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THE STATUS OF CORAL REEFS IN THE SERIBU ISLANDS NATIONAL PARK, INDONESIA IN VARIOUS ZONES

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Coral Reef, Cover, Diversity, Dominance,Marine Protected Area, Seribu Islands, Zone

ABSTRACT

This research aims to find out coral covers at the Seribu Islands' National Park based on each zone to figure out the cover's percentage, diversity, similarity, and coral dominance. Observations were established by Line Intercept Transect (LIT) method in a depth of 7 m using a 25 m transect line with three repetitions in each station. The cover of hard coral reefs in Rengat Island (Core Zone) was 33.71%, a decrease of 4.54% compared to the previous two years; Gosong Sebaru (Protection Zone) was 26.71%, a decrease of 7.79% compared to the last two years. In general, there was a decrease of 8.07% in coral cover in each station compared to the data from the previous two years. The largest change occured in Small Kotok Island which is located in the tourism zone with a percentage decrease of 8.07%. Harapan Island (Residential Zone) is the only observation station whose coral cover increased by 0.19%. The coral distribution in every zone located in the Seribu Islands' National Park was spread evenly with a low dominance index, diversity, and similarity.

INTRODUCTION

The Indonesian archipelago has an extensive coral reef coverage of over 500 coral species [1]. Some of the richest biodiversity areas are found in the coastal zones of the country including coral reefs, mangrove swamps, seagrass beds, lagoons, and estuaries [2]. Indonesian coral reefs have a cover of 32,000 km2 or about 18% of the world's coral reef area. They are classified into four types i.e. fringing reefs, patch reefs, barrier reefs and atolls, of which the largest proportion among Indonesian coral reefs is fringing reefs [3]. The number of species found in Indonesia up to date is 590 and belong to 82 genera [4].

In 1997, more than 26,000 km2 of coral covers were incorporated into 24 conservation areas among which 6 were in the form of national parks, for example : Seribu Islands, Karimunjawa, Cenderawasih Bay, Bunaken, Wakatobi, and Takabonerate [5]. The Seribu Islands is unique as the coral reefs are formed relatively anew (around 12,000 BC) [6]. The size of islands in the Seribu Islands tend to be small with nearly 70% of them having areas of less than 10 ha [7]. The Seribu Islands' coral reefs generally have dense interspecies in the form of base substrate which tends to be flat. Seribu Islands, like Indonesia's seas and mainland, has weather conditions which is influenced by monsoon (West, East, and Transition) [8].

The zonation of Seribu Islands National Park is represented by approximately 110 scattered islands [9]. It is divided into four zones: Coring, Buffer, Tourism, and Residential. Based on the research conducted by the Indonesian Coral Reef Foundation (TERANGI) [10], the coral reefs' condition was categorized as moderate (34.27%) [11]. One of the factors that result in this condition is its zonation function which has been ineffective in fulfilling its role. It was also unfriendly and utilized excessively [12-13]. Strict and effective regulations and supervisions of each island/zone are expected to increase the percentage of coral reefs in the region. Periodic monitoring needs to be done to determine whether there is a change in the condition of coral reefs on the island/zone in the Seribu Islands National Park. The monitoring location in each zone, where the coral reefs' condition and distribution were observed, was determined by visually observing islands with the greatest coral cover percentage.

Coral reefs survive and develop with supports from external conditions. Oceanographic factors such as currents, salinity, temperature and turbidity were also monitored as they promote coral reefs' growth. The rise in temperature can cause coral bleaching [14]. Currents are also one of the most important oceanographic factor for the spread of coral larvae [15].

MATERIAL AND METHODS

Study Site

This research was carried out in the Seribu Islands National Park located in the geographical position of 5° 24'- 5° 45'S and 106° 25'- 106°40'E (Figure 1). The study was conducted in September during the transition monsoon. Monitoring, data collection and identification were done directly on site. Four islands were selected as representatives for zonations in the Seribu Islands National Park.

The zonations in the Seribus Islands National Park were determined based on their roles [16]. Core Zone (4,449 ha) is a part of the National Park Area which is protected and restricted from any kind of human activities. In the Seribu Islands National Park, it is divided into three zones, depending on the ecosystem that is being preserved in that area. Buffer Zone (26,284.50 ha) serves as a buffer for the core zone. Tourism Zone is the largest area (59,634.50 ha) and serves as a place for recreation and tourism activities. Residential Zone (17,121 ha) is a common area for residents and government offices.

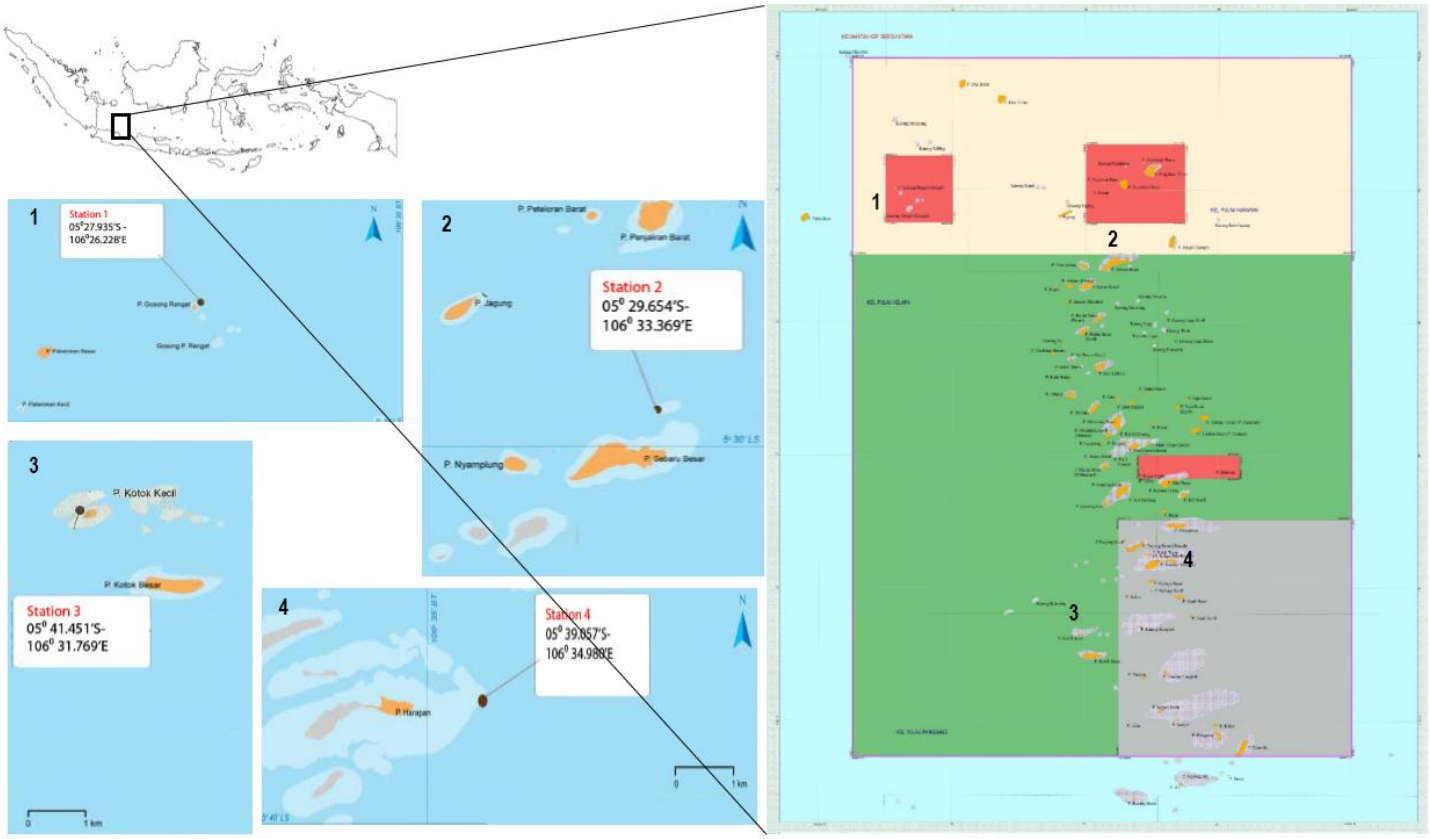

Figure 1. Geographic Map sampling. The locations are in the north of Jakarta Capital Region. Station 1 (Rengat island) as core zone, station 2 (Gosong Sebaru) as a buffer, Station 3 (Small Kotok Island) as Tourism zone, and Station 4 (Harapan Island) as Residential zone.

Data Collection

Coral reef observation was performed by using Line Intercept Transect (LIT) method [13]. The kind of data that was collected was based on changes in coral shapes (in centimeters) by referring to the lifeform. A line is drawn 25 meters parallel to the coastline following the contour of the bottom of the water with a depth of 7 meters and repeated 3 times. A depth selection of 7 meters was chosen because it can represent shallow waters (3 meters) and deep waters (10 meters) in the sea [10].

Other oceanographic parameters which were measured are as follows : temperature, salinity, currents and turbidity. We used a portable instrument to measure these parameters. We also compared the data with previous observations that were carried out by several other scientists. The observation team consisted of four members who collected data for about 1-2 hours in each station. The observation time was between 08.00-12.00 AM.

Data Analysis

The coral covers as indicated in [17] are shown in Table 1. It is generally grouped into Acropora, Non-Acropora, Soft Coral, Sponge, Algae and Others. The Acropora group consists of Acropora Branching (ACB), Acropora Digitate (ACD), Acropora Encrusting (ACE), Acropora Submassive (ACS) and Acropora Tabulate (ACT), whereas Non-Acropora consists of Coral Branching (CB), Coral Encrusting (CE), Coral Foliose (CF), Coral Massive (CM), Coral Mushroom (CMR) and Coral Submassive (CS). The cover percentage of hard coral (HC) is the total coverage of both Acropora and Non-Acropora lifeforms [18].

Table 1. Lifeform categories and codes [13]

Categories		Code	Notes/Remarks
Hard Coral:			
Dead Coral		DC	Recently dead, white to dirty white
Dead Coral with Algae		DCA	The coral remains erect, but is no longer white
Acropora	Branching	ACB	At least 2" branching, e.g: A.Formosam A.Palmata
	Encrusting	ACE	Usually the base-plate of young Acropora forms
	Submassive	ACS	Robust with a knob or wedge-like form, e.g: A.Palifera
	Digitate	ACD	No 2" branching, typically includes A.Digitafera
	Tabulate	ACT	Horizontal flattened plate, e.g: A.Hyacinthus
Non-Acropora	Branching	CB	At least 2" branching e.g Seriatapora hystrix
	Encrusting	CE	Major portion attached to substratum as a laminar plate
	Foliose	CF	Coral attached at one or more points, leaf-like
	Massive	CM	Solid boulder or mound, e.g: Platygyra daedalea
	Submassive	CS	Tends to form small columns, knobs or wedges, e.g: Porites lichen
	Mushroom	CMR	Solitary, free-living corals, e.gL Fungia repanda
	Milepora	CME	Fire Coral
	Heliopora	CHL	Blue Coral
Other Fauna:			
Soft Coral		SC	Soft-bodied corals
Sponge		SP	Sponge, e.g: Aaptos aaptos
Others:			
Algae	Algae Assemblage	AA	Consists of more than one species
	Coraline Algae		Algae with carbonate structure
	Halimeda	CA	Algae from the genus Halimeda
	Macroalgae	HA	Weed/fleshy browns, reds, etc.
	Turf Algae	MA	Lush filamentous algae often found inside damselfish territories
		TA	
Abiotic	Sand	S	
	Rubble	R	Unconsolidated coral fragments
	Silt	SI	
	Water	WA	Fissures deeper than 50 cm
	Rock	RCK	

The coral mortality index [19] for every site was calculated as the ratio of erect dead coral cover to the total cover of both living and dead corals:

MI = (Dead Corals)/((Living Corals+Dead Corals))

Values that are close to zero indicate that there are no significant changes in living corals, whereas values close to one indicate that there are significant changes from living corals to dead corals. The values for Diversity and Similarity Index were calculated using the Shannon Wiener Index [17].

RESULT AND DISCUSSION

Water Quality

The water quality values in the four stations are fairly similar. Temperature ranged between 28-29°C, which is good for coral growth. Coral reefs live well in conditions with a temperature of 22-29°C [20] and in some areas, they are able to tolerate up to 40°C [21]. This environmental condition is not much different compared to previous researches where the temperature range was between 28.3-29.30°C [12]. Salinity in the previous two years ranged from 29-31 ppt whereas at the time of study, its values ranged between 33-35 ppt. This salinity level is common in coral reefs' habitats [22-23]. Even though there is a slight increase, it is still within the optimum salinity range for coral's

life which is between 30-35 ppt [23].

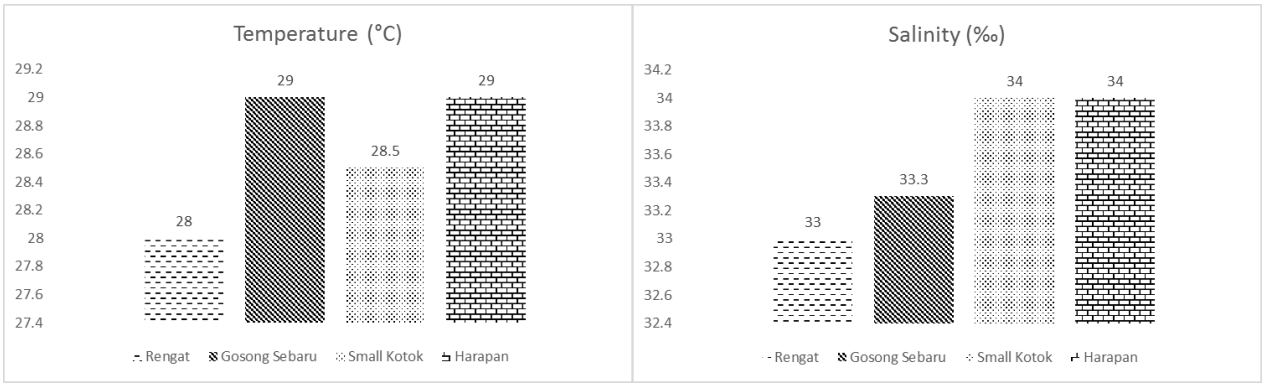

Figure 2. Temperature and Salinity at four stations.

Sea current is an important factor that determines coral zonation, coral morphology, and the depth distribution of coral reefs, algae, and other coral fauna [23]. Currents in every station ranged from 0.09-0.26 m/s. The data was collected during the transition season and was influenced by the east monsoon. The season affects the speed of surface currents which was seen from the station at the east side (Station 1). It was higher than the current at the west part of the island (Station 3). Currents have an important role to provide nutrients and oxygen, especially at night when photosynthesis does not occur [24].

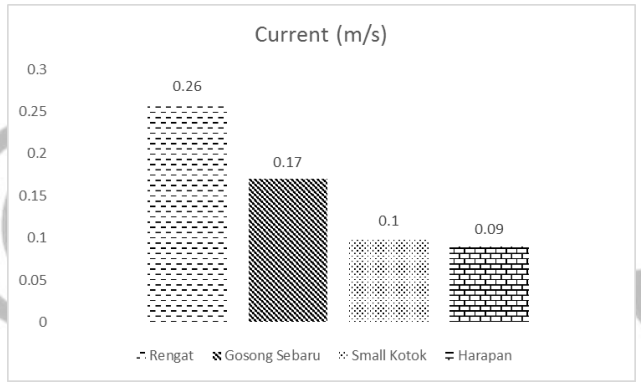

Figure 3. Current Speed in four stations

Turbidity is an important factor in the growth of coral reefs. Sediment load can affect both the population distribution and structures of coral reef communities [25]. Turbidity in the four stations ranged between 75-97%, an indication of change in brightness value compared to the previous two years which had a range of 80-98%. This shows an alteration in sunlight penetration which could be affected by suspension (mud) due to the seasonal effects.

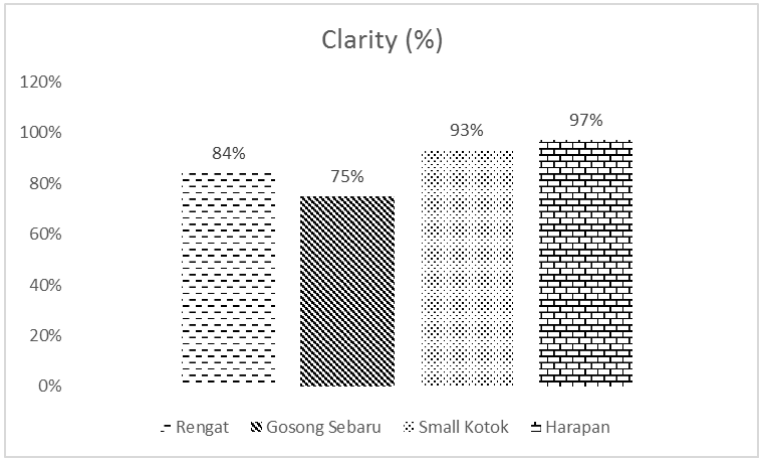

Figure 4. Water Turbidity in four stations

Coral Cover

The coral cover in Rengat Island (Core Zone) was 33.71% with an Acropora coral cover of 13.59% and 20.12% for Non-Acropora. The highest percentage of dead corals covered in algae or Dead Coral Algae (DCA) is 23.28%. The highest Algae percentage is also obtained in this station (7.11%). There appears to be a link between hard coral and algal cover's value; the lower the coral cover is in an area, the higher the algae cover [12]. There are three forms of algal interaction with living corals : 1) direct contact between corals and algae, 2) competition for space and 3) survival to live [26].

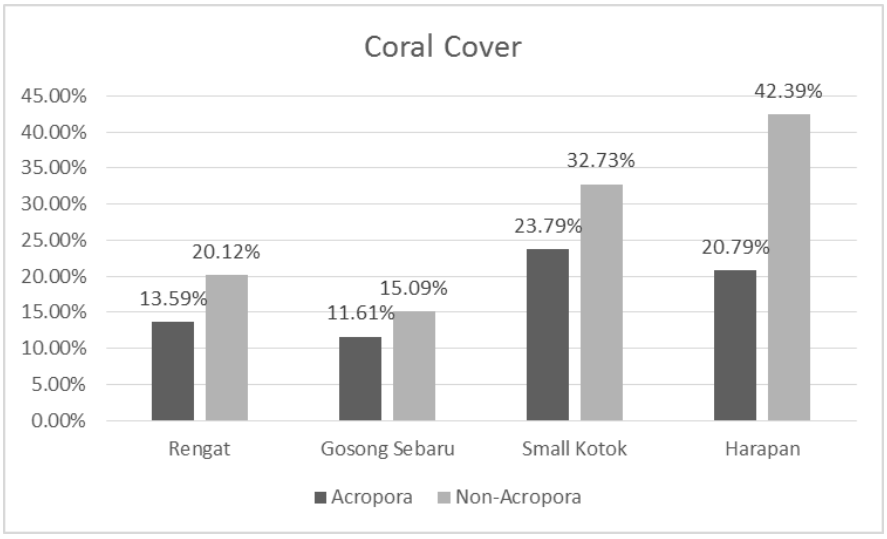

Figure 5. Coral Cover Composition (Acropora & Non-Acropora) in four stations.

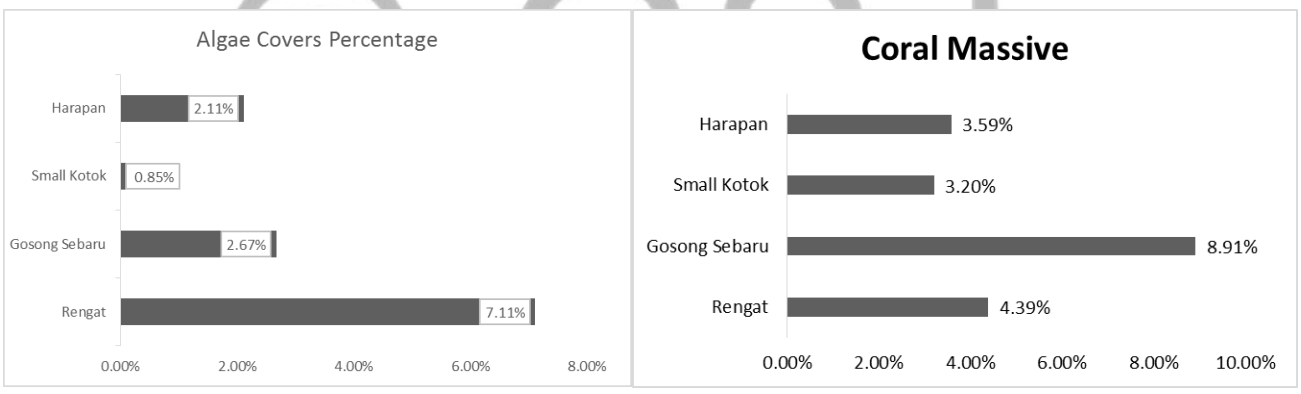

Figure 6. Algae and Coral Massive Covers Comparison

The coral cover in Sebaru Besar (Buffer Zone) was 26.71% with a percentage of 11.62% for Acropora and 15.09% for non-Acropora. The Water (WA) category value was 10.13%, an indication that there were many columns in this station due to large coral colonies. This is proven by a high percentage of Coral Massive (CM) which amounts to 8.91%. The WA category refers to a gap of more than 50 cm deep from the transect line [17]. Low turbidity in this station also supports CM dominance; Massive and submassive corals are more tolerant of high sedimentation and/or eutrophication. Therefore they are defined as stress-tolerators [27][28].

The coral cover in Kotok Kecil (Tourism Zone), which is 56.52%, consisted of 23.79% Acropora and 32.73% non-Acropora. The highest percentage for the lifeform category 'hard coral' belongs to Acropora Branching (ACB); its value is 14.93%. This type of coral usually grows in clear water and in locations where waves break apart. Their colonies' forms are generally branching and are classified as fast-growing coral species. However, they are very susceptible to sedimentation and fishing activities [29]. There is a decrease of hard coral cover by 8.07% compared to the preliminary data two years back.

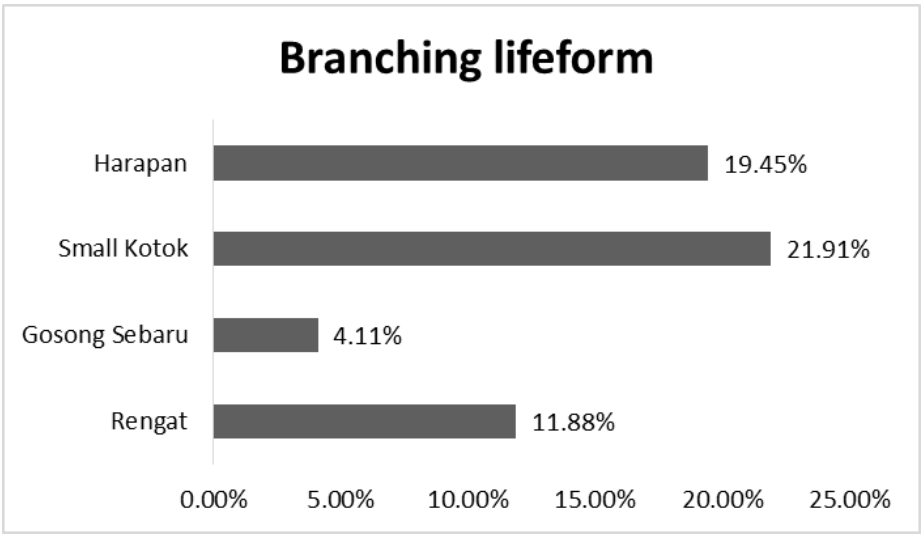

Figure 7. Cover Comparison of Branching lifeform

The coral cover in Harapan (Residential Zone) was 63.17%; 20.79% Acropora and 42.39% non-Acropora. The highest percentage for the lifeform category 'hard coral' belongs to Coral Foliose (CF); it is 20%. Coral Foliose, which belongs to the genus Montipora, grows well because this station has calm waterflow – a necessary trait for Foliose's habitats [30]. It is also supported by sea currents which is only 0.09 m/sec, the lowest compared to the other 3 stations. Corals with branching form grows well in this station. They consist of 7.95% ACB and 11.51% CB with the genus Acropora and Montipora dominating in the Seribu Islands [31].

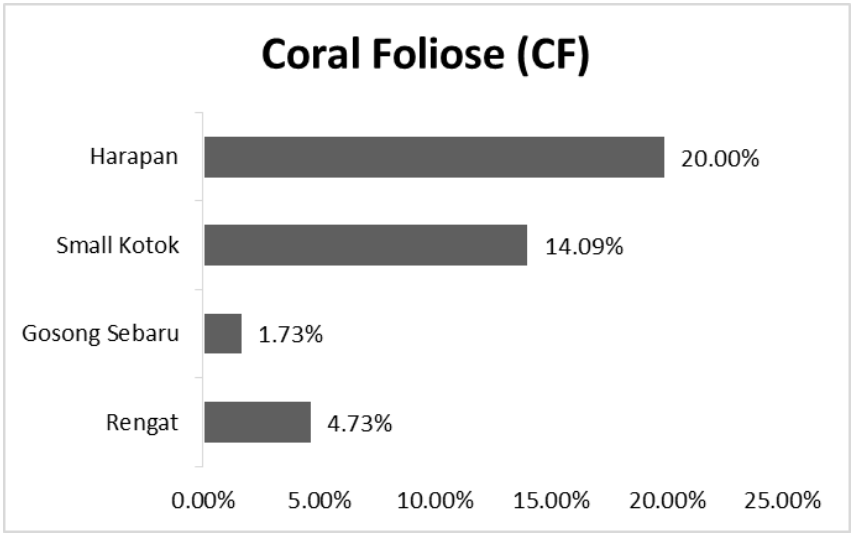

Figure 8. Coral Foliose (CF) Cover Comparison in four stations. CF in Harapan Island covers 1/5 of coral reefs in these stations

Mortality Index

The coral mortality index ranged from 0.161 to 0.587 (Figure 6). Values close to zero indicate that there are no significant changes for living corals whereas values close to one indicate that there is a significant change from living to dead corals. Therefore, the mortality values in these four stations do not have any significant difference.

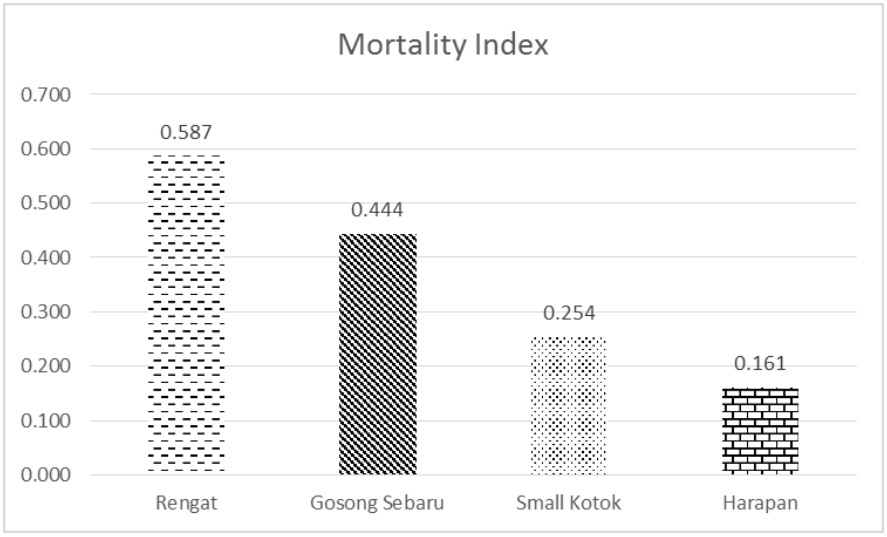

Figure 10. Coral Mortality Index in the four stations indicate there is no significant change in living to dead corals

Coral Distributions

The Similarity Index obtained from the four stations have values ranging from 0.362 to 0.658. It indicates that uniformity in these locations is moderate with the communities having unstable conditions. The coral distribution in each zone located in the Seribu Islands National Park was even (Table 2).

Table 2. The Similarity of Hard Corals

	St.1	St.2	St.3	St.4	Total	Similarity Percentage
ACB	√	√	√	√	4	100%
ACD	√	√	-	√	3	75%
ACE	√	√	√	√	4	100%
ACS	√	√	√	√	4	100%
ACT	-	-	-	-	0	0%
CB	√	√	√	√	4	100%
CE	√	√	-	√	3	75%
CF	√	√	√	√	4	100%
CM	√	√	√	√	4	100%
CS	√	√	√	√	4	100%
CHL	-	-	-	-	0	0%
CML	-	-	-	-	0	0%
CMR	√	√	√	√	4	100%

According to Shannon Wiener Index, based on the Diversity Index data in the four stations, the average value was 1.960. Thus the diversity index is categorized as low. The dominance index obtained from the four stations ranged from 0.147 to 0.216 and is categorized as low dominance.

In general, there was a decrease in coral cover in each station compared to the data from the previous two years [12] ranging from -0.19% to 8.07%. Harapan Island (Residential Zone) is the only observation station whose coral cover has increased by 0.19%. The largest change compared to the previous data is in Small Kotok Island (located in the tourism zone) which decreased by 8.07%. *Non-Acropora* types have a greater dominance than *Acropora* in all observation stations. *Non-Acropora* such as CM and CF have high adaptations to the environment, high competitive power and long life expectancy [32]. The water conditions enable corals of the *Non-Acropora* type to withstand environmental stresses better than *Acropora*, both natural and artificial (human activities). Corals of the *Acropora* group are branch-shaped and fast-growing but are vulnerable to human activities [29].

Bleached corals are also rarely found in the stations. Based on our data, there is no drastic change in temperature or salinity which may result in bleaching [33]. *Ancanthaster plancii*, coral predators that are usually found in ACT corals, were not found in these four stations.

Conclusion

The coral cover in the four stations is categorized as moderate. The hard coral cover percentage are as follows : Gosong Rengat Island (Core Zone) 33.71% (decreased 4.54%), Gosong Sebaru Island (Buffer Zone) 26.71% (decreased 7.79%), Small Kotok Island (Tourism Zone) 56.52% (decreased 8.07%), and Harapan Island (Residential Zone) 63.17% (increased 0.19%). The change in percentage values are obtained by comparing the data to the ones from two years ago with oceanographic parameters still within range for coral reefs to grow well. Coral distribution in the four site stations is evenly distributed with a low dominance, low diversity and moderate similarity.

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