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Regional-scale patterns of mobile invertebrate assemblage structure on artificial habitats off Western Australia

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ABSTRACT

Despite the many functions that mobile invertebrates serve in marine ecosystems, these assemblages remain relatively understudied. This study utilized artificial settling surfaces to determine how mobile invertebrate assemblages vary along a latitudinal gradient encompassing ~1100 km of the Western Australian (WA) coast. We examined the structure of both 'whole assemblages' at a coarse taxonomic level and a subset of the assemblage (crabs) at the species level, across six locations and over two sampling periods. Assemblage structure differed significantly between locations and a moderately strong correlation with latitude was detected. More evident, was distinct partitioning between assemblages at 'warm-water' locations (23–24.5°S) and 'temperate' locations (28–33°S). This division in assemblage structure was consistent between sampling periods and taxonomic resolutions and corresponds to shifts in dominant biogenic habitat along the coast (coral vs. macrophyte). The abundances of some of the dominant crab species suggested discrete, unimodal distribution relationships with latitude/temperature, a pattern observed previously for macroalgae and fish in WA. The regional-scale patterns of mobile invertebrate assemblage structure presented here will contribute to forming a benchmark against which to detect future ecological change.

1. Introduction

Understanding patterns and drivers of spatio-temporal variability in species distributions and community structure is a central facet of ecology. Furthermore, it is a prerequisite for predicting ecological responses to environmental changes such as overfishing, pollution and climate change (Anderson et al., 2005; Smale et al., 2010b; Underwood et al., 2000). For example, studies on shifts in the structure of marine communities along latitudinal gradients have shed light on key ecological processes that operate across multiple spatial scales (Smale et al., 2010a; Underwood et al., 2000; Wernberg et al., 2010). Numerous studies have examined marine community structure latitudinally, to investigate regional-scale processes including temperature gradients. Many however, have found that species and communities do not change predictably with latitude (macroalgae: Anderson et al., 2005; Lima et al., 2007; intertidal invertebrates: Blanchette et al., 2008; fish: Pondella et al., 2005; Tolimieri, 2007). An extensive study by Blanchette et al. (2008) examined intertidal algal and sessile invertebrate communities spanning ~32° latitude along North America's west coast. Although spatial structure was evident in these communities, discrete species abundance distributions with latitude were not found. Breaks in similarity among sites were generally coincident with biogeographic and oceanographic discontinuities characteristic of this region (Blanchette et al., 2008).

The oceanic waters off Western Australia (WA) are dominated by the poleward-flowing Leeuwin Current (LC). It transports warm, low-nutrient water southwards along the WA coast and effectively suppresses nutrient-rich upwellings characteristic of other eastern boundary currents in the Southern Hemisphere (Lourey et al., 2006; Pearce, 1991). The LC also transports tropical propagules/larvae of algae, invertebrate and fish species south, increasing the potential for poleward dispersal and resulting in a north-to-south mixing of species along the coast (Morgan and Wells, 1991; Pearce et al., 2011). The WA coast provides a useful study region for observing the variability of marine assemblages along a latitudinal gradient because there is, as a result of the LC, a clearly defined and predictable nearshore temperature gradient that covaries with latitude. Additionally, other key environmental factors such as nutrient and substrate availability (Lourey et al., 2006; Pearce, 1991), wave exposure (Bosserelle et al., 2012; Wernberg and Thomsen, 2005), light (Staehr and Wernberg, 2009), and invertebrate grazing pressure (Vanderklift and Kendrick,

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2004), do not covary substantially with latitude in this region. The WA coast has therefore been termed a 'natural laboratory' or 'simple model system' for investigating the relationship between temperature and marine organisms (Langlois et al., 2012; Smale and Wernberg, 2009).

Studies along stretches of the WA coastline have focused on macroalgae (e.g. Smale et al., 2010b; Wernberg et al., 2003; Wernberg et al., 2011a, 2011b), algae and sessile invertebrates (Smale et al., 2010a), and fish assemblages (Fox and Beckley, 2005; Langlois et al., 2012; Travers et al., 2010; Tuya et al., 2011). Significant differences in assemblage structure between locations along the coast were found in all cases. Assemblage turnover was, at least partly, a consequence of species abundance distributions varying with temperature. Furthermore, discrete, restricted distributions along the latitudinal gradient have been described for some species (Langlois et al., 2012; Smale et al., 2010a, b; Travers et al., 2010) but not all (Tuya et al., 2008a). In contrast, some studies conducted in other regions have found geographically restricted, unimodal distributions to be rare (e.g. west coast of North America, Sagarin and Gaines, 2002; Blanchette et al., 2008, Chilean coast, Rivadeneira et al., 2010).

The temperate coastline of WA supports high levels of species richness and endemism for some marine groups, particularly macrophyte and fish assemblages (Fox and Beckley, 2005; Phillips, 2001; Smale et al., 2010b). It has been suggested that this elevated biodiversity is a consequence of WA's old, climatically buffered and infertile seascape. The region has been thermally stable and free from large scale disturbance events (i.e. glaciation, tectonic activity) for >40 million years, allowing time for species diversification and/or niche differentiation (Langlois et al., 2012; McGowran et al., 1997). Compared with fish and macrophytes however, few studies have explored invertebrates and even fewer have focused on mobile invertebrates (but for examples in WA see Edgar, 1990a, b; 1992; Tuya et al., 2008b, 2009; Vanderklift and Kendrick, 2004), because they are often highly mobile, cryptic and extremely diverse (>6 phyla) (Hunt and Scheibling, 1997). Mobile invertebrates are a vital component of nearshore marine ecosystems as they contribute to the flux of organc material into the system (Taylor, 1998) and provide the link between primary producers and second-order consumers (Edgar and Shaw, 1995; Robertson and Lenanton, 1984). Additionally, epifaunal grazers contribute significantly to the cycling of detached macrophytes accumulating typically along WA beaches (Robertson and Lucas, 1983), and are essential for maintaining healthy seagrass meadows by preventing excess growth of epiphytic algae (Jernakoff and Nielsen, 1997). However, despite their importance across a wide range of ecological services and functions, regional-scale research on the distribution of mobile invertebrates, particularly crustaceans, remains comparatively limited.

Artificial settling devices can be used for determining assemblage patterns of mobile epifauna, by acting as a control for the high variability in structure and composition of natural settling surfaces (Edgar, 1991, 1992; Paula et al., 2006; Tuya et al., 2009). For the Western rock lobster, *Panulirus cygnus*, artificial settlement "collectors" have been utilized to determine spatial and temporal patterns of its puerulus (or post larval) stage (Phillips, 1972). This has proven to be an accurate predictor of lobster catch 3–4 years later when puerulus have grown to harvestable size (de Lestang et al., 2012). Like natural substrata, artificial settling surfaces provide habitat for animals recruiting from the larval stage, as well as for adults and juveniles migrating from neighboring environments (García-Sanz et al., 2012). This study utilized these collectors to examine the structure of developing assemblages of mobile invertebrates onto artificial 'macrophytic' habitat, to address the knowledge gap in large-scale spatial distributions along the coast of nearshore WA. Specifically, we predicted that as with fish and macroalgal assemblages in WA, mobile invertebrate assemblage structure would change incrementally with latitude.

2. Methods

2.1. Study region

This study utilized pre-established invertebrate collectors deployed by the Department of Fisheries, Western Australia (DoF), which provide artificial substratum suitable for the settlement of mobile invertebrates (Phillips 1972). Collectors were deployed at six locations encompassing ~1100 km (9.1° latitude) along the Western Australian coastline, ranging from the tropical northwest shelf to the temperate waters off southwest Australia (Fig. 1).

In situ environmental data were collected at each location, for temperature, salinity and water movement (Table 1). Temperature loggers (Stow Away TidbiT TBI32-05+37) recorded water temperature every hour to the nearest 0.1 °C. A wave logger deployed at each location, recorded static acceleration on the vertical and horizontal axes, resulting in a relative water movement reading (see Evans and Abdo, 2010 for more details). Data showed that temperature decreased gradually from north to south, from 23.3 °C at Coral Bay to 17.0 °C at Warnbro (winter means). Relative water movement and salinity did not vary substantially with latitude (Table 1). In terms of surrounding habitat, the main differences were observed between 24.5° and 28.7° latitude, where surroundings changed from macroalgal-dominated in the south to coral-dominated in the north, with the offshore location (Abrolhos, 28.7°), comprising a mix of both (Table 1).

2.2. Invertebrate collectors and identification

At each location, 5–6 replicate collectors, located between 40 m and 3 km from the shoreline, were positioned in the lee of reef formations; either fringing coral reefs in the north or limestone reefs from Abrolhos south (Fig. 1). At each location, four randomly chosen collectors (situated ~20–1200 m apart, Table 1) were sampled for mobile invertebrates in August ('winter') and November ('spring') 2009. The current

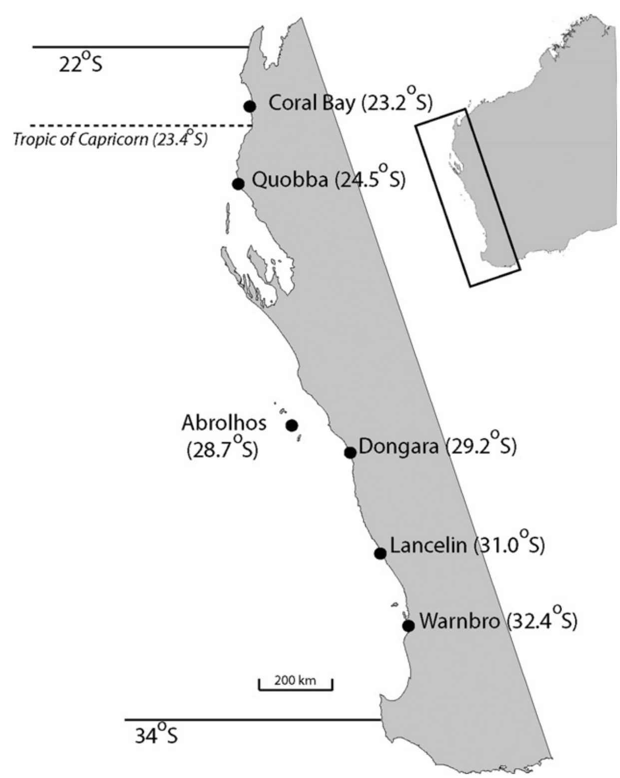

Fig. 1. Map of the West Australian coast (modified from de Lestang et al., 2012), indicating the six study locations.