SBES) only capable of limited surface measurements. Moreover, it requires the use of additional data from other types of captors – *i.e.* side scan SONAR images, aerial photographs, bathymetry, ground truth – to generate complete maps of the seabed.

Since the SBES has proved to be an efficient technology for discrete ASAC, it appears logical to use this methods with a multibeam echo sounder (MBES) which may combine up to several hundreds of single beams and thus, has the advantage of being a surface tool of measurements (Fig. 1). The MBES has already proved its efficiency to map various seabeds (Brown *et al.*, 2011; Prompolini *et al.*, in press) such as sediment types (Huseby *et al.*, 1993) and seagrass meadows (Komatsu *et al.*, 2003).

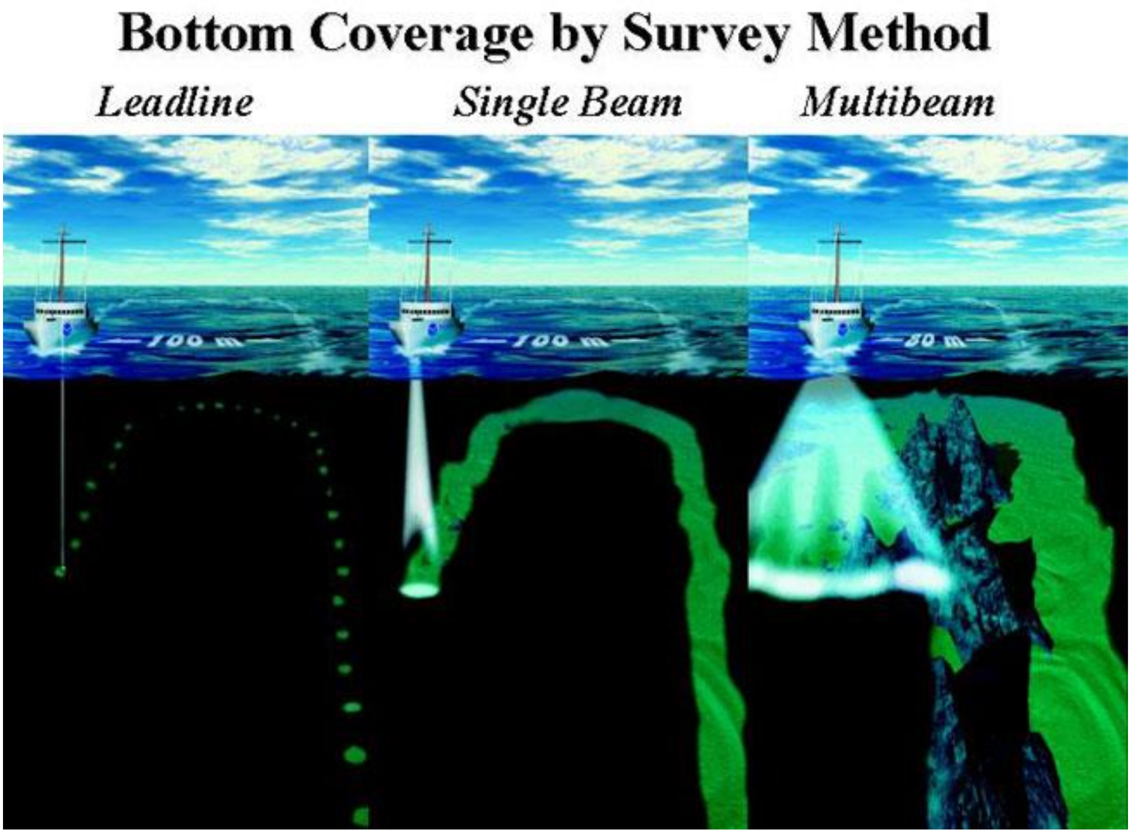

Figure 1: Coverage differences according to the survey method: punctual measures, single beam echo sounder (SBES) and multibeam echo sounder. Source: NOAA.

In the framework of the SACLAF-SMF project we aimed to develop an ASAC process using a MBES and create a new indicator – the BATCLAS index (Bathymetric Automated Treatment for Classification of the Seafloor) – to identify and map natural and artificial underwater structures. Three steps were followed to achieve this objective using a single MBES:

- the generation of bathymetric and SONAR maps (classic methods) ;
- the measurement of echo-integration (ASAC) a the nadir ;
- the development and use of the BATCLAS index to identify natural and artificial structures usually hard to detect.

Methodology

The present study focus on the results provided by the use of the ASAC to map a flat seafloor comparable of those favourable to wind turbine installation. These results benefits from a strong research phase (Fig. 2) which combines data acquisition and classification algorithm development with feedback process (Fig. 2).

Five sites (one pilot site and four additional) were mapped in the framework of the SACLAF-SMF project. In a spirit of conciseness we present here the results for one of the additional sites which shows interesting results for the topic of wind turbine and biodiversity.

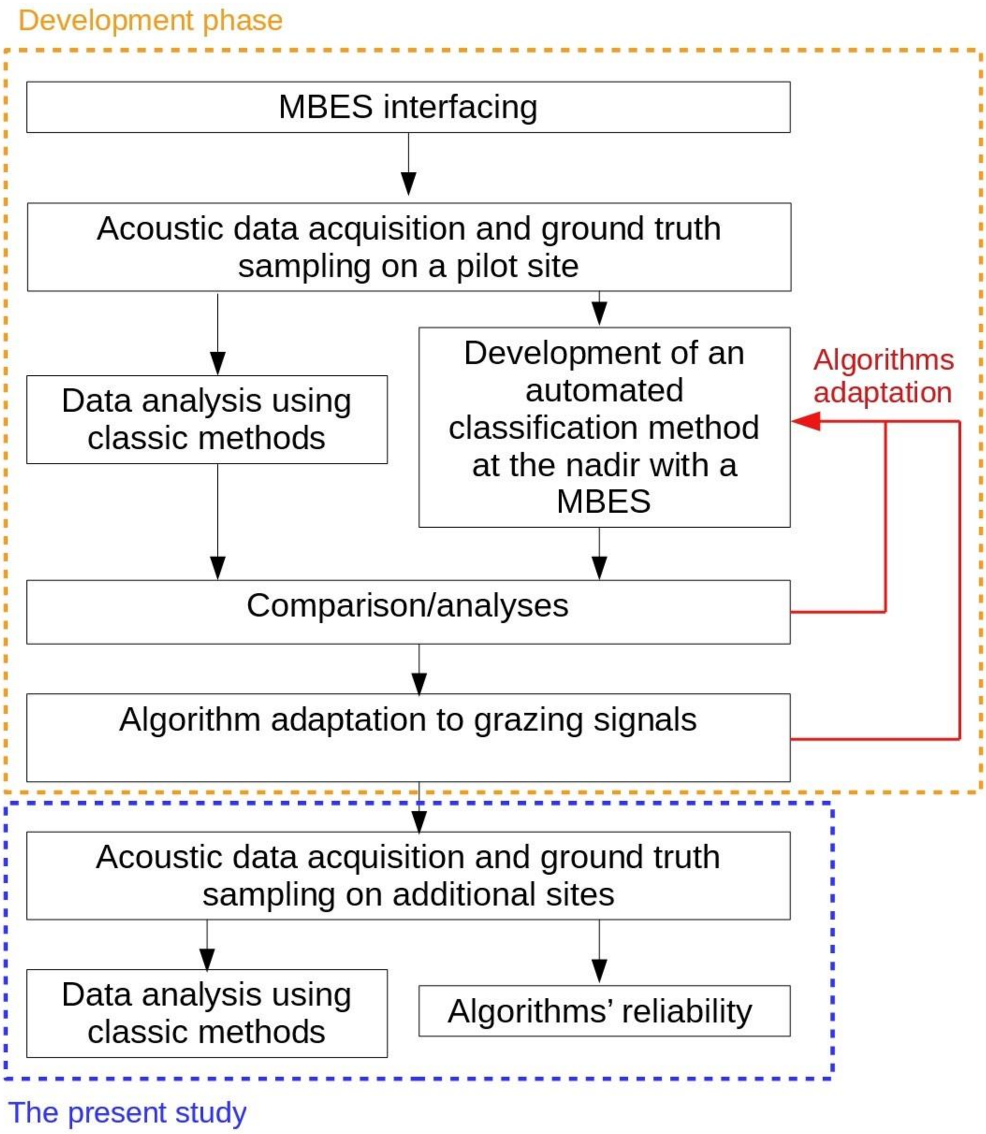

Figure 2: Phases of the SACLAF-SMF project resulting in a new automated classification method to map seabeds.

The chosen study site is situated in La Ciotat Bay in the south of France (5°39'56.82" E; 43°10'20.05" N; Fig. 3). The area sampled covered an area of 1.25 km² and encompasses several types of habitats and artificial structures such as seagrass meadows (*Posidonia oceanica*), rocky beds, artificial reefs and a wreck.

Acoustic data were acquired using a R2SONIC 2022 MBES coupled with an inertial navigation unit (roll and pitch) I2NS encompassing a full GNSS positioning mod. The MBES can provide simultaneous SONAR images while collecting other acoustic data. The navigation unit provide position with an accuracy of 1 cm on x and y axis, and 1.5 cm vertically. All the equipment is fully integrated in the "Seaviews One", a small ship specially built for bathymetric and SONAR campaigns.

Figure 3: Area mapped (red frame) in La Ciotat Bay.

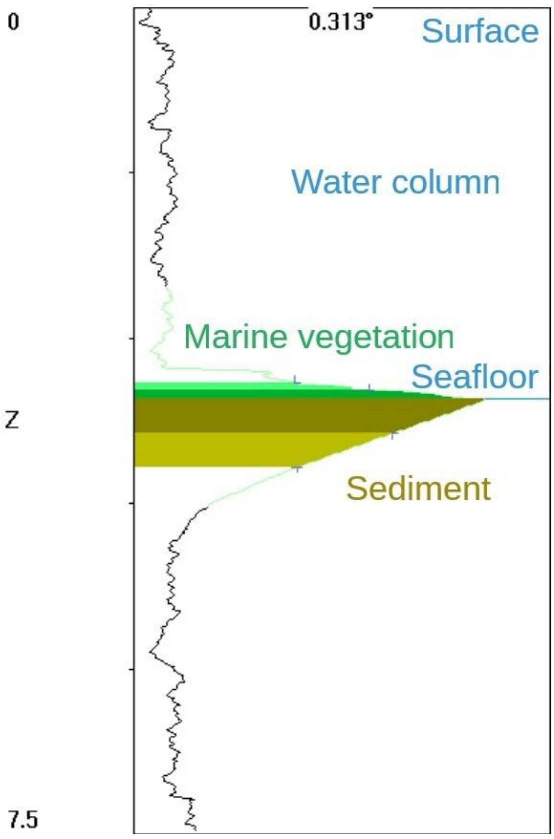

Figure 4: Signal analysis with an algorithm for automated classification of the seafloor. Green: marine vegetation. Brown: sediment.

Bathymetric and SONAR maps were extracted from the acoustic data sampled. These two map types have a resolution of 0.5 cm. The bathymetric data are presented under shape of a two-dimensional digital elevation model (DEM) with a colour gradient to show the depth range. SONAR images are pictures of the seafloor in shades of greys.

The data set was then analyzed using an algorithm which automatically classifies the seafloor's nature by detecting and measuring the signal amplitude above and under the seafloor (Fig. 4). This signal is analyzed at the "nadir", *i.e.* upright under the boat keel with an aperture angle of about 5°. A high signal of high amplitude before the seafloor characterizes the presence of marine vegetation (seagrasses, algae) while a wide and high amplitude signal after the seafloor characterizes a soft and fine sediment (Fig. 4). When no signal is observed both sides of the seafloor limit it reflects a hard seabed, most likely rocky beds. This ASAC provides echo-integration maps revealing marine habitats (seagrass meadows, rocky beds, sediments).

The BATCLAS index is computed by measuring the relief (or roughness) of the seafloor. This new approach of acoustic signal analysis provides a clear view of any natural and artificial submerged structures. The BATCLAS index is accurate enough to detect hard elements flushing with the sediments such as small rocky beds in the range of a decimetre or artificial objects like small wrecks.

Outputs Summary

The depth within the area studied ranges from 10.3 to 48.1 m. The seafloor shows a flat profile with a steady slope (Fig. 5). No relief is observed.

The echo-integration map confirms the observations made with SONAR images. The limit of the seagrass meadow is visible on the north east part of the area and is materialized by the alternation of blue (sediment) and red (seagrass) (Fig. 7). Other patterns such as sediment features are hard to observe at a large scale (Fig. 7) but can be identified at smaller scale of observation.

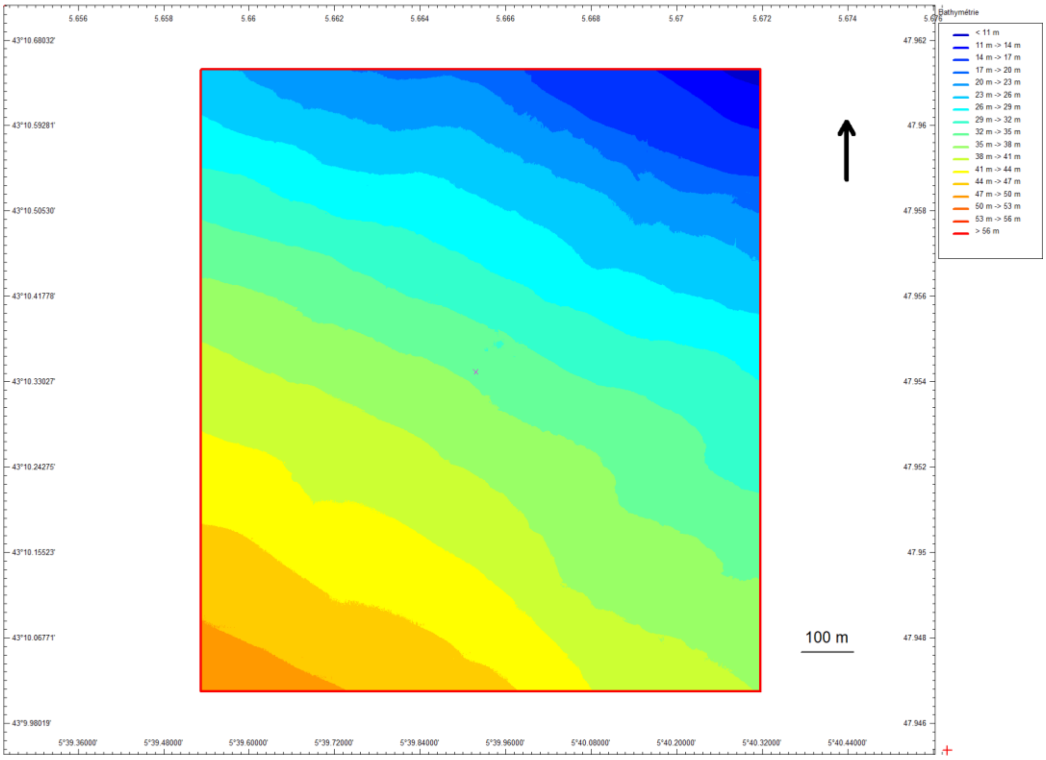

Figure 5: Bathymetric of the area studied in La Ciotat Bay.

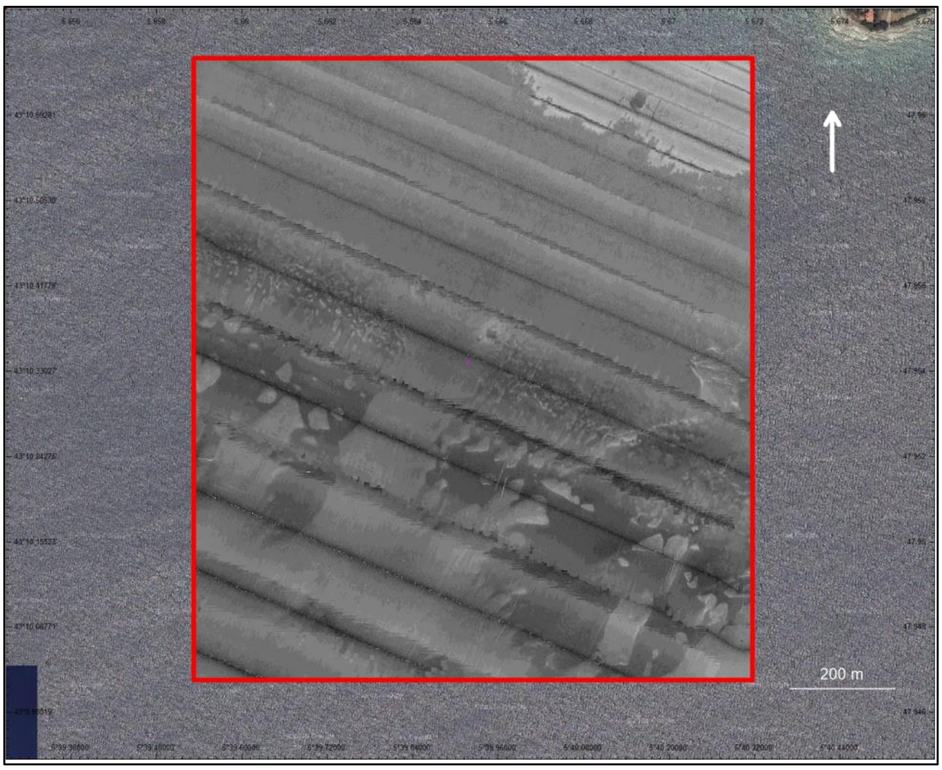

Figure 6: SONAR images of the area studied in La Ciotat Bay.

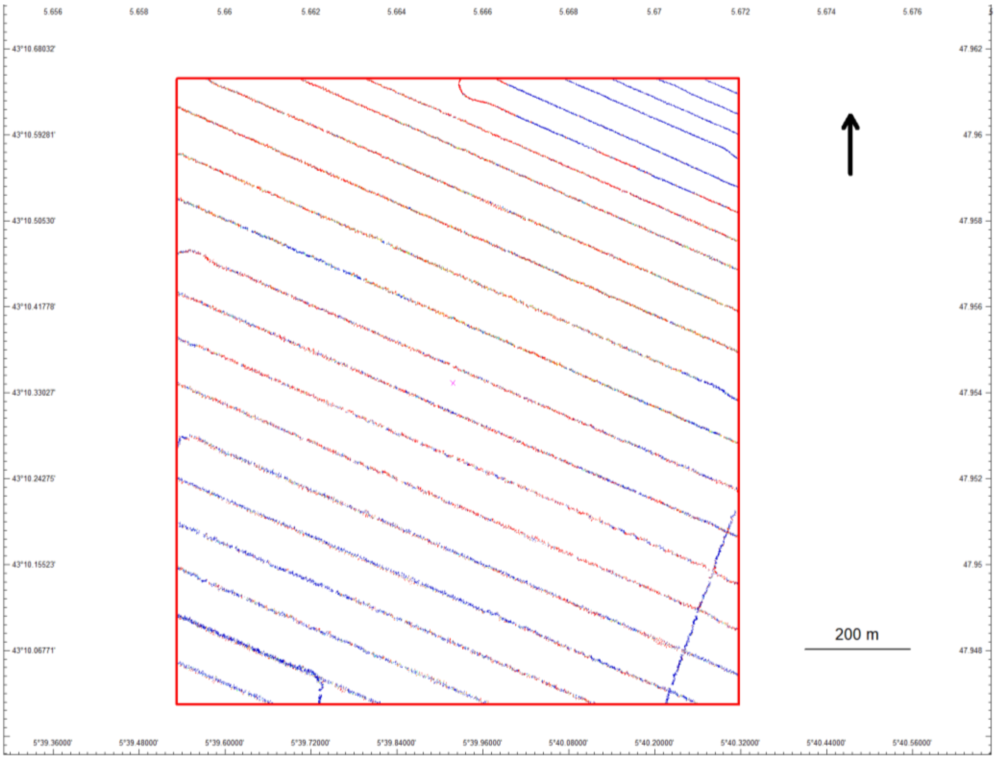

Figure 7: Eco-integration map using an automated classification of the seafloor.

On the BATCLAS index map various types of natural and artificial structures can be seen (Fig. 8). The upper limit of the seagrass meadow (*Posidonia oceanica*) in the north east corner of the map as well as its deep limit are clearly identified (Fig. 8). Small rocks flushing with sediments are also observed. Two types of artificial reefs (one for fish production and one against illegal trawling) are also mapped. The wreck of a World War II aircraft (a famous diving spot) is detected too. At last, some sediment features are observed just like on the SONAR images (Fig. 6).

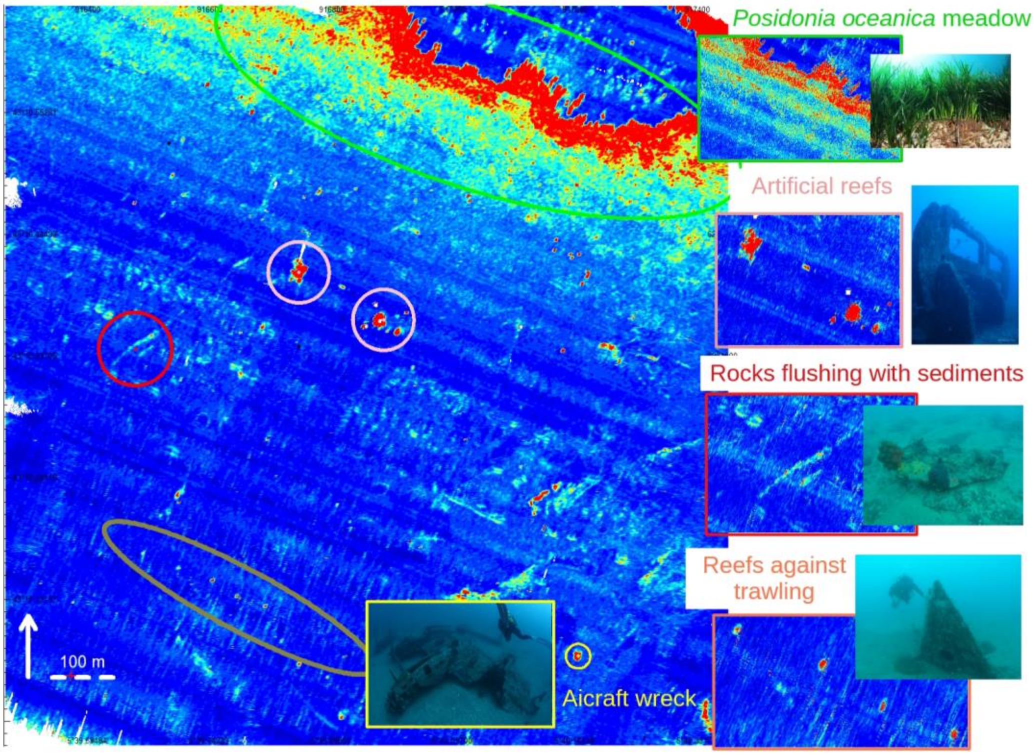

Figure 8: Map of the BATCLAS index and pictures of the ground truth campaign of the area studied in La Ciotat Bay.

Interpretation, findings, prospects and possible developments

In the framework of the SACLAF-SMF project, the use of a MBES for ASAC proved to have several advantages when compared with the use of a SBES:

- the increase of the surface covered and thus a productivity increase
- the use of a single captor to obtain simultaneously bathymetric maps, SONAR images, an automated classification of the seafloor and the BATCLAS index
- an increase of the automated classification depth range without false positive identification: up to 30 m for a SBES and up to 60 m for a MBES in the present study

Despite these advantages, the ASAC with a MBES still requires additional data such as ground truth and aerial photographs (at shallow depth) to generate a complete map of marine habitats. To tackle this issue, the equipment used during the SACLAF-SMF project has been carefully chosen in order to be compact enough for an integration on small boats able to operate in areas not easily accessible. These small ships can be manned vessels such as the "Seaviews One" optimized by Seaviews for acoustic measures and which can carry a scuba diving team; or drones like the Unmanned Surface Vehicle (USV) CAT-Surveyor developed by Subsea Tech (Fig. 9) which can deploy a Remote Operated Vehicle (here a mini ROV) to collect additional ground truth.

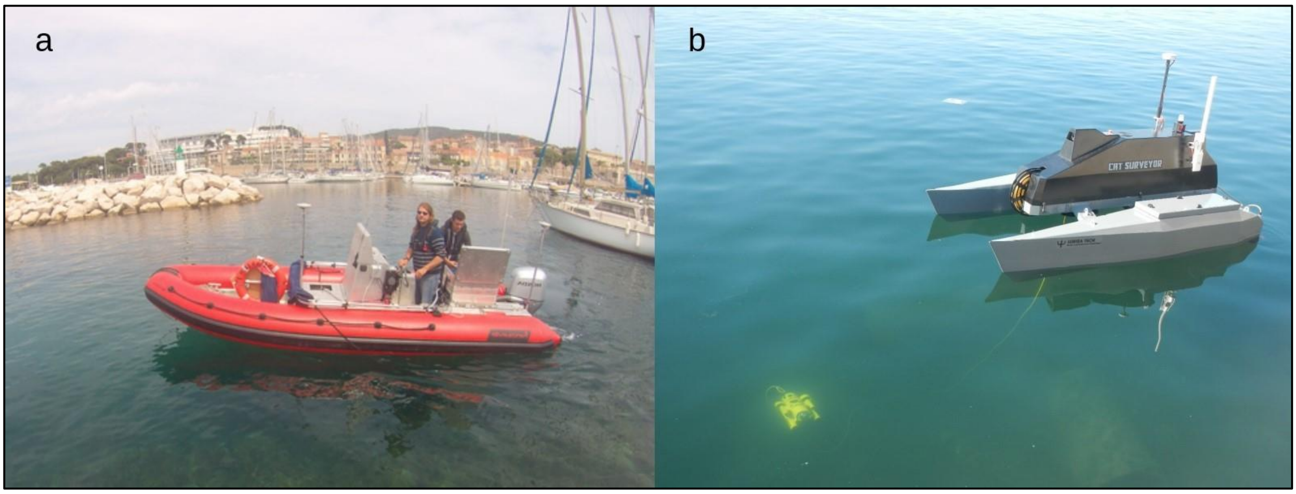

Figure 9: a) The "Seaviews One" optimized by Seaviews for acoustic campaigns; b) The CAT-Surveyor, an unmanned surface vehicle developed by Subsea Tech, able to integrate a multibeam echo sounder for automated seabed acoustic classification.

In an apparently flat study area comparable to those used for wind turbine installation, the use of the BATCLAS index provided valuable information about marine habitats (seagrass meadows, rocks, sediment features) and artificial structures (reefs, wreck) present in the area. Moreover, it has the advantage of providing an exhaustive map of the seabed using a single captor. This approach appears suitable for investigations at a large spatial scale prior to wind farms' settlement in the aim of protecting key habitats from the direct installation impacts.

The first results of the BATCLAS index revealed the potential to use it as a metric data to study and qualify the structural aspects of seagrass beds and sediment features. This next step will require additional ground truth and sampling. However, it will provide in a near future a non-destructive quantitative surface method to monitor the indirect impact over time of wind farms on marine habitats.

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Acknowledgments

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