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Linking morphometric characterisation of rocky reef with fine scale lobster movement

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Abstract

Despite the importance of seafloor topography of rocky reef systems, there is no consensus in the literature about how to define and measure the complexity of seafloor structure. Often a simple 'rough versus smooth' or 'structure versus no structure' characterisation is made. By applying surface analysis theory, developed by terrestrial ecologists, features within a seabed digital terrain model (DTM) can be identified and levels of uncertainty placed on the classification of individual features. Classification models developed using these techniques have specific advantages over traditional techniques of generating habitat maps in they are non-subjective, scale-independent, are quantifiable and are repeatable. Using habitat classification models, generated at biologically relevant scales, we present examples between movement and habitat utilisation of the southern rock lobster *(Jasus edwardsii)* and prominent features in rocky reef habitats. Incorporating habitat complexity models with fine-scale movement, at an appropriate spatial scale, has specific applications in future marine protected area design and represents the next step in managing the Tasmanian rock lobster fishery with an estimated wealth in excess of AU$ 70 MPa.

Keywords: Rocky reef characterisation; Digital terrain model; GIS; Fine-scale habitat mapping; Animal tracking; Home range analysis

1. Introduction

Seafloor topographic complexity is ecologically important because it provides a habitat structure for juvenile and adult animals (Beck, 1997, 1998; Commito and Rusignuolo, 2000; Kostylev et al., 2003) and plays a role in regulating foraging patterns (Erlandsson et al., 1999). Perhaps most significantly, it alters the boundary-layer flow over the seabed (Ke et al., 1994; Green et al., 1998) which affects larval settlement and subsequent population performance because it controls delivery of food, oxygen, and chemical cues (Leonard et al., 1998; Lenihan, 1999). Surface complexity of reef systems also influences erosion, transport and deposition of sediment (Widdows et al., 1998) and the biodiversity of macrofauna (Lacroix and Abbadie, 1998).

Despite the importance of seafloor topography of rocky reef systems, there is no consensus in the literature about how to define and measure the complexity of seafloor structure. Often a simple 'rough versus smooth' or 'structure versus no structure' characterisation is made (Mouritsen et al., 1998). Other works have attempted more quantitative estimates of structure by extracting information from cross sectional

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profiles of the bottom (Ke et al., 1994; Beck, 1997; Cutter and Diaz, 1998; Hill et al., 1999; Kostylev et al., 2001; Garza-Perez et al., 2004). The seabed roughness calculation (Ke et al., 1994; Green et al., 1998), chain technique (Aronson and Precht, 1995; Beck, 1998), and other methods summarised in Beck (1997) utilise profile data to produce a numerical value that characterises topographic complexity.

Detailed studies of benthic assemblages are particularly difficult and a time consuming task in the marine environment, and as a result studies commonly use physical characteristics for identification and classification of marine habitats (Valesini et al., 2003; Diaz et al., 2004; Lundblad et al., 2006). This reflects the fact that remote sensing and acoustic methods are increasingly used as a tool to describe and map the extent of habitat types (Mumby et al., 1997; Fader et al., 1999; Roff and Taylor, 2000; Kostylev et al., 2001). Ecologists are becoming increasingly aware of relationships between physical habitat complexity and benthic community structuring on the continental shelf and inshore habitats (Fonseca and Bell, 1998; ANZECC, 1998; Ward et al., 1999; Barrett et al., 2001; Freeman et al., 2002; Edgar et al., 2004). Despite increasing awareness, advances in techniques used to characterise habitat complexity in the marine environment are limited compared to terrestrial ecology.

Current cost effective techniques for generating broad-scale habitat maps rely upon the processing of acoustic data to classify habitats based on values of hardness and roughness, and to reveal contour lines allowing the researcher to categorise sections of seabed by depth strata. However, the physical parameters that are used in the generation of habitat maps are typically qualitative and scale dependent. These techniques often result in habitat maps that are of limited application in accurately identifying habitat complexity at scales that are either biologically or ecologically relevant.

A more progressive approach, that not only categorises habitats but identifies complexity with heterogenous habitats, is to process the bathymetric data to derive a Digital Terrain Model (DTM), then apply a landscape classification model developed by terrestrial ecologists (Wood, 1996). This technique quantifies the degree and spatial distribution of habitat complexity within a defined area allowing ecologists to establish links between the physical and biological components of rocky reef habitats to gain a greater understanding of ecosystem processes.

In this paper we explore the application of a classification model, derived from a digital terrain model (DTM), to classify the morphometry of reef habitats at biologically meaningful scales and link reef morphometrics to examples of fine-scale movement and habitat utilisation of the southern rock lobster (*Jasus edwardsii*). This case study is exemplary of the technology and techniques being used to improve coastal management of rock reef fisheries given improved mapping methods of fine-scale features of benthic marine habitats.

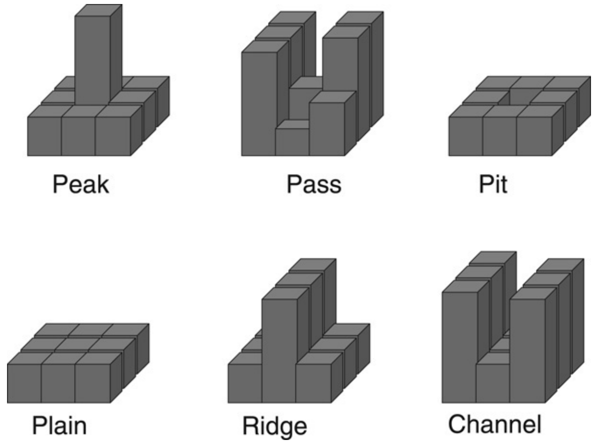

Fig. 1. The six categories of morphometric features illustrated by the relationship between a central DTM cell and its eight neighbours. *Source*: Wood (1996).

2. Methods

By applying geomorphometry theory from terrestrial analysis, it is possible to generate descriptive statistics of the shape of the seabed (Peucker and Douglas, 1974; Wood, 1996; Fisher and Wood, 1998; Pike, 2000) and classify morphometric features into one of six classes: pit, peak, pass, channel, ridge and plain (Wood, 1996; Fisher et al., 2004) (Fig. 1). Morphometry is the measurement of the shape of objects and includes a large range of measurements including numbers, length, surface area, volume, angles, and curvature. These six simple features can be used to characterise rocky reef systems from fine-scale (2 m and 5 m) bathymetric DTMs.

It may seem easy to attribute trivial characteristics to a reef surface, a ridge can be defined by a line of the highest points on any cross section, but to describe or understand the spatial extent that defines the feature (or the region associated with it) is much harder. Several researchers have discussed that many feature classes on the terrestrial landscape are hard to define meaningfully in terms of either their elevation or spatial extent (Baker and Cai, 1992; Wood, 1996; Fisher and Wood, 1998; Jager et al., 2000). This was