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MAPPING OF NATURA 2000 SEAGRASS HABITATS USING REMOTE SENSING TECHNIQUES

INTRODUCTION: Under the requirements of the European Union Habitats directive 92/43 (NATURA 2000) the Greek government, through the Ministry of Environment, funded an extensive project concerning the identification and mapping of several important marine habitats as they are described in Annex I of this directive. Among them the meadows formed by the seagrass species Posidonia oceanica, Cymodocea nodosa, Zostera sp. and Halophila stipulacea are considered priority habitats.

The project is carried out by four Greek research institutions namely the Institute of Marine Biology of Crete (I.M.B.C.), the National Centre of Marine Research (N.C.M.R.), the Institute of Fisheries Research (I.F.R.), and the Biology department of A.U.TH. and will be finished by the end of the year 2000. The project is ongoing and a total of 67 marine sites will be mapped by the end of the project. The relevant results and electronic maps produced by this project will constitute the major coastal database in Greece.

METHODOLOGY: The marine NATURA sites in Greece are distributed all over the extensive and complex coastline of Greece. For the purposes of the mapping project, the boundaries for almost all the sites were the coastline (0m depth) and 50m depth that can be considered the theoretical down limit of the seagrass beds. The accurate mapping of the sub-littoral environment within these boundaries needs an integration of airborne data for the shallow part and acoustic data for the deeper part overlapping the limits that each method has. The airborne data is limited mainly by the water depth and clarity and the acoustic data by the operational and maneuverability capabilities of the research vessel.

The combination of these techniques has been the subject of some previous research (Sotheran et al., 1997, Pasqualini et al., 1998) and for the production of detailed maps of the entire sublittoral environment at present can be considered best practice.

The aerial photographs used for the mapping of the shallow part of the designated sites were high-resolution color photographs (1:5000). For the mapping of the deeper part of the designated sites there were two systems available namely the acoustic ground discrimination system RoxAnn™ and a side scan sonar. These systems were pre-tested during the preparatory stage of the project in order to evaluate their operational capabilities in relation to the mapping project, which demands the scanning of huge areas in a limited time and the identification of several types of biotopes with different reflectance properties. It is well known that side scan sonars give a good signal of the P. oceanica beds because of the formations that this species produces above the sea floor. Furthermore, the combination of the sonograms can result in an accurate map of the limits and distribution of the bed. On the other hand this method is limited as it is time consuming because of the extended ship time that is needed and is unable to discriminate properly between sediment and other benthic habitats with less elevated formations than P.oceanica.

The RoxAnn™ system collects data using transducers mounted on a research vessel. Using this setup it is possible to operate the system at speeds of up to 15 knots while simultaneously performing ground validation by deploying a video sledge from the research vessel. During the preparatory stage of the project the system also proved capable of discriminating between dense, elevated formations of P.oceanica and other formations like dense Cymodocea nodosa, Halophila stipulacea and Caulerpa prolifera beds. The limitation of this system lies in the type of data that are produced. These are point values that need post data collection processing through interpolation in order to produce a map. For this reason the RoxAnn™ system does not give a very precise representation of the spatial distribution of the benthic habitats.

Nevertheless, because of the characteristics detailed above it was decided that the RoxAnn™ of the I.M.B.C. should be used. On board the research vessel «PHILIA» it is connected to an EK-500 Simrad Scientific echosounder, to a portable PC and to the DGPS FUGRO SEA STAR system of the ship. For the ground validation requirements the OSPREY video camera on a sledge was deployed concurrently with the acoustic scanning transects, with the entire system operating at a constant speed of 2 knots. Furthermore, when it was needed, the Smith-McIntyre grab was used to sample vegetation from a soft bottom. For ground validation of formations in shallower areas diving from an inflatable was performed. The inflatable was also equipped with Sonar and a portable GPS for sampling the shallow depth points.

Given the boundaries of the areas under consideration RoxAnn™ sampled the return echo from the 120kHz transducer as this provides good ground discrimination for depths down to 60m. The RoxAnn™ stores the geographical coordinates, the depth and the roughness (E1) and hardness (E2) of each of the seabed points on-line (Chivers et al., 1995). The track spacing varied and was dependent on the bottom topography and the maneuverability of the vessel, with 500m being the widest track spacing.

The final sea grass mapping resulted from integration of sonar (RoxAnn™) and aerial photography data. Both data types were inserted into an ARC/INFO GIS environment as point coverages (sonar data) and images (aerial photography). The thematic coverages and images were geo-located under a common geo-reference system (Transverse Mercator with the units in meters) as described by Valavanis et al. (1998). The basic coverage for this was a 1:50,000 digital map of the coastline provided by the Hellenic Ministry of Environment. Sonar data were organized into ARC/INFO coverages of point topology while aerial photographs were registered and rectified and used as the basis for on-screen digitizing of habitat polygons. The digitized ARC/INFO coverages of polygon topology were converted to coverages of point topology. This conversion allowed the combination of the two point coverages of habitat data (RoxAnn™ and aerial photography) into one point coverage. This combination was performed in order to interpolate coast-neighboring data (aerial photographs) with coast-distant data (RoxAnn™). Subsequently, point values were interpolated using the ARC/INFO TOPOGRID tool, which is based on the ANUDEM program (Hutchinson, 1993), as described by ESRI ARC/INFO Help Documents.

RESULTS-DISCUSSION: As an example of the application of the above methodology presented here is the map of Grandes bay (fig.2), which is located in the N.E. coastal part of the island of Crete. This NATURA site was chosen because it contains the two main soft bottom vegetation habitats, namely the Posidonia oceanica bed and the mixture of Cymodocea nodosa, Caulerpa prolifera and Halophila stipulacea bed.

The values of main signal classes from RoxAnn™ are shown in Figure 1. The classes were produced on-board according to ground validation. The distribution of the values of E1 and E2 for these classes revealed differences between the habitats and permitted their identification. It is interesting to note that not only are the two vegetated habitats distinct from each other but also that they are separable from the surrounding bare sediment types. The sediment types are more or less the same underneath the two vegetation types, which indicates that the type of vegetation (long or short leaves) has an impact on the reflectance of a sediment type. (For simplification reasons in the map we do not show the several bare sediment types).

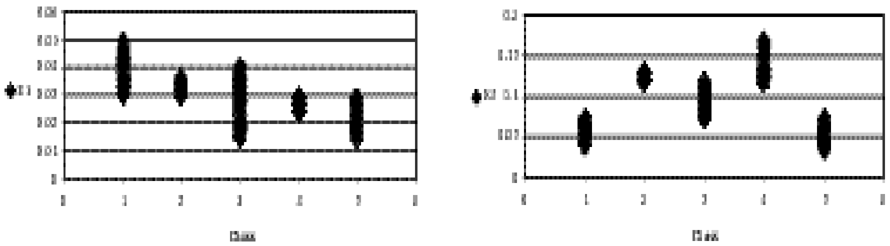

Figure 1. Scatterplots of E1 and E2 values against several habitat types, where: 1 is P. oceanica, 2 is Bare Sand, 3 is C. nodosa - C. prolifera - H. Stipulacea, 4 is Muddy Sand, and 5 is Mud.

The P. oceanica bed in Grandes bay has a limited coverage and appears dense and homogeneous only in the area between the coastline and the inlet. The trawling activity in Grandes bay used to be severe and probably resulted in the decline of more extended P. oceanica beds where there are now only small beds. What is left today between the inlet and the coast is in an area where it is difficult to trawl.

Most of the area of this site is covered by the C. nodosa, C. prolifera and H. stipulacea beds, which extend from 10m depth down to 50 m. The coexistence of C. nodosa and C. prolifera constitutes the main characteristic habitat for the coastal area of Crete (Siakavara, 2000). This coastal area is an unstable environment with a narrow continental self and a high exposure. In some areas around Crete these two species are accompanied by the H. stipulacea, especially in deeper areas (20-25 m depth) where there is a steeper slope. In the area of Grandes bay the most extensive, dense and deep formation of these 3 species was found. In particular, the presence of dense mats of H.stipulacea in this area is located on the slope (see Figure 2 and 3), a finding that agrees with the observations of Lipkin (1975 b).

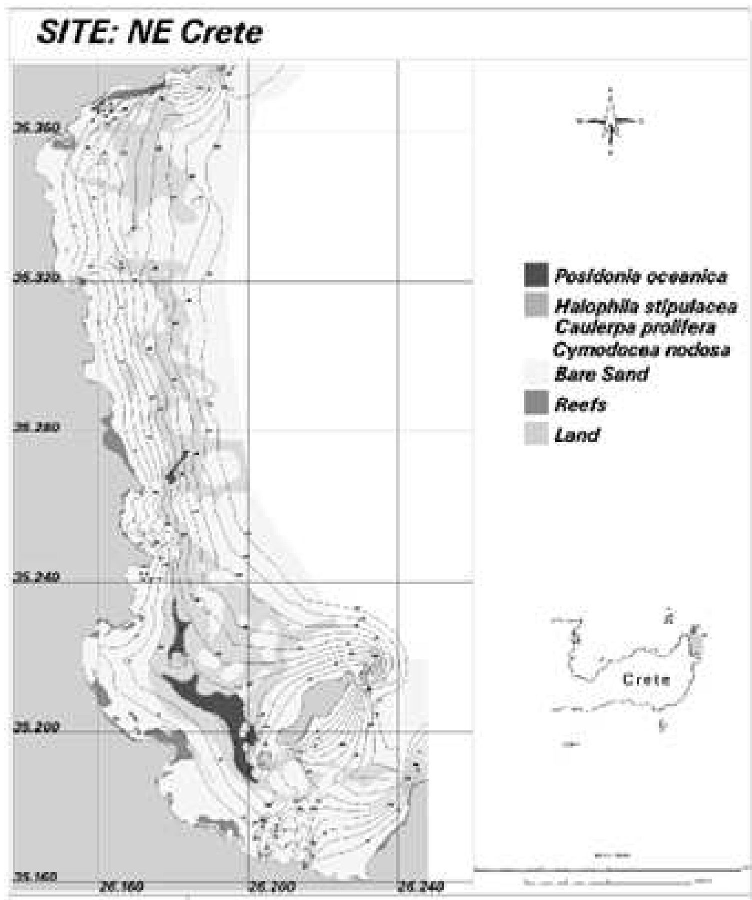

Figure 2. Map of NATURA habitat types in the Grandes bay area of NE Crete (1:16000, 5m contours)

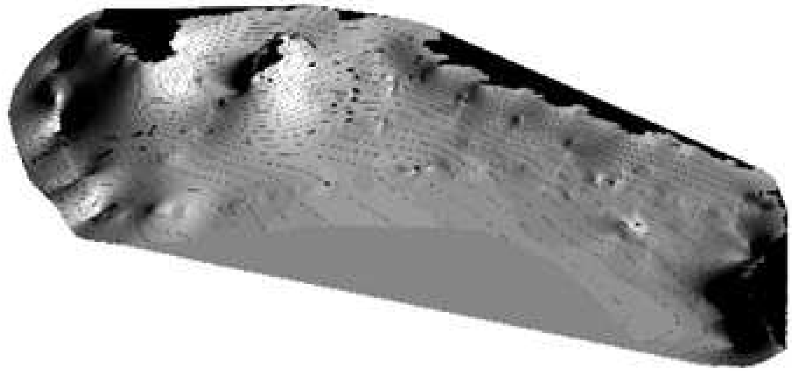

Figure 3. Bathymetry Visualization for the Grandes bay area of NE Crete (5m contours) showing the general slope (exaggeration factor of 7) and major topographical features

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STATUS OF MARINE VEGETATION IN SLOVENIAN COASTAL WATERS

KEY-WORDS: NORTH ADRIATIC, SLOVENIA, MARINE VEGETATION

INTRODUCTION

The Gulf of Trieste is a shallow marine ecosystem where characteristics of the coastal and open waters of the Northern Adriatic are combined. With few exceptions the depth does not exceed 25 m. Because of its shallowness and the freshwater inputs as well, the waters of the gulf experience considerable temperature (8 - 26∞C) and salinity (33 - 38‰) variations. Also remarkable is the tidal amplitude, which can be as much as 1.5 m. The marine vegetation in the Slovenian part of the Gulf of Trieste is at present going through a re-population process. In the first seventies (1972/73) the vegetation experienced a severe decline due to a population explosion of the echinoderm Paracentrotus lividus.

MATERIALS AND METHODS

The paper was written with the aim of giving a general idea of the marine vegetation in the Slovenian coastal waters and thus prepared according to the available existing data and some topographical and ecological informations, gathered during recent field trips.

Regular and systematic research of the benthic flora in the Slovenian coastal waters has been carried out for more than 25 years now (Bussani and Vukovic, 1987; Giaccone, 1978; Turk, 1991; Vricer et al., 1981; Vricer and Vukovic, 1996; Vukovic, 1980; Vukovic, 1982; Vukovic, 1984; Vukovic and Semroud, 1984).

In 1999 the Marine biological Station started a five year project with the aim of assessing the degree of biodiversity of habitat types, biocenosis and species in the Slovenian coastal waters.

RESULTS

The geomorphological characteristics of the Slovenian coastal area - alluvial plains sinking into shallow bays on one hand and steep flysch cliffs on the other, are reflected in the general distribution of marine vegetation in the Slovenian coastal sea. The muddy and sandy bottoms of the shallow bays are overgrown mainly with Cymodocea nodosa and to a much lesser extent with Zostera marina and Zostera noltii. An exception to this rule is a tiny and only meadow of Posidonia oceanica on the southern part of the Gulf of Koper. The meadow is approximately 1 km long, it starts close to the coastline and extends 50 meters offshore, where water depth reaches 4 meters. The maximum depth for the meadows (C. nodosa) is 6 meters in the bay while it is 10 meters along the rest of the coastline.

At the foot of the cliffs the hard bottom is to be found down to a maximum of 16 meters deep. The hard beds, stones and pebbles are overgrown with algae. At present the most common species are the following: