Abrupt transitions between macrobenthic faunal assemblages across seagrass bed margins

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ABSTRACT

The nature of the transition from one contrasting macrobenthic assemblage to another across interfaces between intertidal seagrass and unvegetated sand was investigated in the subtropical Moreton Bay Marine Park, eastern Australia, via six two-dimensional core lattices. The same pattern of transition was manifested in each lattice. Macrofaunal abundance, species density (both observed and estimated total) and assemblage composition did not vary with distance away from the interface within the 0.75 m wide marginal bands of each habitat type. Neither were there significant differences in assemblage metrics or composition between the marginal and non-edge regions of either habitat. There were, however, very marked differences in assemblage composition, abundance and species density across the 25 cm wide strip on either side of the actual interface, the interacting assemblages reacting symmetrically. All these differences therefore took place over an ecotone distance of only 0.5 m at most. Spatial trends in assemblage metrics across the boundary zone were captured accurately by second and third order polynomial regression models. It also appeared that edge effects on individual species within the seagrass were a variable local response not a consistent effect of closeness to the bare sand.

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1. Introduction

Most natural environments, including coastal marine ones (Eyre et al., 2011), are mosaics of different habitat patches and the transitional zones between these patches are increasingly being recognised as ecologically important, not least because landscape structure affects habitat quality (Levin et al., 2001; Zajac et al., 2003; Ries et al., 2004; etc.). The quality of seagrass habitats is of particular current concern because of their recent worldwide decline and fragmentation (Lotze et al., 2006; Waycott et al., 2009; Fourqurean et al., 2012), because of concerns that the resultant denuded habitat may support lesser animal abundance and biodiversity (e.g. Pillay et al., 2010), and because seagrass beds provide economically important ecosystem services, including not only physically protective habitat for the juveniles of commercially-significant fish and crustaceans but also food for those juveniles in the form of the smaller benthic macrofauna that seagrasses

support in abundance (Duarte, 2000; Unsworth and Cullen, 2010; Coles et al., 2011; Barbier et al., 2011).

Throughout much of the world, sheltered intertidal and shallow subtidal sandflats occur in one of two characteristically alternative patch states: one being seagrass beds, the other unvegetated sediment. These two alternatives are dynamic and interchangeable, with each member of the pair expanding into territory held by the other in one area or another of shared sandflats (e.g. Yamakita et al., 2005; Berkenbusch et al., 2007; Carr et al., 2010). Although not always the case in vegetated versus unvegetated comparisons (e.g. Van Houte-Howes et al., 2004), especially in high latitude areas subject only to Arenicola bioturbation (see e.g. Asmus and Asmus, 2000; Polte et al., 2005), wherever the bare sediment is structured by the bioturbation of burrowing thalassinidean crustaceans (Pillay and Branch, 2011) benthic macrofaunal assemblages supported by the two alternative habitat types may be very different, as, for example, in the Nanozostera capensis versus Callichirus kraussi system in Langebaan, South Africa (Siebert and Branch, 2007) and in the Nanozostera muelleri versus Trypaea australiensis system in Moreton Bay, Australia (Barnes and Barnes, 2012). At these localities, as well as at others (Boström and Bonsdorff, 1997), areas of bare sediment are dominated by burrowing species whilst the seagrass supports a large epifaunal component. Such faunal

contrasts can often be linked to the marked change in nature and stability of the substratum induced by the contrasting ecosystem bioengineers (Berkenbusch and Rowden, 2007; Siebert and Branch, 2007; etc.).

Some aspects of the boundary zone between seagrass and adjacent habitat types have received detailed attention. In particular, edge effects within blocks of seagrass have been extensively studied in both the Atlantic and the Pacific (Bologna and Heck, 2002; Tanner, 2005, 2006; Warry et al., 2009; Murphy et al., 2010; etc), with, somewhat paradoxically, it often being reported that densities of seagrass-associated animals were higher on the margins of the bed than nearer its centre. Equivalent work on edge effects in unvegetated sediment is much rarer, however. The studies by Van Houte-Howes et al. (2004) and Tanner (2005) are two of the very few that have extended right across an interface to examine both two habitat types. Van Houte-Howes et al. (2004) explored the boundary between mid-intertidal unvegetated sand and *Nanozostera muelleri* in North Island, New Zealand, and they reported evidence that distinctive assemblages were present at the edges of the seagrass (at least under conditions of abundant seagrass shoots). These authors investigated the transitional zone via a series of sampling points relatively far apart and spanning the relatively large total distance of 100 m (at −50, −10, −1, +1 and +50 m, where zero is the interface itself). Tanner (2005), from the perspective of the abundance of certain seagrass-associated species in fragmented systems, narrowed the zone of investigation to the 2 m on either side of the bare sand/seagrass boundary and showed marked changes in population density of various seagrass polychaetes, crustaceans and bivalves across this zone in a *N. muelleri* meadow at LWS in South Australia.

In order to examine in detail the actual transition from seagrass faunal assemblage to that of the adjacent unvegetated sediment, the present study was designed to investigate the precise interface between the two. Further, this was conducted at a locality for which recent data on the contrasting faunal assemblages of the seagrass and unvegetated sediment away from the interfaces were also available (Barnes and Barnes, 2012), permitting each marginal habitat zone to be placed in context. Three specific questions were addressed. (1) Do faunal transitions between seagrass and bare sediment take the form of sharp ecotones or of more gradual eco-clines (*sensu* Attrill and Rundle, 2002; Yarrow and Marín, 2007)? (2) Do the two interacting faunal assemblages react symmetrically to habitat change across the interface? (3) What is the effect of the transition on the magnitude and spatial variation of local benthic abundance and biodiversity?

2. Methods

2.1. Study area, sample collection and processing

Macrofaunal sampling was conducted over a period of 11 weeks during the 2012 austral spring along the sheltered Rainbow Channel western coast of North Stradbroke, a large (27,400 ha) sand-dune barrier island in the relatively pristine Eastern Banks region of the oligohaline, sub-tropical Moreton Bay Marine Park, Queensland (Dennison and Abal, 1999). The Eastern Banks contain the majority of the Bay's 190 km² of seagrass (Roelfsema et al., 2009) and support its greatest numbers of animal species, including many southern outliers of the tropical Great Barrier Reef fauna (Davie and Hooper, 1998). Here, for example, the seagrass is the refuge and feeding ground for juveniles of many species of penaeid prawns and fish as well as for green turtle and dugong (Weng, 1990; Davie et al., 2011). In the specific area sampled, the beds are predominantly of the dwarf-eelgrass *Nanozostera muelleri capricorni* (= *Zostera capricorni* = *Zosterella capricorni*) with some

Halodule uninervis (especially at lower shore levels) and *Halophila ovalis*, and the seagrass extends from the sublittoral right up into the mangrove zone amongst the seaward pneumatophores of *Avicennia marina*, i.e. over an intertidal vertical height of half the tidal range (i.e. over *c.* 1 m) and in places for a distance of >500 m. Typically, the seagrass plants are of the smaller morphological forms characteristic of shallow areas (Young and Kirkman, 1975). Also within the seagrass zone are unvegetated areas of the fine- to medium-grained quartz sand that comprises the island (Laycock, 1978), often occurring as a series of large patches from about LWN to MSL. Such areas are structured by two bioturbating decapods, the thalassinidean *Trypaea australiensis* and soldier crab *Mictyris longicarpus*, both dependent on sedimentary diatoms (Spilmont et al., 2009).

Data on the macrobenthic assemblages were collected from three sites over a distance of 2.5 km centred on the Moreton Bay Research Station at Dunwich — (a) Deanbilla, (b) Polka, and (c) Yerrol (Fig. 1) — roughly in the middle of a virtually uninterrupted 25+ km long belt of seagrass. Precise sampling sites were located where the margins of the seagrass beds appeared neither to be advancing nor retreating to avoid possible complications resulting from temporally transitional states. Advancing seagrass was identified by lines of young plants extending out from the bed and retreating seagrass by the occurrence of dead root-rhizome mats beneath the surface of the adjacent bare sand. As advocated by Fortin (1994), in all cases data were collected from two-dimensional lattices across and along the bare sand/
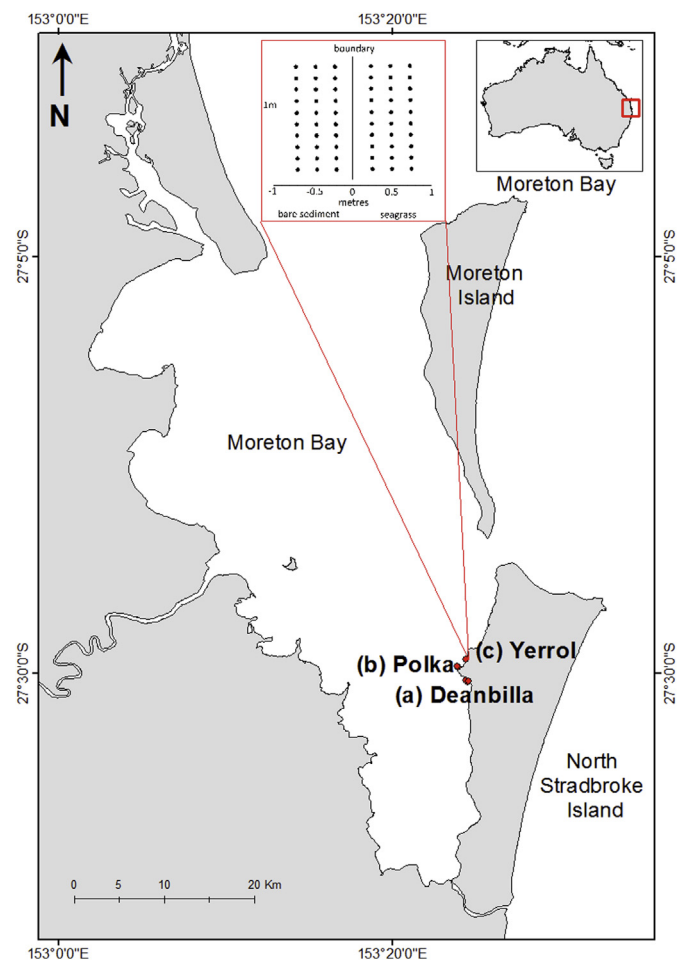

Fig. 1. Sampling locations, with inset showing the structure of the individual core lattices.