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Fish assemblages in locations with alternative structured habitats in an eelgrass, *Zostera*, dominated bay: Biodiversity value and potential for refuge

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ABSTRACT

The eelgrass, *Zostera*, is a key habitat for fish productivity in southern Australia, but it is also susceptible to major declines, as in Western Port, Victoria in the 1970s. The fish assemblages in *Zostera* in Western Port have been relatively well studied, but assemblages in locations with alternative habitats, and their spatial and temporal variability, have been poorly studied. This means that the ability of these locations to serve as refuge areas in periods of *Zostera* decline is unknown. Two primary sampling methods were used for sampling locations with alternative habitats. Underwater stereo video was used to sample locations with higher water clarity and dominated by *Amphibolis*, reef-macroalgae and rhodolith bed habitats. A mini otter trawl was used to sample locations with low water clarity and low relief bottom: one location was dominated by *Caulerpa* habitat and the other was a reference *Zostera* location. The results showed that many species that have previously been found to be common in *Zostera* seagrass were also found in *Caulerpa* habitat, and to a lesser extent with *Amphibolis* habitat. Most species were associated with multiple plant habitats although some were more specific, such as the Weedy Seadragon, *Phyllopteryx taeniolatus*, which was only recorded in *Amphibolis* habitat. Multivariate analysis indicated that fish community structure was very similar between the location with *Caulerpa* and the reference sub-tidal *Zostera* location. Smaller fish were more abundant at all locations in autumn reflecting the spring spawning period of most species. Overall, most species were not limited to associating with *Zostera* habitat and therefore locations with alternative structured habitats may provide a measure of refuge in the face of *Zostera* decline. This conclusion, however, can only be considered preliminary until there is a clearer understanding of the functional relationship between fish species and these alternative habitats. Any potential refuge value is likely to be limited for species with a specific preference for *Zostera* such as some pipefish species, or where species have larvae that settle primarily in shallow habitats or in locations dominated by *Zostera*.

1. Introduction

The relationship between fish and their habitat is fundamental to the persistence of fish populations. The more specific the habitat requirements of fish, the more vulnerable the population is to decline where that habitat is reduced or lost. Many fish species have been shown to have strong links to seagrass beds, either as a nursery habitat offering high food levels and protection from predators, or as adult habitat, offering foraging and reproductive benefits (Bell and Pollard, 1989; Jackson et al., 2001; Heck et al., 2003). Seagrass, however, is vulnerable to reduction in water quality and other environmental threats, and world-wide has declined at a rate of 7% per year since 1990 (Waycott et al., 2009).

For many fish species, whether fish are strictly reliant on seagrass habitat, or whether other habitats can also be used, therefore providing a refuge in the event of seagrass loss is poorly understood. Studies have compared fish in seagrass to other structured habitats (e.g. reef/algae) as well as unvegetated mud or sand habitat (Jenkins and Sutherland, 1997; Jenkins and Wheatley, 1998; Guidetti, 2000; Heck et al., 2003; Franco et al., 2006; La Mesa et al., 2011). Generally, there is some overlap in the fish

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communities in seagrass habitat and other structured habitats, while unvegetated habitats tend to support very different fish communities, usually with fewer species. Even amongst structured habitats, however, some differences in fish communities are usually found (Jenkins and Wheatley, 1998; Guidetti, 2000). Indeed, even within seagrass habitats, different seagrass species with varying morphological characteristics can show differences in fish assemblages (Middleton et al., 1984; MacArthur and Hyndes, 2001; Hyndes et al., 2003; Kendrick and Hyndes, 2003).

Fish communities can vary not only on the basis of habitat, but also spatially and temporally within a habitat. For example, seagrass beds in certain areas may support more juvenile fish than others because they are located in an area relative to current patterns that receives more larval settlement (Bell et al., 1988; Jenkins et al., 1998; La Mesa et al., 2011). Fish communities within one habitat type will also vary with depth, for example because pre-settlement larvae are distributed near the surface and therefore settlement tends to occur in shallow water (Bell et al., 1992; Smith et al., 2012; Hutchinson et al., 2014). Fish community structure will also tend to show strong seasonal patterns because most fish species have distinct spawning periods that result in seasonal patterns of juvenile recruitment (Jenkins et al., 1997b). Finally, fish will often show distinct tidal and diurnal variation in habitat use (Sogard et al., 1989).

Western Port, a temperate bay in the State of Victoria, south-eastern Australia, is a key biodiversity region as well as supporting important fisheries (Jenkins, 2011; Keough et al., 2011). Western Port was listed as a RAMSAR site in 1982, reflecting its status as a wetland of international importance for migratory and resident shorebirds, and contains three Marine National Parks (Keough et al., 2011). Western Port has a large area of intertidal mudflats dissected by dendritic channels with strong tidal currents. The tidal range of 2–3 m means that a large volume of water is exchanged between the bay and the offshore waters on each tidal cycle. Western Port supports large areas of *Zostera* seagrass supporting a rich and diverse fish community (Robertson, 1978, 1980; Edgar et al., 1993; Edgar and Shaw, 1995; Hindell et al., 2004). However, seagrass in Western Port, and *Zostera* in particular, has been subject to large losses, most markedly in the mid-1970s (Shepherd et al., 1989; Walker, 2011).

Fish assemblages in seagrass, *Zostera* sp., habitat (Robertson, 1978, 1980; Edgar et al., 1993; Edgar and Shaw, 1995; Hindell et al., 2004) and mangrove, *Avicennia marina,* habitat (Hindell and Jenkins, 2004; Hindell et al., 2004; Hindell and Jenkins, 2005) in Western Port are relatively well studied, and some information is available on fish assemblages on unvegetated sediment habitats (Edgar and Shaw, 1995; Hindell and Jenkins, 2004; Hindell et al., 2004). In the case of *Zostera*, fish diversity and biomass is high relative to unvegetated habitat (Edgar and Shaw, 1995), and it functions as a nursery area for juveniles of important economic species such as King George Whiting, *Sillaginodes punctatus* (Robertson, 1977; Jenkins et al., 2000). The loss of *Zostera* habitat in Western Port in the 1970's was assumed to have caused a major decline in fish production, although it was also assumed that alternative habitats would not be available (Edgar and Shaw, 1995). It is possible that fish associated with *Zostera* can also use alternative habitats such as macroalgae. If this were the case then these habitats might act as a refuge if losses of *Zostera* occurred. Mangroves apparently do not form an important alternative habitat for seagrass fish, most likely due to their position in the upper intertidal zone (Jenkins, 2011).

There are several locations with other potentially important fish habitats in Western Port about which little is known, both in terms of their intrinsic biodiversity value and also their potential as alternative habitats to *Zostera*. The seagrass *Amphibolis* forms extensive beds in the southern, more exposed part of Western Port (Blake and Ball, 2001; Blake et al., 2012). Anecdotal information suggests that *Amphibolis* in this location could form a key habitat for Weedy Seadragons, *Phyllopteryx taeniolatus*, and also for the spawning of the economically important Southern Calamari, *Sepioteuthis australis*, however, quantitative information on the relationship between these and other fish species within *Amphibolis* is lacking (Jenkins, 2011). Another example of such an alternative habitat is the alga *Caulerpa cactoides* that forms extensive beds of the on the eastern side of Western Port (Bulthuis, 1981; Blake and Ball, 2001). This relatively fragile alga generally occurs at slightly greater depths than *Zostera* but could potentially provide a viable alternative habitat for fish species. Finally, there are also locations with hard substrate including reefs with macroalgae, and rhodolith beds (Blake et al., 2012). Again, there is a lack of information on fish species utilising structured habitats in these locations.

At present it is uncertain whether key species associated with *Zostera* in Western Port are also associated with alternative habitats in different locations within the bay. Understanding the overlap in fish species associated with *Zostera* and alternative habitats in other locations is the first step in assessing the potential for alternative habitats to provide a refuge in the event of *Zostera* loss. In the current study, fish communities at locations with a range of alternative habitats to well-studied *Zostera* and mangroves are investigated. These alternative structured habitats included *Amphibolis* seagrass, reef/algae, *Caulerpa* macroalgae and rhodolith beds. Different habitats occur in different locations within Western Port so that variation in fish abundance and community structure will be partly habitat related but also partly related to characteristics of the location (i.e. differences in exposure, water clarity, currents delivering larvae and many other factors).

The primary aim of this study was to determine the level of overlap of fish assemblages in locations with different structured habitats in comparison with existing information for *Zostera*. Spatial and temporal (seasonal) variation in species richness, abundance and assemblage structure within locations with alternative habitats was examined. A secondary aim was to provide information on the fish biodiversity value of locations with different habitats throughout Western Port for use in identifying significant marine asset areas for management and risk mitigation purposes.

2. Methods

2.1. Sampling locations

Sampling sites for *Amphibolis* seagrass and reef/algae were in the western entrance location (Fig. 1). *Amphibolis* seagrass sites at Balnarring and Flinders consisted of beds growing on relatively flat, sedimentary bottom, while at Point Leo, *Amphibolis* was growing on higher relief reef (Fig. 1). Reef/algae habitat was sampled at Cat Bay on Phillip Island (Fig. 1), where macroalgae such as the brown alga, *Cystophora* sp, was associated with high-relief reef. Depths of sampling in this location ranged from 2.5 to 7 m.

The location on the eastern side of the Rhyll basin ('eastern location' hereafter) dominated by *Caulerpa cactoides* included sites at Coronet Bay and Loelia shoal (Fig. 1), within a large area of this species growing on low-relief unvegetated sediment in depths of 4–7 m. In autumn, additional sampling at a *Zostera* reference location north of Hastings in the lower North Arm (Fig. 1) was undertaken in depths of 3.5–4.5 m where relatively dense beds of *Zostera* seagrass occurred near their lower depth limit in this area (this was the only known area of the bay with a large expanse of deeper sub-tidal *Zostera* suitable for trawl sampling). Rhodolith