

Pioneer assessment on megabenthic community suggest the recent ecological condition of coral reef in Senggigi Beach, Western Lombok Island, Indonesia

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Abstract. Ghafari MIA, Fitrianti V. 2021. Pioneer assessment on megabenthic community suggests the recent ecological condition of coral reef in Senggigi Beach, Western Lombok Island, Indonesia. *Indo Pac J Ocean Life* 5: 14-21. Megabenthic communities are among the excellent bioindicator used nowadays. This study was the first to conduct in Senggigi Beach and provide preliminary useful information regarding the condition of coral reef ecosystem on-site, through assessing the megabenthic community from 2019-2020 to 202-2021. Benthos Belt Transect (BBT) method was used to collect data from 6 different observation sites. There are 3 groups of targeted megabenthic fauna assessed: the bioindicator group (sea urchin and blue starfish), the corallivorous group (drupella snail and crown-of-thorns starfish), and the commercially valued group (edible sea cucumber, giant clam, spiny lobster, and commercial top shells). Sea urchin was found to dominate all stations, indicating a decreasing live coral cover after bleaching. Presence of corallivorous megabenthos was very rare, as it is not a potential threat to corals. There is a trend of increasing density of edible sea cucumber and giant clam by 30% and 50% respectively, with a mass giant clam recruit in 2021. We suspect less or no impact of anthropogenic activity to megabenthic community dynamic in Senggigi Beach to date, but their community dynamic is purely influenced by the decline condition of coral reef ecosystem due to recent 2016 mass bleaching.

Keywords: Benthos Belt Transect (BBT), bioindicator, coral bleaching, megabenthic community, Senggigi Beach

INTRODUCTION

Megabenthos is the largest bottom-dweller of marine organisms that are often used as bioindicator for their excellent sensitivity to represent the condition of their aquatic environment, especially for the coral reef ecosystem health status. The life of benthic invertebrates is directly related to the nutrient and waste cycle in the bottom sediment (Mehdipour et al. 2018; Belal 2019), and it is the main reason for their high sensitivity to small changes in their environmental parameter (Young et al. 2014; Patang et al. 2018). Environmental changes can be easily detected based on the dynamics abundance, species, and spatial distribution of benthic organisms (Ali 2014; Custodio et al. 2018). Unlike any other benthic organisms, megabenthos are the largest type among the benthic community with average size of >10 mm (Maximov et al. 2014), making them easier to observe by naked eyes. Ecological surveys on the coral reefs conducted by several coral reefs monitoring programs such as the Reef Check MAQTRAC program, the Australian Institution of Marine Science Long-Term Monitoring Program (AIMS LTMP), Atlantic and Gulf Rapid Reef Assessment (AGGRA), the Caribbean Coastal Marine Productivity Program (CARICOMP), or the Coral Reef Rehabilitation and Management Program (COREMAP) have used megabenthic fauna as 'indicator

species' to interpret the ecological data they obtain (Hill and Wilkinson 2004; Giyanto et al. 2014).

Senggigi Beach is one of the most popular tourist destinations on Lombok Island (Indonesia), where the coastal ecosystem could suffer from potential threats. The average number of domestic and foreign tourists visiting Senggigi Beach from 2014 to 2020 was quite high, reached 412,575 visitors·year⁻¹ (West Lombok Regency Tourism Office 2021). The existence of a fast boat jetty in Senggigi Beach for inter-island crossing allows the mobilization of large numbers of visitors from Bali. Senggigi Beach is also a place for local people to catch fish traditionally, where the majority of angling and spearfishing is done during low tide. Apart from that, various human activities may potentially become anthropogenic stress that threatens the sustainability of the coral reef ecosystem on the beach. On the other hand, we observed that the coral reefs there have suffered the 2016 bleaching episode, along with other coral reefs in the west coast of Lombok as reported by Bachtiar and Hadi (2019) and Wouthuyzen et al. (2018). The historical background of coral bleaching that has occurred in the area can elevate the chances of decreasing the stability of the coral reef ecosystem on Senggigi Beach.

As best we know, there are no scientific records or ecological monitoring activities that have been carried out in Senggigi Beach. No ecological data available resulted in our nescience on how much human activity and the recent

mass bleaching has stressed the coral reef ecosystem there. In fact, information related to the condition of the coral reef ecosystem is very crucial for the environmental management efforts and the development of environmentally friendly tourism on Senggigi Beach in the future. Assessment of the coral reef ecosystem conditions by utilizing the presence of megabenthic fauna allows us to understand the condition of coral reef ecosystem at Senggigi Beach. Therefore, this study is the first to describe the condition of coral reef ecosystems in Senggigi Beach based on the composition, abundance and distribution of megabenthic communities.

MATERIALS AND METHODS

Study location

The study was conducted consecutively in November 2019 and February 2020 (represent the data series of last 2019-early 2020, first data set), as well as in November 2020 and March 2021 (represent the data series of last 2020-early 2021, second data set) at the coral reef area of Senggigi Beach within 6 observation sites that have been determined, as shown in Figure 1. Senggigi Beach is situated in a bay called ‘Senggigi Bay’, on the west coast of

Lombok Island. This strategic place is annually affected by very strong currents and waves during the west monsoon. The middle part of the Senggigi Beach is a gap that characterized by turbid water and mud-rich bottom due to the discharged sediment through a small river. A jetty was built in this part. The existence of a gap zone in Senggigi Beach causes the formation of 2 different reef areas, later refers to as the northern and the southern coral reef region.

Data collection

The data collection was carried out using Benthos Belt Transect (BBT) method referring to Arbi and Sihaloho (2017) with minor modifications. The transect is laid along 50 m parallel to the shoreline at a depth of 3-5 m. Each station consists of one transect. Observations on megabenthic fauna were done within 1 meter to the left and 1 meter to the right of the transect line, made up the total observation area of 100 m² per transect. There are 8 types of targeted megabenthic fauna included in 3 functional groups based on Arbi and Sihaloho (2017), as shown in Table 1. The individual number of targeted megabenthic fauna encountered was recorded on a slate and documented using an underwater digital camera.

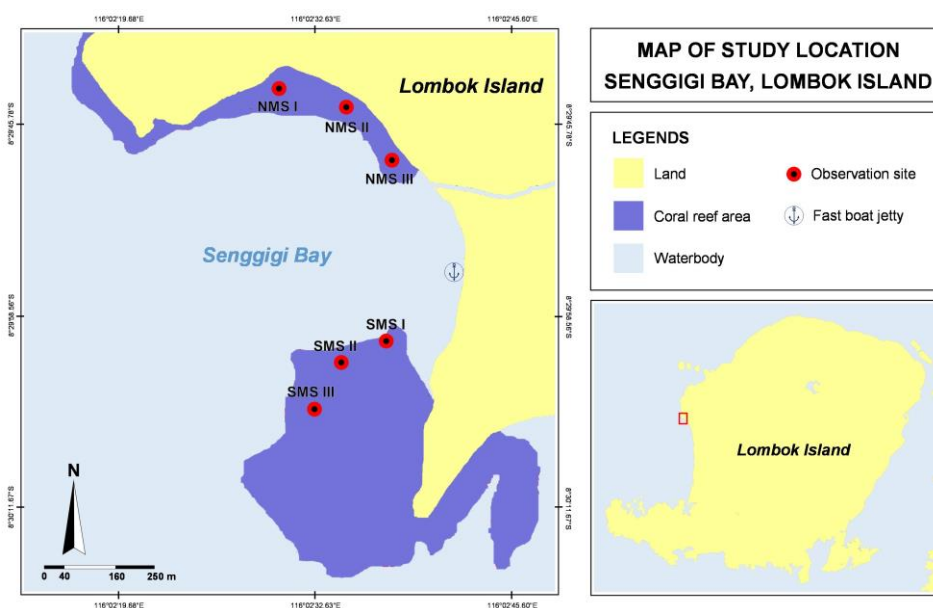


Figure 1. A map of study location showing 6 observation sites in Senggigi Beach, Western Lombok Island, Indonesia: 3 sites (NMS) on the northern coral reef region and 3 others (SMS) on the southern coral reef region

Table 1. Targeted megabenthic fauna on this survey (Arbi and Sihaloho 2017)

Functional group	Megabenthic fauna	Phylum (higher classification)
Bioindicator group	Sea urchin (class Echinoidea)	Echinodermata
	Blue starfish (<i>Linckia laevigata</i>)	Echinodermata
Corallivorous group	Crown-of-thorns (COT) starfish (<i>Acanthaster</i> spp.)	Echinodermata
	Drupella snail (<i>Drupella</i> spp.)	Mollusca
Commercially valued group	Edible sea-cucumber (family Holothuriidae)	Echinodermata
	Giant clam (<i>Hippopus</i> spp; <i>Tridacna</i> spp.)	Mollusca
	Spiny lobster (family Palinuridae)	Arthropoda
	Commercial top shell (<i>Tectus</i> spp; <i>Trochus</i> spp.)	Mollusca

Data analysis

Data analysis were performed using Microsoft Excel 2010 software. Data analysis included analysis of megabenthic composition (percentage), analysis of megabenthic density per square meter ($\text{ind}\cdot\text{m}^{-2}$) and per hectare ($\text{ind}\cdot\text{ha}^{-1}$) for the entire station (which makes up the total area observation of 600 m^2), as well as analysis of megabenthic distribution in the entire station per period ($\text{ind}\cdot\text{period}^{-1}$). A data set comprised of the average of the last and early data of the represented year. Analysis result from the two represented years of survey is then compared and visualized in the form of diagrams and pie charts.

RESULTS AND DISCUSSION

Results

Composition and distribution of megabenthic fauna

In general, the composition of the megabenthic community remained relatively unchanged the first and the second set of observations, as shown in Figure 2. All targeted megabenthic fauna exist in Senggigi Beach, as documented in Figure 3. The composition of bioindicator group was dominated by sea urchins, while blue starfish is very rare. Sea urchin distributed in all stations and makes up more than 70% of the entire composition of megabenthic community during 2 periods of survey. The corallivorous group, especially the COT, appears only in SMS III with very low percentage. Comparing the two sets of observation results, the majority of commercially valued megabenthos seems to have lost in several stations, such as in NMS II and SMS II. Another station seems to have a very dynamic change in their commercially valued group composition. The presence of commercially valued

megabenthos increasing in the megabenthos composition of SMS I.

Megabenthic community from southern coral reef region seems more varied compared to their northern counterpart. This can be related to the different types of coral complexity between the two coral reef regions, where the southern coral reef region has a denser coral cover with a typical of vast reef flat, while the northern part exhibits patchy reef and dominated by both macroalgae and massive corals, as shown in Figure 4. Different composition of megabenthic community between the two coral reef areas is more likely due to the differences substrate types and habitat complexity (Cappenberg and Mahulette 2019; Tatipata and Mashoreng 2019; Olii and Paramata 2020) between the two reef region, rather than the influence of different ecological stressor.

Density of megabenthic fauna

Overall result shows that the overall abundance of megabenthic community has dropped by $0.047 \text{ ind}\cdot\text{m}^{-2}$ (or $467 \text{ ind}\cdot\text{ha}^{-1}$) over the past 2 years. A declining abundance of megabenthos communities may indicate a decrease in live coral cover (Wulandari et al. 2020). It is also found that the fluctuations of the environmental parameter are strongly correlated with changes in benthic community abundance (Coyle et al. 2007; Ghafari et al. 2020). Based on Figure 5, there is a slight decrease in density of bioindicator and corallivorous group and it might be correlated with the decrease of overall megabenthos abundance. Although the abundance of megabenthos community has decreased, the density of most of commercially valued group has increased, which indicate that this group may not be subjected to significant anthropogenic or ecological stresses.

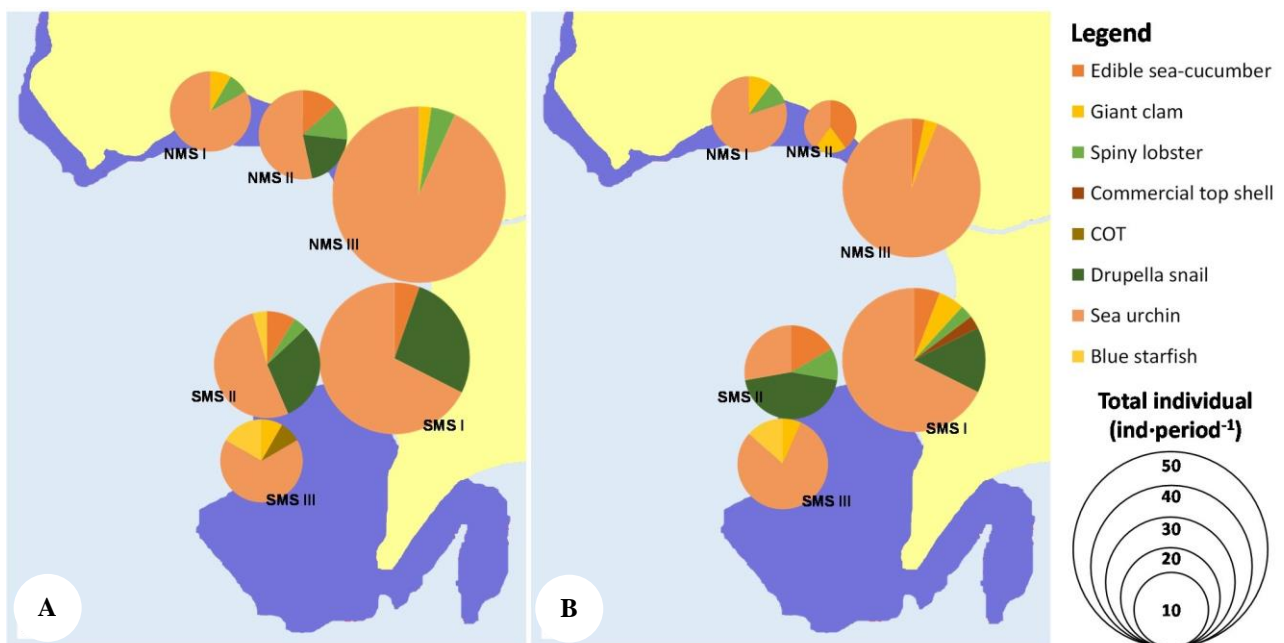


Figure 2. Comparison of megabenthic composition, total abundance (number of individuals collected per period) and distribution from A. 2019-2020 to B. 2020-2021 in all observation sites of Senggigi Beach, Western Lombok Island, Indonesia

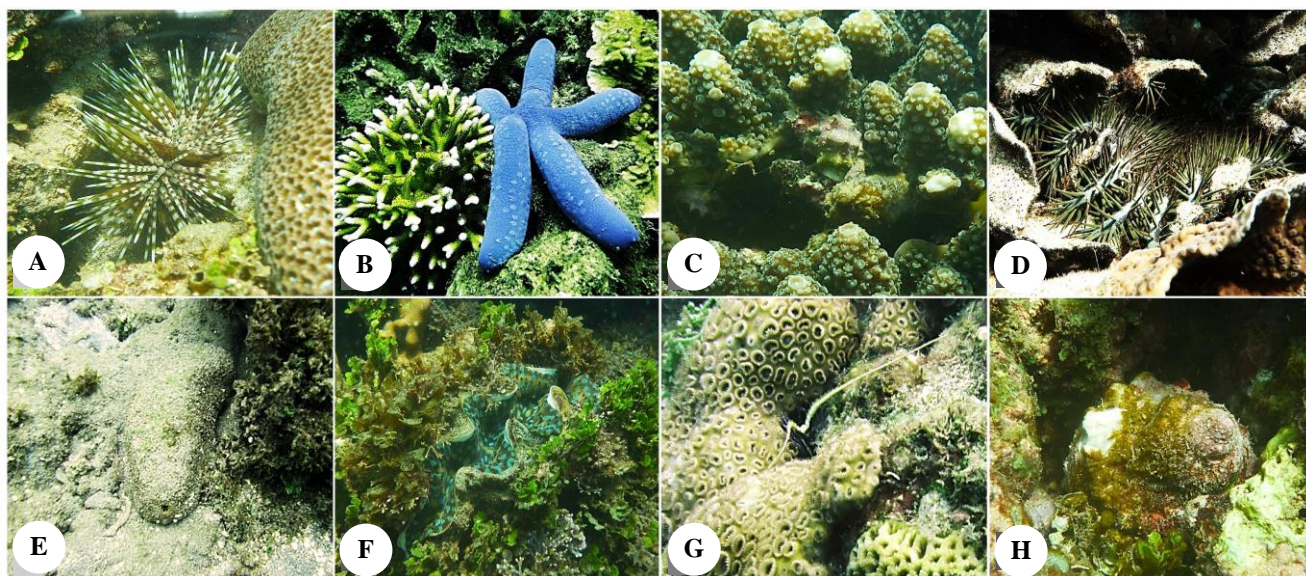


Figure 3. Various megabenthic fauna found in Senggigi Beach, Western Lombok Island, Indonesia during 2 years survey: A. Sea urchin; B. Blue starfish; C. Drupella snail; D. COT; E. Edible sea cucumber; F. Giant clam; G. Spiny lobster; and H. Commercial top shell

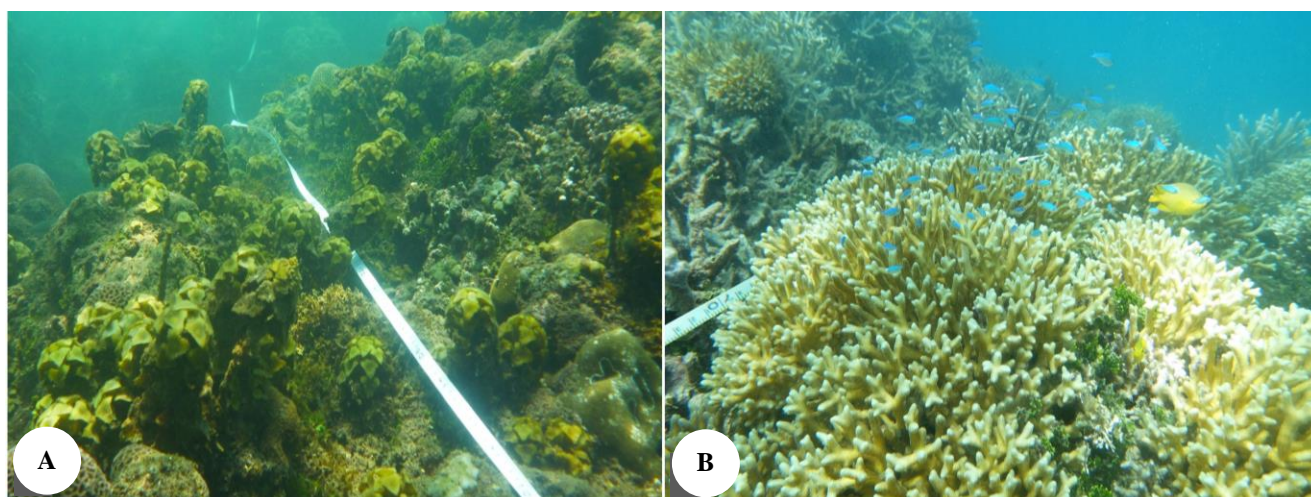


Figure 4. The typical coral reef complexity between 2 reef regions: A. northern coral reef; B. southern coral reef

Discussion

Bioindicator group

Sea urchins appear to dominate all station. The dominance of sea urchins in coral reef areas was also reported by Sese et al. (2018), Akbar et al. (2019), Mutaqin et al. (2020) and Wulandari et al. (2020). In contrast, Ghafari et al. (2020) reported that the condition of the megabenthic community in the nearest area, namely Sekotong bay, shows a trend of blue starfish domination during the 5 years of survey conducted by LIPI (Indonesian Institute of Sciences).

Sea urchin domination among the megabenthic community in Senggigi Beach is thought to be related to decreasing live coral cover as the effect of the recent 2016 bleaching episode, which is simultaneously supported by the overall trend of declining megabenthic abundance during the twice set of observations. Nevertheless, this assumption needs to be proven through direct evaluation of

coral cover. Sea urchin domination over the reef is generally associated with the increasing benthic algae on the substrate as a result of the post-bleaching algal-coral shift phase (Jompa and Cook 2003; Vercelloni et al. 2020). The increasing abundance of planktonic and benthonic algae can lead to the aggregation of sea urchins as the main algae consumers (grazers) and algae controllers on the reef (Ishikawa et al. 2016; Ghafari et al. 2019). Sea urchins are also reported to dominate and become the main grazer in heavily fished coral reef areas (McClanahan and Shafir 1990; O'Leary et al. 2013). However, the density of sea urchins at Senggigi Beach during the 2 years of survey is still less than $0.80 \text{ ind}\cdot\text{m}^{-2}$ (as standard indication of sea urchin aggregation in heavily fished areas mentioned by McClanahan and Shafir (1990), meaning that sea urchin population in Senggigi Beach does not indicate the heavily fished condition.

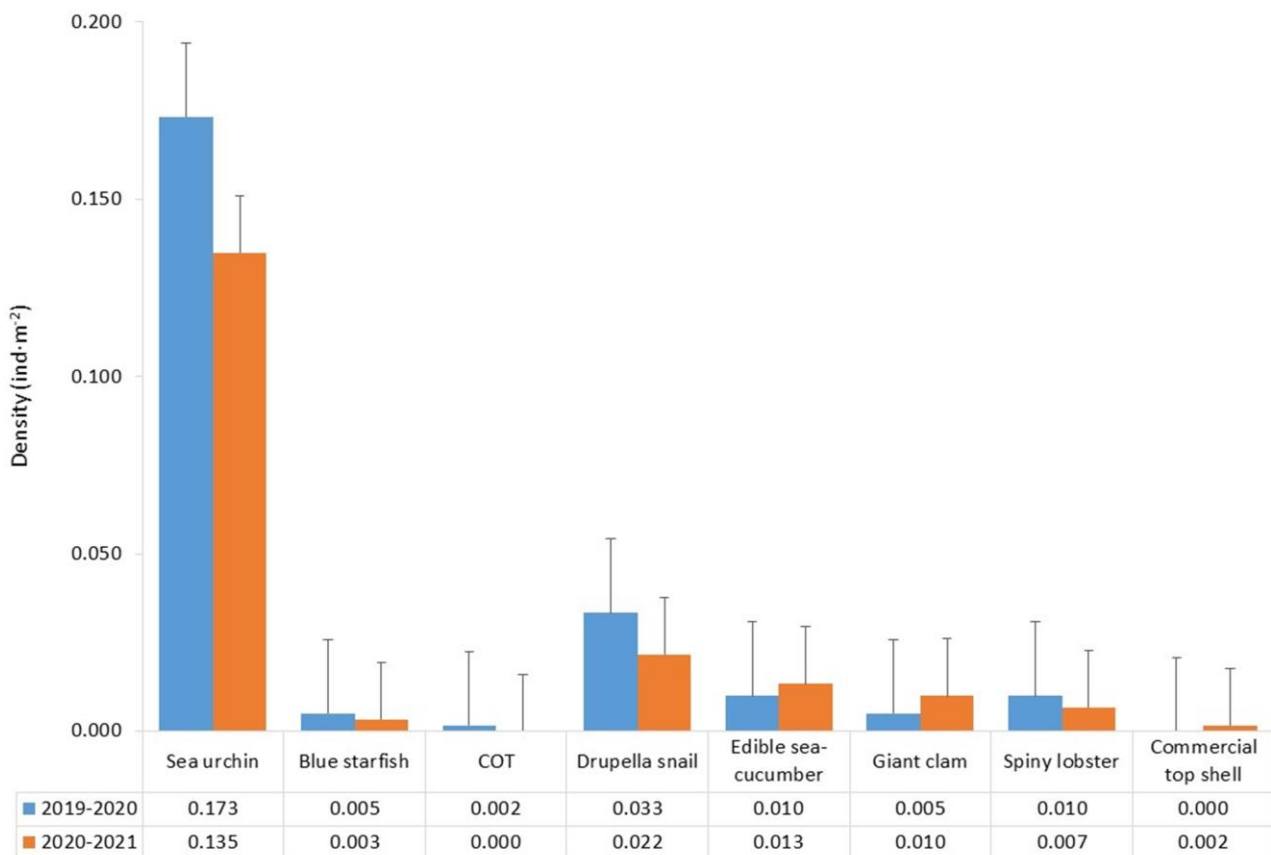


Figure 5. Comparison of average megabenthic density per period ($\text{ind}\cdot\text{m}^{-2}\cdot\text{period}^{-1}$) in Senggigi Beach from the two sets of observation. Each vertical bars represent the standard error

Under normal circumstances (if sea urchins are not in aggregation state), sea urchins can increase coral resilience and recovery by consuming a large amount of benthic algae. A population of sea urchin in an area could potentially reduce algae cover by 30 to 60%, facilitating the attachment of coral juveniles by opens up a living space for coral recruitments (Dang et al. 2020a; Nozawa et al. 2020). Although several studies reported that the dominance of sea urchins in waters has the potential to reduce the space for coral attachment through a bioeroder mechanism (Peyrot-Clausade et al. 2000), the density of sea urchins in Senggigi Beach cannot yet be categorized as potentially damaging the settlement space for coral recruitment as the threatening aggregation of sea urchin supposed to be more than $16 \text{ ind}\cdot\text{m}^{-2}$ (Dang et al. 2020b).

Blue starfish was rare and found in small numbers. Blue starfish is found only at 2 outer stations on southern coral reefs (SMS II and III). Blue starfish often occurs in healthy coral reef, even though their direct role for coral resilience is still unknown (Bos et al. 2008). Blue starfish is very sensitive to environmental changes, so it is rarely found in high anthropogenic stress or polluted waters (Ghafari et al. 2019). Blue starfish favor the area with strong current and low sedimentation rate (Aziz 1996). It could be the reason for blue starfish only appears on the outermost station during the 2 years of the survey, because the wave currents

and proximity from the shoreline bring about low levels of sedimentation and pollution in that area. In a reasonable population size, blue starfish live in confined spaces on the surface of rubble or coralline algae among good healthy corals (Laxton 1974; Arbi et al. 2020) and acts as a grazer that controls the algae population, indirectly facilitate the open space for coral recruit attachment (Zamani 2015). Therefore, it can be said that the coral reef ecosystem conditions in the 2 outer stations are better than the other stations.

Corallivorous group

Drupella snail is one of the coral predators encountered in Senggigi Beach. The majority of drupella snail was found at stations in southern reef, and only found in a few number ($n=3$) at 1 station in northern reef during 2020 survey. *Drupella* snail is coral-eating (corallivorous) gastropods (Arbi 2009) and they prefer acroporid or pocilloporid rather than any other coral species (Schoepf et al. 2010). These types of branching corals are only common in the southern coral reef region and it explained the majority of drupella snail presence in that area.

Drupella snail makes up the second-highest density among other megabenthic fauna in Senggigi Beach with an average density of $0.0275 \text{ ind}\cdot\text{m}^{-2}\cdot\text{year}^{-1}$. Arbi et al. (2017) stated that the aggregation of drupella snail that potentially

threatening live coral is supposed to be at least 50 ind·m⁻² or more. Thus, the presence of drupella snail in Senggigi Beach is still far from potentially threatening the corals. The density of drupella snail population in Senggigi Beach is much lower than those from Perlang village waters, Bangka Belitung (Akbar et al. 2019), Kendari waters (Arbi et al. 2020), or East Sumba waters (Cappenberg and Akbar 2020). However, the density of drupella snail in Senggigi Beach is slightly higher than the drupella's density from the nearest waters, which is in Sekotong Bay (Ghafari et al. 2020), or from other areas such as from Buton Island (Cappenberg and Mahulette 2019) and Waworaha waters (Wulandari et al. 2020). The low drupella's density in Senggigi Beach could be due to degraded coral cover after previous bleaching (Saponari et al. 2021), or due to the presence of coral guards, such as deterring hydrozoans (Montano et al. 2017) and coral crab *Trapezia cymodoce* (Samsuri et al. 2018), which was unable to observe in this study.

It should be noted that the high predation rate of drupella snail against coral polyps could reach up to $1.16 \pm 1.1 \text{ cm}^2 \cdot \text{ind}^{-1} \cdot \text{day}^{-1}$ (Bessey et al. 2018) and their aggregation among healthy coral reef could potentially reduce live coral cover by 70-80% (Baird 1999; Scott et al. 2017). The declining number of reef fish that prey on drupella snail, such as balistid, diodontid, labrid, lutjanid (McClanahan 1994) and protected Napoleon fish (*Cheilinus* spp.) (Ratianingsih et al. 2017), or other factors, such as the presence of El-Niño, increased water temperature and salinity (Lam et al. 2007), stress and disease in corals (Morton et al. 2002; Shafir et al. 2008) could lead to the drupella's outbreak on a reef.

COT is a coral predator megabenthos that is found in very small numbers, where only 1 individual was found during the 2020 survey. COT, along with commercial top shell, has the lowest density among other megabenthic fauna during the 2 years survey. COT populations are considered to be a threat to coral reefs if their density reaches more than 0.014 ind·m⁻² (equivalent to 140 ind·ha⁻¹) (Reichelt et al. 1990). The number of COT found in the coral reefs of Senggigi Beach was 0.001 ind·m⁻²·year⁻¹, so it is still categorized as safe for coral reefs. In healthy coral reefs, COT has limited movement space with a selective dietary preference for fast-growing corals such as acroporids and pocilloporids only (Pratchett 2007). This COT's dietary preference is very useful to compensate for population growth between slow- and fast-growing corals. COT generally comprises 0-1% of megabenthos communities in healthy coral reefs, as confirmed by survey data reported by Cappenberg and Mahulette (2019), Satyawan and Artiningrum (2019), Cappenberg and Akbar (2020), and Wulandari et al. (2020). COT outbreaks are mainly triggered by a declining population of their natural predators, such as the large endangered triton snail (*Charonia tritonis*) (Bose et al. 2017), and various reef fish like pomacanthid, lethriniid, chaetodontid, balistid, tetraodontid, and labrid. (Babcock et al. 2016; Cowan et al. 2017). Other factors that can drive a COT's outbreak are an extreme elevated water temperature (Grossman 2014),

algal blooms, and eutrophication (Birkeland 1982; Babcock et al. 2016).

Commercially valued group

Commercially valued megabenthos made up 10-16% of the composition of the megabenthos findings during the 2 years of the survey. Surprisingly, there is a tendency for an increase in the density of edible sea cucumbers and giant clams by 30% and 50%, respectively. The distribution of edible sea cucumbers, giant clams and spiny lobsters is always above 50%, while commercial top shells are only found at 1 station in 2021 (n = 1, SMS I). The even distribution and the increasing density of the majority of commercially valued megabenthos may suggest that the anthropogenic stress through fishing activities may have less or no impact to the megabenthic community or coral reef ecosystem. In the 2021 survey, we observed the presence of juvenile giant clams in several locations within and outside of transect, which indicates mass recruitment of clams in these waters. Juvenile giant clams greatly contribute to enhance NPP (Net Primary Productivity) due to their nature as fast-growing individuals (Neo et al. 2015). Recruitment of juvenile giant clam indicates that the condition of coral reefs is somehow improving from the latest mass bleaching impact in 2016. The improved condition of coral reefs has certainly contributed to the increasing number of commercially valued megabenthos, especially for clams, spiny lobsters, and sea cucumbers in Senggigi Beach.

The existence of commercially valued megabenthos in nature must be preserved because of their important role in maintaining the health of coral reef ecosystems, even though that many of them do not belong to keystone species. Adult giant clam plays an important role as natural water purification, provider of nurseries area, and contributes to build topographic heterogeneity of the reefs (Cabaitan et al. 2008; Neo et al. 2015). Other types of commercially valued megabenthos, such as spiny lobsters, edible sea cucumbers, and commercial top shells, play a role as consumers and recycle nutrients in coral reef ecosystems and contribute to keeping the coral reef healthy.

In conclusion, the condition of coral reefs in the southern reef region is much better than in the north, as evidenced by more diverse composition of megabenthic communities in the south. The domination of sea urchins at all stations shows that there has been a decline in the condition of the coral reef ecosystem in Senggigi Beach. The dynamics of the megabenthos community in Senggigi Beach are thought to be purely influenced by the bleaching episode which causes changes in the overall condition of the coral reef ecosystem. Although the density of the entire surveyed megabenthos is decreasing, there is a trend towards an increase in the density of commercially valued groups that indicates the absence of significant anthropogenic pressure effects. In addition, the low threat of coral predators provides hope for the acceleration of coral reef recovery in Senggigi Beach. We suggest that future monitoring programs should be implemented for the area.

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