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Assessing fish community structure at two different coral reef depths around Seribu Islands, Jakarta

(Penilaian struktur komunitas ikan terumbu pada dua kedalaman terumbu karang berbeda sekitar Kepulauan Seribu, Jakarta)

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ABSTRACT
Coral reefs structure play important roles for reef fish assemblages. Coral coverage and reef fish abundance are associated with the positive relationship. However, the relationship between reef fish abundance and composition and depth variation around Pramuka Island is poorly known. This study was carried out to investigate the biodiversity and the trophic level of fish communities between two different depths (3 and 10 m) around Pramuka Island regions (Pramuka Island and Sekati Island). The hard coral at the depth of 10 m within both study sites in Pramuka island held significantly higher percent cover than the depth of 3 m except in Dock 2 A total of 2620 individual fishes were counted, belonging to 58 species and 13 families. The fish community in 3 and 10 depth was dominated by omnivorous fishes. The multivariate analysis of fish abundance using the Bray Curtis similarity index and non-metric multidimensional scaling (NMDS) clearly showed the clustering of two different depths. The NMDS results showed that at the depth of 10 m are more clustered than 3 m depth. The present study results showed that the biodiversity of reef fishes around Pramuka Island seemed to be linked to the hard coral condition and depth.

Keywords*: Coral, Depth, Reef fishes, Trophic level*

I. Introduction

The complexity of coral reefs structure play important roles in reef fish assemblages (Alvarez-Filip 2011) and contribute to a differences ecosystem services that value to humans (Lane *et al.*, 2013). Several studies have shown the relationships between various coral and the species richness of fishes. Komyakova *et al.*, (2010) were reported positive correlations between coral and reef fish abundance. Corals are threatened by local disturbances, coral disease (Subhan *et al.,* 2011), coral mining (Subhan *et al.*, 2008) and environmental condition (Friedlander *et al.,* 2017). Seribu Islands located in front of Jakarta and belong to one of the marine national parks in Indonesia (Fahlevy *et al.,* 2017). However, the existences of coral reef in Seribu Islands are threatened. Environmental pressures (e.g pollution) from Jakarta increases the degradation of marine biodiversity in Seribu Islands (Baum *et al.*, 2015).

Degradation of coral structures giving a negative impact on reef fish communities across Seribu Islands (Madduppa *et al.,* 2013). The depletion of reef fishes increased accordingly with the degradation of corals (Burgess *et al.,* 2010) and often associated with over or destructive fishing activities (Robinson *et al.,* 2014). Destructive fishing activities still occur in Seribu Islands (Santoso, 2010).

Management of Kepulauan Seribu Marine National Park is still ineffective (Fauzi and Buchary, 2002). Management and regulation of the area are needed for marine biodiversity protection (Harter *et al.*, 2009). A challenge for completing the fishing regulation is to determine how topography and depth use interact to influence the reef fish structures and ecosystem services (Luiz *et al.*, 2015). The present study aimed to assess reef fish community structures and examine the influence of depth on the fish communities around Pramuka Island regions (Pramuka Island and Sekati Island), Seribu Islands

II. Materials and Methods

2.1 Study sites

The study was conducted during 14-19 December 2014 around Pramuka island regions (Figure 1). Two different depths (3 and 10 m) for each sampling site at reef slope were selected. Pramuka island is one of the main islands located in Kepulauan Seribu (Seribu Islands) Marine National Park, Jakarta (Baum *et al.*, 2015).

2.2 Data collection

Coral structures were assessed and identified to genus level at each location using three replicate 20 m line-intercept transects parallels with shoreline (English *et al.,* 1997) separated by at least 5 m. Fish community composition was assessed along the same transects as corals structure using underwater visual census (English *et al.*, 1997) which are divided into two categories of fish count (real count and estimate). Major fish counts were mostly done by estimation (semi-quantitative), while indicator and target fishes were mostly done by real count. Reef fishes were counted and identified to species and recorded within 2.5 m of each side of the transect line by slowly swimming and wait for at least 5 minutes before the beginning of data recording along the line at a constant speed (Madduppa *et al.,* 2013). The censused fish were then classified into three major groups (target, indicator, and major fish) according to English *et al.,* (1997). The trophic level for each species confirmed and classified using FishBase (Froese and Pauly 2010).

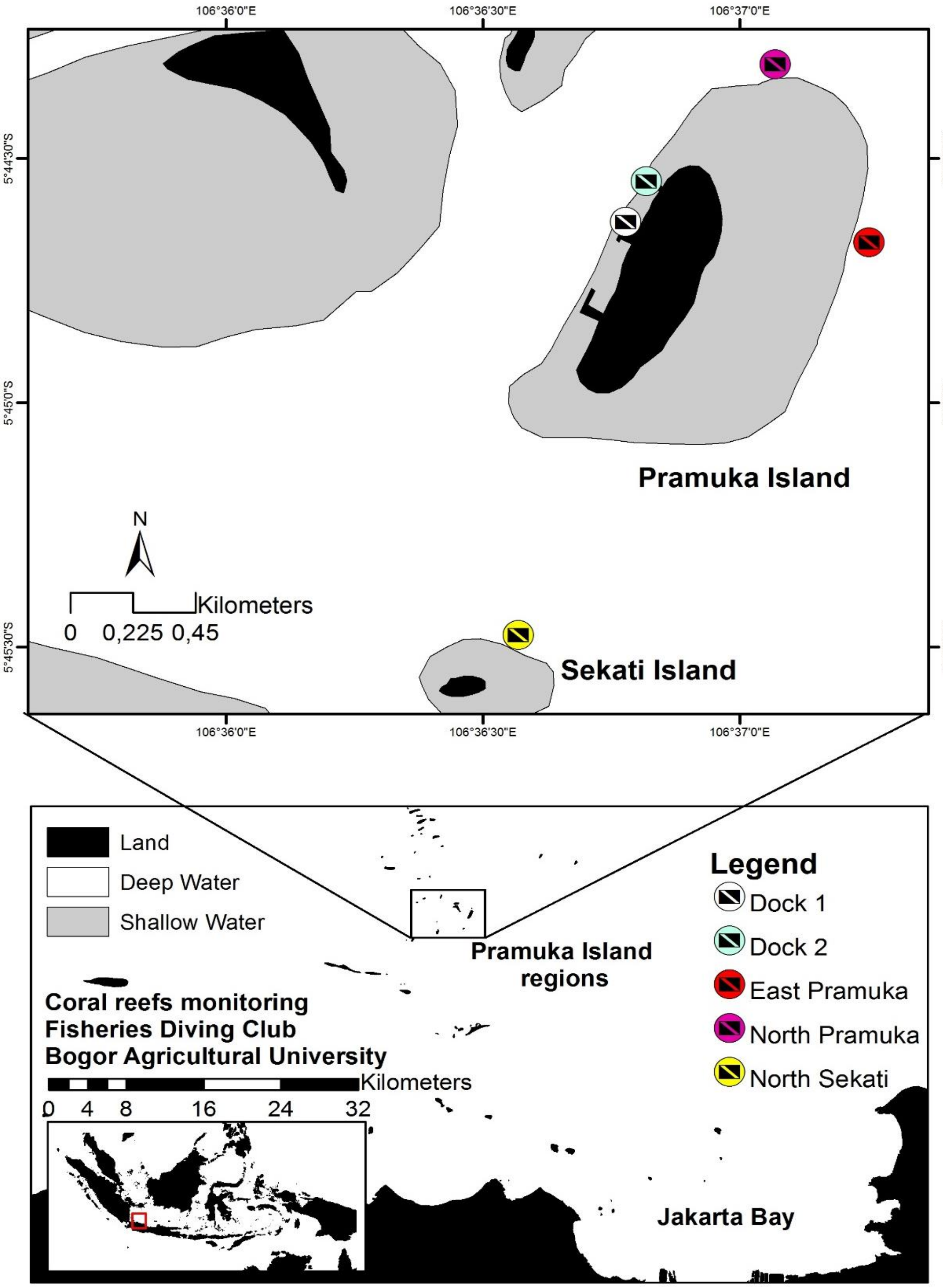

Figure 1. Location of the Pramuka Island regions, north of Jakarta, Java Island, Indonesia. The map below shows the position of Pramuka Island regions relative to Jakarta. The location within Indonesia is shown in the inset on the lower left

2.3 Data analysis

Percentage of the hard coral cover was estimated using English *et al.,* (1997):

$$Percent\ Cover\ (\%) = \frac{A}{B} X\ 100\ \%$$

A = Length of category

B = Length of transect

Shannon-Wiener diversity index H' (ln basis) were calculated (Magurran 1988)

$$H' = -\sum p_i ln\ (p_i)$$

H' = Community Shannon-Wiener diversity index

p_i = Proportion of individuals belonging to the i^{th}

Two-way analysis of variance (ANOVA) was used to test for significant differences in abundance, species richness and community diversity among study sites and two different depths using Ms. Excel 2013. Multivariate analysis of reef fish community was conducted using PRIMER 7. Relative abundance was square root transformed to reduce the disparity between the abundant and uncommon species (Harter *et al.,* 2009). Similarity matrix constructed using Bray-Curtis Similarity (Benfield *et al.*, 2008).

Multivariate analysis of similarity (ANOSIM) based on both the entire fish community was used to determine differences between two depths (3 and 10 m). SIMPER (similarity percentages) was used to examine reef fish assemblages that contributed to 80% of the fish composition of each depth. Prior to analyses, species in which found only in one transect were observed, species contributing <5% in SIMPER analysis at both of depths, and species comprising <1% of the total abundance of fish were deleted to minimize uncommon species disrupting the cluster analysis. Non-metric Multidimensional Scaling (MDS) and similarity were used to visualize the differences in fish communities of the two different habitats (3 and 10 m) (Madduppa *et al.*, 2012a; Madduppa *et al.*, 2012b).

III. Results and Discussion

3. 1 Results

3.1.1 Hard coral cover

In all study sites except Dock 2, coral cover was usually the highest in the depth of 3 m rather than the depth of 10 m (Table 1). Study site that showed signs of damage and had less living hard coral cover (3.73 ± 1.43 %) was located in Dock 2 at the depth of 10 m. The North Sekati exhibited the highest cover at the depth of 3 m (36.27 ± 16.30 %), followed by North Pramuka (18.07 ± 2.53 %), Dock 2 (11.90 ± 4.08 %), East Pramuka (10.07 ± 4.89 %), and Dock 1 (8.47 ± 3.98 %). On the depth of 10 m around Pramuka Island, the four consistently higher coral cover over all sites were East Pramuka (24.57 ± 11.89 %), North Pramuka (22.98 ± 16.05 %), North Sekati (18.65 ± 3.43 %), and Dock 1 (12.02 ± 3.04 %).

Table. 1 Relative percentage of hard coral cover (mean ± SE) in the different study sites and depth

Study Site	Depth	
	3 m (% ± SE)	10 m (% ± SE)
Dock 1	8.47 ± 3.98	12.02 ± 3.04
Dock 2	11.90 ± 4.08	3.73 ± 1.43
East Pramuka	10.07 ± 4.89	24.57 ± 11.89
North Pramuka	18.07 ± 2.53	22.98 ± 16.05
North Sekati	36.27 ± 16.30	18.65 ± 3.43

3.1.2 Fish community structure

A total of 2620 individuals from 58 species of fish belonging to 13 families were counted in this study (Table. 2). Pomacentridae was the most dominant family in terms of abundance followed by Labridae. *Pomacentrus alexanderae* was the most abundant species followed by *Pomacentrus simsiang* and *Chromis viridis*. *Chromis virdis* were not widely found but when its found, they occurred in large schools of over 50 up to 125 individuals.

No significant differences in fish abundance and diversity were found between the study sites and depths, while species richness significantly differed in the study sites, and the effect of sites on abundance and species richness differed between depths (Table 3). The average fish abundance, the average species richness, and the Shannon-Wiener diversity indices of fish communities are shown in Figure 2. North Sekati had the higher value of fish abundance, species richness, and species diversity. The lowest fish abundance found in East Pramuka at the depth of 3 m, while North Sekati at the depth of 3 m is the most abundant.

The fish abundance range from 35 ± 13.45 (East Pramuka) to 156.67 ± 11.72 ind/100 m^2 (North Sekati). Similar pattern was also found for the species richness which ranged between 7.67 ± 1.67 (East Pramuka) and 23 ± 2.64 species/100 m^2 (North Sekati). Among the five study sites, the value of diversity indices (H') of North Pramuka at the depth of 10 m was the lowest, which ranged between 1.35 ± 0.11 (North Pramuka) and 2.05 ± 0.25 (North Sekati).

Table 2. Total number and trophic level of fish species at each study sites (* means estimated count)

Family **Species**	**Category**	**Trophic**	**Dock 1**	**Dock 2**	**East Pramuka**	**North Pramuka**	**North Sekati**
Apogonidae							
Apogon compressus	Major	Carnivore	0	8	15	0	0
Balistidae			0	0	0	0	0

Rhinecanthus verrucosus	Target	Omnivore	0	0	0	1	0
Caesionidae							
Caesio cuning	Target	Carnivore	0	0	2	2	8
Caesio teres	Target	Carnivore	9	0	3	5	29
Chaetodontidae							
Chaetodon octofasciatus	Indicator	Corallivore	9	11	4	16	22
Chelmon rostratus	Indicator	Corallivore	1	0	0	0	0
Labridae							
Bodianus mesothorax	Target	Carnivore	0	3	3	0	2
Cheilinus chlorourus	Target	Carnivore	0	0	0	0	1
Cheilinus fasciatus	Target	Carnivore	25	5	4	49	8
Choerodon anchorago	Target	Carnivore	1	2	2	8	9
Cirrhilabrus cyanopleura	Major	Planktivore	15	15	6	0	62
Halichoeres chloropterus	Major	Carnivore	2	0	0	0	6
Halichoeres hortulanus	Target	Carnivore	0	0	0	4	16
Halichoeres leucurus	Major	Omnivore	10	2	12	9	26
Halichoeres melanurus	Target	Omnivore	8	3	2	0	11
Halichoeres richmondi	Major	Carnivore	2	1	0	0	14
Halichoeres vrolikii	Major	Omnivore	0	0	0	0	3
Labroides dimidiatus	Major	Carnivore	9	2	3	4	0
Thalassoma lunare	Major	Omnivore	0	5	4	24	21
Lutjanidae							
Lutjanus biguttatus	Target	Carnivore	0	0	0	0	1
Nemipteridae							
Scolopsis bilineata	Target	Carnivore	0	2	0	4	22
Scolopsis lineata	Target	Carnivore	0	0	4	5	16
Scolopsis margaritifer	Target	Carnivore	0	0	8	0	4
Scolopsis trilineata	Target	Carnivore	0	0	1	0	4

Ostraciidae							
Ostracion cubicus	Major	Carnivore	0	0	0	0	1
Pomacanthidae							
Centropyge eibli	Major	Omnivore	0	0	0	0	7
Centropyge vrolikii	Major	Herbivore	0	0	0	0	2
Pomacentridae							
Abudefduf bengalensis	Major	Omnivore	3	0	0	0	0
Abudefduf sexfasciatus	Major	Omnivore	4	5	33	11	25
Abudefduf vaigiensis	Major	Omnivore	8	0	0	2	10
Amblyglyphidodon aureus	Major	Omnivore	0	0	1	0	0
Amblyglyphidodon curacao	Major	Omnivore	12	19	8	27	24
Amblyglyphidodon leucogaster	Major	Omnivore	0	0	0	4	0
Amphiprion ocellaris	Major	Omnivore	0	0	0	0	3

Chromis amboinensis	Major	Omnivore	0	0	0	0	50
Chromis lepidolepis	Major	Planktivore	0	100*	0	0	0
Chromis viridis	Major	Omnivore	0	125*	0	0	50
Dascyllus trimaculatus	Major	Omnivore	12	0	0	0	0
Dischistodus perspicillatus	Major	Herbivore	0	17	10	0	0
Dischistodus prosopotaenia	Major	Herbivore	18	29	16	13	6
Neoglyphidodon melas	Major	Omnivore	2	6	3	12	19
Neoglyphidodon oxyodon	Major	Omnivore	0	0	0	0	11
Neoglyphidodon thoracotaeniatus	Major	Omnivore	0	0	0	0	10
Pomacentrus alexanderae	Major	Omnivore	204*	98	168*	122	58
Pomacentrus brachialis	Major	Omnivore	0	6	0	19	6
Pomacentrus burroughi	Major	Herbivore	11	0	0	10	6
Pomacentrus lepidogenys	Major	Planktivore	0	0	0	1	0
Pomacentrus moluccensis	Major	Omnivore	7	6	4	14	40
Pomacentrus nagasakiensis	Major	Omnivore	9	6	6	31	17
Pomacentrus philippinus	Major	Omnivore	2	4	0	54	31
Pomacentrus simsiang	Major	Omnivore	20	27	39	58	38
Pomacentrus smithi	Major	Omnivore	8	32	32	6	21
Scaridae							
Chlorurus capistratoides	Target	Herbivore	1	4	0	2	4
Serranidae							
Cephalopholis boenak	Target	Carnivore	2	1	1	1	3
Cephalopholis microprion	Target	Carnivore	0	0	0	0	3
Cephalopholis miniata	Target	Carnivore	0	0	0	0	1
Siganidae							
Siganus guttatus	Target	Herbivore	0	8	0	0	0
Siganus virgatus	Target	Herbivore	11	0	0	0	0

The most trophic categories among the five study sites was omnivore at the depth of 3 m. Similar things was found at the depth of 10 m, omnivorous fishes dominated in all sites. Therefore, it could be attributed to the result of reef fish abundance. Almost of the entire fish community composition differed significantly between the study sites and a significant effect was found between the depths (Table 4). The SIMPER analyses revealed that three species settled at the depth of 3 m, *Pomacentrus alexanderae*, *Pomacentrus simsiang*, *Dischistodus perspicillatus* (Pomacentridae), and the three species settled at the depth of 10 m, *Pomacentrus alexanderae*, *Dischistodus prosopotaenia*, *Pomacentrus simsiang* (Pomacentridae) are shown in Table 5.

Table 3. Result of repeated-measures ANOVA for abundance, species richness of reef fish (*p<0.05, *n.s.* not significant)

Variable	Factor	*F*	*F crit*	*df*	*p*
Abundance	Site	2.18	2.87	4	n.s
	Depth	0.99	4.35	1	n.s
	Site*Depth	4.52	2.87	4	*
Species Richness	Site	7.99	2.87	4	*
	Depth	0.18	4.35	1	n.s
	Site*Depth	6.39	2.87	4	*
Shanon-Wiener index (H')	Site	0.98	2.87	4	n.s
	Depth	0.02	4.35	1	n.s
	Site*Depth	1.59	2.87	4	n.s

The significant differences in fish communities between two depths in terms of species abundance detected by the ANOSIM (Table 4). The clusters were visible in the MDS plots (Figure 4). The community samples from the 3 m depth clearly separate, while the 10 m depth are clustered more closely together.

3.2 Discussion

3.2.1 Hard coral cover

The results in Table 1 are shown the percentage of coral cover at the study sites. The hard coral cover percentage was very low, it was ranged from 3% - 35%. Therefore, it indicated the coral cover condition does not play a role in the reef fishes individual abundances but more dominantly influenced by the form of coral growth in the study sites. Considering the ship activities very intense in the docks, it has been observed damaging (Dinsdale & Harriot, 2004) and affect the corals (McKenna & Etnoyer, 2010). Ship traffic in Pramuka is high. Local ship, dump ship, freighters, government ship, cruise ships and yachts transit over the docks. Anchor damage are known to cause extensive physical damage to coral. Several study sites having low hard coral cover, human impacts are evident from habitation, tourism and fishing activity and have been identified as local threats. Several anthropogenic factor cause damage to corals (Dinsdale and Harriot, 2004) such as destructive fishing (Fenner, 2012) and coral mining (Hariri, 2012). Local fishermen around Pramuka Island are still using muroami to collect fish (Zamani *et al.*, 2011) and Iskandar (2011) has reported several fishermen in Seribu islands are still using muroami. Muroami is the destructive fishing tools causing the damage on corals (Graham *et al.*, 2011). The loss of coral cover in Indo-Pacific have been underestimated (Bruno & Selig 2007). Coral reefs near human habitation are relatively fragile with regards to impacts from local activities (Riegl *et al.*, 2012) and local dependence on coral is high (Pendleton *et al.*, 2016). Baum *et al.*, (2015) has assessed the local and regional pollution affected the benthic communities in Seribu Islands. Other potential damages on corals also comes from recreational diving activities around Pramuka island. Recreational and tourism activities physically damage the coral (Lane *et al.*, 2013). Environmental condition also threatened the corals (Setyawan *et al.*,, 2011, Zamani and Madduppa, 2011), although several corals have different resistant from the environmental stressors (McClanahan *et al.*, 2004). There are important roles of specific corals on reef fish existence (Madduppa *et al.*, 2014) and the corals influence reef fish assemblages (Benfield *et al.*, 2008; Madduppa *et al.*, 2012b). The important things in the present study, the abundance of several species of fish such as *Pomacentrus alexanderae* and several other species of *Pomacentrus sp.*/*Chromis sp.* are strongly affected by the presence of certain coral species such as the *Chromis viridis* fish species associated with coral species of *Porites cylindrica* (Nanami et al, 2005; Mesmer et All, 2011) and *Pomacentrus alexaderae* with *Acropora spp* (Nanami et al, 2005; Randall et al, 1990).. The structure of coral reefs particularly important for critical resources in their association with reef fishes (Komyakova *et al.*,, 2013; Madduppa *et al.*, 2012b).

3.2.3 Fish community structure

Previous study also observed the most diverse families in Seribu islands were Pomacentridae and Labridae (Estradivari *et al.*, 2007; Madduppa *et al.*, 2013), those are the most dominantly found in reef fish community (Edrus & Abrar, 2016). Reef fish community were observed at small island ecosystem in Kepulauan Seribu National Park (TnKPS). *Pomacentrus alexanderae,* and *Chromis viridis* are classified as major reef fish in functional group which is generally found in large quantities (Sjafrie, 2009; Madduppa *et al.*, 2012a) while *Pomacentrus simsiang* were significantly found at the reefs where the island was present (Dixon *et al.*,, 2011). The corals influence reef fish assemblages (Benfield *et al.*, 2008; Madduppa *et al.*, 2012b). Previous study in Japan, the coral habitat held significantly higher species richness and abundance of reef fish assemblages (Nakamura *et al.*, 2013). Seasonal migration of reef fish also affect the composition of some species (Madduppa *et al.*, 2012b).

Study sites were influenced reef fish species richness. Each study sites have the different percentage of hard coral cover (Table 1), indicating of how the study sites affect the species richness. The previous study indicates positive correlations between fish species richness and location with different of percentage coral cover (Gratwicke & Speight, 2005). *Pomacentridae* (damselfishes) was the most dominant family in terms of abundance. Litsios *et al.*, (2012) were classified the damselfishes into three main class, herbivorous benthic feeders, omnivorous group, and pelagic feeders mainly eat planktonic prey, but damselfishes usually considered as omnivorous fishes. Therefore, it causes the percentage of reef fishes among five study sites was dominated by omnivorous fishes.

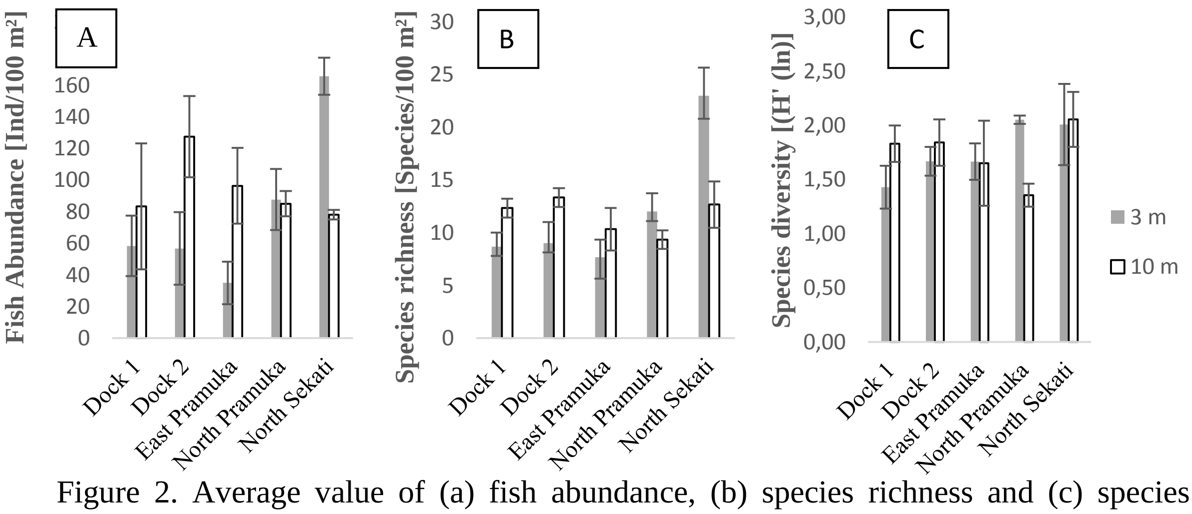

Figure 2. Average value of (a) fish abundance, (b) species richness and (c) species diversity (ln basis) of reef fish assemblages at the study sites

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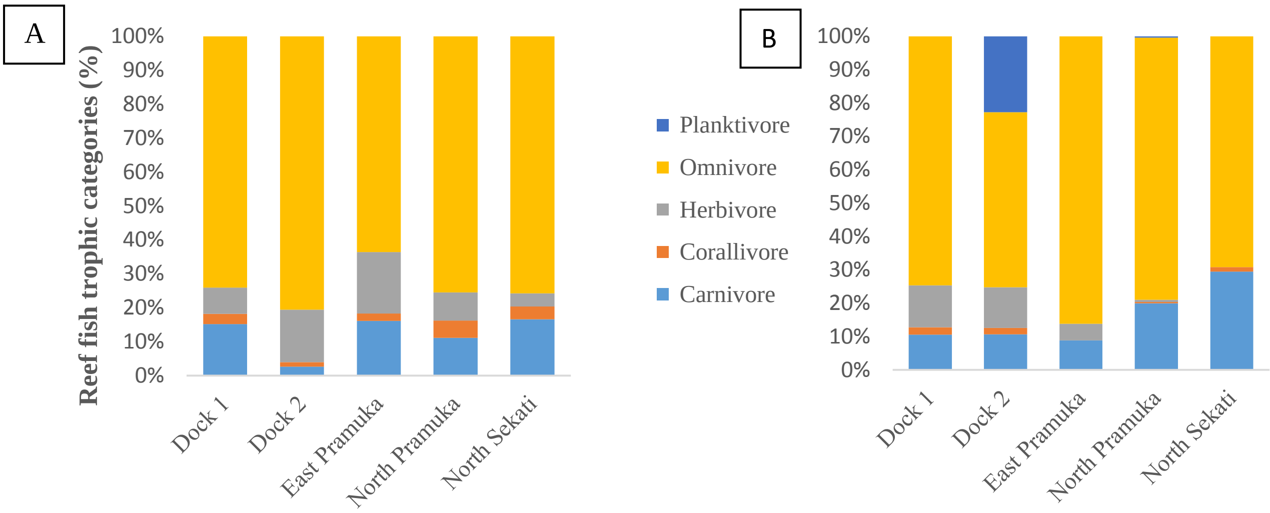

Figure 3. Percentage of reef fishes at the sampling sites, and (a) depth of 3 m, (b) depth of 10 m based on trophic categories

3.2.3 Spatial variation of the fish community from different depths

Both of the three species at the two different depths are from the Pomacentridae family which were found at the depth of 3 m and 10 m in Seribu Islands (Madduppa *et al.*, 2013).

Table 4. Result of a crossed two-way ANOSIM within sites based on abundance of all species (**p*<0.05, *n.s.* not significant)

Relative Abundance				
Test	Factor	Test pairs	ρ	*p* (ρ)
Global Pairwise	Site	Dock 1, Dock 2	0.5	*
		Dock 1, East Pramuka	0.574	*
		Dock 1, North Pramuka	0.63	*
		Dock 1, North Sekati	0.796	*
		Dock 2, East Pramuka	0.13	n.s
		Dock 2, North Pramuka	0.704	*
		Dock 2, North Sekati	0.778	*
		East Pramuka, North Pramuka	0.87	*
		East Pramuka, North Sekati	0.926	*
Global Pairwise	Depth	3 m, 10 m	0.613	*

Although the result from the univariate community parameters could not differentiate between the most of study sites and depths, the clear difference was shown in the multivariate analysis of the reef fish community and able to detect the differences between the composition of the coral reef fish community associated with the difference of depth based on fish abundance.

Table 5. Composition of 10 most high species contribution within each sampling site using SIMPER (Similarity Percentages – Species Contribution)

Species per depth	Av. Abundance	Av. Similarity	%Contribution	%Cumulative
3 m, average similarity: 30,97				
Pomacentrus alexanderae	1,93	4,36	14,07	14,07
Pomacentrus simsiang	1,80	3,10	10,01	24,08
Dischistodus perspicillatus	0,70	3,01	9,74	33,81
Pomacentrus philippinus	0,89	2,31	7,47	41,29
Pomacentrus moluccensis	1,20	2,13	6,86	48,15
Chaetodon octofasciatus	1,34	1,90	6,12	54,27
Amblyglyphidodon curacao	1,11	1,64	5,30	59,57
Neoglyphidodon melas	1,02	1,31	4,23	63,80
Thalassoma lunare	0,81	1,21	3,91	67,71
Chromis viridis	1,12	1,13	3,64	71,35
10 m, average similarity: 45,70				
Pomacentrus alexanderae	5,01	12,72	27,84	27,84
Dischistodus prosopotaenia	1,51	4,18	9,14	36,97
Pomacentrus simsiang	1,20	3,17	6,93	43,90
Cheilinus fasciatus	1,59	2,79	6,10	50,00
Pomacentrus philippinus	1,01	2,65	5,80	55,80
Halichoeres melanurus	0,71	2,51	5,50	61,30
Thalassoma lunare	0,82	1,82	3,99	65,29
Pomacentrus nagasakiensis	1,10	1,70	3,73	69,02
Pomacentrus moluccensis	0,70	1,51	3,31	72,33
Chromis lepidolepis	0,94	1,51	3,30	75,63

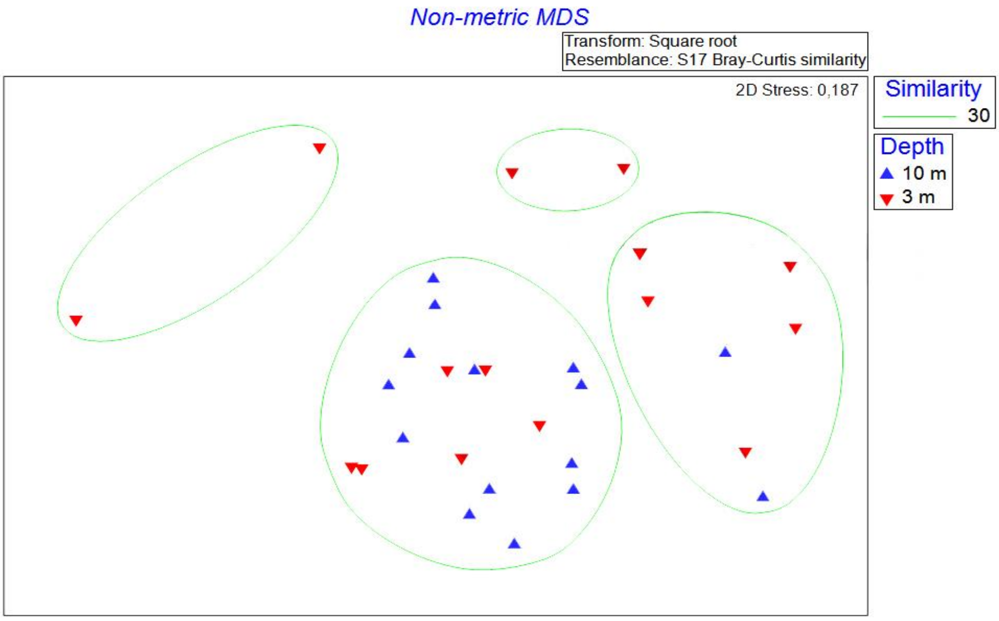

Figure 4. MDS plot of fish communities at the Pramuka Island, showing among pattern of association among 17 species based on abundance

Several factors may have contributed to the reef fish distribution. Food sources and various trophic categories distinguish the fish composition and related to behavior and habitat (Fre´de´rich *et al.*,, 2009; Madduppa *et al.*, 2012b). Vertical migration of zooplankton and phytoplankton during the day influence the feeding behavior of reef fish (Williamson *et al.*, 2011). Zooplankton likely migrates to surface at afternoon and descend to deeper water at dawn (van Haren & Compton, 2013) while the phytoplankton likely migrates to surface at dawn and return back to deeper water at dusk (Gerbersdorf & Schubert, 2011). Variation of coral communities across the depths significantly affect reef fish density (Lison de Loma *et al.*, 2011). However, the percentage of hard coral cover at the depth of 3 m was dominantly low. According to Macdonald *et al.*, (2016), shallow water represents where the reef fish distribution strongly related to the availability of live coral.

IV. Conclusion

The present study results showed that the abundance and species richness of reef fishes around Pramuka Island were higher at 10 m depth and reef fish assemblages were clustered in both of two depth, although several transects in 3 m were separated. Pomacentridae and their member *Pomacentrus alexanderae* was the most dominant family and the most abundant species, respectively. Omnivorous was dominant fish trophic categories. Reef fish composition around Pramuka Island seems to be linked to habitat condition such as coral reefs.

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