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Habitat characteristics and spatial arrangement affecting the diversity of fish and decapod assemblages of seagrass (*Zostera marina*) beds around the coast of Jersey (English Channel)

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Abstract

Recent research and management plans for seagrass habitats have called for landscape level approaches. The present study examines the spatial utilisation of subtidal seagrass beds by fish and decapods around the coast of Jersey (49°N 02° W). A hierarchical scale of landscape configuration and the plant characteristics of eight seagrass beds were measured and the contributions of these variables as predictors of the properties of the fish and decapod assemblages were evaluated using multiple linear regression models. The results indicated that total diversity had a negative relationship with transect heterogeneity and total species number had a weak negative association with increasing fragmentation. Both total diversity and total species number showed a positive relationship with depth. In fact, in all models of species number and densities, values were higher in deeper seagrass beds. Total decapod density increased with aggregation of seagrass patches within a landscape. In addition to landscape configuration, smaller-scale structural changes in both canopy height and epiphyte load appeared to influence densities of decapod crustaceans. At night, fewer patterns could be explained by the independent variables in the model.

Keywords: seagrass; *Zostera marina*; spatial scale; landscape ecology; fish; decapod crustaceans

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1. Introduction

In the United Kingdom, seagrass beds (*Zostera* spp.) are one of the focal biotopes for Marine Habitat Action Plans in the UK (part of the UK Biodiversity Action Plan) and are a named component of “*Lagoons and Shallow Sandbanks*” within the European Union Habitats directive (92/43/EEC). The inclusion of seagrass is due in part to the belief that they support relatively high biodiversity compared to other habitats. Despite this statutory recognition, few studies have assessed the biodiversity value of different seagrass beds in the United Kingdom, particularly for fish and mobile macroinvertebrates (but see Pihl Baden and Pihl, 1984; Costa et al., 1994) and seagrass beds have only been mapped locally in this region (Glémarec et al., 1997).

In Jersey one of the priority objectives for fisheries managers is to protect overall biodiversity; one of their focal habitats is seagrass beds. The habitat “value” of seagrass beds has been shown to vary with coastal location, depth, proximity to other habitats and position within a bay, lagoon or estuary. At the level of individual beds, the degree of spatial heterogeneity (or “patchiness”), and other meso-scale variables, appear to have effects, as do micro-scale variables such as shoot density (Jackson et al., 2001). Seagrass beds exist naturally as vegetational units of various shapes and sizes, or have unvegetated or macroalgal regions interspersed among more homogenous seagrass areas (Robbins and Bell, 1994). These patterns are not necessarily the result of human perturbations, and are attributable to a host of factors (see review by Boström et al., this issue). Jersey’s physical setting and varied coastline,

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however, means that the distribution and landscape patterns of the seagrass habitats found there are exceptionally varied. Despite these differences, the relatively small size of the island means that the seagrass beds are geographically close, sharing larger scale influences such as tidal factors, water currents, climatic conditions and species biogeography.

A number of different models have been proposed to describe the relationships between seagrass habitat characteristics and large mobile fauna. At the landscape level, due to the management implications and results of terrestrial studies, investigations have concentrated on the effects of seagrass habitat fragmentation, or with landscape defined by the predominant mosaic and patchiness of different habitats.

At its simplest, fragmentation is observed as a reduction in the area of seagrass cover, decrease in patch size and an increase in the distance of between patches (decreased connectivity). The predominant concern is that loss of seagrass may result in a reduction of species diversity. One of the main reasons put forward for this prediction is based upon the general principle that species diversity is higher in seagrass compared with adjacent bare sand habitats (e.g. Arrivillaga and Baltz, 1999; but see Jackson et al., 2002).

To take a more landscape mosaic approach (Wiens, 1995), patchy seagrass beds would provide a more diverse habitat, particularly if the seagrass landscape was a mosaic of sand, seagrass and algal habitats. This would attract fish with preferences for both vegetation and bare substrata, which follows Leopold's (1933) theory of increased habitat diversity leading to increased faunal diversity.

Smaller-scales may also be important. When evaluating the relative importance of different seagrass habitats to fauna, it is important to consider, a priori, whether the complexity measures employed are directly relevant to the group of organisms under investigation (Attrill et al., 2000). Seagrass patches can be highly heterogeneous in terms of, for example, leaf density and height within the bed. Increased abundance and diversity of fishes and decapods associated with seagrass meadows have frequently been positively linked to the complexity of the seagrass canopy (Heck and Orth, 1980; Bell and Westoby, 1986; but see Virnstein and Howard, 1987), although the models proposed do differ. Jenkins and Sutherland (1997) saw an increase in the number of juvenile and cryptic species as seagrass complexity increased, but there was no change in the overall species diversity. Worthington et al. (1992) found that the number of fish and decapod individuals increased with increasing leaf density, but like others, found that the relationship was not a simple linear one (Lipcius et al., 1998).

The aims of this study were to measure the configuration and composition of subtidal seagrass landscapes around Jersey, at scales assumed to be appropriate to large mobile faunal, and to understand their influence on faunal diversity. Based on the common findings of the models described, some key patterns were hypothesised for the fauna inhabiting seagrass beds in Jersey. Firstly, it was hypothesised that an increase in the diversity of the habitat mosaic would result in an increase in overall species diversity. As fragmentation of the seagrass landscape increased, it was proposed that species diversity would increase. At a smaller scale, mobile decapod crustacean densities were expected to increase with seagrass structural complexity (canopy height, epiphytal load and homogeneity of seagrass). Increasing depth, it was expected, would be associated with an increase in total fish densities (Bell et al., 1992). At night it is hypothesised that many of these patterns may change, as species move out of the seagrass patches to forage, become less susceptible to predation or become more active at night. In order to make these comparisons both day and night-time sampling were carried out in the present study and the patterns compared separately with predictions.

2. Materials and methods

2.1. Study location and site selection

All fieldwork was carried out around the coast of Jersey (English Channel, Fig. 1). Seagrass (*Zostera marina*) is not distributed evenly around the coast of Jersey (Fig. 1) and the absence of seagrass on the north and west-facing coasts has been attributed to a steeply shelving seabed and high wave exposure. Eight seagrass landscapes were randomly selected. In this study, a seagrass landscape was defined as a separate landscape where the shortest distance from the edge of the seagrass bed to another patch of seagrass was larger than the greatest distance from the epicentre of the bed to an edge.

2.2. Measurement of habitat variables

Table 1 summarises the sample-specific seagrass and environmental variables measured. The mean depth of each trawl replicate was calculated using ArcInfo™ version 8, by overlaying the trawl paths onto digital echo-sounder (Biosonics DT4000™) derived bathymetric maps (Sabol and Burczinski, 1998). The Biosonics DT4000™ was also used to measure canopy height and for each sample, the mean seagrass canopy height was estimated using ArcInfo™, by overlaying the trawl paths onto maps of canopy height derived (using triangular integration networks) from the echo-sounder paths. It is argued here that canopy layer height is a better measure of the habitat from a faunal perspective than actual leaf length as wave movements, epiphyte cover and epiphytic fauna all contribute to the leaf blades bending. Seagrass samples collected in the field from each seagrass bed were used to assess the epiphytic load. An index of epiphytic load was calculated as the dry weight of epiphytes divided by the sum of mean leaf length, width and number. Shoot density was measured in situ using SCUBA divers. The minimum distance from each trawl to the 10 m isobath was also measured using the tools within ArcInfo™ once the trawl path coverage had been overlain onto thematic maps of seagrass coverage.

A measure of transect heterogeneity was calculated as a fractal dimension for each trawl (Burrough, 1986; Manzanera and Romero, 2000). Using ArcInfo™, an intersect-overlay was used to combine the coverage of the trawl transect and the corresponding area from the thematic habitat layer. Along each section, the position of each seagrass/sand or