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Herbivore abundance, grazing rates and feeding pathways on Australian temperate reefs inside and outside marine reserves: How are things on the west coast?

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ABSTRACT

Marine reserves are used as a management tool to conserve biodiversity and maintain ecological processes essential to ecosystem function. Grazing by herbivorous fish contributes to maintaining resilient reefs and marine reserves are important in conserving herbivores and their functional role. On the east coast of Australia, herbivores from the closely related families Girellidae and Kyphosidae are targeted by fishers and marine reserves have been shown to support greater size and abundance of girellids and kyphosids which enhances grazing on temperate reefs. On the west coast, however, kyphosids and girellids are rarely targeted by fishers. This study tested the hypothesis that there would be no difference in the size, abundance and feeding rates of girellids and kyphosids on temperate reefs inside and outside marine reserves at Rottnest Island, Western Australia, due to their relatively low levels of exploitation. The size, abundance and feeding rates of girellids and kyphosids inside and outside marine reserves were quantified using a diver-operated stereo-video system and feeding trials. No significant difference was found in the size and abundance of *Kyphosus cornelii* and *Kyphosus* spp. (*Kyphosus sydneyanus* and *Kyphosus gladius* combined) or feeding rates inside and outside marine reserves. The second aim of the study was to assess the relative importance of grazing and drift-feeding pathways used by kyphosids. Drift-feeding is an alternative form of herbivory to grazing and herbivores switching between grazing and drift-feeding pathways can have significant effects on algal communities, yet little is known about the relative importance of both feeding strategies for fish. A combination of feeding observations (mensurative) and feeding trials (manipulative) were used to quantify the number of feeding bites taken by fish on drift algae and attached algae. There was no significant difference in the number of feeding bites taken by the abundant herbivore, *K. cornelii*, on drift algae and attached algae during feeding observations, however, during feeding trials herbivores consumed significantly more drift algae (*Ulva* sp.) than attached algae. These findings demonstrate that drift-feeding is a common feeding strategy used by kyphosids. The findings in this study also highlight considerable differences in the effects of marine reserves on targeted east coast and non-targeted west coast populations of girellids and kyphosids on temperate reefs.

1. Introduction

The key objectives of marine reserves are to conserve biodiversity and marine habitats, however in light of the indirect effects of fishing on trophic interactions there has been increased focus on the role marine reserves play in maintaining ecological processes important to the functioning of marine ecosystems. For example, on coral reefs marine reserves protect populations of targeted herbivores essential to the functioning of marine ecosystems (Mumby et al., 2006; Harborne et al., 2008). By grazing algae, herbivores maintain space for corals to recruit and grow, preventing phase shifts from coral to algal dominated habitats (Hughes et al., 2007). On temperate reefs, marine reserves enhance the size and abundance of predatory fish and lobsters responsible for maintaining low densities of sea urchins (Babcock et al., 1999; Shears and Babcock, 2002; Shears and Babcock, 2003). This top down control prevents high densities of sea urchins from overgrazing macroalgae, which can lead to phase shifts from kelp forests to urchin barrens (Babcock et al., 1999; Shears and Babcock,

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2002; Shears and Babcock, 2003).

The importance of fish herbivory on temperate reefs and the effects of marine reserves on herbivores and their functional role are less clear. Compared to sea urchins, herbivorous fish are considered to have a minor influence on algal community structure (Jones and Andrew, 1990; Andrew, 1999). Increasingly, however, research is showing that herbivorous fish can have significant effects on temperate reef algal communities (Sala and Boudouresque, 1997; Ojeda and Munoz, 1999; Vergés et al., 2009; Taylor and Schiel, 2010; Verges et al., 2014a; Bennett et al., 2015) and these effects are predicted to increase with the climate-driven range expansion of tropical herbivores onto temperate reefs as waters warm (Verges et al., 2014a; Vergés et al., 2014b; Bennett et al., 2015; Wernberg et al., 2016).

On temperate reefs in Australasia, large bodied herbivores from the closely related families Kyphosidae and Girellidae can form a significant component of the total fish biomass, in some instances > 80% (Russell, 1977; Jones, 1988; Kingsford, 2002; Bennett et al., 2015). They are primarily herbivorous, generally preferring certain types of algae (Russell, 1983; Choat and Clements, 1992; Clements and Choat, 1997; Moran and Clements, 2002; Raubenheimer et al., 2005) and are most abundant in shallow water (Kingsford, 2002). On the east coast of Australia, girellids and kyphosids are targeted by both commercial and recreational fishers, and girellids are amongst the most important recreational species caught on reefs in New South Wales (NSW) (Lincoln Smith et al., 1989; Kingsford et al., 1991; Kingsford, 2002; Gray et al., 2012). Marine reserves have been shown to support greater size and/or abundance of targeted girellids and kyphosids and enhance grazing on temperate reefs in NSW (Ferguson et al., 2016). On the west coast, however, kyphosids and girellids are rarely targeted by fishers and only make up a small proportion of recreational catches (Smallwood et al., 2006; Smallwood et al., 2011). This study tested the hypothesis that there would be no difference in the size and abundance, and hence feeding rates, of kyphosids and girellids inside and outside marine reserves on the west coast due to their relatively low levels of exploitation. The first aim of this study was to quantify the size, abundance and feeding rates of kyphosids and girellids on shallow subtidal reefs inside and outside marine reserves at Rottnest Island, Western Australia (WA).

An alternative form of herbivory to grazing is the consumption of free floating plants or algae which have become dislodged from the place where they were growing – termed drift-feeding (Harrold and Reed, 1985; Vanderklift et al., 2009). Herbivores that switch between grazing and drift-feeding pathways can have significant effects on algal communities. For example, Harrold and Reed (1985) showed that in urchin barrens where drift algae were sparse, sea urchins moved over wide areas actively grazing the substrate, maintaining areas devoid of kelp. Whereas in kelp forests, where drift algae were more abundant, sea urchins exerted little grazing pressure on kelp stands because they were more sedentary and fed predominantly on drift algae. Switching between grazing and drift-feeding pathways has been documented for sea urchins (Harrold and Reed, 1985; Vanderklift et al., 2009) and the importance of drift algae as a food source and habitat for fish has been discussed (Rimmer, 1986; Kingsford, 1995), however little is known about the relative importance of both feeding strategies for fish. The second aim of this study was to assess the relative importance of grazing and drift-feeding pathways for kyphosids on shallow subtidal reefs at Rottnest Island, WA.

2. Materials and methods

2.1. Study area

The study was carried out at Rottnest Island (32°00′S, 115°30′E), located off the southwest coast of WA, approximately 18 km west of Fremantle (Fig. 1). Rottnest Island Marine Reserve covers an area of approximately 3828 ha and is classified into three main zones: "no-take" sanctuary zones (hereafter referred to as marine reserves) where some shore based fishing is allowed, however taking of marine flora and fauna by all other means is prohibited; recreation zones which are closed to commercial and amateur net fishing, and general use waters. Marine reserves comprise 17.3% of Rottnest Island Marine Reserve, recreation zones 50.4% and general use waters 32.3%. The three marine reserves examined in this study, Parker Point, Green Island and Armstrong Bay, were gazetted in 1988 (Parker Point) and 2007 (Green Island and Armstrong Bay) and had been in place for approximately 23 and 4 years respectively prior to the commencement of the study (Fig. 1). Parker Point marine reserve initially covered an area of 5 ha before being expanded in 2007 to cover an area of 89 ha, making it similar in size to both Green Island (92 ha) and Armstrong Bay (82 ha) marine reserves.

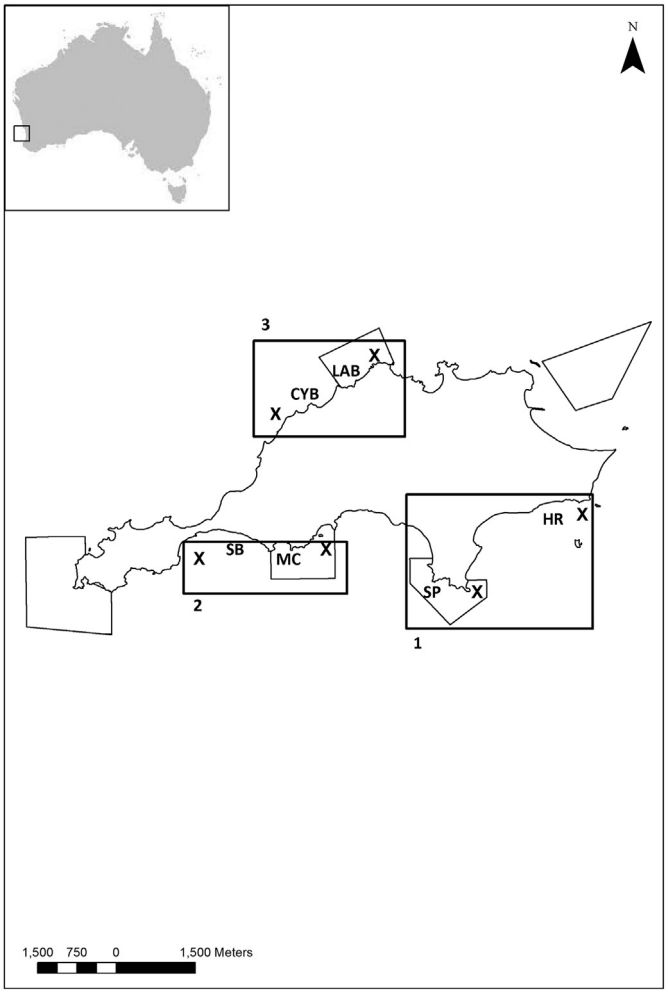

Fig. 1. Map of Rottnest Island, Western Australia, where the study was conducted. Polygons represent marine reserves. Darker rectangles represent Blocks 1 to 3 (numbered) used in the analyses. Parker Point marine reserve is located within Block 1, Green Island marine reserve within Block 2 and Armstrong Bay marine reserve within Block 3. Kingston Reef marine reserve is located to the NE of Rottnest Island. Fish surveys were carried out at a total of 12 sites inside and outside marine reserves (marked with an X or labelled with the abbreviated site name). Feeding observations and feeding trials were carried out at a subset of 6 sites (labelled with the abbreviated site name).

2.2. Fish surveys

Fish surveys were carried out on shallow subtidal reefs at twelve sites during July to August 2011 (Fig. 1). To determine whether there was a difference in the size and abundance of kyphosids and girellids between protected and fished areas, two sites were surveyed within each of three marine reserves and three adjacent recreation zones