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Miniature baited remote underwater video (mini-BRUV) reveals the response of cryptic fishes to seagrass cover

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Miniature Baited Remote Underwater Video (mini-BRUV) reveals the response of cryptic fishes to seagrass cover

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Running Head: Cryptic fishes respond to seagrass cover

Abstract

Seagrass habitats worldwide are degrading and becoming fragmented, threatening the important ecosystem services they provide. Fauna associated with seagrasses, particularly cryptic species, are expected to respond to these changes, but are difficult to detect at ecologically meaningful scales using non-extractive techniques. We used a small, wide-angle camera (GoPro) and a small quantity of bait positioned within the canopy of *Posidonia australis* meadows in Jervis Bay, New South Wales to assess the response of fishes to seagrass cover. We saw a clear positive relationship with the condition of *P. australis*; a high cover of this seagrass had positive effects on the diversity and abundance of cryptic fauna. Our findings highlight ecosystem shifts associated with the loss and fragmentation of biogenic habitat. These changes are of particular relevance for *P. australis* meadows given their current status as an endangered ecological community in several locations in NSW and their slow rate of recovery from disturbance.

Keywords: fish assemblages; seagrass; *Posidonia australis;* sampling method; cryptic species; GoPro camera

Introduction

Seagrass meadows are valuable ecosystems, playing important roles in nutrient recycling, carbon sequestration, trophic transfers, and providing nurseries for a large range of fish and other taxa including key economic species (Duarte 2002; Fourqurean et al. 2012). Despite the value of this habitat, seagrasses are suffering loss and degradation at an alarming rate worldwide and the rate of loss appears to be accelerating (Waycott et al. 2009). In NSW, approximately 85% of estuarine seagrass beds have been lost (RJ West pers. comm.) and six populations of *Posidonia australis* are listed as endangered (DPI 2012). With increasing declines in seagrass worldwide, it is essential to understand how these losses will affect the abundance and diversity of seagrass associated fauna.

Seagrass meadows are affected by an array of human activities. Declines in seagrass cover have been linked to moorings (Demers et al. 2013), eutrophication (Cardoso et al. 2004), anchoring (Okudan et al. 2011) and dredging (Badalamenti et al. 2011). Anthropogenic activities can impact upon a variety of seagrass characteristics that may have important implications for fish assemblages. These characteristics may be classed as either ‘landscape’ or ‘structural’ and will have different effects depending on the species and trophic group in question (Hovel et al. 2002). Landscape characteristics include large-scale attributes such as size, number, shape and perimeter-area ratio (i.e. proportion of edge) of seagrass beds in meadows (Connolly and Hindell 2006), whilst structural characteristics include small-scale local attributes such as seagrass cover, shoot density, epiphyte load and canopy height (Jelbart et al. 2007).

Seagrass structural characteristics are less often used to assess patterns of seagrass fish assemblages due to the difficulty of sampling mobile fauna at small spatial scales (Connolly and Hindell 2006). Instead, most studies assess patterns of infaunal and epifaunal assemblages such as shrimp, gastropods and crabs due to their small size and low mobility (e.g. Edgar 1992; Johnson and Heck 2006). Nevertheless, significant relationships have been found between fish assemblages and the structural characteristics of seagrass such as shoot density (Gullstrom et al. 2008), seagrass cover (Hovel et al. 2002) and epiphyte load (Jackson et al. 2006).

Here, we use a small BRUV unit, deemed 'mini-BRUV' and based on GoPro technology, to sample fish assemblages within the seagrass canopy in areas ranging from degraded meadows to some of the most pristine *Posidonia australis* meadows in southeastern Australia. As cryptic species often rely on this habitat for protection from predators (Heck and Orth 1983) we reasoned that the loss of seagrass cover would affect their diversity and abundance.

Materials and Methods

Study locations and sampling

We sampled in Jervis Bay, a large, marine-dominated embayment located in southeast Australia (35°08' S, 150°45' E) (Fig. 1). We selected five sample locations (Hare Bay, Green Point, Long Beach, Hole in the Wall and Callala Bay) based on the presence of *Posidonia australis*, an endemic Australian seagrass found in large expanses throughout Jervis Bay. Some of these areas have suffered seagrass loss and degradation from anchoring and mooring activities (Demers et al. 2013, author's pers. obs.) All sampling occurred in shallow seagrass beds between 1.0-4.0 m depths. Sampling was done over a 6-week period during October-November 2012.

We developed a miniaturized baited remote underwater video (BRUV) system and placed it within the seagrass canopy. The mini-BRUV consisted of a GoPro (Hero 2) camera affixed to a standard clay brick (23 x 11 x 7 cm) and attached to a steel grid (45 x 30 cm), which served to anchor the unit and flatten the seagrass (Fig. 1). Attached to the grid and opposite the brick was a bait bag (18 x 8 x 6 cm) made of plastic mesh containing a single pilchard (*Sardinops sagax*) weighing approximately 45 g and cut into 4 pieces. Pilchards were replaced before each deployment. A rope and buoy were attached to the unit and used to relocate the equipment. Each GoPro camera was set to the highest possible resolution (Resolution/FPS: 1080-30p) and all LED lights were deactivated. A GoPro flat lens was used on cameras to reduce distortion in water.

At each location, mini-BRUVs were deployed by snorkelers at 3 sites separated by a minimum of 100 m. At each site, 4 mini-BRUV units were simultaneously deployed and placed 20-30 m apart to minimize any overlap of bait plumes. Units were placed at a minimum of 20 m from the seagrass-sand interface and 50 m from nearby reef habitats to prevent sampling fishes associated with bare sand or reef environments. As mini-BRUV units had a restricted field of view and minimal bait was used we were not certain of the number of fish each mini-BRUV would attract. Hence, the abundance and species richness recorded on the 4 mini BRUVs at each site were considered a single deployment and were pooled to form a single replicate (but see section 'Video and statistical analyses'). Mini-BRUVs were left to record for 35 minutes to allow for 30 minutes sampling time. All video sampling was carried out between 0800-1600 hrs to avoid reduced visibility outside of these hours.

We estimated the cover of seagrass using point counts. Two 10m line transects were haphazardly placed within 5 m of each mini-BRUV unit. We recorded the presence or absence of seagrass every 0.5 m giving a total of 160 points for each replicate (8 transects per mini-BRUV replicate). Seagrass presence included any live material of seagrass including shoot, flower or rhizome. Seagrass cover was only quantified after mini-BRUVs had completed filming to prevent any effects of snorkeler presence on fish. Counts were then converted to percent cover.

Video and statistical analyses

Video analysis commenced 3 min after Bottom Time (BT), which was the time when the BRUV unit settled on the sea floor. This allowed fish to recover from the presence of snorkelers. Videos were analyzed for exactly 30 min from BT and all fish and crab individuals observed during this time were recorded.

At the time of sampling, this was the first study in which mini-BRUVs had been used to assess cryptic fish in seagrass environments and combined with a restricted field of view and minimal bait, we were uncertain of the number of fish (particularly cryptic fish) each mini-BRUV would attract. Hence, the species richness recorded on the 4 mini-BRUVs at each site were considered a single deployment and were pooled to form a single replicate.

Fish abundance was estimated with *max* N, the maximum number of individuals of a species observed in a single frame throughout the 30 min video. This prevented recounting the same individual and is therefore a conservative measure of relative fish abundance. As mini-BRUV units comprising a replicate were relatively close to each other, we recorded abundance as the highest *max* N observed by a single camera across the 4 units comprising each mini-BRUV replicate.

We then examined the relationship between the cover of seagrass for the 15 replicate mini-BRUV deployments and the diversity and abundance of cryptic and non-cryptic fishes with least squares regression (JMP V9). We confirmed that model residuals did not show evidence of significant spatial autocorrelation (Moran's I) using the 'spdep' package in R, before proceeding with these regressions.

Fish were categorized as cryptic and non-cryptic based on information from a variety of sources (Hutchins and Swainston 1986, Cappo et al. 2004, Colton and Swearer 2010) as well as our own observations of species behaviour. Cryptic species were typically small (<10cm TL), shy, slow swimming, sedentary and were usually solitary. Many cryptic species were benthic, traveling amongst seagrass blades or close to the substratum. In contrast, non-cryptic fish (also known as pelagic/transient fish) typically school, were medium- to large-sized, highly mobile and often swam above the seagrass canopy or in the water column.

Results

Our mini-BRUV deployments revealed 252 individuals from 28 species (21 families) in 30 hrs of recordings. We considered 9 of these species to be cryptic (Table 1). In addition, a large benthic crab, *Nectocarcinus integrifrons*, was observed on 73% of our recordings.

The cover of seagrass showed a strong positive effect on and explained a significant amount of the variation in the abundance (r^2=0.49, P<0.01) and diversity (r^2=0.59, P<0.001) of cryptic fishes within the *P. australis* meadows of Jervis Bay (Fig. 2a and b). In contrast, seagrass cover explained little of the variation in the abundance (r^2=0.03, P>0.05) and diversity (r^2=0.02, P>0.05) of non-cryptic fish species (Fig. 2c & d). A large school of juvenile *Gerres subfasciatus* represented an outlier in the abundance of non-cryptic fishes and it was removed from figure 2. Its exclusion did not change the nature of the relationship or our interpretation.

Discussion

Our use of a miniaturized BRUV unit ('mini-BRUV') placed within the seagrass canopy of *Posidonia australis* proved highly effective at sampling seagrass fishes, particularly small, cryptic fish species not easily detected by methods such as UVC and conventional BRUV. Importantly, mini-BRUVs produced negligible damage to the environment, which is of particular importance in MPAs and sensitive habitats such as seagrass where trawls would be considered inappropriate. The compact size of these mini-BRUVs combined with the use of a small amount of bait, made this an ideal method to examine the relationship between fish assemblages and small-scale structural attributes such as seagrass cover.

The positioning of mini-BRUV units within the seagrass allowed timid cryptic fishes to approach the bait without the risks associated with open water. The use of a small quantity bait may have been advantageous, as the large volumes of bait used in conventional BRUVs often attract schools of fish including sharks (Bernard and Götz 2012), this may intimidate smaller species (Klages et al. 2014). Although we observed predatory species around mini-BRUV units, their abundance (*max* N) remained low and many individuals were observed simply swimming past, rather than being attracted to the bait. In addition, we did not observe intimidation of cryptic fishes by the large benthic crab, *Nectocarcinus integrifrons* observed in our recordings; the diversity and abundance of cryptic fishes was not significantly correlated with crab abundance(r=0.4 and r=0.01 respectively, df=15).

The use of small quantities of bait in mini-BRUVs may also see useful applications in seascape ecology. The bait plume of conventional BRUVs has the potential to spread over hundreds of metres depending on current speed, direction and soak time (i.e. length of time BRUVs are in water) (Taylor et al. 2013). Thus schooling species drawn from a large area perhaps encompassing several habitats may concentrate around a single BRUV unit, thereby misrepresenting the fish assemblage associated with a particular habitat. The small volume of bait used with mini-BRUVs has the potential to resolve this issue although further research is required to determine bait plume size and optimum bait levels associated with mini-BRUVs over small spatial scales.

This study underscores the importance of seagrass cover to cryptic fishes. We observed a clear positive relationship in cryptic fish abundance and species richness associated with seagrass cover. As many cryptic taxa are highly specialized and likely occupy small ecological niches, they are expected to be vulnerable to habitat loss. Our findings have important implications for seagrass-dependent species as seagrass meadows continue to degrade worldwide. This calls for increased efforts to protect seagrass meadows to ensure the maintenance of the biodiversity that these key habitats support.

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Compliance with ethical standards

Conflict of Interest: The authors declare that they have no conflict of interest.

This work was completed with ethics approval from the University of Wollongong (AE12/07r15).

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Table 1: List of fish and crab[+] species observed across all deployments of mini BRUV units in *Posidonia australis* meadows in Jervis Bay, Australia. Total abundance (*max* N) was categorised into the following; *=1-5; **=6-10; ***=11-15; and ****>16. Species underlined represent cryptic organisms (Hutchins and Swainston 1986; Cappo et al. 2004; Colton and Swearer 2010).

Species	Fish Abundance (Mini BRUV)
Acanthopagrus australis	**
Aldrichetta forsteri	*
Arripis trutta	*
Atypichthys strigatus	*
Brachaluteres jacksonianus	*
Dasyatis brevicaudata	*
Dinolestes lewini	**
Enoplosus armatus	*
Gerres subfasciatus	****
Girella tricuspidata	****
Haletta semifasciata	***
Heteroclinus tristis	*
Meuschenia freycineti	**
Mugil cephalus	*
Myliobatis australis	*
Nelusetta ayraudi	***
Neoodax balteatus	***
Pagrus auratus	*
Pelates sexlineatus	****
Pseudocaranx dentex	****
Scobinichthys granulatus	**
Sillago ciliata	*
Sphyraena novaehollandiae	**
Torquigener pleurogramma	*
Trachurus novaezelandiae	*
Trygonorrhina fasciata	**
Upeneichthys lineatus	*
Nectocarcinus integrifrons[+]	****

Figures Captions

Fig. 1: Mini BRUV unit in the seagrass *Posidonia australis* at Jervis Bay, Australia. The unit consists of; 1) GoPro Hero 2 camera 2) brick (weight) 3) grid and 4) bait bag.

Fig. 2: Regression plots for total abundance (*max* N) and species richness of a) and b) cryptic fish and; c) and d) non-cryptic fish against the cover of seagrass *P. australis* within Jervis Bay, Australia.

Fig. 1

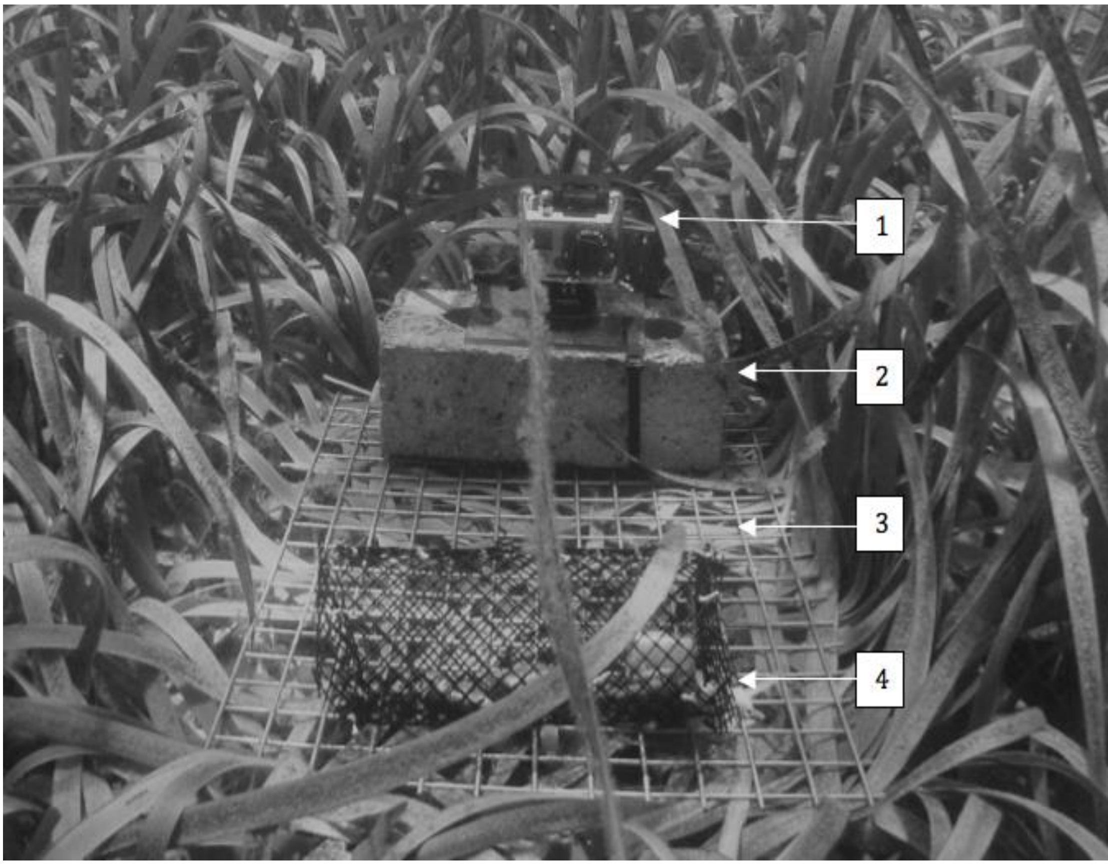
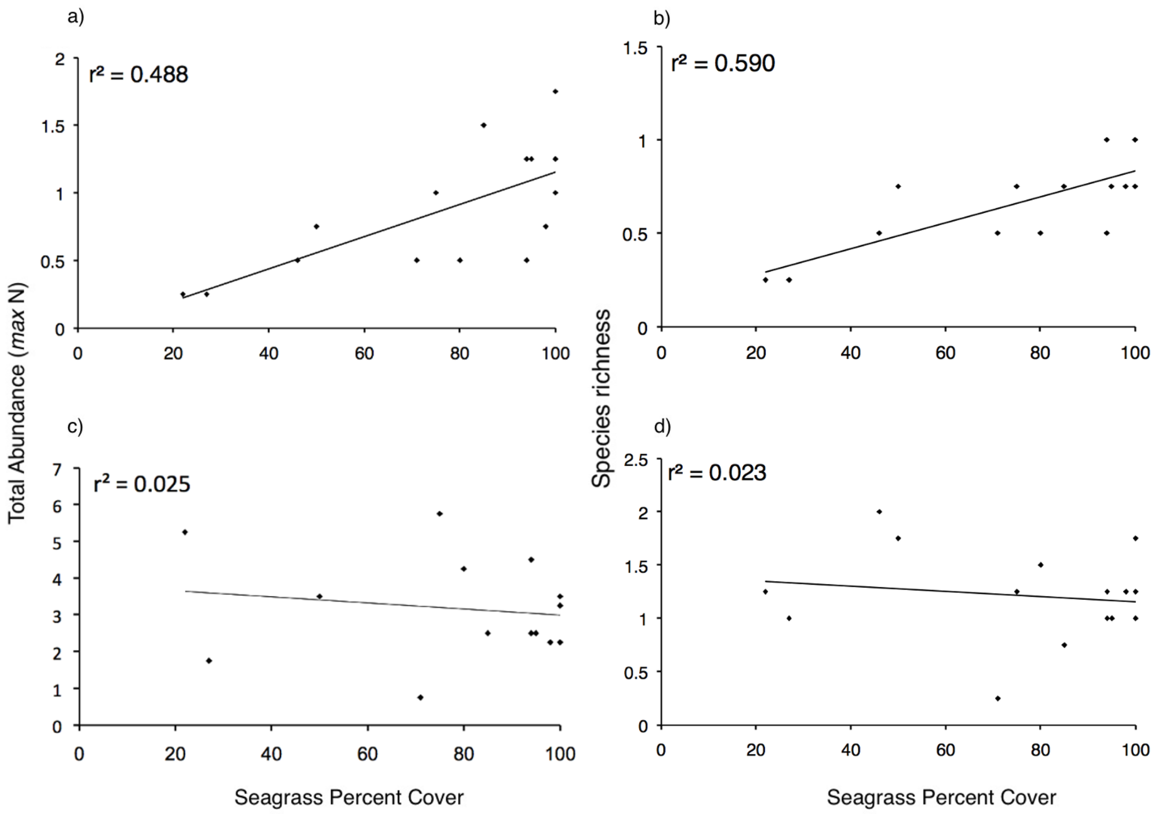


Fig. 2


a)
r² = 0.488
b)
r² = 0.590
c)
r² = 0.025
d)
r² = 0.023
Total Abundance (max N)
Species richness
Seagrass Percent Cover
Seagrass Percent Cover