Journal of Fish Biology

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--Manuscript Draft--

Manuscript Number:	JFB-MS-21-0441
Full Title:	Space use by the endemic common (weedy) seadragon (Phyllopteryx taeniolatus): influence of habitat and prey.
Article Type:	Regular Paper
Manuscript Region of Origin:	AUSTRALIA
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Significance statement

This manuscript describes novel findings of the habitat associations of the highly unique syngnathid, *Phyllopteryx taeniolatus*. We demonstrate previously untested habitat preferences for *P. taeniolatus*, showing individual's preference areas of *Ecklonia radiata* cover between 40-80%, whilst avoiding areas of < 20 % *Ecklonia* cover or rock dominated habitats. Furthermore, we identify mysid shrimp availability significantly influences *P. taeniolatus* microhabitat selection. Our findings may be highly significant in developing conservation strategies for *P. taeniolatus* populations.

Space use by the endemic common (weedy) seadragon (*Phyllopteryx taeniolatus*): influence of habitat and prey.

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This research was funded in-part by the Oatley Flora and Fauna Research Council.

Abstract

The weedy seadragon (*Phyllopteryx taeniolatus*: Syngnathidae) is an iconic fish endemic to the southern coastal waters of Australia. We analysed the habitat preferences and factors influencing microhabitat selection by *P. taeniolatus* in a population from Kurnell, NSW, Australia. Using field surveys and the resource selection probability function, we determined that *P. taeniolatus* significantly preferred kelp (*Ecklonia radiata*) - dominated habitat and avoided rock dominated habitat. We demonstrated *P. taeniolatus* preferred habitat of between 40 - 80 % coverage of *Ecklonia*, whilst avoiding areas of < 20 % cover. Furthermore, across all ~~habits~~, mysid prey availability significantly influenced *P. taeniolatus* habitat selection. The strong dependence of *P. taeniolatus* on *Ecklonia* habitat, which is reducing under climate change, could render seadragon populations vulnerable to habitat loss or degradation.

Key words: *Ecklonia radiata*, habitat preference, mysid shrimp, Syngnathidae, weedy seadragon.

Introduction

Studies on resource selection are critical to developing effective conservation strategies for species threatened by the effects of anthropogenic climate change (Aarts *et al.*, 2008; Madej *et al.*, 2011; Mei *et al.*, 2017). Habitat loss can have devastating impacts on the population structure and density of some species and drastically affect ecosystem functions (Wiegand *et al.*, 2005; Mora *et al.*, 2011). The preservation of habitat is therefore closely linked to species conservation (Airoldi *et al.*, 2008). Habitat preference studies have been used to answer a number of ecological questions, such as space use by animals and geographic distributions (Aldridge *et al.*, 2008; Roever *et al.*, 2008; Beyer *et al.*, 2010). Habitat preference may be quantified by comparing the habitat an animal uses relative to habitat availability within a site (Manly *et al.*, 2007; Aarts *et al.*, 2008), which interacts with animal behaviour to influence fitness (Beyer *et al.*, 2010).

Marine kelp forests support high levels of marine biodiversity, however, are in decline globally and locally (Marzinelli *et al.*, 2015; Krumhansl *et al.*, 2016; Martínez *et al.*, 2018; Castro *et al.*, 2020). Declines are more evident along North-South coastlines, such as temperate reefs of south-east Australia (Wernberg *et al.*, 2011; Krumhansl *et al.*, 2016). Increased sea surface temperatures and range extensions of herbivorous grazers, such as the sea urchin (*Centrostephanus rodgersii*)¸ have driven declines in important habitat forming kelps such as *Ecklonia radiata* (hereafter *Ecklonia*) and *Macrocystis pyrifera*, creating urchin barrens (Marzinelli *et al.*, 2015; Provost *et al.*, 2017; Williams *et al.*, 2020). Kelps support significant associated communities of important invertebrates and fish by increasing the surrounding structural heterogeneity and complexity and can provide essential habitat for a range of fish species (Fulton *et al.*, 2016; Teagle *et al.*, 2017; Quaas *et al.*, 2019).

The Syngnathidae, including seadragons, seahorses, pipehorses and pipefishes, is a family of morphologically diverse fishes characterised by small home ranges, sparse distributions and low fecundity (Foster and Vincent, 2004; Sanchez-Camara and Booth, 2004; Sanchez-Camara *et al.*, 2006; Vincent *et al.*, 2011). They are cryptic fish typically associated with structurally complex habitats, such as kelp, seagrass, corals and sponges (Kendrick and Hyndes, 2003; Sanchez-Camara *et al.*, 2006; Harasti *et al.*, 2014). These structurally heterogeneous habitats support an abundance of food for syngnathids, for example small crustaceans (Howard and Koehn, 1985; Foster and Vincent, 2004), and allow for effective predator avoidance (Curtis and Vincent, 2005). Studies on habitat associations of syngnathids are sparse. *Hippocampus whitei* Bleeker, 1855, was found to prefer sponge and soft coral *Dendronephthya australis* habitat, and these preferences shift ontogenetically (Harasti *et al.*, 2014). *Hippocampus reidi,* Ginsburg, 1993, strongly associated with holdfasts on mangrove structures in Brazil (Aylesworth *et al.*, 2015), while Curtis and Vincent (2005) compared habitat preferences of *Hippocampus guttulatus* Cuvier, 1829, and *Hippocampus hippocampus* Linnaeus, 1758. Furthermore, the highly specialised nature of syngnathids renders them particularly susceptible to effects of habitat loss and degradation (Vincent *et al.*, 2011; Harasti, 2016).

The weedy seadragon, *Phyllopteryx taeniolatus* (Syngnathidae) Lacepede, 1804, is an iconic fish found on the temperate reefs of southern Australia. *Phyllopteryx taeniolatus* range from Port Stephens, NSW to Geraldton, WA (Edgar, 2008; Sanchez-Camara *et al.*, 2011). Charismatic species such as the weedy seadragon can be used as effective flagship species in conservation, which in turn benefits numerous other marine species and habitats (Clucas *et al.*, 2008; Parsons *et al.*, 2015). Whilst the species is listed as 'Least Concern' on the IUCN Red List ~~(IUCN, 2017)~~, there are anecdotal reports that the species has declined in abundance at numerous sites in eastern Australia (Sanchez-Camara et al. 2011, Booth unpub data). Seadragons are poor swimmers, and rely on their exceptional camouflage to hunt prey and remain hidden from predators (Edgar, 2008; Sanchez-Camara *et al.*, 2011). Despite the charismatic nature of *P. taeniolatus*, many aspects of their ecology remain critically understudied, with only a handful of studies published (Sanchez-Camara and Booth, 2004; Kendrick and Hyndes, 2005; Sanchez-Camara *et al.*, 2005; Forsgren and Lowe, 2006; Sanchez-Camara *et al.*, 2006; Martin-Smith, 2011; Sanchez-Camara *et al.*, 2011; Harvey *et al.*, 2012; Wilson *et al.*, 2017; Klanten *et al.*, 2020). The only study to assess habitat associations of *P. taeniolatus* found that the most favourable habitat for *P. taeniolatus* is along the kelp-sand interface, suggesting that this may be the best trade-off between food availability and shelter (Sanchez-Camara *et al.*, 2006).

Ecklonia is the most ~~dominate~~ habitat-forming macro algae on Australia’s temperate reefs (Irving *et al.*, 2004; Fowler-Walker *et al.*, 2005; Coleman, 2013), and its presence strongly influences the associated community structure (Irving *et al.*, 2004; Coleman, 2013). Weedy seadragons are often found on reefs dominated by the canopy forming *Ecklonia* (Edgar, 2008). However, the majority of information on seadragon habitat association is anecdotal, derived from citizen science projects such as Dragon Search (Baker, 2005). The highly specialised morphology of *P. taeniolatus* is well suited to feeding on mobile-midwater plankters (Kendrick and Hyndes, 2005). The dietary composition of *P. taeniolatus* consists of over 80% mysid shrimp (*Mysida* spp.), which live in small swarms near temperate reefs (Kendrick and Hyndes, 2005). Prey availability and habitat availability are key drivers of resource selection in fishes (Malavasi *et al.*, 2007; Vaudo and Heithaus, 2013), so, the availability of mysid shrimp and *Ecklonia* may influence the habitat preferences of *P. taeniolatus.*

The dearth of information pertaining to *P. taeniolatus* habitat preferences could impair our ability to assess indirect effects on *P. taeniolatus* populations. Our aim was to determine which habitats are preferred by *P. taeniolatus* and what factors may be influencing this preference. From previous evidence, it was expected that *P. taeniolatus* would prefer *Ecklonia* habitat

(Sanchez-Camara *et al.*, 2006).Therefore, we aimed to investigate to what extent mysid prey and kelp habitat drive habitat usage and preferences of *P. taeniolatus*. Furthermore, we predicted that a particular combination of *Ecklonia* cover and mysid presence would be preferred. We assess the significance of our findings in relation to wider distribution of weedy seadragons and their management.

2.0 Materials & Methods

Ethical statement

This project was conducted in accordance with animal ethics permit UTS ACEC ETH17-1707 and NSW DPI Permit F94/696. Any handling of animals complied with Australian animal welfare laws

2.1 Study site

The study was conducted in Botany Bay near Kurnell, in Sydney's south (34.0116° S, 151.2069° E), New South Wales, Australia. This area was chosen as there is a known population of *Phyllopteryx taeniolatus* which has been the subject of previous research and long-term monitoring (Sanchez-Camara and Booth, 2004; Sanchez-Camara *et al.*, 2005; Sanchez-Camara *et al.*, 2006; Sanchez-Camara *et al.*, 2011). The location has a sloping rocky reef formation that runs parallel to the shoreline ending on an open sand flat at around 12 m depth. The macrophyte community is dominated by *Ecklonia,* with scattered patches of *Sargassum* spp. and *Caulerpa* spp. interspersed by rocky habitat urchin barrens, sponges and sand. Surveys were conducted along the kelp-sand interface (9-13 m depth), with regular incursions of approximately 15 m into shallower habitat to search for *P. taeniolatus.* The survey area spanned 210 m along the reef, measured using a diver towed GPS (Garmin eTrex10®) attached to dive flag, resulting in a total survey area of ~ 3000 m^2. Surveys focused on the kelp/sand border as previous studies have suggested this to be the most favourable habitat for *P. taeniolatus* (Sanchez-Camara and Booth, 2004). Dives proceeded in a westwards/inshore direction on an incoming or high tide, for safety reasons.

2.2 Habitat preference

All observations for this study were conducted using SCUBA from March 2020 - March 2021; a total of 28 dives over 20.5 hours. Habitat preference of *P. taeniolatus* was determined via a habitat use vs availability design (Manly, 2002; Manly *et al.*, 2007). The null hypotheses was that *P. taeniolatus* would display no significant preference for a habitat type in the use-availability design. Furthermore, we compared *P. taeniolatus* distribution against distribution of *Ecklonia* habitat throughout the site to assess if *P. taeniolatus* preferred certain percentages of *Ecklonia* cover. Individual *P. taeniolatus* were identified using I3S Spot software version 4.02 (den Hartog and Reijns, 2014), to record the number of individuals and sightings during the study period. This eliminates the need for tagging the animal and has been found to be over 98% effective in identifying individual *P. taeniolatus* (Martin-Smith, 2011).

2.2.1 Habitat use

Habitat use data were obtained by roaming diver survey (Kingsford and Battershill, 2000) searching for *P. taeniolatus* within the study area. A team of two SCUBA divers searched for *P. taeniolatus* along the permanent transect, with an average dive time of 45 minutes. At each *P. taeniolatus* sighting, a 5 m microhabitat transect was run from the point of initial sighting and filmed facing directly downwards using a GoPro 5 camera (www.gopro.com) approximately 1 m above the substrate. The field of vison from the GoPro resulted in transects covering 15 m^2. From each 5 m transect video, 3 screenshots, each 5 m^2, were taken and analysed for benthic cover percentage using Coral Point Count with Excel extension (CPCe) (Kohler & Gill 2006) with 30 points overlayed per image, where each point was assigned a benthic group (Table 1). Samples of microhabitats without seadragons present ("unused") were taken by randomly placing 5 m transects within the 3000 m^2 study area at a minimum distance of 10 m from the previous transect. Benthic coverage was analysed using the same methods stated above.

2.2.2 Habitat availability

Habitat availability within the study site was estimated using a point-transect method (Choat and Bellwood, 1985; Harasti *et al.*, 2014). Two belt transects of 210 m (7 x 30 m) were placed along the study site at a parallel distance of 15 m apart. This was the area searched for *P. taeniolatus* in roaming surveys. To avoid repeat samples of available habitat, each transect was placed at the end point of the one preceding it. Benthic coverage was estimated using CPCe with approximately 20 images per 30 m transect. Any *P. taeniolatus* individuals sighted in availability measurements were excluded from habitat use metrics, as there was not time within the dive plan to sample 5 m microhabitats and availability within the same dive.

2.3 Mysid presence and absence

Mysid swarms were recorded as either present or absent within each 5 m microhabitat transect, including used and unused samples. For the purpose of this study, a swarm of mysids was defined as a cohesive group displaying regular spatial arrangement (Wittmann, 1977; Ohtsuka *et al.*, 1995).

2.4 Statistical analysis

2.4.1 Use-availability habitat preference

The resource selection probability function (RSPF) (Manly, 2002), was used to determine habitat preferences of *P. taeniolatus* at Kurnell. RSPF is a concept that has been widely adapted in many ecological studies (Johnson *et al.*, 2006; Hooten *et al.*, 2013). A RSPF computes the probability that an animal will use certain resources from a combination of environmental variables (Manly, 2002). The formula $\hat{W}_i = O_i \pi_i^{-1}$ was used to determine the habitat preferences of *P. taeniolatus* where $\hat{W}_i$ is the preference score of habitat, O_i the proportion of available habitat type *i*, and π_i is the proportional use of habitat *i*. Animals cannot select single points of habitat, rather a small region surrounding a point (McDonald, 2013). Therefore, each 5 m transect where a *P. taeniolatus* occurred, was assigned to the benthic category that occurred at the highest proportion within that 15 m^2 microhabitat.

The substrate groups included in the analyses were *Ecklonia*, sand and rock. All other benthic groups were excluded, as they were not the dominate benthos in any transect where *P. taeniolatus* was present (Manly, 2002). Statistical significance of preference scores was inferred using 95 % confidence intervals (CI). If the lower bound was > 1, then a habitat was significantly preferred. If the upper bound is < 1, then a habitat is significantly avoided. CI between < 1 and > 1 meant that habitat was used by with no preference or avoidance displayed, i.e. in proportion to its availability.

Chi-squared goodness of fit tested if *P. taeniolatus* prefer a certain cover percentage of *Ecklonia*, by comparing the observed proportion of *P. taeniolatus* occupying *Ecklonia* habitat versus the distribution of *Ecklonia* through the study site. Habitat was grouped into 5 categories of *Ecklonia* percent cover: < 20 %, 20 - 39 %, 40 - 59 %, 60 - 79 % and > 80 %. There were no replicates with > 80 % cover, furthermore, groups 40 - 59 % and 60 - 79 % were pooled to ensure expected cell count met the assumptions of the test.

2.4.2 Microhabitat selection

The null hypothesis that habitat composition would not differ between habitats used and unused by *P. taeniolatus* was tested using an independent samples t-test. Analyses were performed with IBM SPSS statistics, version 27 (IBM Corp, 2020). T-tests compared the mean percent cover of *Ecklonia*, sand and rock in microhabitats where *P. taeniolatus* were presents and absent. Benthic categories *Sargassum* spp., *Caulerpa* spp., sponges and rubble were omitted from the analysis as they contributed < 1 % of total substrate coverage. Data were Arcsine transformed (McDonald, 2014) to meet the assumptions of homogeneity of variance.

Pearson's chi-squared tested mysid presence/absence against *P. taeniolatus* presence/absence, and also mysid presence/absence in each habitat category used by *P. taeniolatus*. Data from all sightings were pooled for analysis, to increase statistical power of the study as outlined by Sanchez-Camara *et al.* (2006).

3.0 Results

3.1 Habitat availability and preferences

On shallow rocky reefs in Kurnell, sand was the most common habitat present, (47.1 % cover), followed by rock (31.2 % cover), and *Ecklonia* (19.9 % cover, Fig 1A). *Sargassum* spp., *Caulerpa* spp., sponge and rubble were each less than 1 % of total available habitat. There were 43 individuals of *Phyllopteryx taeniolatus* sighted a combined 90 times, 28 individuals were found over *Ecklonia*, 45 over sand and 17 over rock. Relative to the available habitat within the study site and using the RSPF, *P. taeniolatus* exhibited a significant preference for *Ecklonia*, no association with sand, and significantly avoided rock dominated habitat (Fig. 1B). Sightings of male and female individuals were grouped, as there were not enough sightings for valid statistical comparison of sexes.

Figure 2 shows the distribution of available habitat within the study site against the habitat used by *P. taeniolatus* individuals. Chi-squared goodness of fit showed *P. taeniolatus* were found significantly more often than expected in habitats grouped into 40 - 80 % cover ($\chi^2 = 90.40$, $p < 0.05$). *Phyllopteryx taeniolatus* were found as often expected in 20 - 39 % cover ($\chi^2 = 2.63$, p < 0.05), and were found to significantly avoid habitat of < 20 % cover (χ^2 = 19.42, p < 0.05). This demonstrates *P. taeniolatus* actively preference areas of higher *Ecklonia* cover (40 - 80%).

3.2 Microhabitat selection- influence of habitat and mysids.

The mean percent coverage in habitats used by *P. taeniolatus* were 33.8 % (± 1.81 %) *Ecklonia* coverage, 43.2 % (± 2.43 %) sand coverage, compared to 55.4 % (± 2.63 %) and 19.6 % (± 1.61 %) respectively in areas where *P. taeniolatus* were absent (Fig. 3). *Ecklonia* cover (t = – 5.259, d.f. = 149, p = 0.000) and sand cover (t = 2.973, d.f. = 149, p = 0.003) differed significantly between microhabitats used and not used by *P. taeniolatus*, whilst average cover of rock did not (t = 0.269, d.f. = 149, p = 0.788).

The presence of mysid shrimp was significantly associated with habitat used by *P. taeniolatus* (χ^2 = 9.199, p < 0.05), with mysids recorded within 71 out of 90 microhabitats where *P. taeniolatus* were found. However, there was no relationship of mysid availability in habitat not used by *P. taeniolatus*. In each of the three major habitat categories in this study, *Ecklonia* (χ^2 = 31.000, p < 0.05), sand (χ^2 = 97.000, p < 0.05) and rock (χ^2 = 22.000, p < 0.05), *P. taeniolatus* habitat use was strongly associated with mysid presence, compared to availability of mysids in areas not used by *P. taeniolatus* (Fig. 4). Preference for microhabitats where mysids are present demonstrates active selection by *P. taeniolatus* for areas where mysid prey is readily available.

4.0 Discussion

This study demonstrates a strong relationship of *P. taeniolatus* occurrence with *Ecklonia* habitat and mysid availability. We found that *P. taeniolatus* actively preference areas of above 40% *Ecklonia* cover within our study site. Similarly, individuals select habitat where mysid shrimp are present. The significant preference exhibited by *P. taeniolatus* in this study for *Ecklonia* habitat supports the findings of Sanchez-Camara *et al.* (2006), that the kelp-sand interface is the most favourable habitat for *P. taeniolatus*. However, identifying that *P. taeniolatus* prefer specific proportions of *Ecklonia* cover, can be a highly useful tool in the long-term conservation of *P. taeniolatus* populations through future protection of *Ecklonia* habitat.

The unique morphology of syngnathids is related to both the habitat they occupy, and the prey they consume (Kendrick and Hyndes, 2005; Manning *et al.*, 2019). Mysid shrimp are known to select open-water over vegetated habitat when presented with a choice (Flynn and Ritz, 2001). The density of mysid shrimp was higher over sand habitat than *Ecklonia* during this study. This may explain the association of *P. taeniolatus* with sand habitat over bare rock, despite individuals displaying no significant preference for sand habitat. The strong relationship of mysid shrimp with *P. taeniolatus* is not unexpected; however, this is the first study to show that mysid shrimp significantly influence habitat selection of *P. taeniolatus*. The results of this study will be useful for assessing habitat suitability and predicting *P. taeniolatus* abundance throughout their north-eastern range limits.

The strong dependence on habitat type and prey availability of *P. taeniolatus* are indicative of high levels of trophic specialisation, which is typical for syngnathids (Howard and Koehn, 1985; Foster and Vincent, 2004; Kendrick and Hyndes, 2005). This high level of specialisation coupled with other life history traits, such as small home ranges and strong site fidelity (Sanchez-Camara and Booth, 2004), render seadragons particularly susceptible to population declines (Foster and Vincent, 2004; Vincent *et al.*, 2011). In the only long-term population study of *P. taeniolatus*, from 2001-2009 population declines were evident in NSW and Tasmania (Sanchez-Camara *et al.*, 2011). The causes of these declines were unattributed; however, it was suggested that they may have been due to natural fluctuations in recruitment or potentially as a result of habitat loss.

Habitat loss provides one of the most critical threats to marine populations (Dulvy *et al.*, 2003; Airoldi *et al.*, 2008; Vincent *et al.*, 2011) and has been shown to have detrimental impacts on syngnathids populations (Harasti, 2016). The distribution and abundance of *Ecklonia* throughout its range in Australia is influenced by range expanding herbivorous grazers (Vergés *et al.*, 2014; Provost *et al.*, 2017), nutrients in the water column (Gorman and Connell, 2009) and temperature (Wernberg *et al.*, 2019; Williams *et al.*, 2020; Davis *et al.*, 2021). *Ecklonia* is widely accepted to not inhabit waters exceeding 26 °C (Davis *et al.*, 2021). Sea surface temperature (SST) is not a strong predictor of *Ecklonia* distribution over 10 degrees of latitude in NSW (– 28 to – 37 degrees) (Williams *et al.*, 2020); however, bottom temperature significantly predicts *Ecklonia* cover (Davis *et al.*, 2021). Kelp cover in Sydney is highest in the shallow waters where *P. taeniolatus* are found; under increasing temperatures these shallow waters are predicted to lose kelp cover first (Martínez *et al.*, 2018).

A loss of *Ecklonia* habitat would cause a shift to habitats more heavily dominated by sand and rock. Similarly, the increased occurrence of herbivorous fish and sea urchins, such as C*entrostephanus rodgersii* (Provost *et al.*, 2017; Williams *et al.*, 2020) and *Tripneustes gratilla* (Williams *et al.*, 2020), have impacted the distribution of kelp, particularly *Ecklonia*, resulting in more frequent urchin barrens (Flukes *et al.*, 2012; Filbee-Dexter and Scheibling, 2014). In NSW, higher densities of *C. rodgersii* is strongly associated with low *Ecklonia* cover particularly at higher latitudes (Davis *et al.*, 2021). Urchin barrens are rock-dominated habitats mostly devoid of kelp, with much lower structural complexity than the kelp forests they supersede (Filbee-Dexter and Scheibling, 2014). In the present study, *P. taeniolatus* were shown to actively avoid these rocky urchin barren habitats, and areas with <20% *Ecklonia* coverage. Therefore, predicted and observed shifts in habitat caused by degradation and decline of kelp forests may drastically affect populations of *P. taeniolatus*.

Habitat loss may be the greatest threat to highly specialised and habitat specific fish such as *P. taeniolatus*. Additional strategies to ensure the protection of *Ecklonia* dominated reefs could be a highly beneficial management tool for ensuring the continuance of this species into the future. Similarly, understanding the interactions of *P. taeniolatus* with mysid prey and *Ecklonia* habitat may provide valuable insight into understanding the population dynamics and northern range edge of *P. taeniolatus* populations on the east coast of Australia. Populations at northern range edges may be particularly vulnerable as they will be subjected to these effects first, particularly if climate change is continually exacerbated.

Acknowledgments

This research was funded in-part by the Oatley Flora and Fauna Research Council. Thanks to the many people who assisted in the field work and diving for this project, with special thanks to Helen Price, for assisting on countless dives during the study period.

Contributions

S. J. A. (corresponding author), contributed to conceptualisation of the study and study design, data acquisition, analysis and drafting the original manuscript. M. J. O. contributed to data acquisition, analysis and critically revising the work. O. S. K. contributed to study design and conceptualisation, data analysis and critical review of the manuscript. D. H. contributed to data analysis and interpretation, and critical revisions of the manuscript. D. J. B. contributed to conceptualising the study design and concept, data collection, analysis and interpretation and manuscript revisions.

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Tables

Table 1. Major benthic substrate groups observed at Kurnell, NSW (pers obv). Depth ranges are listed within the depth of the study site.

Habitat type	Habitat description	Depth range within study site (m)
Caulerpa spp.	Family: Caulerpaceae. Small grass like coverings of green seaweeds from the genus *Caulerpa*, thallus up to 300 mm.	3-13
Ecklonia radiata	Family: Lessoniaceae. Common brown algae found on rocky reefs. Thallus length up to 2 m.	3-13
Rock	Constituted bare rock, urchin barren and rock with crustose coralline algae.	0-13
Rubble	Included uprooted kelp, urchin remains, shells or rubbish.	0-13
Sand	Bare sand habitat with nothing else present.	0-13
Sargassum spp.	Family: Sargassaceae. Brown algae up to 1 m long in genus *Sargassum*.	3-13
Sponge	Various species of sponges.	5-13

Figure captions

Figure 1. (A) Available habitat at Kurnell, expressed as a percentage of benthic substrates within the study site. (B) Habitat preferences scores (± 95 % CI) for *Phyllopteryx taeniolatus* based on 90 sightings at Kurnell, NSW. Lower CI > 1 indicates significant preference. Upper CI < 1 denotes significant avoidance of that habitat.

Figure 2. Grey represents distribution of *Ecklonia* cover throughout Kurnell, NSW (< 20 % n = 36, 20 - 39 % n = 21, 40 - 59 % n = 3, 60 - 79 % n = 1). White shows distribution of throughout *Ecklonia* habitat in Kurnell, NSW (< 20 % n = 21, 20 - 39 % n = 40, 40 - 59 % n = 22, 60 - 79 % n = 7, * indicate significant differences).

Figure 3. Mean percent coverage of major benthic substrate groups from 15 m^2 transects for areas of used (N = 90) and unused habitat (N = 61) of *Phyllopteryx taeniolatus* at Kurnell, NSW (mean ± SE, * indicate significant differences).

Figure 4. Comparison of presence/absence of mysids and the presence/absence of *Phyllopteryx taeniolatus* (Pt.) in *Ecklonia*, sand and rock habitats. Bars expressed a proportion of total transects in each habitat group where *P. taeniolatus* was either present/absent (* indicate significant differences).

Figures

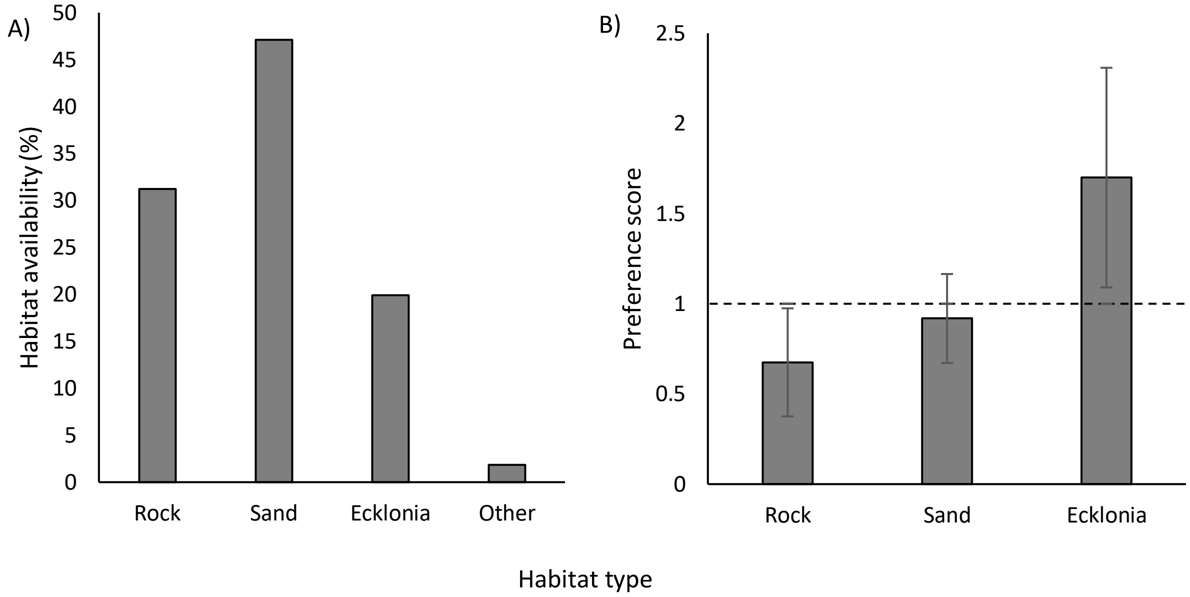


Figure 1.

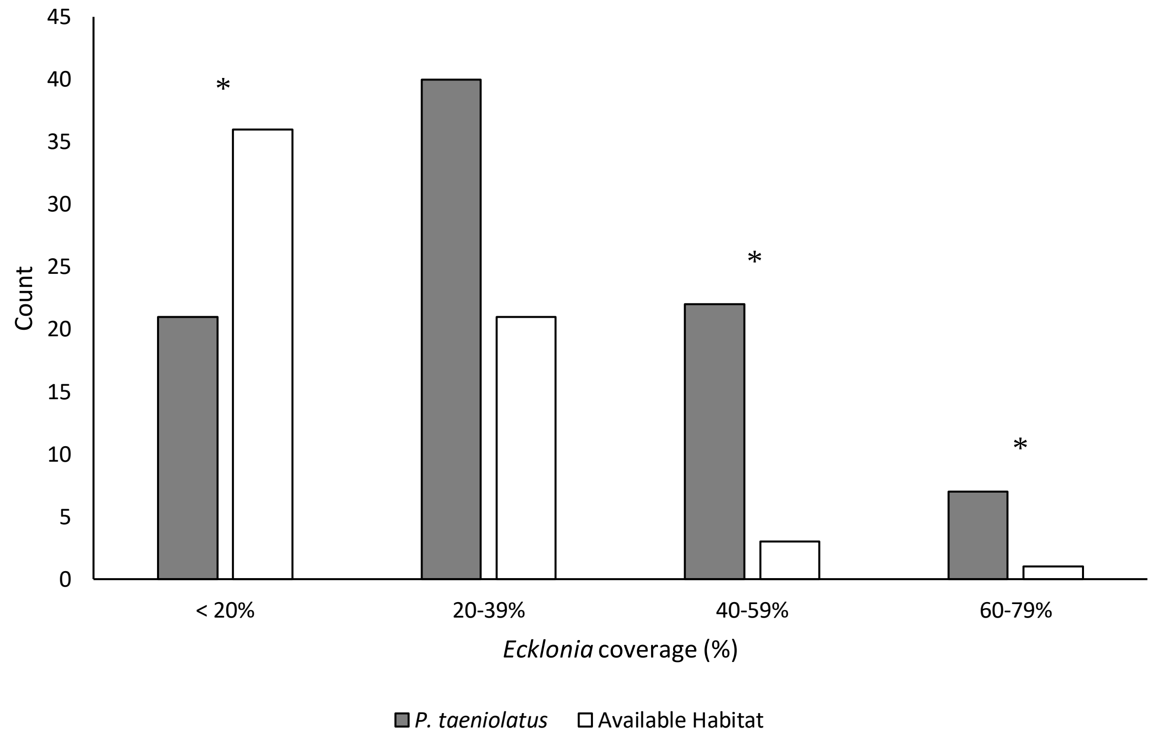

45
40
35
30
25
20
15
10
5
0
Count
< 20%
20-39%
40-59%
60-79%
Ecklonia coverage (%)
P. taeniolatus
Available Habitat

Figure 2.

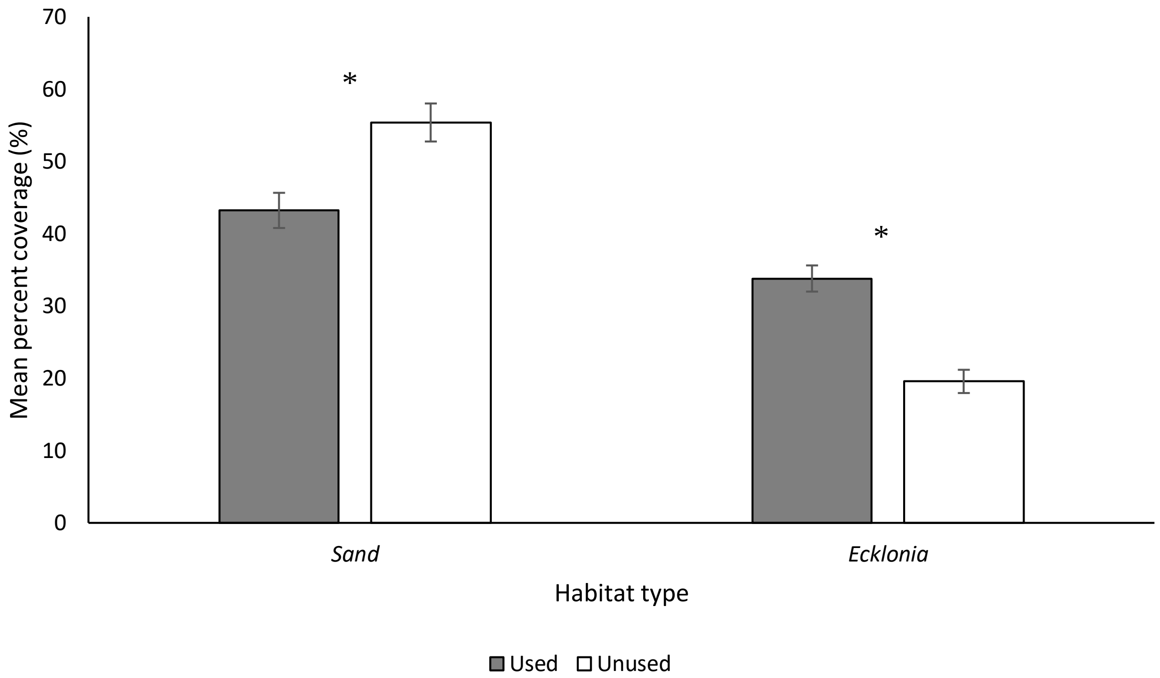
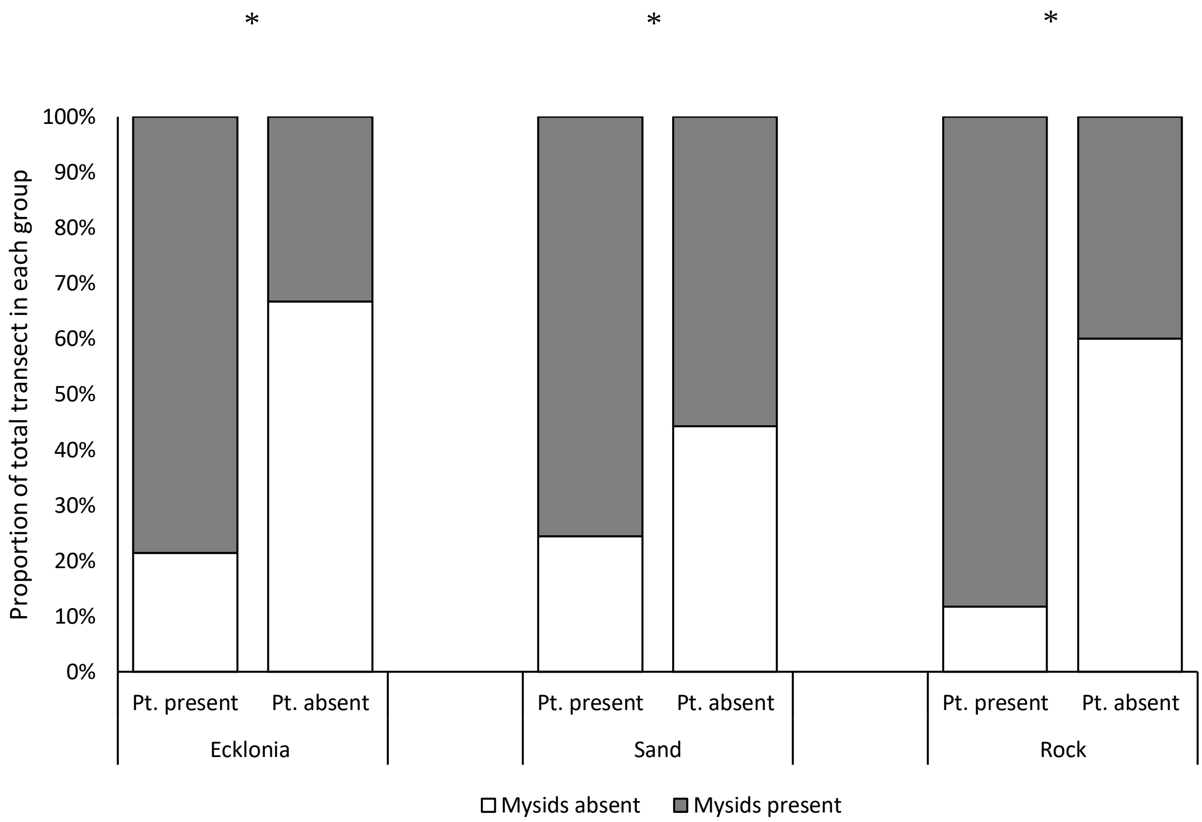

70
60
50
40
30
20
10
0
Mean percent coverage (%)
*
*
Sand
Ecklonia
Habitat type
Used
Unused

Figure 3.



*
*
*
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Proportion of total transect in each group
Pt. present
Pt. absent
Ecklonia
Pt. present
Pt. absent
Sand
Pt. present
Pt. absent
Rock
Mysids absent
Mysids present

Figure 4.