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DIEL VARIATIONS AND DIVERSITY OF FISH COMMUNITIES ALONG THE UNRECLAIMED SHALLOW COASTAL HABITATS OF CHANGI POINT BEACH, SINGAPORE

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ABSTRACT. **–** Shallow coastal habitats function as nursery, feeding and breeding grounds for many marine and estuarine fishes. Even though fish diversity in Southeast Asia is high, there is a paucity of information with regards to the fish ecology of shallow coastal habitats in Singapore. To investigate the possible function of Changi Point Beach (an unreclaimed shallow coastal habitat) and the diversity of the fish community inhabiting this area, monthly nocturnal and diurnal samplings were performed. Results indicate that, although impacted, Changi Point Beach appears to be a nursery area and supports a large diversity of fish species. This includes several species which are economically important as a food resource. Changi beach is also a popular recreational area, which is frequented by the local citizenry as well as tourists. With increasing coastal habitat degradation due to anthropogenic activities, it is important to conserve these habitats for the benefit of both the immediate fish community as well as for maintaining fish diversity in Singapore.

KEY WORDS. **–** Fish community, Changi, subtidal, diversity, conservation.

INTRODUCTION

Worldwide, the icthyofaunal ecology of different shallow coastal habitats has been relatively well studied. These productive habitats are important to numerous coastal fish species at various life stages (Rountree & Able, 1997; Jenkins & Wheatley, 1998; Hajisamae & Chou, 2003; Hajisamae et al., 2003; Jaafar et al., 2004; Unsworth et al.., 2006; Crona & Rönnbäck, 2007; Kopp et al., 2007). Besides being permanent habitats for certain smaller fish species such as *Sillago sihama*, *Ambassis kopsii* and *Stolephorus indicus* (Hajisamae & Chou, 2003), these habitats are widely recognised to function as nursery grounds (Parrish, 1989; Blaber et al., 1995; Paterson & Whitfield, 2000; Hajisamae & Chou, 2003; Crona & Rönnbäck, 2007), feeding (Heck & Orth, 1980; Chong et al., 1990) and refuge sites (Jenkins & Wheatley, 1998; Paterson & Whitfield, 2000) for the larvae and juveniles of many fish species (e.g. *Sillaginodes punctata* and *Acanthaluteres* spp.). Shallow coastal areas are also hunting grounds for larger piscivorous nocturnal fish species that patrol during high tide searching for prey (Parrish, 1989; Rountree & Able, 1997; Nagelkerken et al.., 2000). It is known that fish abundance and diversity in shallow coastal habitats can vary 1) spatially and temporally (Robertson & Duke, 1990; Santos & Nash, 1995), 2) between different substratum types (Chong et al., 1990; Jenkins & Wheatley, 1998; Lugendo et al., 2006) and 3) with different environmental variables such as diel and tidal rhythms (Jaafar et al., 2004). Given the complex dynamics of different shallow coastal habitats (Blaber, 1997), an understanding of fish ecology in Singapore is needed before a comprehensive model of a shallow coastal ecosystem can be developed.

Tropical coastal ecosystems in Southeast Asia are rich in aquatic resources (Blaber, 1997; Chou, 1996), but little reserach on fish ecology (Pinto, 1988; Chong et al., 1990; Poovachiranon & Satapoomin, 1994; Jaafar et al., 2004) has been conducted regionally, with Singapore particularly poorly studied (Hajisamae et al., 2003; Hajisamae & Chou, 2003; Jaafar et al., 2004). Due to rapid development, a tenth of Singapore's 660km^2 total lands mass has been reclaimed**,** mainly to the southern and northeastern coast of the island. Shallow littoral habitats, which were once a common feature of Singapore coasts, cover only 0.5% (approximately 3.3km^2) of the land area (Jaafar et al., 2004). The shallow coastal habitat of Changi Point Beach is presently unaltered by reclamation projects (Chou L.M., pers. comm.). To date, no intensive studies have been conducted on Changi Point

Beach, with only visual observations made in 1994 (Loo et al., 1994) and in 2005 (Goh, 2005). Results from these two researchers indicate a change in coastal vegetative species over the last few years and suggested that a change in the fish community of Changi Point Beach might have occurred, as found in the seagrass beds in Australia and the Mediterranean (Young, 1981; Abal et al., 1998; Guidetti & Bussotti, 2000).

This paper is a preliminary investigation in an attempt to describe (a) species composition, (b) density, (c) diel variations in the icthyofaunal community and (c) the possible function of Changi Point Beach's shallow coastal habitat for the more common species. In Singapore's ever changing coastal environment, it is important to provide a baseline for the species found in this unreclaimed area for future reference.

MATERIALS AND METHODS

***Study site.* –** The shallow coastal habitat of Changi Point Beach (CPB) is located on the northeastern coast of Singapore (1°23'18'N 104°0'50'E) at the entrance of Sungei Changi and exposed to the Straits of Singapore (Fig. 1). CPB is one of the few remaining unreclaimed shallow coastal habitats of Singapore and stretches approximately 1,500 m. CPB has a mixed sandy and muddy bottom with a patchy distribution of *Halophila ovalis* (Hydrocharitacea) and *Ulva lactuca* (Ulvaceae) at the subtidal zone. During low tide, the gradient at CPB is gentle (approx. 12°) and the beach generally consists of coarse sand at the supra-littoral zone with gradually finer sand and mud towards the sublittoral zone.

***Fish collection.* –** *During* spring tides, beach seines (20 m x 1.7 m x 5 mm mesh and 0.5 m cod end) were performed nocturnally and diurnally every four weeks during a three month period from October 2006 to Dec.2006. Spring tides were targeted as it was only possible to seine over the seagrass beds during this time when low tides were 0.5 m below standard datum, this approach also avoided any tidal bias. During each sampling period, three haphazard 40 m seine tows were performed, covering 800 m^2 per haul. All fish specimens collected were immediately iced, transported to the laboratory, and preserved in 70% alcohol.

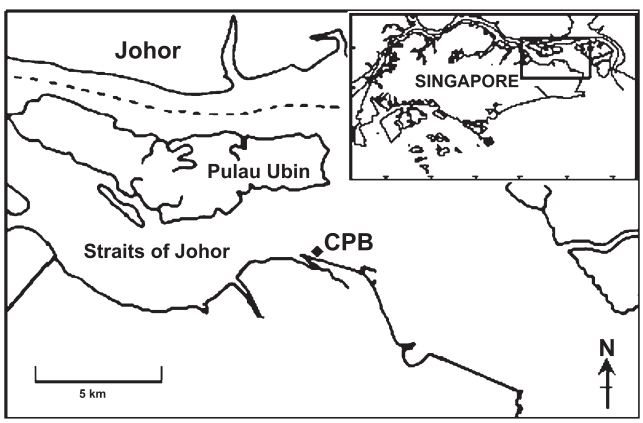

Fig. 1. Map of study area showing site by name (CPB: Changi Point Beach)

***Laboratory analysis.* –** In the laboratory all fish were sorted and identified. The abundance and standard lengths (SL) for each species was recorded. For more abundant fish species, a random sub-sample of 20 specimens was measured. Vernier callipers (± 0.01 mm) were used to measure small specimens under a SL of 150 mm, while a 300 mm ruler (± 0.5 mm) was used for specimens larger than 150 mm.

***Data analysis.* –** All fish densities were expressed as relative abundances, i.e. as percentages of total fish catch. Mean richness of species per sampling occasion was calculated as the average of the total number of species found in three replicate catches performed on each sampling occasion. The Shannon-Wiener diversity index of was also calculated for each sampling occasion (Pielou, 1975).

Information of fish maturation size for each species was determined (based on literature) and the fishes were classified into three size groups, i.e. juvenile (a third or less of the maximum length of the species), subadult (more than a third to two-thirds of the maximum length of the species) and adult (more than two-thirds of the maximum length of the species). Classification of size class in this way was tested and confirmed by Nagelkerken & van der Velde (2004). Two-sample *t*-Tests for independent samples were used to compare fish abundance and species diversity between day and night

RESULTS

***Species composition and density.* –** A total of 4,062 fish belonging to 75 fish species and 45 families were collected at CPB during the three months. Of the total catch, most were juveniles and adults of small-sized fish species. Engraulids were the most abundant family making up 24.86% of the total catch followed by Teraponids (13.61%), Monacanthids (11.2%), Syngnathids (11.18%) and Apogonids (7.63%). Among the icthyofanual species, Thryssa spp (Engraulididae) (24.84%), *Pelates quadrilineatus* (Terapontidae) (12.04%), *Monacanthus chinensis* (Monacanthidae) (11.1%), *Hippichthys cyanospilus* (Syngnathidae) (11.05%) and *Choerodon oligacanthus* (Labridae) (4.73%) were the most widely occurring species (Table 1). The other species made up less than 4% of the total catch, with many species represented by a single individual only. Based on all catches, a Shannon-Weiner's diversity index, *H'*, of 2.79 was calculated for CPB.

***Comparison of community between day and night.* –** Even though more fish were collected during nocturnal sampling (51.8%) as compared to diurnal sampling (48.2%), an unpaired *t*-Test (df = 17) indicated that there was no significant difference in fish abundances between nocturnal and diurnal communities at CPB. Similarly, there was no significant difference in total species richness between day and night. During the entire three month period, one third (25 out of 75) of the species were found every month at CPB.

Table 1. Relative abundance (%) of fish species caught at Changi Beach Point between the months of Oct. and Dec.2006 (species marked with a * and in **bold** denote the five most abundant species).

Family	Species	Relative abundance (%)
Ambassidae	*Ambassis kopsii*	0.24
Apogonidae	*Apogon hyalosoma*	0.98
	Apogon margaritophorus	3.49
	Apogon quadrifasciatus	2.90
	Cheilodipterus quinquelineatus	0.02
	Sphaeramia orbicularis	0.02
Atherinidae	*Atherinomorus duodecimalis*	0.02
Batrachoididae	*Batrachomeous trispinosus*	0.07
Belonidae	*Strongylura strongylura*	0.02
Callionymidae	*Callionymus schaapi*	0.81
Carangidae	*Alectis indicus*	0.02
	Gnatahanodon speciosus	0.05
Chaetodontidae	*Chaetodon octofasciatus*	0.02
Chanidae	*Chanos chanos*	0.02
Clupeidae	*Anodontosoma chacunda*	0.14
	Escualosa thoracata	2.58
	Sardinella albella	0.45
Cynoglossidae	*Cynoglossus puncticeps*	1.32
Dasyatidae	*Dasyatis kuhlii*	0.02
	Himantura Walga	0.02
Engraulididae	*Stolephorus indicus*	0.02
	Thryssa spp*	**24.15**
Ephippidae	*Platax teira*	0.02
Haemulidae	*Diagramma labiosum*	0.02
	Pomadasys maculatum	0.02
Hemiramphidae	*Hyporhamphus quoyi*	0.02
	Hyporhamphus limbatus	0.02
Labridae	***Choerodon oligacanthus****	**4.60**
	Halichoeres bicolor	0.43
	Halichoeres nigrescens	0.05
Latidae	*Psammoperca waigiensis*	1.10
Leiognathidae	*Gazza minuta*	0.07
	Gazza oyena	0.12
	Leiognathus elongatus	1.34
	Leiognathus equulus	0.36
	Secutor hanedai	0.91
Lethrinidae	*Lethrinus lentjan*	0.69
Lutjanidae	*Lutjanus malabaricus*	0.02
	Lutjanus russelli	0.10
	Lutjanus johnii	0.05
Monacanthidae	*Anacanthus barbatus*	0.02
	Monacanthus chinensis*	**10.79**
	Paramonacanthus choirocephalus	0.07
Muraenesocidae	*Muraenesox bagio*	0.02

Table 1. Cont'd.

Family	Species	Relative abundance (%)
Mugilidae	Mugilidae spp	1.75
	Ellochelon vaigiensis	0.17
Mullidae	*Upeneus tragula*	0.86
Nemipteridae	*Nemipterus nemurus*	0.02
	Pentapodus setosus	0.05
Ophichthidae	*Pisodonophis cancrivorus*	0.07
Paralichthyidae	*Pseudorhombus arsius*	0.67
Pegasidae	*Pegasus volitans*	0.12
Platycephalidae	*Cymbacephalus nematophthalmus*	2.06
Plotosidae	*Plotosus canius*	1.70
	Plotosus lineatus	0.19
Scatophagidae	*Scatophagus argus*	0.14
Sciaenidae	*Johnius belangerii*	0.02
Scorpaenidae	*Paracentropogon longispinus*	2.03
	Trachicephalus uranoscorpus	0.74
Serranidae	*Centrogenys vaigiensis*	0.05
Siganidae	*Siganus canaliculatus*	1.27
Sillaginidae	*Sillago ciliata*	0.50
	Sillago sihama	0.96
Soleidae	*Brachirus orientalis*	0.02
	Zebrias zebra	0.07
Sphyraenidae	*Sphyraena jello*	0.26
Syngnathidae	***Hippichthys cyanospilus****	**10.75**
	Hippocampus kuda	0.12
Synodontidae	*Saurida tumbil*	0.02
Terapontidae	***Pelates quadrilineatus****	**11.70**
	Terapon jarbua	1.46
	Terapon theraps	0.07
Tetraodontidae	*Lagocephalus lunaris*	0.02
Triacanthidae	*Tripodichthys blochii*	0.77
Gobiidae	Gobiidae	3.04

Of these 25 species, only *Sphyraena jello* was found during the day. These 25 common species made up 89% (3,614 individuals) of the total catch during the entire sampling period (Table 1).

Size class distribution of five most common species. – Juveniles of *Pelates quadrilineatus* (Terapontidae) and *Monacanthus chinensis* (Monacanthidae) were found in high numbers, while small-sized *Hippichthys cyanospilus* (Syngnathidae) and *Apogon margaritophorus* (Apogonidae) generally occured in subadult to adult size ranges. Based on maximum and minimum sizes of individual species, we found that larger juveniles were generally caught during the night while smaller sized adult fish species were caught more often in the day. The size class distributions of *Pelates quadrilineatus* (Terapontidae), *Monacanthus chinensis* (Monacanthidae), *Hippichthys cyanospilus* (Syngnathidae), *Choerodon oligacanthus* (Labridae) and *Apogon margaritophorus* (Apogonidae) were constructed to determine how each species might utilize the habitat at CPB. For most species, numbers-per-size-class were normally distributed with the exception of *P. quadrilineatus*, which showed no clear distribution pattern.

Pelates quadrilineatus can attain SL of up to 300 mm (Paxton et al., 1989) but all specimens caught ranged from 10 mm to 89.9 mm, and were thus considered juveniles. The majority of specimens were between 20 mm and 79.9 mm. Smaller individuals were caught more often in the day, while larger individuals were more abundant at night. There was no clear size distribution pattern for *P. quadrilineatus* (Fig. 2).

Monacanthus chinensis can reach SL up to 380 mm (Shen, 1993). Size distribution of *M. chinensis* at CPB was normally distributed with a mean size class of 50 mm to 59.9 mm (Fig. 3). Overall, specimens ranged from <10 mm to 109.9 mm, and all were classed as juveniles. Smaller individuals were caught more often in the day, while larger individuals were more abundant at night.

The maximum SL of *Hippichthys cyanospilus* was 160 mm (Dawson, 1985). Size distribution of *H. cyanospilus* at CPB was slightly skewed to larger sizes (Fig 4), but generally exhibited a normal distribution pattern. Although *H. cyanospilus* had a mean size class of 80.0 mm to 89.9 mm, the size class mode ranged from 90 mm to 99.9 mm. Most of the specimens were well within the size range of subadults and adults. More individuals of this species were caught in the day than at night.

Choerodon oligacanthus can attain sizes of up to 282 mm SL (De Beaufort, 1940). Size distribution of *C. oligacanthus* was normal with a mean size class of 50 mm to 59.9 mm. Similar to both *P. quadrilineatus* and *M. chinensis*, smaller individuals of *C. oligacanthus* appeared to occur more in the day than at night, while larger ones were more prevalent at night (Fig. 5).

Apogon margaritophorus can reach size of up to 65 mm SL (Allen, 1997). The size range of *A. margaritophorus* was normally distributed with a mean size class of 20 mm to 29.9 mm (Fig. 6). Most of the specimens were in the size class range of subadults and adults. As with *H. cyanospilus*, more individuals were found to occur at night than in the day.

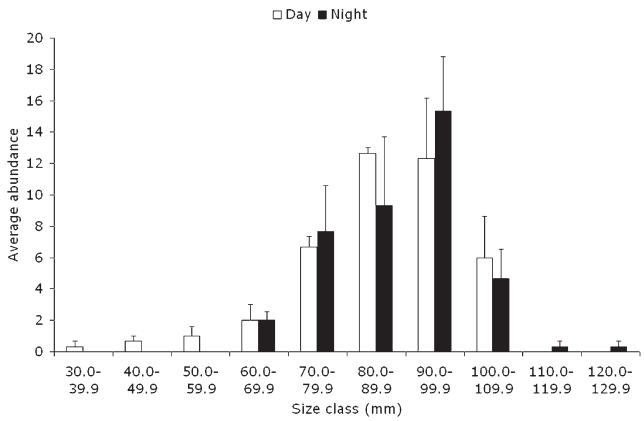

Fig. 4. Size class distribution of *H. cyanospilus* captured by day and night seines at Changi Point Beach between Oct. to Dec.2006 (error bars ± S.E.).

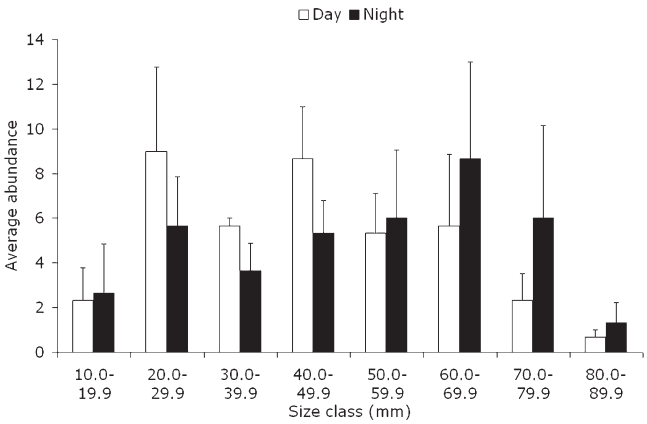

Fig. 2. Size class distribution of *P. quadrilineatus* captured by day and night seines at Changi Point Beach between Oct. to Dec.2006 (error bars ± S.E.).

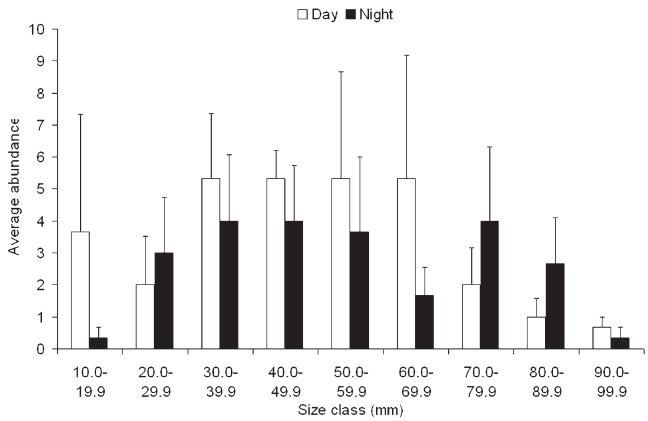

Fig. 5. Size class distribution of *C. oligocanthus* captured by day and night seines at Changi Point Beach between Oct. to Dec.2006 (error bars ± S.E.).

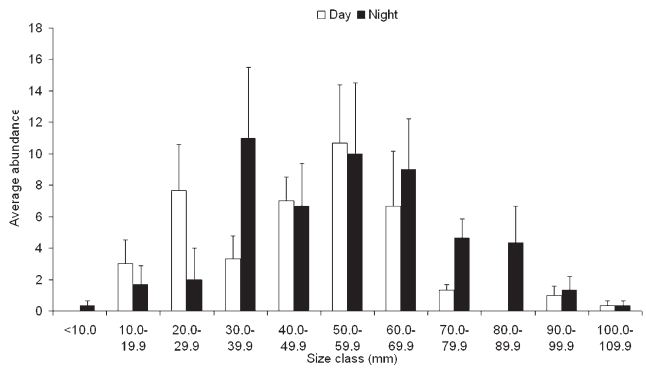

Fig. 3. Size class distribution of *M. chinensis* captured by day and night seines at Changi Point Beach between Oct. to Dec.2006 (error bars ± S.E.).

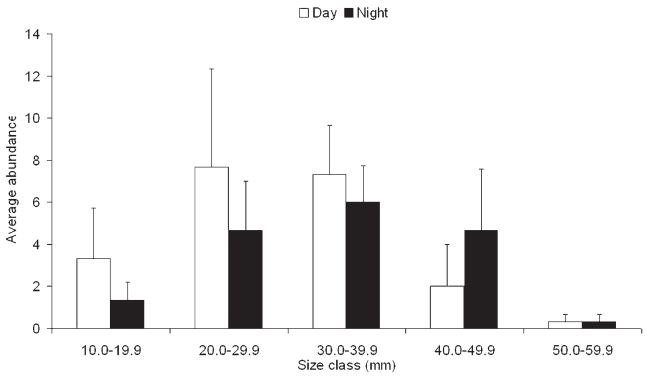

Fig. 6. Size class distribution of *A. margaritophus* captured by day and night seines at Changi Point Beach between Oct. to Dec.2006 (error bars ± S.E.).

Table 2. Average abundance of fish caught during day and night samples between Oct. and Dec.2006 (species marked with a * and in **bold** denote those that were caught during all three months).

Fish Species	October				November				December			
	Day		Night		Day		Night		Day		Night	
	Average	SD(±)	Average	SD (±)	Average	SD (±)	Average	SD (±)	Average	SD (±)	Average	SD (±)
Ambassidae												
*Ambassis kopsii**	**0.00**	**0.00**	**0.67**	**0.58**	**3.00**	**1.00**	**0.33**	**0.58**	**0.00**	**0.00**	**1.00**	**1.00**
Apogonidae												
*Apogon hyalosoma**	**0.00**	**0.00**	**4.00**	**3.46**	**0.00**	**0.00**	**3.67**	**3.51**	**0.67**	**1.51**	**4.67**	**2.52**
*Apogon margaritophorus**	**3.00**	**2.00**	**0.00**	**0.00**	**16.00**	**7.00**	**5.33**	**9.24**	**10.00**	**17.32**	**9.33**	**16.17**
*Apogon quadrifasciatus**	**0.33**	**0.58**	**21.00**	**5.29**	**10.00**	**2.00**	**7.00**	**8.82**	**3.00**	**5.20**	**4.00**	**4.00**
Cheilodipterus quiquelineatus	0.00	0.00	3.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sphaeramia orbicularis	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58	0.00	0.00	0.33	0.58
Atherinidae												
Atherinomorus duodecimalis	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58	0.00	0.00	0.00	0.00
Batrachoididae												
Batrachomeous trispinosus	0.33	0.58	0.00	0.00	0.00	0.00	0.33	0.58	0.33	0.58	0.00	0.00
Belonidae												
Strongylura strongylura	0.00	0.00	0.33	0.58	0.00	0.00	0.00	0.00	0.33	0.58	0.00	0.00
Callionymidae												
*Callionymus schaapi**	**1.00**	**1.73**	**6.33**	**5.86**	**0.67**	**1.15**	**2.00**	**2.65**	**0.00**	**0.00**	**1.33**	**0.58**
Carangidae												
Alectis indicus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58
Gnathanodon speciosus	0.00	0.00	0.00	0.00	0.33	0.58	0.00	0.00	0.00	0.00	0.33	0.58
Chaetodontidae												
Chaetodon octofasciatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58	0.00	0.00
Chanidae												
Chanos chanos	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58	0.00	0.00
Culpeisdae												
Anodotosoma chacunda	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	3.46	0.00	0.00
*Escualosa thoracata**	**0.33**	**0.58**	**15.33**	**16.44**	**0.67**	**0.58**	**1.33**	**2.31**	**11.00**	**9.85**	**7.67**	**10.02**
Sardinella albella	0.00	0.00	0.00	0.00	0.00	0.00	0.67	1.15	1.00	1.00	4.67	3.06
Cynoglossidae												
*Cynoglossus puncticeps**	**0.67**	**0.58**	**8.00**	**10.58**	**2.33**	**1.15**	**4.00**	**4.36**	**0.00**	**0.00**	**3.33**	**1.53**
Dasyatidae												
Dasyatis kuhlii	0.00	0.00	0.33	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Himantura Walga	0.33	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

Table 2. Cont'd.

Fish Species	October				November				December			
	Day		Night		Day		Night		Day		Night	
	Average	SD(±)	Average	SD (±)	Average	SD (±)	Average	SD (±)	Average	SD (±)	Average	SD (±)
Engraulididae												
Stolephorus indicus	0.00	0.00	0.33	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Thryssa spp**	**0.00**	**0.00**	**4.00**	**5.29**	**3.67**	**3.06**	**81.33**	**122.32**	**225.67**	**118.29**	**21.67**	**21.55**
Ephippidae												
Platax teira	0.33	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Haemulidae												
Diagramma labiosum	0.00	0.00	0.67	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pomadasys maculatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58	0.00	0.00
Hemiramphidae												
Hyporhamphus quoyi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58	0.00	0.00
Hyporhamphus limbatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58	0.00	0.00
Labridae												
*Choerodon oligacanthus**	**4.67**	**5.69**	**2.00**	**1.00**	**22.33**	**7.64**	**11.33**	**6.35**	**8.67**	**11.59**	**15.00**	**16.64**
*Halichoeres bicolor**	**2.67**	**3.79**	**0.00**	**0.00**	**1.00**	**1.00**	**0.00**	**0.00**	**3.50**	**0.71**	**0.00**	**0.00**
Halichoeres nigrescens	0.00	0.00	0.00	0.00	0.67	1.15	0.00	0.00	0.00	0.00	0.00	0.00
Latidae												
*Psammoperca vaigiensis**	**1.00**	**1.00**	**0.00**	**0.00**	**3.00**	**2.00**	**2.00**	**2.00**	**5.67**	**8.14**	**3.00**	**5.20**
Leiognathidae												
Gazza minuta	0.33	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	1.15
Gazza oyena	0.33	0.58	0.00	0.00	0.00	0.00	0.33	0.58	1.00	1.00	0.00	0.00
Leiognathus elongatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.33	9.45	11.00	11.53
Leiognathus equulus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.67	3.06	2.67	3.79
*Secutor hanedai**	**0.00**	**0.00**	**6.67**	**5.51**	**5.00**	**1.73**	**0.00**	**0.00**	**0.67**	**1.15**	**1.00**	**1.73**
Lethrinidae												
*Lethrinus lentjan**	**1.00**	**1.73**	**0.00**	**0.00**	**2.00**	**1.73**	**1.33**	**2.31**	**1.67**	**2.89**	**3.67**	**1.53**
Lutjanidae												
Lutjanus malabaricus	0.00	0.00	0.33	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lutjanus russelli	0.00	0.00	0.00	0.00	0.67	1.15	0.33	0.58	0.33	0.58	0.00	0.00
Lutjanus johnii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58	0.33	0.58
Monacanthidae												
Anacanthus barbatus	0.00	0.00	0.33	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Monacanthus chinensis**	**9.67**	**7.37**	**14.00**	**7.00**	**38.00**	**13.89**	**46.33**	**10.21**	**19.67**	**22.14**	**22.67**	**15.01**
Paramonacanthus choirocephalus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00

Table 2. Cont'd.

Fish Species	October				November				December			
	Day		Night		Day		Night		Day		Night	
	Average	SD(±)	Average	SD (±)	Average	SD (±)	Average	SD (±)	Average	SD (±)	Average	SD (±)
Muraenesocidae												
Muraenesox bagio	0.00	0.00	0.00	0.00	0.33	0.58	0.00	0.00	0.00	0.00	0.00	0.00
Mugilidae												
Ellochelon vaigiensis	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33	1.15	0.00	0.00
Mullidae												
*Upeneus tragula**	**0.67**	**0.58**	**1.67**	**0.58**	**1.33**	**0.58**	**1.00**	**1.73**	**3.00**	**2.00**	**3.33**	**1.53**
Upeneus sulphureus	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.73	0.00	0.00	0.00	0.00
Nemipteridae												
Nemipterus nemurus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58
Pentapodus setosus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	1.15
Ophichthidae												
Pisodonophis cancrivorus	0.00	0.00	0.00	0.00	0.33	0.58	0.67	1.15	0.00	0.00	0.00	0.00
Paralichthyidae												
*Pseudorhombus arsius**	**0.67**	**1.15**	**4.67**	**1.16**	**1.00**	**1.00**	**1.33**	**1.15**	**0.00**	**0.00**	**1.67**	**0.58**
Pegasidae												
Pegasus volitans	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Platycephalidae												
*Cymbacephalus nematophthalamus**	**1.67**	**1.53**	**3.67**	**4.04**	**3.67**	**2.52**	**3.33**	**2.89**	**1.67**	**1.53**	**14.67**	**10.50**
Plotosidae												
*Plotosus canius**	**1.67**	**2.08**	**0.67**	**0.58**	**11.33**	**4.51**	**5.67**	**8.96**	**1.00**	**1.00**	**3.33**	**2.52**
Plotosus lineatus	0.67	1.15	2.00	2.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scatophagidae												
Scatophagus argus	0.00	0.00	0.00	0.00	1.00	1.73	0.00	0.00	0.33	0.58	0.67	1.15
Sciaenidae												
Johnius belangerii	0.00	0.00	0.33	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scorpaenidae												
*Paracentropogon longispinus**	**3.67**	**6.35**	**2.33**	**1.53**	**5.67**	**2.08**	**2.67**	**3.79**	**3.67**	**4.62**	**12.00**	**9.54**
*Trachicephalus uranoscorpus**	**1.67**	**1.53**	**5.33**	**5.13**	**0.33**	**0.58**	**1.00**	**1.00**	**0.33**	**0.58**	**1.67**	**1.53**
Serranidae												
Centrogenys vaigiensis	0.00	0.00	0.00	0.00	0.67	1.15	0.00	0.00	0.00	0.00	0.00	0.00
Siganidae												
Siganus canaliculatus	0.00	0.00	0.00	0.00	2.00	2.00	9.67	4.51	2.33	4.04	3.67	3.79

Table 2. Cont'd.

Fish Species	October				November				December			
	Day		Night		Day		Night		Day		Night	
	Average	SD(±)	Average	SD (±)	Average	SD (±)	Average	SD (±)	Average	SD (±)	Average	SD (±)
Sillaginidae												
Sillago ciliate	0.00	0.00	0.00	0.00	0.67	1.15	0.33	0.58	0.00	0.00	6.00	3.61
*Sillago sihama**	**0.00**	**0.00**	**0.67**	**0.58**	**0.00**	**0.00**	**7.33**	**7.02**	**0.33**	**0.58**	**5.00**	**4.00**
Soleidae												
Brachirus orientalis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58
Zebrias zebra	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58
Sphyraenidae												
*Sphyraena jello**	**1.00**	**1.73**	**0.00**	**0.00**	**0.33**	**0.58**	**0.00**	**0.00**	**2.00**	**1.00**	**0.33**	**0.58**
Syngnathidae												
*Hippichthys cyanospilus**	**13.00**	**7.00**	**8.00**	**2.65**	**18.00**	**7.81**	**57.00**	**21.52**	**19.67**	**15.95**	**34.00**	**46.86**
Hippocampus kuda	1.00	1.00	0.33	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Synodontidae												
Saurida tumbil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58
Terapontidae												
*Pelates quadrilineatus**	**13.00**	**14.42**	**9.67**	**9.61**	**57.67**	**27.57**	**40.00**	**43.31**	**11.00**	**9.85**	**31.67**	**28.88**
*Terapon jarbua**	**3.00**	**3.46**	**3.33**	**2.52**	**5.67**	**1.53**	**5.33**	**6.81**	**2.00**	**3.46**	**1.00**	**1.73**
Terapon theraps	0.33	0.58	0.33	0.58	0.33	0.58	0.00	0.00	0.00	0.00	0.00	0.00
Tetraodontidae												
Lagocephalus lunaris	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.58	0.00	0.00
Triacanthidae												
*Tripodichthys blochii**	**1.67**	**2.89**	**2.67**	**1.53**	**2.33**	**4.04**	**3.00**	**1.00**	**0.67**	**0.58**	**0.33**	**0.58**
Gobiidae*	**5.67**	**4.04**	**5.67**	**4.93**	**9.33**	**4.93**	**6.00**	**6.56**	**5.67**	**0.58**	**14.67**	**2.08**

DISCUSSION

Although previous surveys around the coastal areas of Singapore indicate that CPB is likely to be heavily impacted (Chou, 1996), CPB appears to be an important ecosystem, supporting an abundant and diverse assemblage of juveniles of large-sized fish species and subadults and adults of small-sized fish species. At least 75 fish species from 45 families were found in CPB and comparisons to other local sites indicate that the species list found at CPB is larger than other locations along similar coastal habitats in Singapore (Hajisamae & Chou, 2003; Jaafar et al., 2004). Previous research by Hajisamae & Chou (2003) reported 43 species from Sembawang Site (west of CPB), 61 and 68 species from Pasir Ris (north of CPB) site A and site B respectively (Site A: a completely reclaimed sandy beach and Site B: a replanted mangrove habitat). Jaafar et al. (2004) reported 71 species from a reforested mangrove habitat at Pasir Ris and 67 species from a sandy habitat at Pasir Ris. Significantly more species were caught in the vegetated habitat of CPB as compared to less or non-vegetated habitats, such as those reported at Sembawang site (Hajisamae & Chou, 2003). This is consistent with various studies which note that vegetated coastal habitats support higher number of fish species as compared to less or non-vegetated ones (Jenkins & Wheatley, 1998; Jaafar et al., 2004; Nagelkerken & van der Velde, 2004).

The diversity (*H'*) of 2.79 found at CPB can be considered high when compared to other Singapore coastal habitats such as Sembawang, $H' = 0.95$, and Pasir Ris, $H' = 2.38$ (Hajisamae & Chou, 2003; Jaafar et al. ., 2004), indicating that the fish community of CPB is more diverse and thus less likely to be dominated by a single species. At least four fish species (Thryssa spp (Engraulididae), *Pelates quadrilineatus* (Terapontidae), *Monacanthus chinensis* (Monacanthidae), *Hippichthys cyanospilus* (Syngnathidae) co-dominated the coastal habitat of CPB. In addition, the fish diversity found at CPB is comparable to that at Saiburi estuary, Gulf of Thailand with a *H'* value of 2.75 (Hajisamae et al.., 1999), and Malaysia mangrove systems and adjacent habitats with *H'* values between 2.59 and 3.24 (Chong et al., 1990) suggesting that, although heavily impacted, CPB supports a regionally-comparable diversity of fish species.

Diel comparisons in species diversity and fish abundance indicated that there was no significant difference between day and night. This is consistent with previous research in the vegetated coastal habitats of Australia (Gray et al., 1998) and Portugal (Ribeiro et al., 2006). However, some studies (Rountree & Able, 1993; Guest et al., 2003; Unsworth et al., 2006) noted higher number of species and fish abundance at night, while Jaafar et al. (2004) reported a greater mean fish density during the day. These contrasting reports indicate that the dynamics of each fish community can differ and coastal habitats should be studied on estuary-by estuary or bay-by-bay, and species-by species basis (Blaber, 1997). Significant differences in abundance and diversity of fish were probably not observed because (a) there was equal exchange of transient species between day and night or (b) the density of transient species during day and night was very low. Nevertheless, more larger-sized juveniles were caught at night than smaller individuals, and more small-sized adult fish species were caught during in the day than at night. The fewer occurrences of smaller individuals at night could be due to avoidance of predation by larger reef fishes which are known to migrate to shallow coastal habitats to feed nocturnally (Parrish, 1989).

The function of vegetated coastal habitats as nursery grounds for juveniles (Nagelkerken et al., 2000), for feeding (Chong et al., 1990; Hajisamae & Chou, 2003) and for shelter (Paterson & Whitfield, 2000) for juveniles of large-sized fish species and subadults to adults of small-sized fish species have all been well documented. Moreover, Hajisamae & Chou (2003) reported that even impacted coastal habitats can serve as nursery grounds for fish. Size class distribution from our study suggest that CPB possibly functions as a nursery for at least two of the five most abundant species, and is a potential feeding ground and refugia for juveniles of large-sized fish species and subadults to adults of small-sized fish species.

In conclusion, CPB supports a highly diverse fish community and possibly functions as a nursery. Contrary to other studies, fish community structure at CPB is not significantly influenced by diel variations. This indicates that fish communities found in Singapore may exhibit different traits than found in other regions and this is worthy of further study. Impacted coastal habitats such as CPB should be conserved because they still perform important ecological functions. Appropriate coastal management to prevent further habitat degradation is recommended.

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