DEVELOPMENT OF TECHNIQUES TO CLASSIFY MARINE BENTHIC HABITATS USING HYPERSPECTRAL IMAGERY IN OLIGOTROPHIC, TEMPERATE WATERS

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This thesis is presented for the degree of Doctor of Philosophy in the School of Environmental Science, Murdoch University

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Declaration

I declare that this thesis is my own account of my research and contains, as its main content, work which has not been previously submitted for a degree at any tertiary education institution.

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Abstract

There is an increasing need for more detailed knowledge about the spatial distribution and structure of shallow water benthic habitats for marine conservation and planning. This, linked with improvements in hyperspectral image sensors provides an increased opportunity to develop new techniques to better utilise these data in marine mapping projects. The oligotrophic, optically-shallow waters surrounding Rottnest Island, Western Australia, provide a unique opportunity to develop and apply these new mapping techniques. The three flight lines of HyMap hyperspectral data flown for the Rottnest Island Reserve (RIR) in April 2004 were corrected for atmospheric effects, sunglint and the influence of the water column using the Modular Inversion and Processing System. A digital bathymetry model was created for the RIR using existing soundings data and used to create a range of topographic variables (e.g. slope) and other spatially relevant environmental variables (e.g. exposure to waves) that could be used to improve the ecological description of the benthic habitats identified in the hyperspectral imagery. A hierarchical habitat classification scheme was developed for Rottnest Island based on the dominant habitat components, such as *Ecklonia radiata* or *Posidonia sinuosa*. A library of 296 spectral signatures at HyMap spectral resolution (~15 nm) was created from >6000 *in situ* measurements of the dominant habitat components and subjected to spectral separation analysis at all levels of the habitat classification scheme. A separation analysis technique was developed using a multivariate statistical optimisation approach that utilised a genetic algorithm in concert with a range of spectral metrics to determine the optimum set of image bands to achieve maximum separation at each classification level using the entire spectral library. These results
determined that many of the dominant habitat components could be separated spectrally as pure spectra, although there were almost always some overlapping samples from most classes at each split in the scheme. This led to the development of a classification algorithm that accounted for these overlaps. This algorithm was tested using mixture analysis, which attempted to identify 10,000 synthetically mixed signatures, with a known dominant component, on each run. The algorithm was applied directly to the water-corrected bottom reflectance data to classify the benthic habitats. At the broadest scale, bio-substrate regions were separated from bare substrates in the image with an overall accuracy of 95% and, at the finest scale, bare substrates, *Posidonia*, *Amphibolis*, *Ecklonia radiata*, *Sargassum* species, algal turf and coral were separated with an accuracy of 70%. The application of these habitat maps to a number of marine planning and management scenarios, such as marine conservation and the placement of boat moorings at dive sites was demonstrated.
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