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Soft sediment macroalgae in two New Zealand harbours: Biomass, diversity and community composition

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ABSTRACT

Macroalgae play key roles in coastal soft sediment environments, acting as primary producers, habitat structure, coastal filters and influencing water movement and sedimentation. Their contribution to biomass and productivity may vary significantly over space and time. Very little research has been carried out on soft sediment algal communities in New Zealand. In this study we documented macroalgal richness, biomass and community composition, comparing sites in Whangarei and Otago Harbours, at two sampling times, and two tidal levels using two collecting methods. We also investigated the contribution of phyla and growth forms to biomass and species diversity. Algal biomass and diversity did not vary significantly between harbours, but did between sites, and temporal variation in biomass was significant. Community composition varied significantly between harbours, times and sites, and was influenced by fetch (a proxy for exposure) and distance to harbour mouth (potentially a proxy for sedimentation or salinity). The contribution of each phylum to biomass was variable, but the Chlorophyta (primarily *Ulva* and *Codium* spp.) made a larger contribution in Otago Harbour. Numerically, red algae (Rhodophyta) were dominant in both harbours. Variation in growth forms between harbour, site and time revealed no clear patterns and there were no significant correlations with substrate. The two collecting methods resulted in similar numbers of taxa (161 and 156 respectively), but each method collected ~30% taxa unique to that method, indicating that they are complementary when used to assess diversity. Our results show that soft sediment environments can offer an unexpectedly high diversity of macroalgal taxa (209 taxa), that areas with low algal biomass can harbour a high diversity of taxa, and, that macroalgal communities appear highly variable in both space (within and between harbours) and time.

1. Introduction

Macroalgae play key roles in coastal soft sediment environments as primary producers and providers of structurally complex three dimensional habitat space for associated biota, including sites for reproduction and settlement of larvae (e.g. Hansen et al., 2010). In addition, macroalgae influence water movement and sedimentation (Lenihan and Micheli, 2001; Cornelisen and Thomas, 2004; Lawson et al., 2012) as well as act as "coastal filters" in eutrophic bays and lagoons (McGlathery et al., 2007).

As macroalgae normally require hard substrata for attachment, they occur less frequently in soft sediment environments than on rocky reefs, and their diversity is greater in areas where stable settlement surfaces are available (Rowden et al., 2012; Hurd et al., 2014). Soft sediment habitats where macroalgae are found are physically highly diverse, ranging from harbours and estuaries (with varying sediment types and sizes, freshwater influence, tidal flushing, current flows), to coarse stabilised sediments (shell fragments, cobbles, and coarse gravels), and biogenic habitats such as worm tubes, horse mussel beds, brachiopod beds, mangrove forests, rhodolith (maerl) beds and seagrass meadows. The interface between rocky substrata and sand e.g. beyond the lower edge of the kelp forest, in areas with high sediment loads or shifting sand, has also been observed to be a zone that is characterised by distinct algal communities (e.g. Francis and Grace, 1986).

Macroalgal diversity in estuarine environments is relatively impoverished when compared with that of coastal waters but biomass and productivity may be very significant in certain locations and/or at particular times of the year (Nienhuis, 1994; Raffaelli et al., 1998). Shallow areas of soft sediment such as outer harbour areas are less well studied than estuarine envi-

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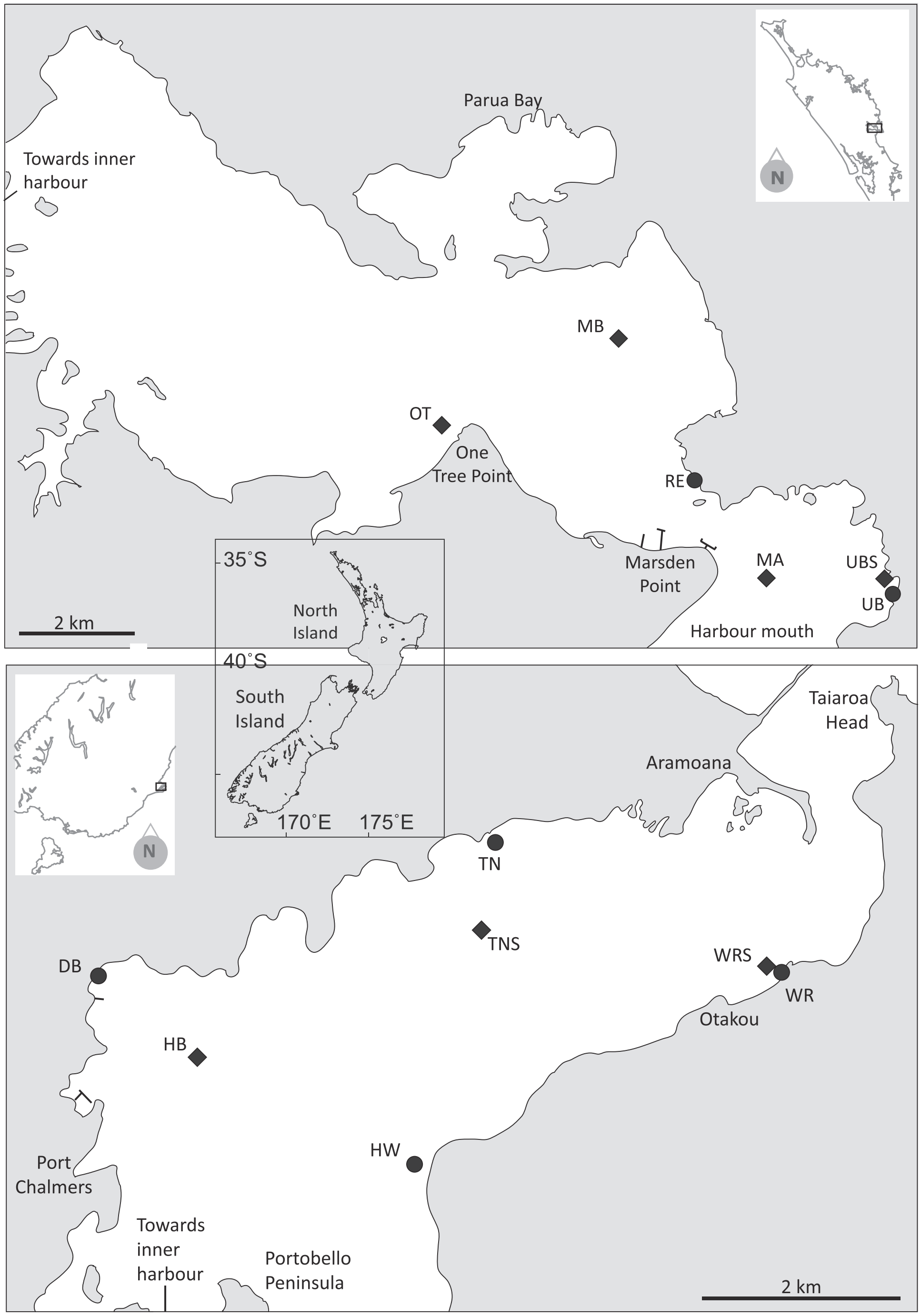

Fig. 1. Whangarei Harbour (top). Map showing the location of intertidal (circles) and subtidal (diamonds) sites sampled. OT = One Tree point, MB = McDonald Bank, RE = Reotahi, UB = Urquharts Bay and MA = Mair Bank. Otago Harbour (bottom). Map showing the location of intertidal (circles) and subtidal (diamonds) sites sampled. HW = Harwood, HB = Hamiltons Bay (opposite), DB = Deborah Bay, TN = Te Ngaru, TNS = Te Ngaru subtidal, WR = Wellers Rock and WRS = Wellers Rock subtidal.

ronments and are highly vulnerable to human-induced changes through land and catchment use/management, as well as to sea temperature changes, changes in freshwater inflows (e.g. altered rainfall patterns), and modification of sedimentation regimes (Thrush et al., 2006; Barbier et al., 2011; Lawson et al., 2012). Eutrophication in harbours can result in opportunistic species (e.g. *Ulva* spp., *Gracilaria* spp.) growing rapidly and forming mats that may accumulate intertidally and subtidally over soft sediments, where they continue to grow and to photosynthesise. In some situations algal mats provide refuge for invertebrates (Raffaelli et al., 1998; Thomsen et al., 2012), although accumulation of large drifts can modify silt deposition and create hostile chemical conditions when decomposition occurs, modifying macrofaunal distributions and biomass as well as infauna larvae (Everett, 1994; Taylor, 1999; Sfriso et al., 2001; Salovius and Kraufvelin, 2004; Lyons et al., 2014; Thomsen and Wernberg, 2015).

Only a small proportion (<10%) of the New Zealand macroalgal flora (ca. 900 spp.) has been reported to live in association with soft sediment environments (Adams, 1994; Hurd et al., 2004). In a review of biodiversity in soft sediment habitats around New Zealand, Rowden et al. (2012) found that the underlying knowl-