SPECTRAL LIBRARIES FOR EMERGED AND SUBMERGED SANDY BEACH USING HYPERSPECTRAL DATA

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1. Scientific Issue

Research objective aims at providing field based spectral libraries in order to give feed-back from ecological variability to coastal landscape analysis and management.

?Are the spectral libraries truly representatives of ecological variability**?**
? Detailed maps could serve as a quantification of structural and functional indicators**?**
?Which are the informative thematic layers we can extract for environmental management**?**

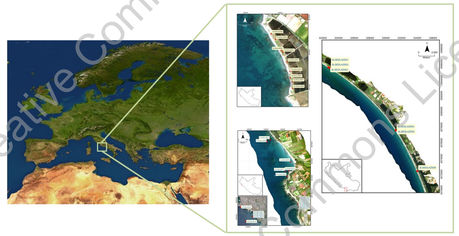
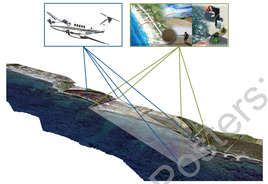


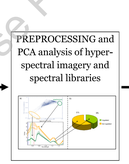
Figure 1 – Study area localized in the Central Tyrrhenian sea (Italy), along the Lazio sandy coasts. Two different stretch of coast are analyzed on the base of MIVIS hyperspectral images (102 spectral channels from Visible to Thermal and 3 m spatial resolution).

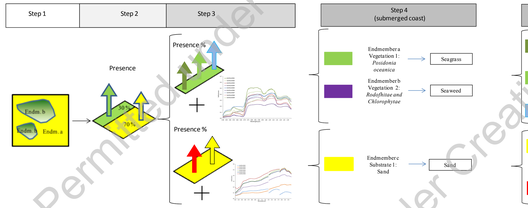
2. Data collection and Methodology

In order to get structural and functional indicators useful in coastal dynamics analysis an accurate field survey was carried out and series of spectral profiles was obtained for sands and vegetation typologies. The spectral libraries database was obtained for two different coastal sandy beaches during three years (2009-2010-2011) of fieldwork. Ten hyperspectral images was collected with the airborne LiDAR—MIVIS acquisitions (2009—2010). Radiometrically corrected imaging spectrometry data were processed with the Spectral Mixture Analysis (SMA—Small, 2004; Taramelli et al., 2004) in order to obtain end-member fraction distributions **(Step 1)**.



PREPROCESSING and PCA analysis of hyperspectral imagery and spectral libraries





The numerical analysis of hyperspectral images quantifies the signal response through thematic maps obtained by classification process. Theme layers consists of set of pixels associated to a cover percent level **(Step 2)** then fraction of pixels are extracted by introducing spectral libraries **(Step 3)** and converted into structural and functional indicators useful in coastal dynamics analysis through the unmixing model **(Step 4)**.

3. Boundary conditions analysis : WATERS

WATERS

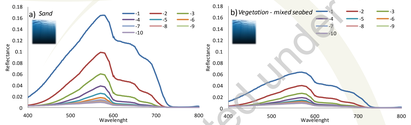


Figure 2 - Simulations of spectral profiles of the water column for bathymetries ranging from 1 to 10 m: a) mixed seabed colonized by vegetation and b) sandy bottom. The effect of the water column are simulated between 0 and 10 m depth with bio – optical modeling (not with SMA). For bathymetries greater than **6-7 m**, reflectance values are reduced to about 5% over the same simulated signal with bathymetry of 1 m in the presence of sandy bottom and about 4% in the presence of *P. oceanica* and seaweeds. Accuracy of the model in the mixed seabed beyond these depths is lower if compared with the detail of mapping these quality parameters. These evidence are used to define accuracy of coastal seabed mapping.

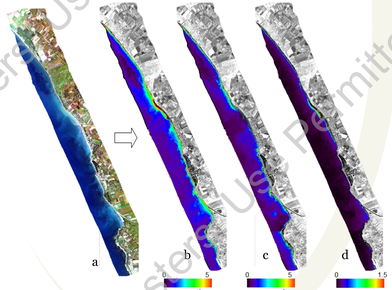


Figure 3 - a) From Image_03_May_2010 - MIVIS, through the application of the bio optical model BOMBER (Giardino et al., 2012) in "optically deep waters" option, maps of concentration b) total suspended solids (TSM), c) chlorophyll-a (Chl-A) and d) yellow substance (CDOM) that shows typical values of coastal marine waters. These results shows that accuracy in mapping is not limited by quality of coastal waters but only by waters optical thickness on the base of seabed reflectance contribution (sand or vegetation).

4. Results: SUBMERGED COAST

SEAGRASS and SEAWEEDS

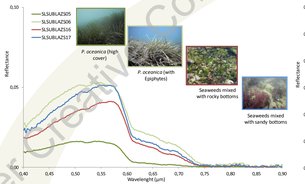


Figure 4—a)In situ spectral library of vegetation presence and cover within the mixed seabed. Spectral signatures of *Posidonia oceanica* more or less dense and matching funds are identified within green (*Chlorophytes*) and red (*Rodophytes*) seaweeds that shows more mixed spectral profiles with combined effects of waters, sandy bottom and algal coverage. The result is a set of signal in which the effect of chlorophyll in the Visible range and the effect of absorption of the water column in the Near Infrared determines maximum reflectance at around 0,50 µm and a strong attenuation of the signal at 0,70 µm. The effect of epiphytes on the spectral signature is analogous to that of a sandy bed in which the *P. oceanica* is sparse.

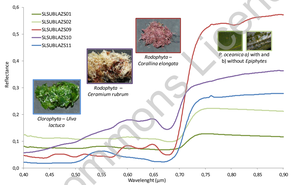


Figure 4—b)Ex situ spectral library for vegetation presence and cover within the mixed seabed. Endmember collection for Spectral Mixing Analysis (Small, 2004; Taramelli et al., 2012) asked for the analysis of pure reflectance/absorption properties of sea grass and seaweeds. For a better analysis of the spectral behavior of these indicators were collected signatures from ex situ and in contact probe that mainly differ in the distance of the instrument from the target analyzed. Without waters interface, radiance is only affected from the atmosphere thickness that with airborne measurement is generally reduced.

BOTTOMS

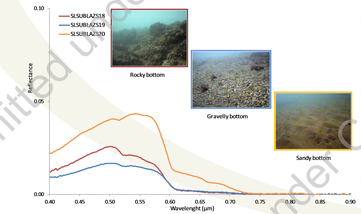


Figure 4—c)In situ spectral library for sandy, rocky and gravelly bottoms within the mixed seabed. Sandy bottom presents higher values of reflectance and its spectral behavior shows a maximum at the wavelengths around 0.55 µm. The spectral behavior of the bedrock and gravel are very similar; both have two maximum reflectance at 0.50 µm and 0.54 µm. The gravel has a total reflectance values lower then rocky and sandy because of the presence of shadows and dark areas created by the pebbles on the bottom.

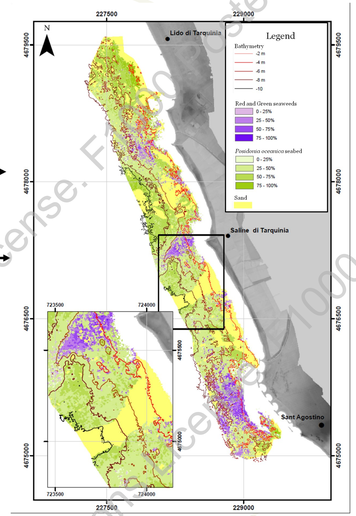


Figure 5 – 1:5000 seabed map. Spectral signature of *P. oceanica* and seaweeds more or less dense on sandy and rocky bottoms from 3 meters deep to the limit of - 10 meters zone. In areas where *P. oceanica* patches are dense and comprised between **-3 m** and **-6 m**, accuracy of mapping allowed classification of presence and cover percent. Where the effect of the bottom on the spectral behavior is almost null and the entire field of view of the sensor is occupied by the set of physical—optical response due to leaves and algal absorption, a major group of marine algae that shows absorption peaks at 0.44 µm and 0.67 µm is detectable.

4. Results: EMERGED COAST

DUNE PLANTS

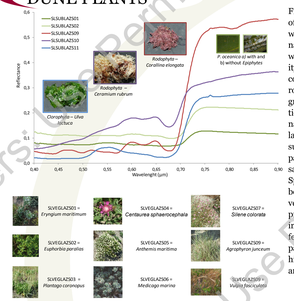


Figure 6— a) In situ spectral library of vegetation presence and cover within the dune cords. Dunes are naturally occurring coastal features with an essential role in the stability of coastal communities. In this context vegetation plays a major role in dune stabilization and growth with its structural functions. The majority of spectral signatures collected was in the grassland and bush/shrub land that we supposed it represents the major part of spectral variability within sandy and vegetated mixed pixels. Spectral library shows differences between green vegetation and dead vegetation. Moreover data collected provides evidence on the flowering influence on spectral signal, this effect increase in low cover percent patches where homogeneous and high reflective sands mix flowering and foliage signal.

BEACH DUNE SEDIMENTS

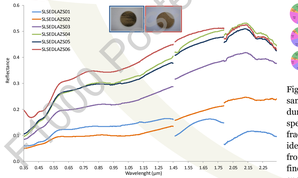


Figure 6—b) In situ spectral library of sands presence and cover within the dune cords. Comparison between field spectra, X-Ray results, grain size and fractions maps from SMA allowed the identification of a model distribution from the northern area where sand is finer and has higher amount of pirroxens (diopside,augite) than the southern area. Based on the idea that mineralogical composition, grain size, moisture and organic matter content affect the spectral response of sediments, comparison between spectral libraries, grain size, mineralogy composition and SMA results on imagery showed a valuable level of accordance.

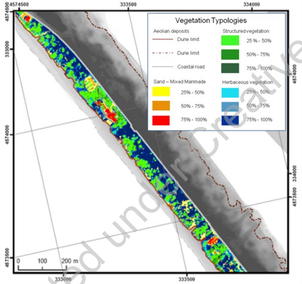


Figure 7 – 1:2000 beach dune map. The unmixing linear model enhanced with in situ spectral libraries of species, allowed classification using 3 or 4 endmembers selection. Observing processing results, structured vegetation is present in patches at the ridge of sand dunes adjacent to the coastal road and interspersed with other plant communities that appear less structured and with low % cover. More internally, in contact with the secondary dunes vegetation there are not yet structured (i.e *hemicrypto-chamaephitic*) shrub land, forming a discontinuous layer with pioneer junipers. These dunes represents the transition between not consolidated phytocoenoses and those of the Mediterranean coastal forestry of consolidated dunes that are back of the ridge (not mapped). For the substrates were selected 'Mixed substrates' and 'Sand and herbaceous' in view of the presence of completely rigid buildings, gardens, fences, private houses, pools, which often coincide with the foot of the dune itself or even go in front zone of the back beach.

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