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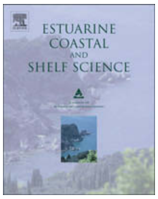

Seagrass (*Zostera muelleri*) patch size and spatial location influence infaunal macroinvertebrate assemblages

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ABSTRACT

Seagrass landscapes are coastal environments that support diverse and abundant faunal communities. This study investigated infaunal assemblage patterns in fragmented and continuous *Zostera muelleri* habitat in southeastern New Zealand. Intertidal macroinvertebrate assemblages were examined in fragmented seagrass habitat (containing discrete patches varying in size from 1 to 200 m^2) and continuous meadows ($>$1000 m^2), in a small and a large tidal inlet. Community indices differed between seagrass habitat types and the total number of taxa was significantly lower at fragmented seagrass sites in one of the inlets. The total number of individuals and diversity were significantly different between fragmented and continuous seagrass habitat in both inlets, but diversity values showed inconsistent patterns between inlets. Multivariate analysis confirmed that different seagrass habitat types support distinct macrofaunal assemblages in each inlet and position on the shore was identified as the single most important variable explaining dissimilarities in assemblage compositions. These findings confirm the influence of seagrass habitat size on infaunal assemblages and also highlight the importance of spatial position of seagrass habitat in intertidal areas.

1. Introduction

Seagrasses have a worldwide distribution in temperate and tropical regions (Green and Short, 2003) where they grow from midlittoral zones to subtidal depths of 40–50 m in sedimentary habitats (Den Hartog and Phillips, 2001; Green and Short, 2003). There is strong evidence that the presence of seagrass enhances biodiversity through increased habitat complexity, provision of refuge, and increased food supply (Orth, 1973; Boström and Bonsdorff, 2000; Ford et al., 2001; Jenkins et al., 2002; Boström et al., 2006a). Furthermore, faunal communities in seagrass areas have been shown to be distinctly different in comparison with those in unvegetated habitat, over relatively small spatial scales (i.e., from centimetres to tens of metres) (Boström and Bonsdorff, 1997; Connolly, 1997).

Habitat fragmentation is a landscape-scale process where a single continuous habitat breaks up into smaller fragments, or "patches" (Fahrig, 2003). Biodiversity and community composition can be affected positively or negatively through the changes in size, shape, and location of the remaining habitat patches (Fahrig, 1997). For example, the reduction of continuous habitat may contribute to increased predation rates on patch inhabitants, decreasing diversity (Andrén, 1994; Irlandi, 1994), whereas a higher edge to interior ratio in smaller patches provides a larger edge area for the interception of new inhabitants from the surrounding area, thereby may increase diversity (Harris, 1988; Eggleston et al., 1999). Landscape-scale research on habitat fragmentation has traditionally been focused on terrestrial habitats (e.g. Andrén, 1994; Fahrig, 1997; Bender et al., 1998), however, heterogeneous marine seagrass landscapes have received recent attention (e.g. Bell et al., 2001; Boström et al., 2006a).

Seagrass landscapes can become fragmented through natural biotic and abiotic factors (Fonseca et al., 1996; Hovel and Lipcius, 2001) and through anthropogenic causes (Short and Wyllie-Echeverria, 1996). At the same time, the natural expansion of seagrass results in interspersed discrete seagrass patches of varying size and age in otherwise unvegetated sediments (Posey, 1988). As a consequence, seagrass habitats are frequently characterised by mosaics of extensive, continuous meadows interspersed with discrete patches separated by bare sediment (Robbins and Bell, 1994; Borg et al., 2005).

Recent studies have shown that fragmented seagrass habitat influences the abundance, composition and survival of fauna, in response to different landscape-scale qualities, such as configuration, size and position of seagrass patches (see reviews by Bell et al., 2001; Connolly and Hindell, 2006). For example, several small seagrass beds were inhabited by a significantly greater number of

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fish and macroinvertebrates and were more diverse than a single larger bed (McNeill and Fairweather, 1993; Healey and Hovel, 2004). Similarly, infaunal assemblage composition has been shown to differ significantly between fragmented and continuous seagrass habitat (Frost et al., 1999) and also between different-sized seagrass patches (Bowden et al., 2001). In addition, the physical setting of a seagrass patch and flow-on effects from the presence of plant structure, such as increased organic matter and decrease in sediment grain size, have consistently been found to be important for infauna through the provision of shelter and nutrition (Frost et al., 1999; van Houte-Howes et al., 2004; Boström et al., 2006b).

To understand the underlying processes that determine ecological communities, it is necessary to first observe community patterns (Underwood et al., 2000). The present study assessed infaunal assemblage patterns in relation to seagrass habitat fragmentation by investigating two different types of intertidal seagrass habitat, fragmented and continuous seagrass areas, in two tidal inlets. The main questions addressed in this study were: (1) are fragmented and continuous seagrass habitat types characterised by distinctly different infaunal assemblages; and (2) are infaunal assemblage patterns associated with fragmented and continuous seagrass habitat consistent between different locations?

2. Materials and methods

2.1. Study sites and field sampling

The present study was conducted in southeastern New Zealand, in Papanui Inlet (4.1 km^2) and at Harwood in Otago Harbour (46 km^2) (Fig. 1). Both inlets had a similar mean tidal range, between 1 and 2 m (Heiss et al., 2000; Albrecht and Vennell, 2007) and contained large areas vegetated by seagrass, *Zostera muelleri* (previously *Zostera capricorni*) (Jacobs et al., 2006). *Zostera muelleri* is a small (blade lengths ~5–15 cm) and predominantly intertidal seagrass that occurs throughout New Zealand and in southern Australia (Inglis, 2003; Turner and Schwarz, 2006). In New Zealand, *Z. muelleri* habitat varies in extent and biomass and frequently occurs as a mosaic of different-sized patches, with extensive areas of continuous seagrass coverage being less common (Turner et al., 1999; Inglis, 2003; Turner, 2007).

Based on naturally occurring *Z. muelleri* at each location, an area of continuous seagrass (>1000 m^2) and a similar sized area of fragmented seagrass (containing discrete circular seagrass patches) were selected as natural "treatment" sites. The selection of seagrass areas at each location was dictated by the presence of an extensive, continuous seagrass meadow in the same area as fragmented seagrass habitat. At Harwood, the continuous seagrass habitat was at the same tidal height as the fragmented seagrass habitat, in the low intertidal zone. In Papanui Inlet, however, extensive, continuous seagrass habitat was only located in the lower intertidal, whereas fragmented seagrass habitat was in the upper intertidal zone. This difference in spatial arrangement between fragmented and continuous seagrass areas in Papanui Inlet enabled assessment of the relative importance of spatial position within the inlet in addition to seagrass habitat type.

Five replicate samples were taken from within the continuous seagrass habitat and 10 samples were collected from within the fragmented seagrass habitat in summer and winter (Papanui Inlet, 10 February 2005 and 1 August 2005; Harwood, 9 February 2005 and 23 July 2005). Approximately circular seagrass patches (five small (1–5 m^2) and five large patches (100–200 m^2)) were haphazardly selected within the fragmented seagrass habitat. To avoid possible edge effects, samples were taken from the centre of each patch and 100 m from the edge in continuous seagrass habitat. The spatial position of each sample was determined by GPS. On each sampling occasion, a flat ring (10 cm Ø) was placed on the sediment. All seagrass blades within the ring were cut off at the sediment surface and retained. Macrofauna was subsequently sampled in the same position with a benthic core (10 cm Ø, 10 cm depth). An additional core (5 cm Ø, 10 cm depth) was taken adjacent to the macrofauna core for sediment grain size and organic content analysis. Sediment samples were kept frozen until analysis.

2.2. Laboratory analysis

Faunal cores were sieved on 500-μm mesh with sea water, separated from seagrass belowground material (roots and rhizomes), preserved in 50% isopropyl alcohol and stained with Rose Bengal. Macrofauna was counted and identified to the lowest practical taxonomic level, which in most cases was species.

Fig. 1. Map of New Zealand indicating the location of study sites in Papanui Inlet and Harwood, Otago Harbour.