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Objective automated classification technique for marine landscape mapping in submarine canyons

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ABSTRACT

This study proposes a fully automated and objective technique to map marine landscapes in submarine canyons. The method is suitable for broad and regional scale mapping derived from sonar data using multivariate statistical analysis. The method is divided into two main parts: the terrain analysis and the multivariate statistical analysis. The first part aims to optimise the sonar data and comprises three steps 1) data resampling, 2) determination of length scale, and 3) multiple scale analysis. The second part covers the actual marine landscape classification and consists of 1) principal component analysis (PCA), 2) K-means clustering, and 3) cluster determination. In addition, a confidence map is presented based on cluster membership derived from cluster distance in attribute space.

The technique was applied in the Lisbon–Setúbal and Cascais Canyons offshore Portugal. The area was classified into 6 marine landscapes that represent the geomorphological features present in submarine canyons. The main findings from the study are 1) the transferability of a tool from geomorphometric analysis – Estimation of Scale Parameter (ESP) – to detect the length scale of potential patterns in bathymetric grids; 2) multiple scale terrain analysis allows an appropriate discrimination of local and broad scale geomorphic features in marine landscape mapping; 3) the method not only delineates geomorphic seafloor features but also points out properties that might influence biodiversity in a complex terrain.

1. Introduction

Over the past decade, the ongoing effort to develop an efficient and reliable method to map and study benthic habitats in various environments has promoted the advancement of classification techniques in the habitat mapping community (Brown et al., 2011). Benthic habitats are physically distinct areas of seafloor that are associated with particular communities of plants and/or animals. Of those two components that structure a benthic habitat – the physical environment and the species community – it is often the detailed species information that is lacking during seafloor characterisation. General geophysical mapping is therefore commonly used as the basis for benthic habitat mapping. Advances in sonar technology now permit seafloor imaging with high resolution and wide coverage using a wide variety of instruments and systems of different frequencies and resolutions (Hayes and Gough, 2009; Hansen et al., 2011; Nakanishi and Hashimoto, 2011; Paull et al., 2013; Harris et al., 2014; Wynn et al., 2014). These data can be used to depict various seafloor geomorphic features and interpreted to provide potential habitats represented on a marine landscape map.

"Marine landscape" is a concept introduced originally by Roff and Taylor (2000), who developed a classification based on enduring geophysical features that reflect changes in biological community compositions. They emphasized the importance of identifying and conserving representative spaces or landscapes rather than preserving individual species. They produced a classification using geophysical features to identify representative and distinctive benthic habitats supporting different communities, which works as an ecological framework for marine conservation.

Based on this fundamental concept, the marine landscape in this study is defined as an environment distinguished by its abiotic characteristics with a potential to provide colonization ground for specific biological assemblages. This approach has been applied successfully in the marine realm, specifically in shallow water environments (Al-Hamdani et al., 2007; de Grosbois et al., 2008; Verfaillie et al., 2009; Kotilainen and Kaskela, 2011). On a global scale a similar approach was used to segment the ocean floor based on a multivariate analysis of biophysical data by Harris and Whiteway (2009).

Although the aim of the studies mentioned above is similar, i.e., to classify the seabed in relation to its biological association, either for managerial purposes or to predict biological occurrences, each study offers a different methodology. The methods vary from the conventional

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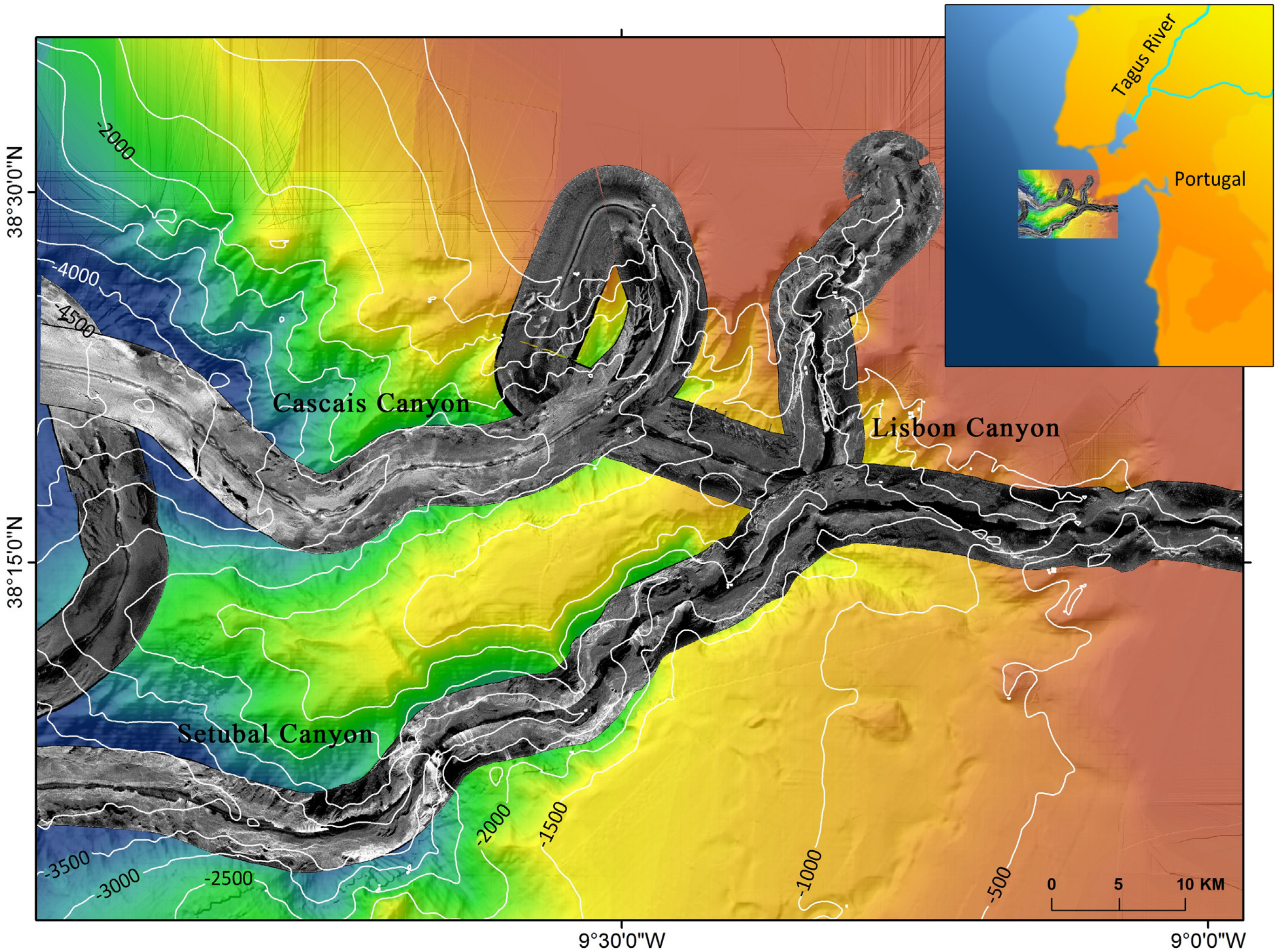

Fig. 1. Bathymetry map of Lisbon–Setúbal and Cascais Canyons offshore Portugal, overlain by TOBI sidescan sonar imagery coverage. Contour interval is 500 m. The inset map shows the location of the study area relative to the location of Portugal.

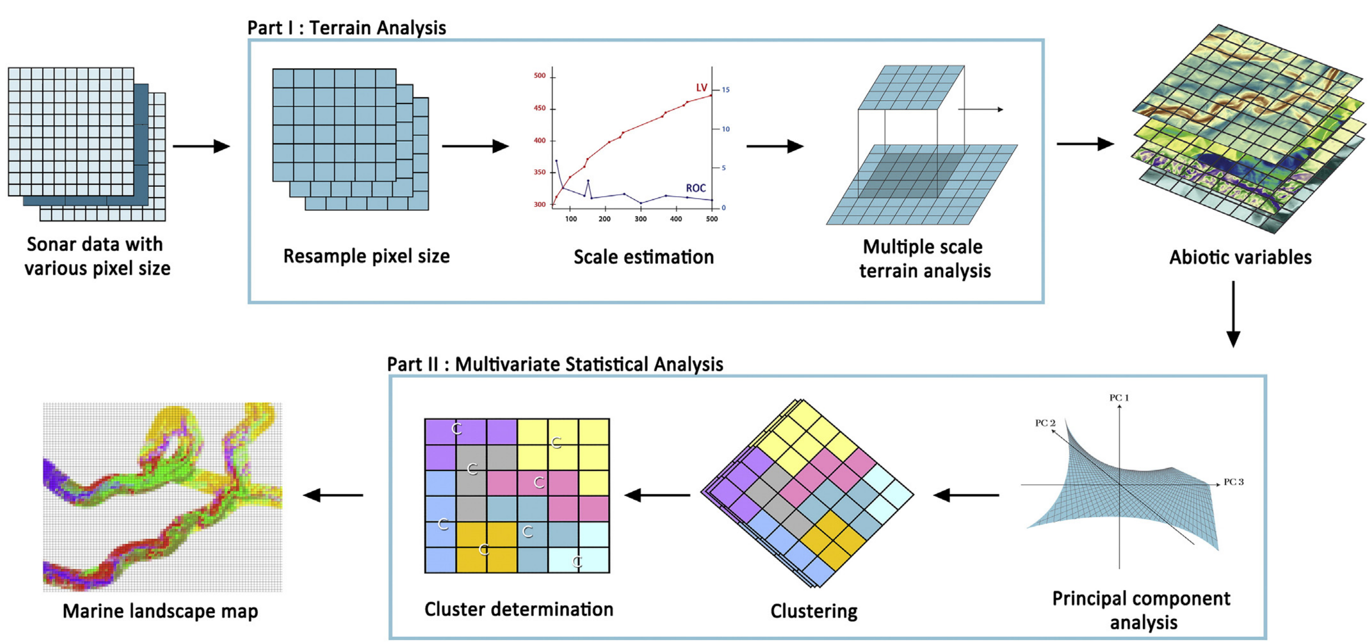

Fig. 2. A simplified flow chart of the automated and objective techniques used to produce marine landscape maps for submarine canyons. The method consists of two parts; terrain analysis and multivariate statistical analysis.