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## INTERTIDAL BIOTOPES OF SANTA MARIA ISLAND (AZORES): MAPPING AND PREDICTING GEOGRAPHICAL DISTRIBUTION

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### INTRODUCTION

Coastal areas present valuable biodiversity and provide the means for the establishment and development of human activities (Bellan & Bellan-Santini, 2001). The pressure driven by those activities mitigates the ecosystems' ability to recover, thus highlighting the need for proper coastal management (Lacerda, 2003). Environmental management puts increasing demand on spatial surveys of marine ecosystems that support a wide array of habitats with diverse associated biotic assemblages. If these are to be protected then identification of their variety and delineation of their spatial extent and boundaries are required. Modelling patterns of community distribution suggested by Zacharias & Roff (2001) and Zacharias et al. (1999) propose models for predicting spatial distribution of intertidal communities based on biological and environmental data. In addition, the wide use of Geographic Information Systems (GIS) for graphic representation of habitats and biotic communities highlights the need for scientifically accurate maps for integrating environmental management processes (Johnson, 1990; Mironga, 2004). Recent coastal community classifications have been developed based on biotic and abiotic associations - biotopes - with management concerns (Tittley Neto, 2000; Wallenstein & Neto, 2006; Wallenstein et al., in press) though not focusing on mapping these with environmental planning purposes. Legal protection areas of the Azores consist of Natura 2000 sites and Protected Areas, both created to protect the natural patrimony. In this context, based on a recent study by Wallenstein et al. (unpublished data) on algae-based biotopes for three substrate categories (cobbles, boulders and bedrock) of Santa Maria and São Miguel islands (Fig. 1), the present study intends to create a tool to predict intertidal algae communities' geographic occurrence on Azorean coasts. The overlap of such information with further ecological information and environmental legislation is intended to be used in further studies on the ecology of intertidal communities of the Azores and for management purposes.

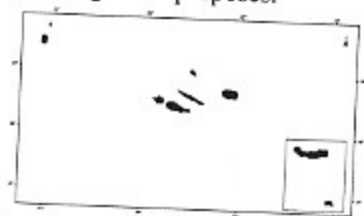


Fig. 1 - Map of the Azorean archipelago. Insert with Santa Maria (bottom) and São Miguel (top) islands.

### METHODS

Bio-geo-morphological data used for the present study was collected using a balanced sampling design regarding substrate type (cobbles, boulders and bedrock), and a total of 15 study sites were surveyed. At each site transect lines were used for recording the starting and ending points of selected ecological categories used for biotope definition: green algae; calcareous turf; non-calcareous turf; *Stypocaulon scoparium* / *Halopteris filicina*; *Laurencia* spp. / *Osmundea* spp.; erect calcareous; calcareous crusts. For each ecological category's shore height distribution calculations were made for: maximum average height (MH), minimum average height (mH) and respective standard deviations (SDM and SDm). For generalization purposes it was assumed that the probability of finding each category on the shore is 100% between its respective MH and mH, decreasing proportionately to 0% from MH to (MH+SDM), and from mH to (mH-SMm) (Fig. 2).

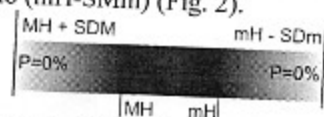


Fig. 2 - Scheme for the probability distribution of ecological categories along the shores of Santa Maria.

Additionally, the average percentage cover of each ecological category [Wallenstein et al. (unpublished data)] was considered constant within 5 shore levels of the same amplitude [(max MH+SDM)/5]. Consequently, the distribution of biotopes on the shores of Santa Maria results from the conjunction of two distribution criteria: (i) probability of occurrence; and (ii) average % coverage. On each of the 3 substrata shore coverage of each ecological category varies with shore height according to the following formula:

$$PO_i \times A\%C_{Li}$$

PO - probability of occurrence

A%C - average percentage coverage

i - shore height [0 to (max MH+SDM)]

Li - shore height level (L1 to L5)

$$0 \leq L1 < (\max \text{MH} + \text{SDM}) / 5$$

$$(\max \text{MH} + \text{SDM}) / 5 \leq L2 < 2 * [(\max \text{MH} + \text{SDM}) / 5]$$

$$2 * (\max \text{MH} + \text{SDM}) / 5 \leq L3 < 3 * [(\max \text{MH} + \text{SDM}) / 5]$$

$$3 * (\max \text{MH} + \text{SDM}) / 5 \leq L4 < 4 * [(\max \text{MH} + \text{SDM}) / 5]$$

$$4 * (\max \text{MH} + \text{SDM}) / 5 \leq L5 < (\max \text{MH} + \text{SDM})$$

This model was combined with substratum distribution charts and shore altimetry data by using a Geographical

Information System for predicting each ecological category's shore coverage around the island of Santa Maria. Biotopes were then mapped with ArcGIS 9.1® and biotope distribution subsequently overlaid to graphic representation of legally protected sites to assess the level of protection of the defined biotopes.

## RESULTS

Spatial distribution of intertidal communities shows a higher density in bedrock sites than on boulders, followed by cobbles. Cobbles present a higher occurrence of "green algae", while boulders and bedrock share a greater incidence of turfs (Fig. 3).

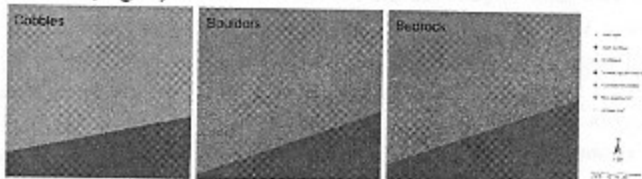


Fig. 3 – Spatial distribution of intertidal communities on cobbles, boulders and bedrock sites.

Intertidal biotopes are distributed along the rocky shores of Santa Maria and cover 85.64% of the total intertidal mapped area for this island (Fig. 4). The island's protected sites cover approximately 50.11% of the total intertidal biotope predicted area (Fig. 5).

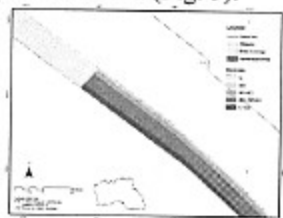


Fig. 4 – Intertidal biotopes distribution on Santa Maria.



Fig. 5 – Intertidal biotopes distribution and overlay with protected sites on Santa Maria.

## DISCUSSION

Modelling distribution patterns of intertidal communities has proved to reflect previous biotope description (Wallenstein & Neto, 2006), as well as substratum influence on intertidal communities described in Macedo (2002). As such, the proposed model proved useful and accurate to the extent needed for representing biotopes on Azorean shores. Cartography process allowed determining that intertidal biotopes cover a significant percentage of the total mapped area on Santa Maria. Santa Maria's biotopes are covered by protection sites to a great extent, and might thus be indicative of an excessive protection of the coast on that island. Protected Areas, although representing a strong protective tool, might also have a negative impact on traditional implemented activities such as tourism and fisheries, consequently mitigating economical development. Consequently, it might be worth considering the reduction of such protection areas to levels that are acceptable from both points of view – conservationism and economic

development. However, these levels have never been defined for intertidal algae communities. The definition of minimum areas that assure maximum effectiveness in protecting intertidal communities would help greatly as a guideline for the definition of intertidal protection areas.

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