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Use of SPOT 5 and IKONOS imagery for mapping biocenoses in a Tunisian Coastal Lagoon (Mediterranean Sea)

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ABSTRACT

Mapping marine biocenoses is an efficient method for providing useful data for the management and conservation of Mediterranean lagoons. Fused images from two satellites, SPOT 5 and IKONOS, were tested as management tools for identifying specific ecosystems in the El Bibane lagoon, situated in southern Tunisia near the Libyan border. The objectives of this study were to provide a precise map of the entire El Bibane lagoon using fused images from SPOT 5 and to compare fused images from SPOT 5 and IKONOS over a test-area. After applying a supervised classification, pixels are automatically classified in four classes: low seagrass cover, high seagrass cover, superficial mobile sediments and deep mobile sediments. The maps of the lagoon revealed and confirmed an extremely wide distribution of seagrass meadows within the lagoon (essentially *Cymodocea nodosa*; 19 546 ha) and a large area of mobile sediments more or less parallel to the shore (3 697 ha). A direct comparison of overall accuracy between SPOT 5 over the entire area, SPOT 5 over the test-area and IKONOS over the test-area revealed that these tools provided accurate mapping of the lagoon environment (83.25%, 85.91% and 73.41% accuracy, respectively). The SPOT 5 images provided greater overall accuracy than the IKONOS image, but did not take into account the heterogeneous spatial structure of the seagrasses and sediments present in the lagoon environment. Although IKONOS imagery provided lower overall accuracy than SPOT 5, it proved a very useful tool for the mapping of heterogeneous structures as it enabled the patchiness of formations to be better taken into account. The use of SPOT 5 and IKONOS fused images appears to be very promising for completing the mapping of lagoons in other regions and countries of the Mediterranean Sea.

1. Introduction

Coastal lagoons perform various functions that are essential to the life of the organisms depending on them (feeding, reproduction, shelter, refuge and rest). These biological functions give wetlands a distinctly higher productivity rate than other environments (Kjerfve, 2000). Although they are registered in Annexe I of the EU Habitats Directive as a priority habitat, and some of them are on the list of sites covered by the Ramsar Convention, Mediterranean lagoons are rarely truly protected, and their destruction continues. Increasing anthropogenic pressure on Mediterranean lagoons (industry, agriculture, aquaculture and domestic waste), has led to the decline or even disappearance of seagrasses (Van Lent et al., 1995; De Casabianca et al., 1997; Charpentier et al., 2005; Bernard et al., 2007). Seagrasses constitute a major component of lagoon ecosystems (Duarte et al., 2002; Menendez, 2002; Marzano et al., 2003; Sfriso et al., 2003). These plants are of particular interest in view of their ecological, sedimentological and economic roles (Tamisier and Boudouresque, 1994; Skinner and Zalewski, 1995; Costanza et al., 1997). *Cymodocea nodosa*, which is one of the most important seagrasses in the Mediterranean Sea, is often linked to competition with *Posidonia oceanica*. Its development is generally more extensive in lagoons where *P. oceanica* is absent (Short et al., 2001).

The preservation and management of biodiversity is a major issue for all the countries bordering the Mediterranean Sea and participating in the Action Plan for the Conservation of Marine Vegetation in the Mediterranean Sea (Anon., 2000). In order to reach these objectives, the acquisition of recent, accurate and reliable data about coastal vegetal ecosystems has been shown to be necessary (Pasqualini et al., 1998; Phinn et al., 2005). Mapping

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marine biocenoses (e.g. seagrass meadows) is an efficient method of assessing environmental conditions (Komatsu et al., 2003) and provides useful data for the management and conservation of such ecosystems (Piazzi et al., 2000; Charpentier et al., 2005; Pasqualini et al., 2006; Bernard et al., 2007). The mapping of marine biocenoses has been carried out more in the countries of the Northern shoreline of the Mediterranean. Data concerning marine vegetation in Tunisia reveals a lack of monitoring of this area (Platini, 2000).

Several methods and tools are available for mapping seagrasses (McKenzie et al., 2001). The choice of which tools to use needs to be concomitant with the aim of the study (e.g. size of the area, degree of precision, time/cost budget; Green et al., 1996; Mumby et al., 1999; McKenzie et al., 2001; Mumby and Edwards, 2002). While satellite remote sensing is widely used for large-scale mapping at present, most of the moderate spatial resolution instruments, such as Landsat (TM; spatial resolution 30 m) or SPOT (HRV; spatial resolution 20 m), provide a descriptive resolution of the ecosystem which, though useful, is limited by the pixel size (Mumby et al., 1999). Landsat, SPOT, Quickbird and IKONOS can be used to map seagrasses (Mumby and Green, 2000; McKenzie et al., 2001; Mumby and Edwards, 2002; Andréfouët et al., 2003; Pasqualini et al., 2005; Phinn et al., 2005; Dekker et al., 2006; Fornes et al., 2006). IKONOS can only be a cost-effective option if (1) independent field data are available to identify habitat patches, (2) the area to be mapped is fairly small ($<500\ km^2$) and (3) small-scale (<10 m) habitat dynamics are to be monitored (Mumby and Edwards, 2002). Research in progress therefore aims to improve the resolution of mapping without, however, reducing the area under study. The SPOT 5 satellite launched in May 2002, and IKONOS satellite launched in September 1999, provide fused multispectral images at high-resolution (2.5 m and 0.60 m, respectively). These fused images are obtained by combining multispectral and panchromatic images taken simultaneously and are produced by the image provider. Despite the references concerning the use of satellite imagery for seagrass detection, there were no references for the use of SPOT 5 and IKONOS satellite imagery (fused images) for mapping seagrasses in lagoons.

The aim of this study was to test the use of SPOT 5 and IKONOS fused images for mapping seagrasses in lagoons. The investigations were carried out on the El Bibane lagoon (Tunisia, Mediterranean Sea; Fig. 1), about which little information was known concerning seagrasses. SPOT 5 fused imagery was used to provide a precise map of the main benthic assemblages and bottom types of the entire El Bibane lagoon, and the SPOT 5 and IKONOS fused images were then compared over a test-area.

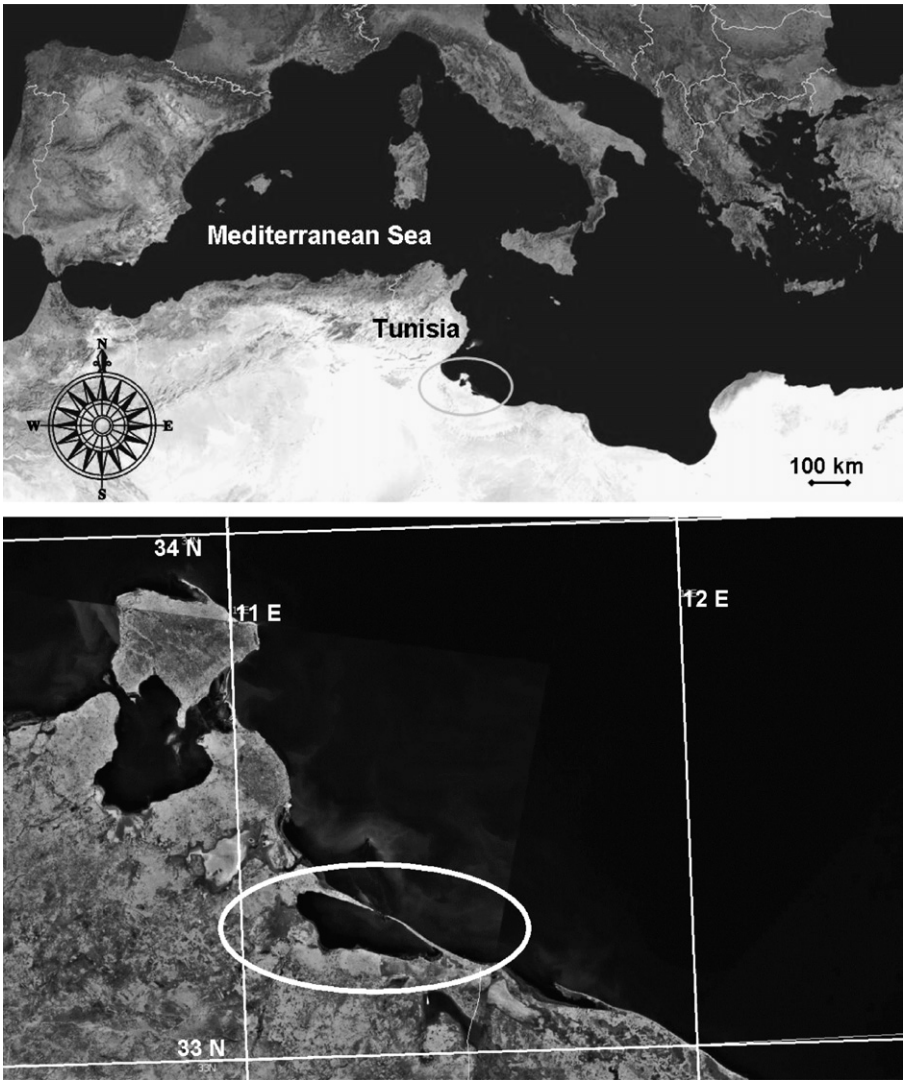

Fig. 1. Location of the El Bibane lagoon, situated in southern Tunisia near the Libyan border.