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MAPPING *POSIDONIA OCEANICA* LOWER LIMIT COMBINING HIGH RESOLUTION INSTRUMENTS (SSS AND MBS)

Abstract
High resolution Side Scan Sonar (SSS) combined with MultiBeam echo Sounder (MBS) was used for mapping Posidonia oceanica lower limit. For this purpose an acoustic survey was performed in Mondello Bay (Palermo, Italy) where a progressive lower limit of the seagrass occured. To improve the positioning precision of the SSS sonograms, data were joined by GIS platform and a repositioning process was performed. In particular, each sonogram was joined with the Digital Terrain Model (DTM) obtained by MBS, in which recognizable shapes of the sea-bottom were used as control points. After the repositioning process of the SSS data, the limit investigated during different periods showed a negligible error in absolute position, with an high level of spatial concordance compatible with the intrinsic error of the system.

Key-words : *Posidonia oceanica*, seagrass lower limit, Sicily, Side Scan Sonar, MultiBeam echo Sounder.

Introduction
The assessment of the status of *Posidonia oceanica* meadows is based on the monitoring of a set of variables among which the progressive lower limit (Pergent-Martini *et al*., 2005). It represents a good indicator because any changing in its position highlights a variation of the environmental condition (Boudouresque *et al*., 2009). Traditionally, the progressive lower limit is identified and monitored by the "*balisage* method" (Meinesz and Laurent, 1978). However, this technique shows many drawbacks as the positioning and the regular maintenance of the *balise*, labor intensive and time consuming of scuba divers (Montefalcone *et al*., 2014). Currently, it is possible to map *P. oceanica* meadows by using high resolution sonar systems, able to provide morphometric and bathymetric information on large surface areas, such as those occupied by *P. oceanica* along the Mediterranean coasts (Di Maida *et al*., 2011 and reference therein). The aim of this research was to apply a powerful and innovative methodology for a fast and accurate mapping and monitoring of *P. oceanica* progressive lower limit.

Material and methods
The investigations were carried out on seabed of the northwest coast of Sicily (Bay of Mondello), characterized mainly by a sandy substratum colonized by an extensive *P. oceanica* meadow (Calvo *et al*., 1993). On June 2010, a preliminary survey was carried out by using a Remote Operated Vehicle (ROV) to find progressive lower limit of *P. oceanica* meadow. Then, on July 2010 and on February 2011, two acoustic surveys were simultaneously carried out by SSS (Klein 3900) and MBS (RESON SEABAT 8125) for acquiring morphometric and bathymetric data. Sonograms obtained by SSS were corrected for speed, direction and TVG (Time Varying Gain). After correction, the sonograms were imported on GIS platform (Esri ArcGIS 9.3) for mosaicing and vectorizing seabed morphologies and *P. oceanica* lower limits. Bathymetric data, acquired

by MBS, were manually processed to remove each bathymetric spike or errors. Therefore, a DTM with a pixel size of 0.5 m^2 was constructed using GIS platform. Both SSS and MBS data for each survey were joined on GIS platform with the primary goal to remove the positioning errors of sonograms by a re-georeferencing process. In particular, each sonogram was matched with the corresponding DTM by the recognizable shapes of the sea-bottom used as control points. Afterwards, ArcGis Spatial Analyst tool was used to calculate the distances between *P. oceanica* lower limits detected during two different surveys. This procedure allowed to extrapolate information about possible position errors. In particular, minimum, maximum and mean error and Standard Deviation were calculated.

Result and discussion

The analysis of the sonograms obtained by SSS, comparing the relative backscatter responses, allowed to easily discriminate by different shades of grey *P. oceanica* meadow and its limit from sandy substratum. The SSS data showed that the meadow exhibited a gradual coverage decrement close to its lower limit according to a progressive limit (Meinesz and Laurent, 1978). Moreover, according to Kamman and Huston (1999), the lower limit positions, acquired in the different periods, showed a wide difference (up to 5 m) in the absolute position. The MBS data allowed to give the bathymetric range of meadow lower limit (28.98 m and 40.17 m) and morphological features of the sea-bottom. Moreover, the comparison of the different DTMs, created by MBS data acquired in the two periods, showed that MBS was able to locate the correct position of every pixel with a negligible error. After the re-georeferenziation process of the SSS data with the relative DTMs, the overlapping of the lower limits investigated during the different periods showed a negligible error in absolute position, with an high level of spatial concordance. Indeed, it was observed a range between 0 m and 0.70 m with an average error value of 0.1 m and a Standard Deviation of 0.0966 m. These results showed that the combining of SSS and MBS data represents a powerful and innovative methodology for a fast and accurate mapping and monitoring of *P. oceanica* progressive lower limit.

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