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Benthic community structure and geomorphology of uncharted nearshore reefs in Kuantan coastal waters.

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Abstract

The nearshore reefs play several important ecosystem functions in marine environments, especially in coastal areas. Six relatively unknown nearshore reef sites were surveyed in the southern Kuantan coastal waters using the coral video transect (CVT) technique between April 2021 and September 2022 to estimate coral reef benthic components. Data analysis on coral reef benthic components indicated that these uncharted nearshore reefs have ‘fair’ coral cover with an average percentage of 39.4 % ± 17.8 in which ST 1 recorded the highest live coral cover coverage with 68.06 %. Abiotic components (sand and rock) were the second-most abundant and the coverage of dead coral was relatively low at all stations. A total of 33 coral genera were recorded in this study in which Porites, *Acropora* and *Montipora* mean percentage cover dominated most of the reef sites. Bathymetry data indicated that some of these uncharted reefs were located on submerged shoals with a depth range between 12 – 17 meters. The variation in benthic community composition observed among reef sites highlights the importance of location-specific management and conservation strategies.

1. INTRODUCTION

Coral reefs are important ecosystems boasting abundant biological diversity. They play a crucial role in coastal protection and offer significant economic benefits through the tourism industry (Costanza *et al*. 2014; Mustapha *et al*. 2014). Malaysian waters host a remarkable abundance of coral species, with around 398 scleractinian coral species identified. This represents over 80% of the total number of coral species found in the 'Coral Triangle,' making it one of the most significant regions for coral diversity (Affendi and Rosman 2012; Huang *et al*. 2015). Pahang, a state located on the east coast of Peninsular Malaysia, boasts a diverse and vibrant coastal ecosystem. Its coastal waters are home to a rich array of marine life, coral reefs, and pristine beaches, making it an attractive destination for both tourists and nature enthusiasts. One notable feature of Pahang's coastal waters is the presence of a marine protected area, Tioman Island Marine Park which aimed at conserving the region's biodiversity and maintaining its ecological balance.

Turbid reefs are commonly found in shallow waters (< 20 m) near the coastline (< 20 km). These areas experience high sediment yields and wave-induced resuspension of fine sediments on the seafloor, resulting in significant turbidity fluctuations ranging from 0 to over 100 mg/l (Browne, 2012). Despite being known as turbid reefs, they could provide equivalent ecosystem services such as those reefs in the marine protected area and have become critical habitats for the livelihood of people living in the coastal area. Based on the recent review by Zweifler *et al.* (2021), they mentioned that such reefs remain largely unexplored despite covering 30% of the reefs in the Coral Triangle and 12% globally. These reefs remain hidden and unknown from the public due to relatively low visibility conditions both directly (in situ) and indirectly using remote sensing technologies as suggested by Morgan *et al.* (2016).

While most conservation actions were done in remote reefs within the marine protected area, less attention was given to explore the existence of potential uncharted reefs area in nearshore area due to turbid water environment. There has been a limited number of studies available on coral distribution of nearshore reefs in Malaysia although some studies reported nearshore turbid

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reefs in the west coast of peninsular Malaysia. For instance, Safuan *et al*. (2016) reported ‘poor’ coral reefs condition (less than 25% total percentage cover) in the Pulau Sembilan Archipelago while Ismail *et al*. (2021) reported ‘fair’ coral cover around 3 nearshore islands in Malacca. Previous evidence indicated that nearshore reefs area near Balok, Kuantan has ‘fair’ average coral cover which is dominated by stress-tolerant taxa as reported by Hanapiah *et al.* (2019). Elsewhere, there have been several studies which reported relatively high coral cover turbid reefs area (Morgan *et al*., 2016; Browne *et al*., 2019). These reefs were assumed to be more resilient towards climate change and should be managed accordingly as suggested by Browne *et al.* (2019).

One of the key findings from the work done by Hanapiah *et al.* (2019) was that nearshore reefs patches discovered existed on the submerged shoal with average depth between 15 – 20 meters. This could be critical information in our quest to map these uncharted reefs, especially in Kuantan coastal waters. Therefore, the present study aimed to provide a detailed description on community structure, community distributions and the geomorphological pattern for uncharted nearshore reefs area in the southern Kuantan, Pahang. The primary objectives of this study are (1) to provide preliminary data on coral community structure and distribution pattern and (2) to describe a geomorphological model for nearshore reefs area constructed from bathymetric surveys.

1.1. Study area

The study area is located approximately 10 km offshore from Cherok Paloh, Kuantan. Based on our observation, most of the fishing activities in this area involve the use of fish traps and angling fishery. For this research, a total of six reef sites were surveyed in the southern Kuantan coastal waters as shown in Figure 1. The location of each reef site was suggested by local fishermen with depth range between 12 – 18 meters. The survey was conducted between April 2021 and September 2022.

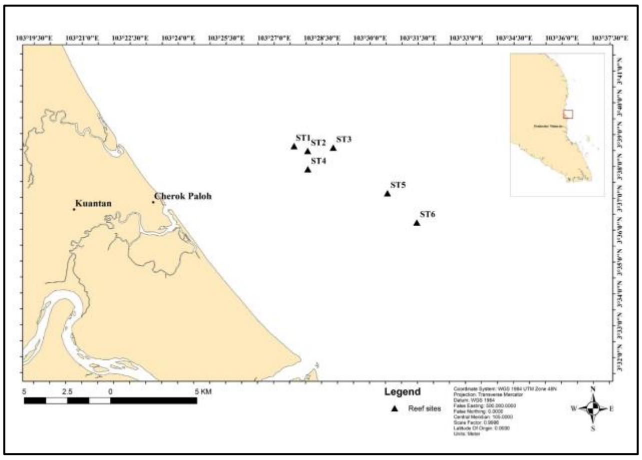

Figure 1: Location map for the study area

2. MATERIALS AND METHODS

2.1. Coral community structure

Coral reefs benthic components for each station were surveyed using Coral Video Transect (CVT). This method involves recording a high-resolution video along 30 m transect lines using compact underwater camera (Olympus TG-2). Four random transects were overlaid onto reef during the survey. The camera was held at a constant distance of 30 to 35 cm from the substrate and the photographer slowly swam along the transect line. The classification of this benthic components was based on English *et al.* (1994). The coral condition was categorized by live coral cover percentage following Chou *et al.* (1994). This was categorized as excellent (>75%), good (>50%), fair (>25%) and poor (<25%).

2.2. Video processing and images analysis

The video footage was trimmed into picture frames and then analyzed using Coral Point Count with Excel extension (CPCe) software established by Kohler & Gill (2006). Fifty random points were overlaid on each frame and coral colonies were identified up to genus level based on Veron (2000). Coral reefs benthic components were classified as live coral (LC), dead coral (DC), other invertebrates (OT) and abiotic (A).

2.3. Bathymetry Survey

The bathymetry survey was conducted by using a single-beam echo sounder (Humminbird 998c). The bathymetry survey covered approximately (40 km2) of the nearshore reefs area in the southern part of Kuantan coastal waters. The hydrographic survey package HYPACK was used to generate bathymetric data. The digital terrain models of the reef from the bathymetric data were illustrated using Surfer software version 15. The morphological profiles and reef surface areas at specific depths were derived from the model.

2.4. Data analysis

For statistical analysis, coral reef benthic component distribution pattern in Kuantan coastal waters was compared among reef sites using SPSS Statistics for Windows, version 19 (IBM Corp., New York). The normality test indicated the coral distribution patterns data were normally distributed. Therefore, spatial variation of benthic component data was analyzed using one-way analysis of variance (ANOVA).

3. RESULT

Figure 2 shows the mean percentage cover of benthic community structure (live coral, dead coral, other invertebrates and abiotic) from six reef sites surveyed.

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Results indicated that southern Kuantan coastal waters have 'fair' coral cover with mean (n = 24) live coral of 39.4 % ± 17.8 followed by abiotic component (34.96 % ± 19.42) (Figure 2). Other invertebrates (such as sponges) comprise about 20.05 % ± 10.66 while dead coral only contributed to 4.6 % ± 6.76, respectively.

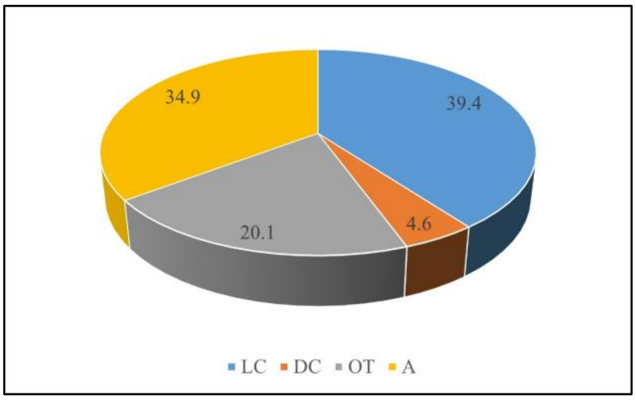

Figure 2: Overall coral reef benthic components cover southern Kuantan coastal waters.

Analysis of variances (ANOVA) test analysis indicated that live coral (F = 9.76, df = 5, ρ < 0.01), dead coral (F = 4.97, df = 5, ρ < 0.01), other invertebrates (F = 9.48, df = 5, ρ < 0.01) and abiotic (F = 13.39, df = 5, ρ < 0.01) varied significantly among sites. Based on Figure 3, ST 1 recorded the highest coral cover percentage with 68.06 % while lowest coral cover was observed at ST 4 (23. 44 %). Dead coral cover was relatively low among reef sites except at ST 5 which recorded the highest cover (17.04 %) as indicated in Figure 3. For other invertebrates' categories, ST 6 has higher mean percentage cover (35.52 %) compared to other sites. Meanwhile, ST 4 recorded the highest abiotic cover with (58.9 % ± 14.52) followed by ST 3 (46.84 % ± 6.87) and ST 2 (44.5 % ± 7.68).

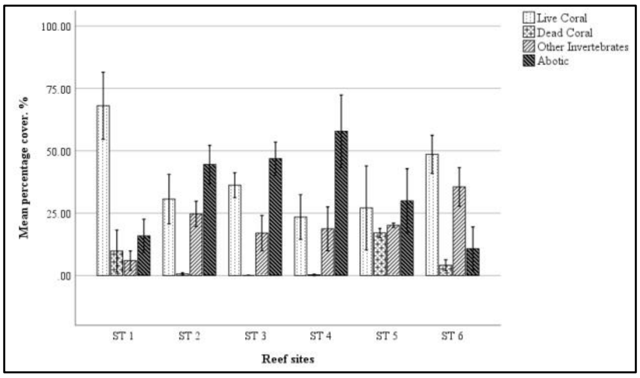

Figure 3: Mean percentage cover of coral reefs benthic components for each reef site.

Thirty-three scleractinian coral genera from twelve families were recorded in this study. The distribution pattern of coral genera is demonstrated in Table 1. It can be noticed that ST 4 recorded the highest number of coral genera (22 coral genera) while lowest number of coral genera recorded at ST2 (13 coral genera). *Porites* (13.48 %), *Acropora* (7.96 %) and *Montipora* (6.4 %) dominated the reefs surved (Table 1). It can be noticed that other coral genera were less abundant from the survey with mean percentage cover ranging from 0.01 % - 2.05 % (Table 1).

Table 1: Distribution of coral genera based on reef sites. (+) symbol represented average cover percentage of each genus at both depths throughout the survey.

Genera	ST1	ST2	ST3	ST 4	ST5	ST6
Acropora	+	+	+	+	+	+
Montipora	++	-	+	+	+	+
Stylopora	+	-	-	+	-	+
Goniopora	+	-	-	-	+	+
Porites	+	+	+	+	+	+
Leptoseris	-	-	-	+	-	-
Pachyseris	+	+	+	-	-	+
Pavona	+	+	-	+	-	+
Astrea	-	-	-	+	-	-
Barabattoia	-	+	-	-	-	-
Caulastraea	-	-	+	-	-	-
Cyphastrea	-	-	-	-	-	+
Dipsastraea	-	+	+	+	-	-
Favites	+	+	+	+	+	+
Goniastrea	+	-	-	+	+	+
Leptoria	+	-	-	-	+	+
Paramontastrea	-	-	-	+	+	-
Pectinia	-	-	+	+	+	+
Platygyra	-	-	+	-	-	-
Lobophyllia	-	-	+	+	-	+
Symphyllia	+	-	+	+	+	+
Euphyllia	+	-	-	-	+	+
Ctenactis	-	-	-	+	-	-
Cycloseris	-	+	+	+	-	-
Fungia	+	+	+	-	-	+
Lithophyllon	-	+	+	+	-	-
Heteropsammia	-	-	+	-	-	-
Tubastrea	+	-	-	-	+	-
Turbinaria	+	+	+	+	+	+
Psammocora	-	-	-	+	-	-
Leptastrea	-	+	+	+	+	-
Oulastrea	-	+	-	+	-	-
Physogyra	-	-	+	+	-	-
Total no. of Genera	15	13	18	22	14	17

+ = 0-25 ++ = 26-50 +++ = 51- 75 ++++ = 76-100

The echogram from the single beam echosounder managed to detect coral mounds structures during the survey. This has been the basic guide for us in determining the CVT survey location. This information can be used to understand the physical features of the reef and their relationship with the surrounding environment. Based on three-dimensional bathymetric model of surveyed area, 3 reef sites were located on submerged shoals (ST 1, ST 2, and ST 4) with depth range between 12 – 14 meters (Figure 4a). In addition, 3 reef sites (ST 3, ST 5, and ST 6) located near this underwater feature with slightly deeper depth range (between 15-17 meters) as shown in Figure 4a and Figure 4b.

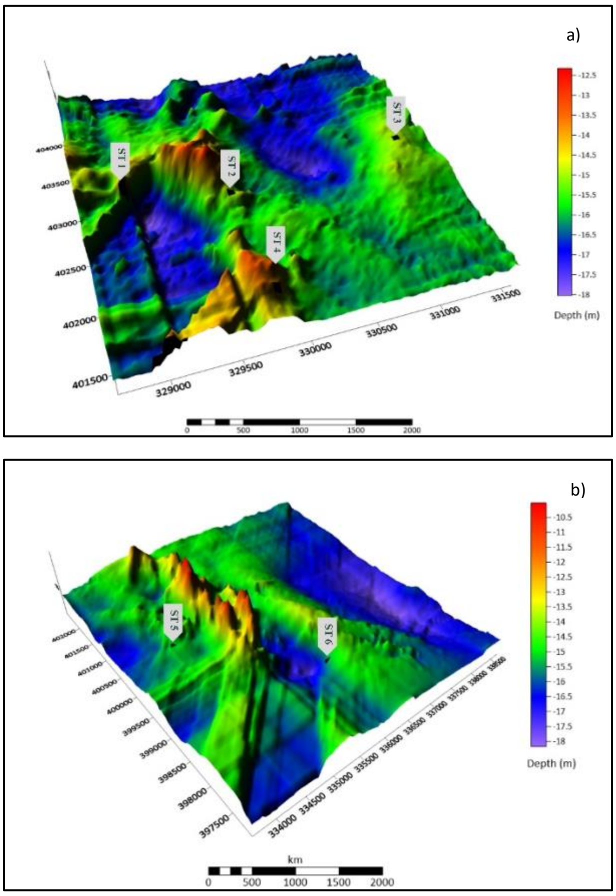

Figure 4: Bathymetric models of surveyed area for a) ST1 – ST 4 and b) ST 5 – ST 6.

4. DISCUSSION

The present study revealed interesting findings on uncharted reefs in the southern Kuantan coastal waters in terms of community structure compositions and geomorphological preferences. It is interesting to note that ST1 recorded a high percentage cover (68%) which exceeds the previous record reported in Balok nearshore reefs area (Hanapiah *et al*., 2019). This result was comparable with coral conditions reported in marine protected area such as those reported in Tioman Island and Redang Island (Shahbudin *et al*., 2017). In fact, most of the reef sites surveyed have better coral cover compared to nearshore reefs in the west coast of Peninsular Malaysia as mentioned by Safuan et al. (2016). They reported relatively poor live coral cover (< 25 %) at 6 reef sites in Pulau Sembilan and Pulau Jarak. In addition, most of the reefs surveyed have better coral cover compared to nearshore/turbid reefs in Singapore (Guest *et al*., 2016), Okinawa (Hongo and Yamano, 2013; Shilla *et al*., 2013) and Hong Kong (Duprey *et al*., 2016). The mean percentage cover of dead coral was relatively low at all sites (except for ST 1 and ST 5) and there was no direct destruction of coral colonies observed during the survey. It can be suggested that since most of the reef lies within fishing Zone A (0 – 5 nm), they are protected from reef destructive fishing such as trawling. Most of the fishing activities near reef area involves deployment of bubu trap and angling which are less destructive for coral reef area.

Live corals are an important component of coral reefs as they provide habitat, food, and other resources for a wide variety of marine organisms (Hughes *et al*., 2017). The present evidence could suggest that the coral reefs in this area may be healthy (based on the total percentage cover) and could support a diverse marine ecosystem. The high percentage cover of abiotic materials, such as sand and rocks, may also indicate that the reef substrate is suitable for supporting a diverse range of organisms as suggested by Ritson-William *et al.* (2016). They highlighted the importance of substrate availability in the reef ecosystem for newly settled coral larvae recruitment as well as provide shelter and habitat for other marine organisms. The discrepancies observed in benthic components among the reef's sites suggested there might be differences in environmental conditions. For instance, ST 1 had the highest coral cover percentage, while ST 4 had the lowest which might indicate that the environmental conditions may differ between these sites although located nearby (Figure 1). Factors such as water quality, fishing pressure, and climate change can all influence the health of coral reefs and the composition of benthic communities (Hughes *et al*., 2017).

The southern Kuantan coastal waters have relatively low number of coral genera (33 genera) compared to other well-known coral reef area in the east coast of Peninsular Malaysia such as those in Tioman Island (65 genera) and Redang Island (55 genera) as reported by Akmal *et al*. (2019). It can be suggested that the relatively high turbidity environment in the study area was the main reason since most coral requires low level of suspended sediment to thrive. Jones *et al.* (2016) also suggested that suspended sediment could affect coral growth in various stages of coral life. It was interesting to note that the highest number of coral genera (22 genera) was recorded for the lowest coral percentage cover site (ST 4) compared to ST 1 (15 genera). It can be postulated that turbid reefs such as in the present study might have higher coral diversity despite low coral cover due to several

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factors. For instance, Morgan *et al.* (2017) suggested that turbid waters can help to reduce the amount of light penetrating the water column, which can lead to reduced competition among corals for light and space. In addition, turbid reefs might experience fewer disturbances such as crown of thorn starfish that is rarely found in the study area. These factors may create conditions that are more favorable for the survival and growth of a greater diversity of coral genera, even if overall coral cover is low. The emergence of *Porites*, *Acropora*, and *Montipora* in the surveyed reefs, as indicated in Table 1, is consistent with previous studies although *Porites* was reported to be more dominant in the middle of Kuantan coastal waters (Balok reefs) as reported by Hanapiah *et al.* (2019).

The study revealed that three of the surveyed reef sites were situated on submerged shoals with a depth range between 12-14 meters, while the other three reef sites were situated near these underwater features at a slightly greater depth range of 15-17 meters. The presence of submerged reefs is well-documented in the Great Barrier Reef, Australia. According to Harris *et al*. (2013), predictive habitat modeling suggests that out of the total submerged bank area of 25,600 km2, over half of it (approximately 14,000 km2) is identified as suitable habitat for coral communities. Submerged reefs have been largely overlooked when estimating the total expanse of coral habitats, despite emerging evidence suggesting their potential significance. This finding is crucial for understanding the distribution and abundance of coral reefs in the study region. The outcomes of this study may have significant implications for future research and conservation efforts. The location of the reef sites on submerged shoals provides insights into the potential impact of sea level rise and changes in ocean currents on the health and survival of these reefs.

This study highlighted the reliability of using a single beam echosounder to survey the geomorphology of coral reefs on submerged shoals. The identification of coral mound structures via the echogram provides valuable information on the physical characteristics of the reefs and their interaction with the surrounding environment. The precise location and survey of these reef sites are critical for conservation and management efforts. Furthermore, the 3-dimensional bathymetric model of the surveyed area can be used to identify areas of high coral cover and diversity, which can be targeted for further monitoring and conservation efforts.

5. CONCLUSION

The results of these studies provide valuable insights for the management and conservation of coral reefs. The high percentage cover of live coral and abiotic materials observed in southern Kuantan coastal waters indicates that these areas are important habitats for marine organisms and require conservation efforts. The variation in benthic community composition observed among reef sites highlights the importance of location-specific management and conservation strategies.

REFERENCES

Affendi, Y. A. and Rosman F. R. (2012). Current knowledge on scleractinian coral diversity of Peninsular Malaysia. In Malaysia's Marine Biodiversity: Inventory and Current Status, edited by Kamarruddin I, Mohamed CAR, Rozaimi MJ et al. Putrajaya: Department of Marine Park Malaysia. pp. 21-31.

Akmal, K. F., Shahbudin, S., Hanapiah, M. F. M., Hamizan, Y. M. (2019). Diversity and Abundance of Scleractinian Corals in the East Coast of Peninsular Malaysia: A Case Study of Redang and Tioman Islands. Ocean Science Journal, 54(3), 435–456.

Browne, N. K. (2012). Spatial and temporal variations in coral growth on an inshore turbid reef subjected to multiple disturbances. Marine Environmental Research, 77, 71–83.

Browne, N., Braoun, C., McIlwain, J., Nagarajan, R., Zinke, J. (2019). Borneo coral reefs subject to high sediment loads show evidence of resilience to various environmental stressors. PeerJ, 7, e7382.

Chou, L. M., Wilkinson, C. R., Licuanan, W. R. Y., Alino, P., Cheshire, A. C., Loo, M. G. K., Tanjaitrong, S., Sudara, A., Ridzwan, A. R. Soekarno (1994). Status of Coral Reefs in the ASEAN Region. Proceedings of the Third ASEAN-Australia Symposium on Living Coastal Resources. Australian Institute of Marine Science. Townsville, Australia.

Costanza, R., DeGroot, R., Sutton, P., *et al*. (2014). Changes in the global value of ecosystem services. Glob. Environ. Change 26: 152-158.

Duprey, N. N., Yasuhara, M., Baker, D. M. (2016). Reefs of tomorrow: eutrophication reduces coral biodiversity in an urbanized seascape. Glob. Chang.

English, S. S., Wilkinson, C. C., Baker, V. V. (1994). Survey manual for tropical marine resources. Australian Institute of Marine Science (AIMS).

Guest, J. R., Tun, K., Low, J. *et al*. (2016). 27 years of benthic and coral com- munity dynamics on turbid, highly urbanised reefs off Singapore. Sci. Rep. 6, 36260.

Mustapha, M. A., Lihan, T., Khalid, L. I. (2014). Coral reef and associated habitat mapping using ALOS satellite imagery. Sains Malaysiana, 43(9), 1363–1371.

Hanapiah, M. F. M., Shahbudin, S., Ahmad, Z. *et al*. (2019). Assessment of benthic and coral community structure in an inshore reef in Balok, Pahang, Malaysia. Biodiversitas Journal of Biological Diversity, 20(3), 872–877.

Harris, P. T., Bridge, T. C. L., Beaman, R. J. *et al*. (2013). Submerged banks in the Great Barrier Reef, Australia, greatly increase available coral reef habitat. ICES Journal of Marine Science, 70(2), 284–293.

Hongo, C. and Yamano, H. (2013). Species-specific responses of corals to bleaching events on anthropogenically turbid reefs on Okinawa Island, Japan, over a 15-year period (1995–2009). PLoS One 8, e60952.

Huang, D., Licuanan, W. Y., Hoeksema, B. W. et al. (2015). Extraordinary diversity of reef corals in the South China Sea. Marine Biodiversity, 45, 157 - 168.

Hughes, T. P., Barnes, M. L., Bellwood, D. R. *et al*. (2017). Coral reefs in the Anthropocene. Nature. 546(7656):82-90.

Ismail, S., Ismail, M. S. Bin, Ismail, M. S. I., Aziz, A. (2021). Biodiversiti dan pemuliharaan terumbu karang di tiga buah pulau, Melaka. Jurnal Pengajian Umum Asia Tenggara, 22(1), 180–197.

Jones, R., Bessell-Browne, P., Fisher, R., Klonowski, W., Slivkoff, M. (2016). Assessing the impacts of sediments from dredging on corals. Marine Pollution Bulletin, 102(1), 9–29.

Kohler, K. E., Gill, S. M. (2006). Coral Point Count with Excel extensions (CPCe): A visual basic program for the determination of coral and

eISSN Number: 2462-2389

substrate coverage using random point count methodology. Com & Geosciences 32(9): 1259–1269.

Morgan, K. M., Perry, C. T., Smithers *et al*. (2016). Evidence of extensive reef development and high coral cover in nearshore environments: Implications for understanding coral adaptation in turbid settings. Scientific Reports, 6(July).

Morgan, K. M., Perry, C. T., Johnson, J. A., Smithers, S. G. (2017). Nearshore turbid-zone corals exhibit high bleaching tolerance on the Great Barrier Reef following the 2016 ocean warming event. Frontiers in Marine Science, 4(Jul).

Ritson-Williams, R., Arnold, S. N., Paul, V. J. (2016). Patterns of larval settlement preferences and post-settlement survival for seven Caribbean corals. Mar Ecol Prog Ser 548:127–138.

Safuan, M., Idris, I., Bachok, Z. (2016). Current status on community structure of coral reefs. Journal of Sustainability Science and Management , Special Is(1), 107–117.

Shahbudin, S., Akmal, K. F., Faris, S., et al. (2017). Current status of coral reefs in Tioman Island, Peninsular Malaysia. Turkish Journal of Zoology, 41, 294–305.

Shilla, D. J., Mimura, I., Takagi, K. K., Tsuchiya, M. (2013). Preliminary survey of the nutrient discharge characteristics of Okinawa Rivers, and their potential effects on inshore coral reefs. Galaxea, Journal of Coral Reef Studies, 15 (Supplement), 172–181.

Veron, J. E. N. (2000). Corals of the world. Australian Institute of Marine Science, Townsville, Australia.

Zweifler, A., O'Leary, M., Morgan, K., Browne, N. K. (2021). Turbid Coral Reefs: Past, Present and Future—A Review. Diversity, 1

eISSN Number: 2462-2389