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RESEARCH PAPER

Site and depth influence on reef structure and composition in Seribu Islands, Jakarta

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ABSTRACT

The coral reefs structure and composition are influenced by environmental condition and depth. Therefore, this study was conducted to find and examine the influence of site and depth on coral reef structures in Pramuka Island regions, Seribu Islands, located in the northern of Jakarta. The study was carried out from November to December 2016. The data was taken by Line Intercept Transect Method which is laid 20 meters x 3 replicated parallels with shoreline at the depth of 3 and 10 meters. The hard coral at the depth of 3 m within both study sites in Pramuka island held higher percent cover than the depth of 10 m except in North of Pramuka. Coral mortality index varied and ranged from 0.39 to 0.98. West of Pramuka Island dominant hasthe lowest value of mean number of families, genera, and life form. Percentage of hard coral cover, coral mortality index, mean numberof family, genera, and life form differed significantly between sites. The different of depth only affecting the percentage of coral cover and mean number of life form. Corals have a limiting factor which are affected their development and growth.

Keywords: Damaged; Genera; Mortality Index; Resilience; Life Form;

INTRODUCTION

Resistance and recovery of corals are related significantly to the condition of the environment (McClanahan *et al.*, 2012). The differences of environmental condition affecting survival growth of corals (Fadli et al., 2013) and their associated organisms (Madduppa *et al.*, 2013). Zooxanthellate corals have the limiting factor because it depends on the symbiotic dinoflagellate (Wooldridge, 2013), which is related to depth and penetration of light. One of the main factor restricting the shallow-water corals is seawater temperature (Denis *et al.*, 2013). There were another several of physical environments factor affecting the growth and survival rate of corals such as light reduction (Subhan *et al.,* 2012), sedimentation (Fabricius, 2005), dissolved oxygen (Haas *et al.*, 2014), salinity (Kuanui *et al.*, 2015), and the most important parameter is depth (Cleary *et al.*, 2005). Coral reefs are the essential ecosystem in coastal environment (Gaol *et al.,* 2009; Ramadhani *et al.,* 2015; Awak *et al.,* 2016). Every coral have a different resilience of stressor (Visram and Douglas, 2007). Osborne *et al.* (2011) has grouped various different stressors, including disease, bleaching, predators, and storms in Great Barrier Reefs, Australia. Coral reefs in Pramuka Island regions, Seribu Islands are under pressure from acute stressors such as human disturbance and environmental condition that threatened their continued existence (Setyawan *et al.*, 2011, Madduppa, 2014). Although, Pramuka Island constitute the marine national park, the coral cover in Pramuka island categorized as moderate coverage (Ardyansah *et al.*, 2013). Subhan *et al.* (2011) has found severals stressor in Pramuka which was affect the Fungiidae corals.

Reef zones (crest, slope, flat) are having each difference of depth and disturbances encourage the corals structures variation (Graham *et al.*, 2014). Variation of depth giving a different layer for corals to

growth, live (Kahng and Kelley, 2007; Williams, *et al.* 2013), and resilience on bleaching mortality (Bridge *et al.*, 2014). The previous study by Miller (1995) used *Oculina arbuscula* to see the influence of light and depth on coral growth has giving a significant result. The corals and genera richness differed significantly onlatitude and depth (McClanahan *et al.*, 2014). However, Suryanti *et al.* (2011) has reported there were no significant differences between depth (3 m and 10 m) on coral morphology in Karimunjawa national park. The main aims of this study were to determine the influence of study sites and two different depths (3 and 10m) on percentage of coral cover, coral mortality index, mean composition number of families, genera, and life form that found in four islands (Pramuka, Air, Panggang, Sekati) within Seribu Islands, Jakarta.

MATERIALS AND METHODS

Study sites

Reef zones depth (3 m and 10 m) were carried out at six sites in mid region of Seribu Islands, representing, West of Pramuka, North of Pramuka, South of Pramuka, Southwest of Panggang, South of Air , and North of Sekati Island (Fig. 1) from November to December 2016. Pramuka island are located in Kepulauan Seribu (Seribu Islands) Marine National Park, Jakarta (Baum *et al.,* 2015).

Data collection

To estimate the effect of a depth of habitat characteristic on the structures of corals community within the Pramuka regions, the locations of the study sites were determined initially by manta tow and snorkelling, and observing the coral reef conditions of the representative areas (3 and 10 m depth). Benthic surveys were carried out at the depth of 3 and 10 meters using 3 replicates of 20 meter line intercept transect (Hill and Wilkinson, 2004) that were parallel to the shoreline. For each transect line, benthic genera and life form was visually identified along the entire length of the line and categorized based on the work of English *et al.* (1997) and Subhan *et al.* (2016).

Data analysis

The average percentage cover of each life-form categories was verified following English *et al.,* (1997) formula:

Percent Cover (%) $= \frac{A}{B} X\ 100\ \%$, Where, A= Length of category, B = Length of transect

The percentage cover sampled at each transect was the basis of replication used in the statistical analyses. The percentage cover of hard coral, dead coral, and dead coral with algae were determined and the coral mortality index (CMI) for a site was calculated with a simple ratio of dead coral cover to the sum of dead and hard coral cover as following the Gomez *et al.* (1994); Zamani and Madduppa (2011) formula as follow:

CMI= DC/(DC+HC), Where, CMI= Coral mortality index, DC = Dead coral, HC = Hard coral

Summing and averaged the number of genera, families, and life form found in each sites, and the decimal number as the result from mean were changed to integers number. Percentage of hard coral cover, coral mortality index, mean number of families, genera, and life form were compared among sites and depth using two-way replication ANOVA to detect differences between experimental group means (Sawyer, 2009) in the Ms. Excel 2010.

Table 1. Coordinate information for study sites

Study sites	Longitude	Latitude
West of Pramuka Island	106°'36'46.44"	05°'44'38.04"
South of Air Island	106°'37'59.06"	05°'44'03.28"
Southwest of Panggang Island	106°'37'49.36"	05°'44'32.91"
North of Pramuka Island	106°'37'07.36"	05°'44'18.19"
South of Pramuka Island	106°'36'39.96"	05°'45'05.40"
North of Sekati Island	106°'36'32.01"	05°'45'28.25"

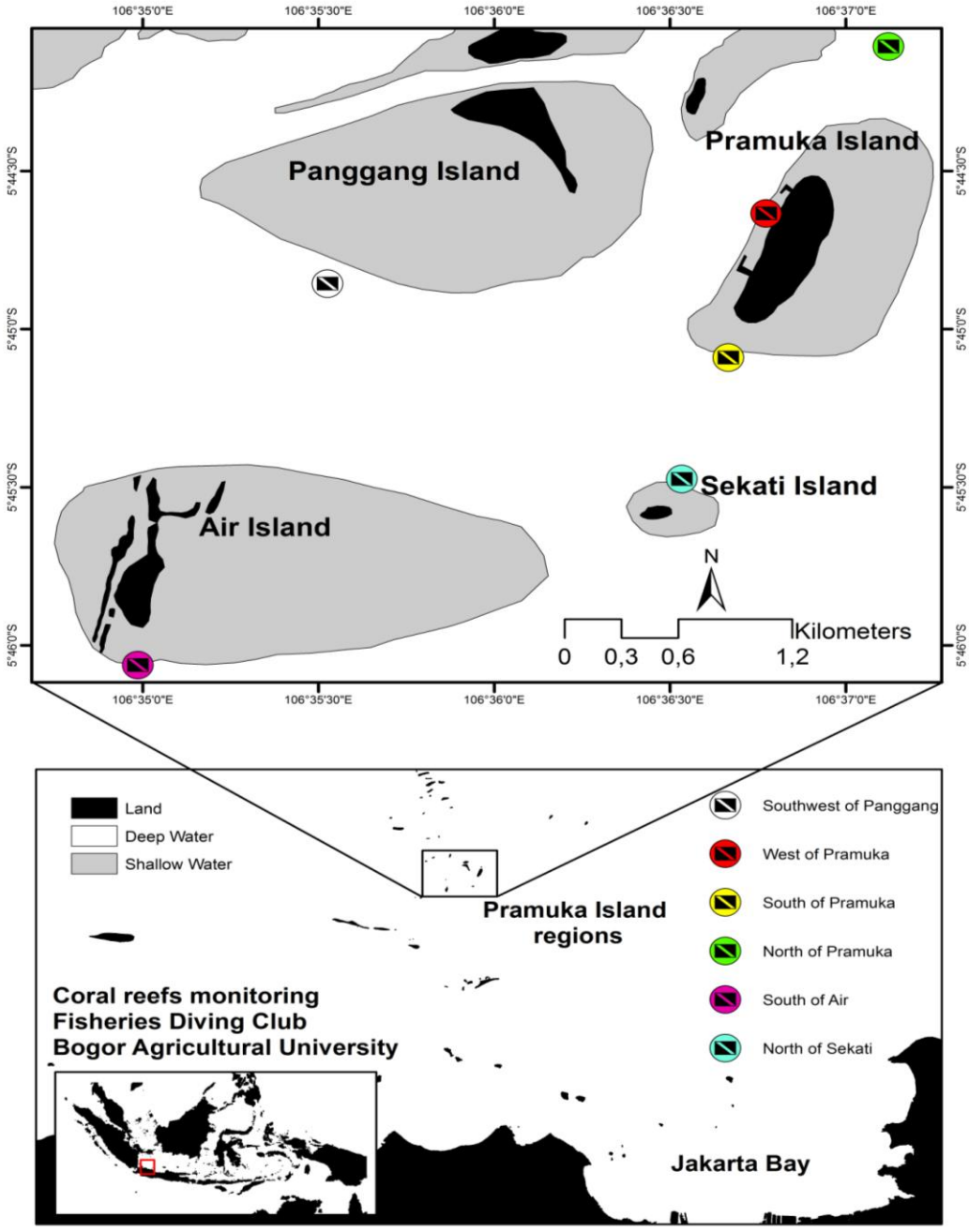

Figure 1. Location of the Pramuka Island regions, north of Jakarta, Java Island, Indonesia. The map below shows the position of Pramuka Island regions relative to Jakarta. The location within Indonesia is shown in the inset on the lower left

RESULTS

Percentage of hard coral cover and mortality

The percentage of hard coral (HC) cover at the depth of 3 m has a dominant higher value than the 10 m depth. The highest percentage of HC located in the North of Sekati Island (52.73 ± 13.33%) and

the lowest are located in North of Pramuka Island (19.27 ± 2.94%) at the depth of 3 m, while at the depth of 10 m is located in Southwest of Panggang Island (41.15 ± 5.49%) and the lowest percentage is located in West of Pramuka Island (4.06 ± 1.16%) is shown in Figure 2. Coral mortality rate varied in each sampling station. Table 2 shown the CMI value ranged 0.32-0.98 at the depth of 3 m and 0.39-0.98. Both of the depth in West of Pramuka island have the highest value of CMI (0.48) and the lowest value located in South of Pramuka Island (0.32) at the 3 m depth, while at the depth of 10 m the lowest value located in Southwest of Panggang island (0.39).

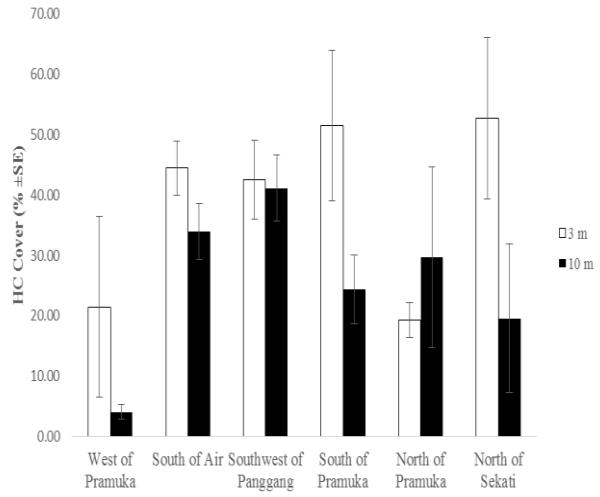

Figure 2. Percentage of Hard Coral Cover at 3 and 10 m depth in Pramuka Island region

Table 2. Coral Mortality Index (CMI) Value at 3 m and 10 m depth in Pramuka Island region

Study Sites	3 m	10 m
West of Pramuka	0.48-0.98	0.94-0.98
South of Air	0.43-0.58	0.53-0.69
Southwest of Panggang	0.43-0.66	0.39-0.63
South of Pramuka	0.32-0.64	0.56-0.86
North of Pramuka	0.74-0.84	0.40-0.88
North of Sekati	0.26-0.71	0.52-0.91

Number of coral taxa and life forms

The mean number of coral family were found in Pramuka Island region at 3 m and 10 m depth is shown in Figure 3a. where the highest number at the depth of 3 m located in North of Pramuka (6±2.33) Island and the lowest number located in West of Pramuka (3±0.33), while at the 10 m depth the highest number located in South of Air Island (8±0.58) and the lowest number located in West of Pramuka Island (2±0.58).

The mean number of coral life form were found at the six sampling sites is shown in Figure 3b. The highest number of life form were found are located in South of Air Island (6±0.58) Southwest of Panggang Island (6±0.33), South of Pramuka Island (6±0.33), and North of Sekati Island (6±0.58) and the lowest number were found located in West of Pramuka Island (3±0.67) at the 3 m depth, while at the depth of 10 m The highest number of life form were found located in South of Air Island (7±0.58) and the lowest located in West of Pramuka Island (2±0.58). Among the six sites assessed, South of Air Island has the highest mean number of life form were found at both of 3 m and 10 m depth.

Mean of coral genera were found during observation has the highest number located in South of Pramuka Island (8±0.67) and North of Pramuka Island (8±2.91) and the lowest number located in West of Pramuka at 3 m depth, while at the 10 m depth the highest number located in South of Air Island (13±1.53) and the lowest located in West of Pramuka Island (2±0.88) (Figure 3c).

Site and depth effects on hard coral

Hard coral cover differed significantly between site and depth. The CMI, mean number of families, mean number of life form, and mean number of genera all differed significantly over the study sites, and the effect of study sites on mean number of genera differed between site and depth. No significant

differences in CMI, mean number of families, and mean number of genera were found between the depth (Table 3).

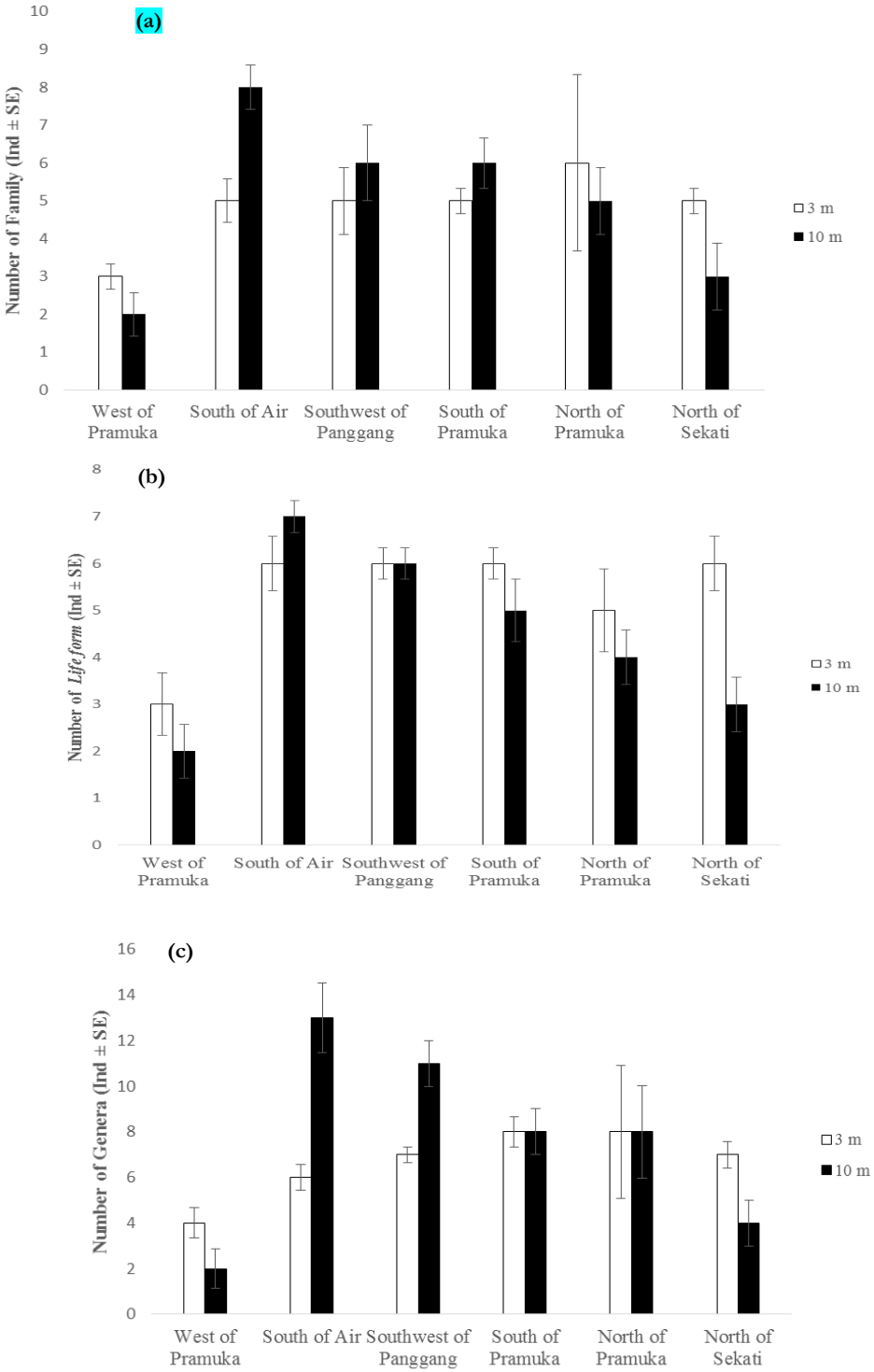

Figure 3. (a) Mean number of families found at 3 m dan 10 m depth in Pramuka Island region; (b) Mean number of life form found at 3 m and 10 m depth in Pramuka Island region; (c) Mean number of genera found at 3 m and 10 m depth in Pramuka Island region

Table 3. Repeated-measures ANOVA summaries for percentage of HC cover, CMI, mean number of families, mean number of life form, and mean number of genera. (*p<0.05, **p<0.01, ***p<0.001, n.s: not significant)

Variable	Factor	F	df	p
HC Cover	Site	2.76	5	*
	Depth	5.72	1	*
	Site x Depth	1.45	5	n.s
CMI	Site	3.64	5	*
	Depth	3.48	1	n.s
	Site x Depth	1.59	5	n.s
Mean number of families	Site	4.38	5	**
	Depth	0.01	1	n.s
	Site x Depth	1.80	5	n.s
Mean number of life form	Site	11.15	5	***
	Depth	9.53	1	*
	Site x Depth	2.26	5	n.s
Mean number of genera	Site	6.84	5	***
	Depth	2.64	1	n.s
	Site x Depth	4.11	5	**

DISCUSSION

In this study, West of Pramuka Island has the lowest percentage of HC cover has been linked to the presence of Pramuka island jetty, where the ship activities very intense in this area. Subhan *et al.,* (2008) has reported the percentage of coral cover in west of Pramuka Island were damaged. North of Sekati and South of Pramuka island have a close distance and both of that sites are having high coral percentage at 3 m depth. The distance between North of Sekati and South of Pramuka Island is a ships or boats line, it indicate the corals at 10 m depth has a low percentage. In addition, the huge ships cannot accros the 3 m depth so it cannot the damage the corals. Dinsdale and Harriot (2004) has explained the coral reefs that experience high intensities of ship activities are increasing the damage of corals.

There are several causes of coral mortality such as the changes of environmental, human (Riegl *et al.*, 2012), competition with algae (Subhan *et al.*, 2014) and disease (Baird *et al.*, 2012; Subhan *et al.*, 2011). Overfishing and destructive fishing, ship anchor, coral mining are the examples of the human factor on coral mortality (Hariri, 2012). The risk of coral mortality are the increasing of wave energy reaching the island shores (Sheppard *et al.*, 2005). During the field observation, breakwater construction around the Pramuka Island region are the reduction effort of the strong wave energy. Degradation of corals, affect the wave-driven flooding of tropical coastline (Quataert *et al.*, 2015). Coral mortality can also drive cyclical changes in fish assemblages (Rudi *et al.,* 2012).

Poritidae were found dominant in each station and both of depth at 3 m and 10 m. Compared to the other coral families, Poritidae was a family which have the largest number of species and having a coral massive life form (Puspitasari *et al.*, 2013). There are another several quite predominant coral families dominant were found besides Poritidae such as Acroporidae, Fungiidae, and Faviidae. Estradivari *et al.* (2007) has reported these Poritidae, Acroporidae, Fungidae, and Faviidae are the common corals in Seribu Islands.

Coral growth influenced by environment factors (Saptarini *et al.*, 2017). Coral life form have a different resistance. According to Piquero *et al.* (2015) massive coral life form more resistant and able to resist the strong wave than the branching and digitate, however the massive life form were slow growing

than the branching and digitate coral life form which are fast growing corals. During field observation, coral massive (CM) were found in every sites and have the highest abundance. Eventhough, the abundance of corals doesn't influence the percentage of coral life form cover. Zamani *et al.* (2011) has reported the percentage of Acropora branching (ACB) cover were a dominant coral life form were found in the Pramuka, Panggang and several islands in the Seribu Archipelago.

Pramuka and Panggang Island study sites were close to human habitat, while the Sekati and Air Island were a Private Island. Local activities around Pramuka Island are more intensed than Panggang Island. The corals near the human habitat are increasingly threatened by the local activities (Annas *et al.,* 2017). Management regimes and fisheries activity are affect the hard corals (McClanahan *et al.*, 2014). The differences of sites and environment condition influence the coral growth (Saptarini *et al.*, 2017; Cahyarini, 2008). The hard corals cover and life form has been influenced by depth. Branching and plating life form of coral grow quickly and occur at shallow depth (Graham *et al.*, 2014), while the massive coral have optimal growth and occur at 10 m water depth (Lough and Cantin, 2014). Light spectrum intensities is one of the most important abiotic factors and play a role in coral-dinoflagellate symbioses (Schutter *et al.*, 2008; Wijgerde *et al.*, 2014). Dinoflagellate loss affect the corals growth (Kusuma *et al.,* 2016a; Kusuma *et al.,* 2016b). The value of light intensites decreases exponentially with depth (KÜhl *et al.*, 1994).

Among the coral genera were found during observation, *Porites* has the highest abundance and very often seen compared to the other genera, eventhough there are severals quite predominant genera were found such as *Acropora, Montipora,* and *Fungia.* Munasik and siringoringo (2011) has said one of the group of hard corals resistant to environmental stresses is *Porites* sp.. The genus *Porites* has a relatively high level of resilience on their growth and development limiting factors (Zamani *et al.*, 2011). McClanahan (2004) and has explained if massive *Porites* are moderately resistant to bleaching and heat stress (McClanahan, 2004; Visram and Douglas, 2007). The occurence of specific coral genera also affecting the number of specific fish that are dependent on them for food or shelter (Madduppa *et al.*, 2012a; Madduppa *et al.,* 2012b; Madduppa *et al.* 2014).

The percentage of hard coral cover were dominant higher at the 3 m depth. Previous study conducted by Kahng and Kelley (2007) in Hawai, the light can penetrate around 100 m when the water is optically clear. Increasing of sediment concentration is another factor impacting the intensities of light. Considering the study sites were located near the Jakarta city and Seribu Archipelago is the part of Jakarta Bay which have 13 rivers, it has been observed affect the coral fish communities across environmental gradient (Madduppa *et al.*, 2013). The turbidity of water also reduce the intensities of light and decrease the net photosynthesis of symbiotic dinoflagellate (Anthony and Connolly 2004), although several coral species can tolerate the physical impact like water turbidity (Junjie *et al.*, 2014).

CONCLUSIONS

The percentage of Hard Coral Cover, Coral Mortality Index, mean number of families, mean number of life form, and mean number of genera were significantly different between sites. Hard coral cover and mean number of life form differed significantly between two different depths. The percentage of coral cover at the shallow water is mostly higher rather than the deep water corals around Pramuka Island. The study sites were significantly influenced the mean number of genera between depth. Most coral reefs are severely affected by local human activities such as fishing and pollution. Corals have a limiting factor which are affect the coral growth.

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REFERENCES

Annas, R.A., Z.A. Muchlisin, M.A. Sarong. 2017. Short communication: coral reefs condition in Aceh Barat, Indonesia. Biodiversitas, 18(2): 514-519.

Anthony, K.R.N., S.R. Connolly. 2004. Environmental limits to growth: Physiological niche boundries of corals along turbidity:light gradients. Oecologia, 141: 373–384. doi:10.1007/s00442-004-1647-7.

Awak, D.S.H.L.M.K., J.L. Gaol, B. Subhan, H.H. Madduppa, D. Arafat. 2016. Coral reef ecosystem monitoring using remote sensing data: case study in Owi Island, Biak, Papua. 12/2016; 33., Procedia Environmental Sciences, 33: 600 – 606. DOI:10.1016/j.proenv.2016.03.113.

Baird, A.H, S.J. Campbell, N, Fadli., A.S. Hoey, E. Rudi. 2012. The shallow water hard corals of Pulau Weh, Aceh Province, Indonesia. AACL Bioflux, 5(1): 23-28.

Baum, G., H.I. Januar, S.C.A. Ferse, A. Kunzmann. 2015. Local and regional impacts of pollution on coral reefs along the Thousand Islands North of the Megacity Jakarta, Indonesia. *PLoS ONE,* 10(9): e0138271.

Bridge, T.C.L., A.S. Hoey, S.J. Campbell, E. Muttaqin, E. Rudi, N. Fadli, A.H. Baird. 2014. Depth-dependent mortality of reef corals following a severe bleaching event: implications for thermal refuges and population recovery. F1000Research, 2: 187 (doi: 10.12688/f1000research.2-187.v3)

Cahyarini, S.Y. 2008. Annual growth band analysis of *Porites* corals: case study Seribu Islands corals, Indonesia. Jurnal Riset Geologi dan Pertambangan, 18(2): 51-59.

Cleary D.F.R., L.E Becking, N.J. de Voogd, W. Renema, M. de Beer, R.W.M. van Soest, B.W. Hoeksema. 2005. Variation in the diversity and composition of benthic taxa as a function of distance offshore, depth and exposure in the Spermonde Archipelago, Indonesia. Estuarine, Coastal and Shelf Science, 65: 557–570.

Denis, V,T. Mezaki, K. Tanaka, C.Y. Kuo, S. De Palmas, S. Keshavmurthy, C.A. Chen. 2013. Coverage, diversity, and functionality of a high-latitude coral community (Tatsukushi, Shikoku Island, Japan). PLoS ONE, 8(1): e54330. doi:10.1371/journal.pone.0054330.

Dinsdale, E.A., V.J. Harriott. 2004. Assessing anchor damage on coral reefs: a case study in the selection of environmental indicators. Environmental Management, 33: 126-139.

English, S., C. Wilkinson, V. Baker. 1997. Survey manual for tropical marine resources. 2nd ed. Australian Institute of Marine Science. Australia (AIMS), Townsville.

Estradivari, M. Syahrir, N. Susilo, S. Yusri, S. Timotius. 2007. Terumbu karang Jakarta: Pengamatan jangka panjang terumbu karang Kepulauan Seribu 2003-2005 [Coral reefs of Jakarta: long term observation of coral reefs of Seribu Islands 2003- 2005]. Terangi Foundation, Jakarta, 87 pp.

Fadli, N., K. Von Jutarzenka, E. Rudi, Z.A. Muchlisin. 2013. A preliminary study of corals recruitment using coral rubbles substrate in Seribu Island waters, Indonesia. AACL Bioflux, 6(3): 246-252.

Gaol, J.L., R.E. Arhatin, N.P. Zamani, H. Madduppa. 2009. Kebutuhan data spasial kelautan dan keterbatasan metoda inderaja dalam mendukung pemetaan sumberdaya kelautan. Majalah Ilmiah Globe, 11 (1): 1-7.

Graham, N.A.J, K.M. Chong-Seng, C. Huchery, F.A. Januchowski-Hartley, K.L. Nash. 2014. Coral reef community composition in the context of disturbance history on the Great Barrier Reef, Australia. PLoS ONE 9(7): e101204. doi:10.1371/journal.pone.0101204.

Gomez, E. D., P. M. Alino, H. T. Yap, W. Y. Licuanan. 1994. A Review of the status of Philippine Reefs. Marine Pollution Bulletin, 29: 62-68.

Haas, A.F, J.E. Smith, M. Thompson, D.D. Deheyn. 2014. Effects of reduced dissolved oxygen concentrations on physiology and fluorescence of hermatypic corals and benthic algae. PeerJ 2: e235; DOI 10.7717/peerj.235.

Hariri, M.S.B. 2012. The Present Status of the Red Sea Coral Reefs between Haql and Yanbu, Saudi Aarabia. Life Science Journal, 9(4): 3852-2859.

Hill, J., C. Wilkinson. 2004. Methods For Ecological Monitoring of Coral Reefs. A Resource For Managers.Australian Institute of Marine Science, Townsville (AU).

Junjie, R.K, N.K. Browne, P.L.A. Erftemeijer, P.A Todd. 2014. Impacts of Sediments on Coral Energetics: Partitioning the Effects of Turbidity and Settling Particles. PLoS ONE, 9(9): e107195. doi:10.1371/journal.pone.0107195.

Kuanui, P., S. Chavanich, V. Viyakarn, M. Omori, C. Lin. 2015. Effects of temperature and salinity on survival rate of cultured corals and photosynthetic efficiency of zooxanthellae in coral tissues. Ocean Science Journal, 50(2):263-268.

KÜhl, M., C. Lassen, B.B. Jorgensen. 1994. Penetration and light intensity in sandy marine sediments measured with irradiance and scalar irradiance fiberoptic microprobes. Marine Ecology Progress Series, 105: 139-148.

Kusuma, A.B., D.G. Bengen, H. Madduppa, B. Subhan, D. Arafat. 2016a. Keanekaragaman genetik karang lunak Sarcophyton trocheliophorum pada populasi Laut Jawa, Nusa Tenggara dan Sulawesi. Jurnal Enggano, 1(1): 89- 96.

Kusuma, A.B., D.G. Bengen, H. Madduppa, B. Subhan, D. Arafat, B.F.S.P. Negara. 2016b. Close genetic connectivity of soft coral Sarcophyton trocheliophorum in Indonesia and its implication for marine protected area. Aceh Journal of Animal Science, 1(2): 50-57.

Lough, J.M., N.E. Cantin. 2014. Perspectives on massive coral growth rates in a changing ocean. Biology Bulletin, 226**:** 187–202.

Madduppa, H. 2014. Bioekologi dan biosistematika ikan terumbu. Institu Pertanian Bogor Press., Bogor. ISBN: 978-979-493-657-3.

Madduppa, H.H., S.C.A. Ferse, U. Aktani, H.W. Palm. 2012a. Seasonal trends and fish-habitat associations around Pari Island, Indonesia: Setting a baseline for environmental monitoring. Environmental Biology of Fishes, 95(3-3): 383-398. DOI:10.1007/s10641-012-0012-7.

Madduppa, H.H., S.B. Agus, A.R. Farhan, D. Suhendra, B. Subhan. 2012b. Fish biodiversity in coral reefs and lagoon at the Maratua Island, East Kalimantan. Biodiversitas, 13 (3): 145-150.

Madduppa, H.H., Subhan, B., Suparyani, E., Siregar, A.M., Arafat, D., Tarigan, S.A., Alimuddin, Khairudi, D., Rahmawati, F., Bramandito, A. 2013. Dynamics of fish diversity across an environmental gradient in the Seribu Islands reefs off Jakarta. Biodiversitas, 14(1): 17-24. DOI:10.13057/biodiv/d140103.

Madduppa, H.H., S.C.A. Ferse, N.P. Zamani, B. Subhan, U. Aktani. 2014. Feeding behavior and diet of the eight-banded butterflyfish Chaetodon octofasciatus in the Thousand Islands, Indonesia. Environmental Biology of Fishes, 97(12): 1353-1365. DOI:10.1007/s10641-014-0225-z

McClanahan, T.R. 2004. The relationship between bleaching and mortality of common corals. Marine Biology, 144:1239–1245.

McClanahan, T.R., S.D. Donner, J.A. Maynard, M.A. MacNei, N.A.J. Graham, J. Maina, A.C. Baker, J.B. Alemu, M. Beger, S.J. Campbell. *et al.* 2012. Prioritizing key resilience indicators to support coral reef management in a changing climate. PLoS ONE, 7(8): e42884. doi:10.1371/journal.pone.004288.

McClanahan, T.R, M. Ateweberhan, E.S. Darling, N.A.J. Graham, N.A. Muthiga. 2014. Biogeography and change among regional coral communities across the Western Indian Ocean. PLoS ONE, 9(4): e93385. doi:10.1371/journal.pone.0093385.

Munasik, R.M. Siringoringo. 2011. Struktur Komunitas karang keras (scleractinia) di perairan Pulau Marabatuan dan Pulau Matasirih, Kalimantan. Ilmu Kelautan, 16(1): 49-58.

Osborne, K., A.M. Dolman, S.C. Burgess, K.A Johns. 2011. Disturbance and the dynamics of coral cover on the Great Barrier Reef (1995–2009). PLoS ONE, 6(3): e17516. doi:10.1371/journal.pone.0017516

Piquero, A.S., G.G. Delan, R.L.V. Rica, C.M. Corrales, I.A. Monte. 2015. Coral lifeform structure in selected Marine Protected Areas in Southern Cebu, Philippines. Tropical Technology Journal, 19(1): 1-4.

Puspitasari, L. S. Samino, C. Retnaningdyah. 2013. Alteration of coral reef community structure caused by athropogenicactivity in the coastal area of Giliketapang Island, Probolinggo, East Java, Indonesia. The Journal of Tropical Life Science, 3(1): 23-27.

Quataert, E., C. Storlazzi, A. van Rooijen, O. Cheriton, and A. van Dongeren. 2015. The influence of coral reefs and climate change on wave-driven flooding of tropical coastlines. Geophysical Research Letter, 42. doi:10.1002/2015GL064861.

Ramadhani, R.A., A. Damar, H. Madduppa. 2015. Management on coral reef ecosystem in the Siantan Tengah District, Anambas Islands. Jurnal Ilmu dan Teknologi Kelautan Tropis, 7 (1): 173-189.

Riegl, B.M., C.R.C. Sheppard, S.J. Purkis. 2012. Human Impact on Atolls Leads to Coral Loss and Community Homogenisation: A Modeling Study. PLoSONE, 7(6): e36921. doi:10.1371/journal.pone.0036921.

Rudi E., T. Iskandar, N. Fadli, H. Hidayati. 2012 Impact of mass coral bleaching on reef fish community and fishermen catches at Sabang, Aceh Province, Indonesia. AACL Bioflux, 5(5): 309-320.

Saptarini, D., Mukhtasor, I.F.M. Rumengan. 2012. Short communication: Coral reef lifeform variation round power plant activity: Case study on coastal area of Paiton Power Plant, East Java, Indonesia. Biodiversitas, 18(1): 116-120.

Sawyer, S.F. 2009. Analysis of variance: The fundamental concepts. The Journal of Manual and Manipulative Therapy, 17(2):27E–38E.

Schutter, M., B. van Velthoven, M. Janse, R. Osinga, M. Jansen, R. Wiffels, J. Verreth. 2008. The effect of irradiance on long-term skeletal growth and net photosynthesis in *Galaxeafascicularis* under four light conditions. Journal of Experimental Marine Biology and Ecology, 367: 75-80. doi: 10.1016/j.jembe.2008.08.014.

Setyawan E., S. Yusri, & S. Timotius (ed.). 2011. Terumbu karang jakarta: pengamatan jangka panjang terumbu karang Kepulauan Seribu (2005-2009). Terangi Foundation, Jakarta.

Sheppard, C., D.J. Dixon, M. Gourlay, A. Sheppard, R. Payet. 2005. Coral mortality increases wave energy reaching shores protected by reef flats: examples from the Seychelles. Estuary, Coastal and Shelf Science, 64: 223–234.

Subhan, B., D. Arafat, G. Andono, Mursalin, H. Madduppa. 2008. Kajian tutupan substrat dasar di daerah terumbu karang di Pulau Karang Besar, Pulau Air, Pulau Panggang, dan Pulau Pramuka, Kepulauan Seribu, Daerah Khusus Ibukota Jakarta [Study on substrate cover in coral reefs region in Karang Beras, Air, Panggang, and Pramuka Island, Seribu Archipelago, Special Capital Regio, Jakarta]. Proceedings of the seminar and the 2008 National Conference on Waters Utilization of Aquatic Resources Sector;

Subhan, B., F. Rahmawati, D. Arafat, N.A. Bayu. 2011. Kondisi kesehatan karang Fungiidae di perairan Pulau Pramuka, Kepulauan Seribu[Coral health condition of family Fungiidae on Pramuka Island, Seribu Islands]. Jurnal Teknologi Perikanan dan Kelautan, 2(1): 41-50.

Subhan, B., D. Soedharma, D. Arafat, H. Madduppa, F. Rahmawati, A. Ervinia, A. Bramandito, D. Khaerudi, A.T. Ghozali. 2012. The effect of light on survival and growth rate of transplanted soft coral *Lobophytum strictum* (Octocoralia: Alcyonacea) in recirculation system. Jurnal Teknologi Perikanan dan Kelautan, 3(2): 35-42.

Subhan, B., H. Madduppa, D. Arafat, D. Soedharma.2014. Bisakah Transplantasi karang perbaiki ekosistem terumbu karang. Jurnal Risalah Kebijakan Pertanian dan Lingkungan, (3):159-164.

Subhan, B., M. Khair, H. Madduppa, I.W. Nurjaya, R.L. Ardiwijaya, D. Prabuning, A.W. Anggoro, D. Arafat. 2016. Terumbu Karang Tulamben. Institut Pertanian Bogor Press, Bogor. ISBN: 978-979-493-912-3

Suryanti, Supriharyono, Y. Roslinawati. 2011. The depth influence to the morphology and abundance of corals at Cemara Kecil Island, Karimunjawa National Park**.** Jurnal Saintek Perikanan, 7(1): 63 – 69.

Visram, S., A.E. Douglas. 2007. Resilience and acclimation to bleaching stressors in thescleractinian coral Porites cylindrica. Journal of Experimental Marine Biology and Ecology, 349: 35–44.

Wijgerde, T., A. van Melis, C.I.F. Silva, M.C. Leal, L. Vogels, C. Mutter, R. Osinga. 2014. Red Light Represses the Photophysiology of the Scleractinian Coral *Stylophora pistillata*. PLoS ONE, 9(3): e92781. doi:10.1371/journal.pone.0092781.

Williams, G.J., J.E. Smith, E.J. Conklin, J.M Gove, E. Sala, S.A Sandin. 2013. Benthic communities at two remote Pacific coral reefs: effects of reef habitat, depth, and wave energy gradients on spatial patterns. PeerJ, 1: e81 http://doi.org.secure.sci-hub.cc/10.7717/peerj.81.

Wooldridge, S.A. 2013. Breakdown of the coral-algae symbiosis: towards formalising a linkage between warm-water bleaching thresholds and the growth rate of the intracellular zooxanthellae. Biogeosciences, 10: 1647–1658.

Zamani, N.P., Y. Wardiatno, R. Nggajo. 2011. Development strategy of yellow tail fusilier fish (*Caesiocuning*) resources management on coral ecosystem in the Seribu Islands. Jurnal Saintek Perikanan, 6(2): 38-51.

Zamani, N.P., Madduppa, H.2011. A Standard criteria for assesing the health of coral reefs: implication for management and conservation.Journal of Indonesia Coral Reefs, 1(2): 137-146

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