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Storm versus calm: Variation in fauna associated with drifting macrophytes in sandy beach surf zones

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ABSTRACT

New insights about nearshore dynamics came from studying the effects of regular storms in South Australia on drifting marine macrophytes, consequent wrack accumulation and associated fauna in beach surf zones across three different regions. This study examined whether the influence of storms may be more pronounced in sheltered coastal waters compared to more exposed coastlines where biota could have adaptations to persist in larger swell conditions. There were obvious regional differences for wrack species richness, abundances and assemblages that matched the attached floral subtidal landscape in each region. Consequently, invertebrates also differed amongst regions, which highlight the close affinity that some invertebrates have with drifting macrophytes. Fish were not so closely aligned to the regional patterns identified for wrack or invertebrates suggesting that many fish are using wrack accumulations as habitat but, being highly mobile, they may actively and constantly move into, out of and within these habitat features. Well-known beach-type models focused upon beach morphology may be more pertinent to the ecology of the surf zones offshore than previously thought, being the most consistent indicator of wrack accumulations and their fauna. This new evidence on the ecology of nearshore waters during storm versus calm weather in multiple regions and the subsequent influence on wrack–fauna associations in sandy-beach surf zones are important for future beach management, particularly when and where large wrack accumulations occur.

1. Introduction

Drifting macrophytes consist of many species of seagrass and algae. During storms or large swell events, seagrass and algae are often ripped from the seafloor by hydrodynamic forcing and either float to the surface and drift, or tumble along the seafloor (Kirkman and Kendrick, 1997). In the nearshore zone of sandy beaches, drifting macrophytes are pushed into the surf zone by wave, tidal and current forcing where they form dense accumulations before being washed ashore (Kirkman and Kendrick, 1997). The dense macrophyte accumulations that are formed in the surf zone of sandy beaches may also include many other drifting objects such as animal carcasses and human-sourced litter (e.g. plastics, cans, bottles and lost fishing equipment). Drifting macrophytes may eventually be stranded on beaches and form large piles of beach-cast wrack which can then re-enter the surf zone with subsequent high tides (Kirkman and Kendrick, 1997).

Eventually, beach-cast wrack begins to decompose over varying amounts of time, depending on the physical structure of particular seagrass (Harrison, 1989) or algal (Mews et al., 2006) species. Drifting macrophyte accumulations and piles of beach-cast wrack are very dynamic habitats and contribute to multiple trophic pathways in marine and coastal terrestrial ecosystems. Drifting macrophytes in the surf zone of sandy beaches provide a habitat matrix and food resource for marine macroinvertebrates, which in turn attract multiple fish species (both fished and non-fished species) to aggregate around the drifting habitats (Crawley et al., 2006; Lenanton and Caputi, 1989). The presence of many juvenile fish around drifting macrophytes suggests that they may be an important temporary habitat or nursery for young fish (Lenanton et al., 1982). The question of why juvenile fish are attracted to drifting macrophytes is still not totally resolved but it appears that fish may be using drifting macrophytes as a refuge from larger predators and/or for better food resources due to larger abundances of invertebrate prey than in surrounding clear waters (Lenanton et al., 1982).

Large amounts of wrack are often observed deposited on sandy beaches immediately after large storm events (Kirkman and Kendrick, 1997). Some studies have investigated the impact of storm events on attached algae and seagrass but most of these focused on very large events such as hurricanes and none have contrasted storm versus calm periods (Cruz-Palacios and van Tussenbroek, 2005; Filbee-Dexter and Scheibling, 2012). Investigations of storm impacts on marine environments have often focused on the immediate change to subtidal habitats

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including sedimentation (Cruz-Palacios and van Tussenbroek, 2005) and shifts in macrophyte biomass and associated fauna (Ebeling et al., 1985). Other studies have also investigated the mechanical force required to dislodge algae (Milligan and DeWreede, 2000) or seagrass (Rivers et al., 2011) from the seafloor. In contrast, there is very little information on the changes in drifting macrophyte volume or biomass and associated fauna in the surf zone immediately after storms.

One challenge with the study of drifting macrophytes in the surf zone of sandy beaches is the constant changes in physical structure of macrophyte accumulations due to multiple hydrodynamic influences such as changes in tides, swells or wind-induced waves. The physically-turbulent nature of surf zones may be a reason why there are very few studies that have investigated the immediate underlying dynamics of drifting macrophytes moving into and around the surf zone, particularly after storm events. Instead, many studies have focused on the habitat association and community structure of fauna associated with drifting macrophytes without further consideration of the external influences that result in drifting macrophytes to accumulate as wrack in surf-zones.

The composition of drifting macrophytes found in the surf zone of sandy beaches may be a reflection of the type of attached macrophytes that live in subtidal habitats close by. However, little information is known of the composition of drifting macrophyte accumulations (i.e. whether it is predominantly seagrass or algae, or a mixture of the two) in the surf zone of sandy beaches and the role that different compositions might play as potential habitat for fish and invertebrates. Lenanton and Caputi (1989) identified that a prevalence of both red algae and senesced seagrass contributed to an increase in the abundance of the commercially-important fish *Cnidoglanis macrocephalus* from two sandy beach sites in Western Australia. In addition, Crawley et al. (2006) identified that two fish species, *C. macrocephalus* and *Pelsartia humeralis*, preferred either detached clumps of mixed brown algae and seagrass or seagrass alone, respectively, in manipulative habitat-preference trials undertaken in aquaria. Crawley and Hyndes (2007) identified that the common surf-zone amphipod *Allorchestes compressa* used drifting macrophytes as a habitat and food resource but any preference for a particular macrophyte composition was unclear and changed under different laboratory and field conditions. Lenanton and Caputi (1989) and Crawley et al. (2006) also found that fish abundances increased with an increase in the overall volume of drifting macrophytes.

In eastern South Australia there are three separate bioregions along the coastline that represent very different coastal marine habitats: the protected Gulf St Vincent bioregion consists of dense seagrass meadows; the Coorong bioregion has a mixture of patchy to dense seagrass meadows and patchy subtidal rocky reefs; and the Otway bioregion consists of mainly low-to-medium profile continuous subtidal rocky reefs (Edyvane, 1999). Consequently, these three regions also have distinct macrophyte accumulations: the seagrass-dominated metropolitan Adelaide; the seagrass- and macroalgal-dominated Fleurieu Peninsula; and the macroalgal-dominated South-East region of South Australia (Duong, 2008; McKechnie and Fairweather, 2003). This study location therefore provides a good model for investigating drifting macrophytes and their associated fish and macroinvertebrate assemblages amongst very different marine regions. This study was designed to quantify drifting macrophyte amount, composition and any associated fauna within the surf zone of sandy beaches across multiple storm and calm events and multiple contrasting regions, without being confounded with smaller-scale temporal and spatial variation.

This study therefore aims to determine whether there are greater volumes of drifting wrack, and greater abundances and species richness of drifting macrophytes and associated fauna in the surf zone of sandy beaches after storms compared to calm-weather events. In addition, we test whether the composition of drifting macrophytes and the abundance and species richness of associated fauna is different between multiple regions regardless of weather events. This provides much-needed information on the compositions of drifting macrophytes and associated macroinvertebrate and fish fauna that coincide with storm pulses over multiple regions. The information obtained also provides further understanding of the productivity and function of sandy-beach ecosystems and their potential role as a habitat for critical life stages of fish and their invertebrate prey.

2. Materials and methods

2.1. Sampling regions and sites

Three separate regions were chosen for this study on the basis of the types of attached macrophytes that are found in each region, which are subsequently found in the wrack washed ashore on beaches (Fig. 1; Duong, 2008). Metropolitan Adelaide (MA) is the coastline adjacent to a metropolitan capital city centre within the large inverse estuary of Gulf St Vincent. This region was classified as seagrass-dominated due to the presence of dense seagrass meadows off shore and few rocky reefs (Edyvane, 1999). Further south, Fleurieu Peninsula (FP) has coastlines within Gulf St Vincent and Encounter Bay and was classified as a seagrass/algae mix due to the presence of both dense seagrass meadows and extensive subtidal reefs (Edyvane, 1999). The most southern region in this study was the South-East (SE), which also has the most open coastline, receiving oceanic swell from the deep Southern Ocean. The South-East was classified as an algal-dominated region due to the presence of many subtidal offshore reefs, large kelps, and sparse seagrass meadows (Edyvane, 1999). Three sandy-beach sites per region were

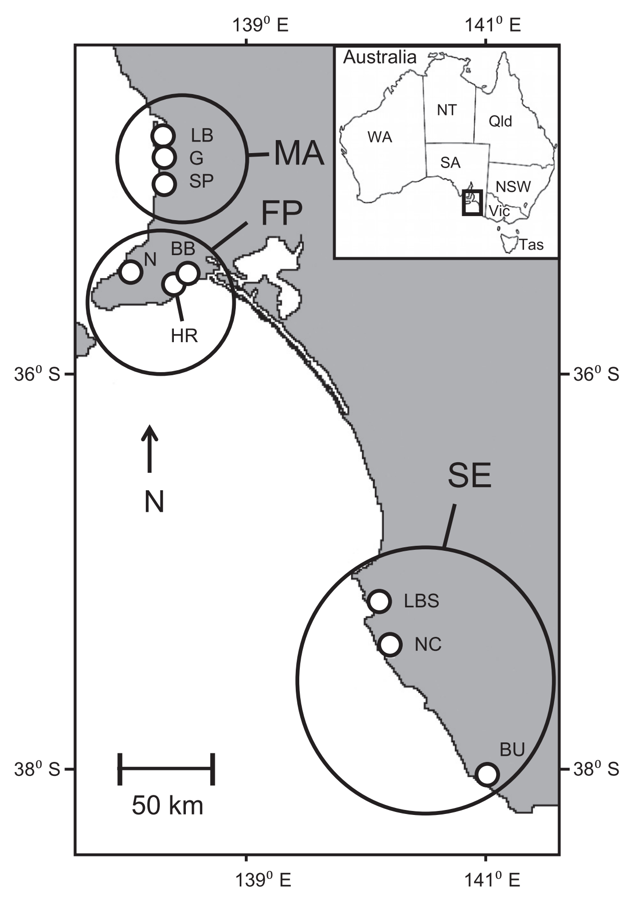

Fig. 1. Map of the three regions and nine sites represented by large circles and small circles, respectively, that were studied during storm and calm events in 2012. Regions and Sites are MA = Metropolitan Adelaide (LB = Largs Bay, G = Grange, SP = Somerton Park), FP = Fleurieu Peninsula (NV = Normanville, HR = Hindmarsh River, BB = Basham Beach), and SE = South-East (LB = Long Beach South, NC = Nora Creina, BU = Bucks Bay).