Can general models of marine biota be applied broadly for accurate and affective habitat mapping?

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1. Introduction

It is generally accepted that protection of marine systems requires the introduction of landscape-level planning and government policies to prioritise conservation areas and to effectively manage the existing biodiversity and ecosystem function (Bellwood and Hughes 2001, Beger et al. 2003). However the implementation of this type of planning is hampered by the lack of comprehensive spatially explicit biological data and the resources and expertise necessary to gain this information (Williams and Gaston 1994, Margules and Pressey 2000). Ideally, comprehensive species information from all major taxa over a broad range of spatial locations would be incorporated (Gaston and Blackburn 2000, Gladstone 2002). This rarely happens, and more frequently a number of habitats delineated using expert interpretation from available climatic, geological, geomorphological and ecological information are used as surrogates for biodiversity (Ward et al. 1999, Day et al. 2000).

The use of ecological modeling to produce biodiversity surrogates, for example modeling major biotic and functional groups could be a highly efficient way of reducing the resources and expertise needed to assess habitats for biodiversity value (Williams and Gaston 1994). Indicator groups, also has the potential to enhance our understanding of the fundamental ecological relationships (Beger et al. 2003). For example, recent studies have demonstrated that having information on just one complete taxa can be useful as a total biodiversity surrogate, in both temperate systems (Ward et al. 1999, Gladstone 2002) and tropical systems (Beger et al. 2003).

These biotic surrogates may provide a potentially cost-effective way to determine major habitats over large habitats marine areas if they can be modeled from forms of remotely sensed data (such as satellite imagery, aerial photography). In the past there application to marine mapping has been largely been limited areas under 20 meters to water depth by light availability, however in resent years this has changed with in the introduction of sensors that can collect high resolution “Multibeam” sonar data. Multibeam sonar provides the potential to map at broad scale by providing high resolution bathymetric and substrate information from water depths of 20 to over 100 meters. When combined with video imagery provides base data that can be used to map sea floor biota using an ecological modeling approach. This could provide valuable predictive models that can be applied spatially for important marine biota whose distribution is strongly tied to physical attributes of the marine environment. This modeling approach also provides incite into distribution drivers which in turn can be used to asses dominant and marginal areas for major biota and areas that may be more susceptible to man made or natural disturbances.

Here present the development of and assessment of a general biotic model applied spatially for the genus *Ecklonia* a group of large Kelp species found along much of the temperate Australian coastline. That is to see if models based on the dominantly biotic drivers developed in one geographic region are more widely applicable to separate geographic regions. *Eckloina* was chosen as a test case as not only is it an important primary produce but it is often the dominant biota, has strong effects on associated assemblages promoting a diverse range of fish and invertebrates species (Goldberg and Kendrick 2004). If models are reliably and can be applied with remote sensing they may provide a cost effective method for marine habitat mapping over large geographic areas while requiring less validation data.

2. Methods

In this study, three geographically separate marine park areas were selected from the Victorian Coastline of Australia. Each as was know to have significant *Ecklonia* habitats. These sites were situated between 10 and 90 meters water depth and are located at Discovery Bay, Point Addis and Twelve Apostles. Multibeam bathymetric and backscatter data (collected over the study area at a 2.5 meter pixel size), were used to target underwater tow video surveys to characterize the full range of benthic variation within each area. Then, individual georeferenced video frames were scored for *Ecklonia* presence. This were considered the dependent variables for model development, while bathymetry and the derivatives variables of slope, aspect, and range(local relief, the differences between maximum and minimum depth values for 5 and 50 pixel kernels) were used as the independent variables. The bathymetry datasets acted as proxies for the processes controlling substrate structure and texture, and the environmental drivers of *Ecklonia* distribution. Eckonia presence was individually modeled for each study area with classification trees using a ten-fold cross-validation. Each area model was then tested against the spatially independent data for the other study areas and maps of model agreement and discord were produced. Finally models were assessed by calculating Receiver Operator Characteristics (ROC) using the p-fair cutoff value.

3. Results

The majority of the regression tree models indicated good classification accuracy with for both the areas where they were generated and the geographically independent areas where they were tested. AUC values between 0.69 and 0.97 (Table 1). The model generated for Twelve Apostles (Table 1) did show increased prediction accuracy in other areas (average AUC of 0.85) compared to Point Addis (average AUC of 0.75) and Discovery Bay (average AUC of 0.77) that had similar performance. Both Discovery Bay and Point Addis regression tree models also use different combinations of less important variables (Table 2) which may indicate there reflect finer scale more localised distribution drivers.

Regression tree models also showed the same dominate driving variables in each study area (Table 2). The most important for *Eklonia* presence being depth (between 38 and 24 meters) explaining more 50% of model variance (Table 2) and coarse range values (50 pixel kernel) with variability greater than 0.5 which are indicative reef areas of higher rigosity (explaining between 10% and 29% of model variance). The lest important variable was aspect, while fine scale range values (50 pixel kernel) and slope explained significant proportions of variance but only for specific models (Table 2) .

4. Discussion

The major points demonstrated by this study area

a) Any of the ecological models of *Ecklonia* produced independently for three widely separated geographic regions, could effectively be used for prediction at each study site.
b) Model accuracy was generally high with large proportion of variability explained by depth and broad scale range values indicative of reef areas. This would indicate that *Ecklonia* distribution is strongly driven by abiotic physical factors and substrate. This makes it a good candidate for broad-scale habitat mapping
c) The effectiveness of models from one area being to predict accuracy in other areas largely depends on weather the two area have comparable ranges of abiotic variables. The Twelve Apostles study area provides the most universally applicable model and this may reflect the presence of the widest range of abiotic variables that effect *Ecklonia* distribution. When selecting locations for generating general biotic models areas with the wide ranges of abiotic variables form the most suitable locations.
d) Model accuracy can probably be improved by using information from more than one area if they significantly differ. This increasing the range of abiotic input variables used in aprior predictions. One simple method to achieve this is a model voting approach if models from multiple study areas are available.
e) General biotic models may provide a cost-effective way of predicting biota over large areas if distribution is strongly mediated by the physical environment, they provide a suitable surrogate for other communities and can be modeled accuracy.

5. Tables

Initial model	Validation area	Area Under Curve (AUC)*	False Positive Rate (1-specificity)	False Negative Rate (1- sensitivity)	Correct Classification Rate
Discovery Bay	Discovery Bay	0.97533	3%	2%	97%
	Point Addis	0.84603	5%	33%	73%
	Twelve Apostles	0.70212	22%	22%	78%
Point Addis	Point Addis	0.86318	8%	23%	80%
	Discovery Bay	0.82183	35%	1%	94%
	Twelve Apostles	0.69188	46%	18%	78%
Twelve Apostles	Twelve Apostles	0.94041	5.6%	8%	93%
	Discovery Bay	0.97588	2.8%	2%	98%
	Point Addis	0.73119	7.7%	32%	73%

* AUC < 0.5 No discrimination, 0.7 < AUC < 0.8 Acceptable, 0.8 < AUC < 0.9 Excellent, AUC > 0.9 Outstanding (Hosmer and Lemeshow 2000)

Table 1: Model evaluation of Ecklonia presence absence prediction at each study area calculated using Receiver Operator Characteristics (ROC) on 25% spatially independent blind validation data removed from the original analysis

	% Explained variance of each physical variable at each study area		
Model variable	Discovery Bay	Point Addis	Twelve Apostles
Aspect		4.1	
Depth	73.4	53.2	70.7
Range 5 pixels	16.1		
Range 50 pixels	10.5	16.5	29.3
Slope		26.2	

Table 2: Contribution of each model variable (as a percent) of total explained variance for *Ecklonia* at each study area

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7. References

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