

## GROWTH RATE, SPATIAL-TEMPORAL VARIATION AND PREVALENCE OF THE ENCRUSTING CYANOSPONGE (*Terpios hoshinota*) IN SERIBU ISLANDS, JAKARTA

### TINGKAT PERTUMBUHAN, VARIASI, SPASIO-TEMPORAL DAN PREVALENSI CYANOSPONG BERKERAK (*Terpios hoshinota*) DI KEPULAUAN SERIBU, JAKARTA

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#### ABSTRACT

*Terpios hoshinota* is a cyanosponge encrusted on the substrate in coral reefs that may cause mass mortality on the infested corals. This research was conducted to investigate the magnitude of damage level of corals due to the *T. hoshinota* outbreaks by assessing its growth rate, spatiotemporal variation, and prevalence between two sites in Seribu Islands. Four-time observation (T0-T3) in over 18 months (2016-2017) was conducted to see the growth level of sponge using a permanently quadratic photo transect method of 5x5 m (250.000cm<sup>2</sup>). The total coverage area of sponge on study site in the T0 was 65.252cm<sup>2</sup> and becomes 81.066cm<sup>2</sup> in T3. The highest level occurred on T2 of 2.051cm<sup>2</sup>/months in Dapur Island (the closest to Jakarta) and 483cm<sup>2</sup>/months in the Belanda Island (the further site). The highest sponge growth rate occurred on T1-T2 during transitional season from rainy to dry. The lowest growth rate was observed on T3 during transitional season from dry to rainy. In general, prevalence percentage was higher in Belanda Island than in Dapur Island. This study showed a persistence invasion of encrusting *T. hoshinota* on coral reef ecosystem that may overcome the function and role of associated organisms.

**Keywords:** coral mortality, cyanosponge, invasive, seasonal variation

#### ABSTRAK

*Terpios hoshinota* adalah cyanosponge bertatahan pada substrat di terumbu karang yang dapat menyebabkan kematian massal pada karang yang terpapar. Penelitian ini dilakukan untuk menyelidiki besarnya tingkat kerusakan karang akibat wabah *T. hoshinota* dengan menilai tingkat pertumbuhan, variasi spasial, dan prevalensi antara dua lokasi di Kepulauan Seribu. Pengamatan empat kali (T0-T3) selama lebih dari 18 bulan (2016-2017) dilakukan untuk melihat tingkat pertumbuhan spons menggunakan metode transek foto kuadrat permanen 5x5 m (250,000cm<sup>2</sup>). Total cakupan area spons di lokasi penelitian di T0 adalah 65,252cm<sup>2</sup> dan menjadi 81,066 cm<sup>2</sup> di T3. Level tertinggi terjadi pada T2 2,051cm<sup>2</sup>/bulan di Pulau Dapur (terdekat dengan Jakarta) dan 483cm<sup>2</sup>/bulan di Pulau Belanda (situs selanjutnya). Tingkat pertumbuhan spons tertinggi terjadi pada T1 –T2 selama musim transisi dari hujan ke kering. Tingkat pertumbuhan terendah diamati pada T3 selama musim transisi dari kering ke hujan. Secara umum, persentase prevalensi lebih tinggi di Pulau Belanda daripada di Pulau Dapur. Penelitian ini menunjukkan invasi persisten dari *T. hoshinota* pada ekosistem terumbu karang yang dapat mengatasi fungsi dan peran organisme terkait.

**Kata Kunci:** cyanosponge, invasif, kematian karang, variasi musiman

#### I. INTRODUCTION

A series of threats on coral reefs are responsible for broad damage, including

coral bleaching, coral diseases, coral predator, and invasive species (Shi *et al.*, 2012; Subhan *et al.*, 2011; Wilkinson, 2004). The status of Indonesian coral reefs in 2019

was categorized as very good with only 74 reefs (6.42%) and 390 reefs (33.82%) classified as poor out of 1153 reefs. (Hadi *et al.*, 2020). Some of the major threats on coral reefs are the epidemic coral diseases, invasive species, and human pressures (Wilkinson, 2008). Coral reefs damages are able to be caused by two factors namely abiotic (e.g. stress, temperature, sedimentation, un-stable nutrients of chemical materials, and ultra-violet radiation) and biotic factors (e.g. predation, competition with algae, infecting by diseases) (Subhan *et al.*, 2014; Subhan *et al.*, 2011; Johan, 2010). The coral reefs can be categorized as a healthy ecosystem when its living corals are higher than its abiotic components, a low threat level from other biotas that are recognized as competitors for coral reefs.

The competition of spaces to living and growing in the coral reefs ecosystem also become a threat for a broad coral cover and commonly activity discovering in the ecosystem. The existence of competitors for substrates in terms of life and growth is able to be said as a form of ecological process which is also affected by percent cover from each individual and community group happening naturally. The marine sponge is an integral part of coral reefs and is regarded as a strong competitor of space (Raj *et al.*, 2018; Rossi *et al.*, 2015; Diaz *et al.*, 2001). Some sponges compete with stony corals for space through directly and indirectly contacts and releasing an allelopathic compound that is able to kill the coral tissues and significantly decreasing the photosynthesis potency of symbiotic zooxanthellae (Fonnegra *et al.*, 2008; Pawlik *et al.*, 2007; Porter & Targett, 1988). One of several recognized sponges as benthos biota or sessile organism causing living corals decreasing is *T. hoshinota*. This sponge species is a plague that can drop the living coral cover significantly in Indo-Pacific coral reefs that are commonly happened during several decades (Wang *et al.*, 2015). The black sponge covering coral reefs is a

thin layer with less than 1 mm thickness is free of epibionts. Commonly in black or dark brown color, while individuals in the shallow habitat often are in greyish color due to having some calcium grains on the sponge' surface (Hirose & Murakami, 2011; Yamaguchi, 1986). The process of killing coral reefs is executed by blocking off the body or surface of coral reefs which inhibits the photosynthesis of the coral reefs. Furthermore, *T. hoshinota* also can be transformed from a thin sheet-like encrusting and also uses tissues like small strings or fine tendrils to move to another place and continue a new normal life in the new place (Soong *et al.*, 2009).

The Seribu Islands are composed of many small chained islands scratching off north Jakarta and has tropical coral reefs ecosystems in each island with the various condition and depends on the environment surrounding it from Jakarta Bay to the north. The first report on the emergence of *T. hoshinota* sponges in the Indonesian region by growing too large on the Seribu Islands, Java, and having examined the spicula through the COI mitochondrial DNA sequence affirming this specimen identity as *T. hoshinota* (de Voogd *et al.*, 2013). It seems that this sponge is still growing steadily for 4 years and has reaffirmed the sequential morphological characteristics of COI DNA mitochondria located on the Dapur Island (Utami *et al.*, 2018 Madduppa *et al.*, 2017). Kayu Angin Bira, Belanda and Pramuka Seribu Islands (Madduppa *et al.*, 2017). This study aims to see the ability of black sponge killer hard rock *T. hoshinota* to master the basic substrate in the coral reef ecosystem of Dapur Island and the Belanda Island of the Seribu Islands region, Jakarta.

## II. RESEARCH METHODS

### 2.1. Study Sites

This research was conducted in four times over 18 months of data collection between 2016 (T0= March, T1= June, and

T2= October) and 2017 (T3= August) in Dapur Island and Belanda Island. Dapur Island is characterized by the physical land condition of this small island has been submerged due to the abrasion process and only left the fringing reefs. There are four islands lost due to abrasion, including the Dapur island since 1970 based on the Governor's Decree of 2000 from a total of 115 islands to 109 (Sutanto, 2014). For the

location of the Belanda Island is located in the core zone of Thousand Islands National Park. Is an absolute protection zone for the sake of plasma preservation in the form of habitat development, the Belanda island is included in the core III zone as protection of coral reef ecosystems. (Mujiyani *et al.*, 2001). Following is the location of *T. hoshinota* coral killer sponge observations (Figure 1).

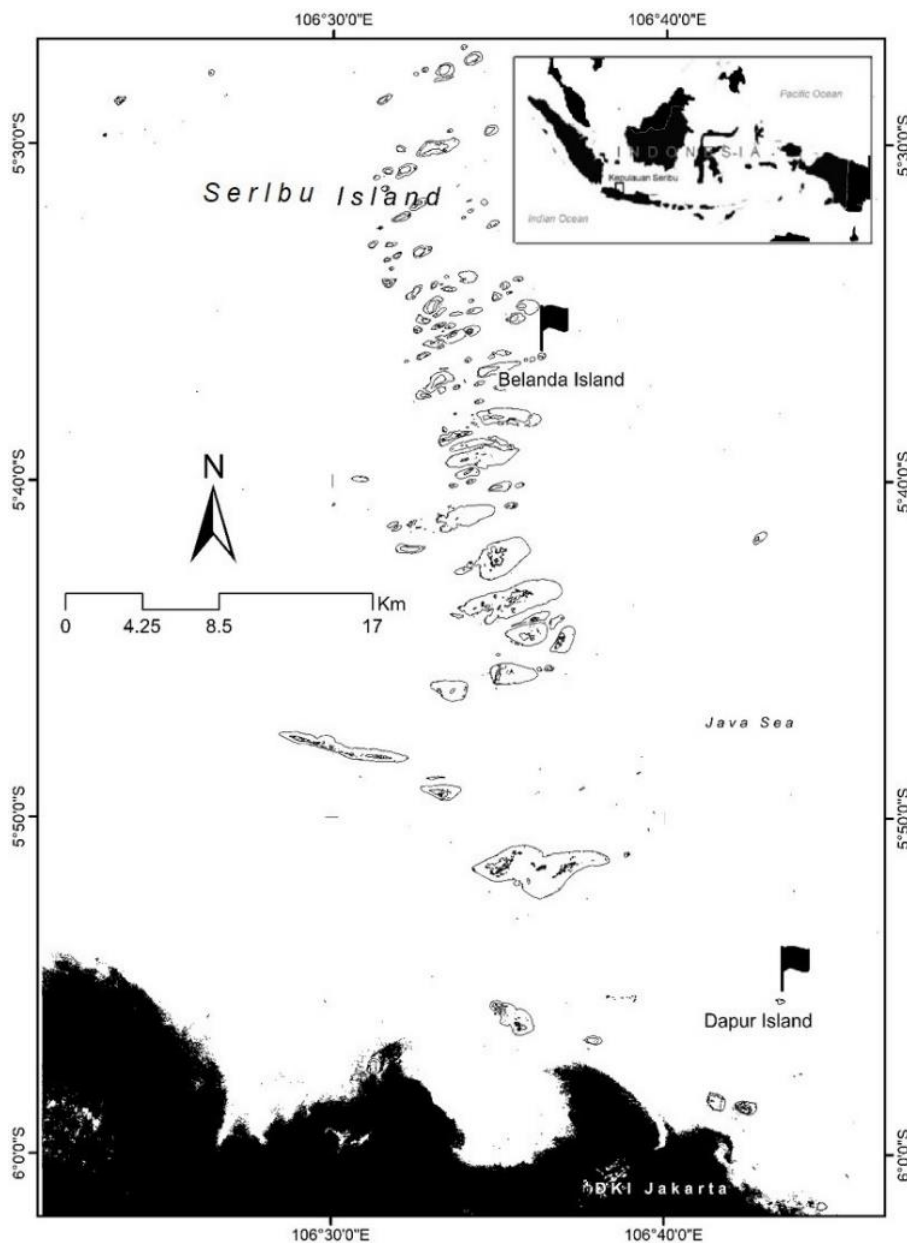


Figure 1. The study sites of killing corals sponge *T. hoshinota* outbreak in Thousand Islands, Jakarta. Closest to Jakarta Bay is Dapur Island, and the farthest is Belanda Island (the core zone of Seribu Islands Marine National Park).

## 2.2. Data Collection

The data collection was set as many as four times in different months: March 2016 (T0), June 2016 with code T1, October 2016 with (T2), and August 2017 with the code T3. Coral Reefs Condition in the Surrounding Areas of *T. hoshinota* Outbreaks were observed using 2 replicates of 25m long Line Intercept Transect (LIT) (English *et al.*, 1997). with the UPT method (Underwater Foto Transect) (Giyanto, 2013).

Growth rate, growth area coverage, and prevalence of sponge *T. hoshinota* was observed by setting a permanently quadratic transect of 5x5m (250.000cm<sup>2</sup>). In this transect, a total of 25 small quadratic transects with a size of 1x1 m were set and then photographed sequentially for analysis in the same way and at the same place at different times.

## 2.3. Data Analysis

The measurement of coral reef condition was carried out using a line incept transect (LIT) to acquire the coral reef percent cover referring to English *et al.* (1997) and to assess the standard of living coral reefs based on the Zamani & Madduppa (2011). Analyzing the mortality index was referred to Gomez *et al.* (1994) and Edinger *et al.* (1998). Images from quadrat transect were further analyzed to quantified growth rate, a growth area, and prevalence by using Image-J software, Java-based software is able to analyze the size, the value of pixels and particles in digital images to get the level of accuracy of the area measured by a square centimeter. The prevalence data processing was based on the gained sponge distribution referred to the formula of Raymundo *et al.* (2008), Prevalence is the proportion of coral colonies infected or exposed to black sponge outbreaks of the total coral species found in each survey. Data analysis was presented using graphs and tables from Microsoft Excel simple software.

## III. RESULTS AND DISCUSSION

### 3.1. Results

#### 3.2.1. Coral Reefs Condition in the Surrounding Areas of *T. hoshinota* Outbreaks

The average percentage of live coral cover on Dapur Island was observed to be lower (19.04%) than that of the Belanda Island (23.56%), where the criteria of both islands were categorized as being in poor condition. The highest percent of Abiotics consisting of sand, rubble, silt, and rock in the Belanda Island (67.38%) and Dapur Island (55.75%) with the category of cover are both sufficient. The highest average of algae cover was in Dapur Island (7.43%) from the Dutch Island (2.18%) with the category of cover on both islands classified as very good. and percent of the mortality index (MI) in Dapur Island was observed to be higher (0.7%) which indicates that there was a significant change from live corals to dead corals more than in the Belanda Island (0.6%) (Table 1).

The black sponges was observed on all hard substrates. A total of seven life forms and six genera were overgrown by black sponges at the study site (Table 2). Dapur Island has 4 genera and 6 coral life forms meanwhile in Belanda Island has 4 coral genera and 5 coral life forms. This condition is caused by the criteria of each location for the structure of the ecosystem of its coral habitat, the location of Dapur Island tends to have large and unbranched coral species, while the location of the Dutch island is more dominated by branching corals. (Figure 2).

#### 3.3.2. Growth Rate of Sponge *T. hoshinota*

Dapur Island, was observed a significant increase of the Sponge *T. hoshinota* growth during three times of observational period. The growth rate in Dapur Island ranged from June 2016 (T1) to October 2016 (T2), while in Belanda area

Table 1. Percentage value of the coral reef condition between two islands over time. Live Coral (hard coral *Acropora* and non-*Acropora*). Dead Coral (dead coral and dead coral with algae). Abiotik (sand, rubble, silt and rock). Other Biota (soft coral, sponge, zoanthid, other biotas and unidentified). Algae Cover (macro algae, turf algae, coralline algae, halimeda and algae assembling). MI (Mortality Index).

Location	Time	(%) Live Coral	(%) Dead Coral	(%) Abiotic	(%) Other Biota	(%) Algae Cover	(%) MI
Dapur Island	Mar/2016	10.01	3.02	60.05	16.42	10.50	0.8
	Jun/2016	23.50	0.70	50.66	16.76	8.38	0.6
	Oct/2016	16.20	2.84	62.05	10.50	8.41	0.7
	Aug/2017	26.46	1.56	50.22	19.35	2.42	0.6
	Average	19.04	2.03	55.75	15.76	7.43	0.7
Standard deviation		7.40	1.10	6.18	3.74	3.48	0.1
Belanda Island	Mar/2016	20.14	2.36	67.48	6.00	4.02	0.7
	Jun/2016	21.52	6.30	67.36	1.20	3.62	0.6
	Oct/2016	25.76	4.26	68.28	1.34	0.36	0.7
	Aug/2017	26.80	4.48	66.40	1.60	0.72	0.4
	Average	23.56	4.35	67.38	2.54	2.18	0.6
Standard deviation		3.22	1.61	0.77	2.32	1.91	0.1

Table 2. The overgrown living coral and abiotic (solid substrate and rubble) by the sponge *T. hoshinota* at each island.

Composition of life form (Genera)		Dapur Island	Belanda Island
Living coral:	ACB ( <i>Acropora</i> )	+	+
	ACT ( <i>Acropora</i> )	-	+
	CM ( <i>Lobophyllia</i> )	-	+
	CM ( <i>Porites</i> )	+	-
	CB ( <i>Pocillopora</i> )	-	+
	CB ( <i>Seriatopora</i> )	+	-
	CF ( <i>Porites</i> )	+	+
	CSM ( <i>Porites</i> )	+	-
	CMR ( <i>Fungia</i> )	+	-
Abiotic:	Solid Substrate non-coral	+	+
	Rubble	+	+

+ = overgrown present

- = absent.

ranged from October 2016 (T2) to August 2017 (T3), which is represented by observation transect 2. In general, this black sponge outbreak has symptoms of growth that occur between entering the dry season and at the end of the dry season, the peak of the rainy season occurs in January and the peak of the dry season is in August.

### 3.3.3. Spatial and Temporal Variation of Sponge *T. hoshinota*

Spatially, Dapur Island in the south showed a massive overgrown coral substratum by *T. hoshinota* in a total of 72.573cm<sup>2</sup> compared with Belanda Island covered in a total of 8493cm<sup>2</sup> after 18 months of observation. The width of this

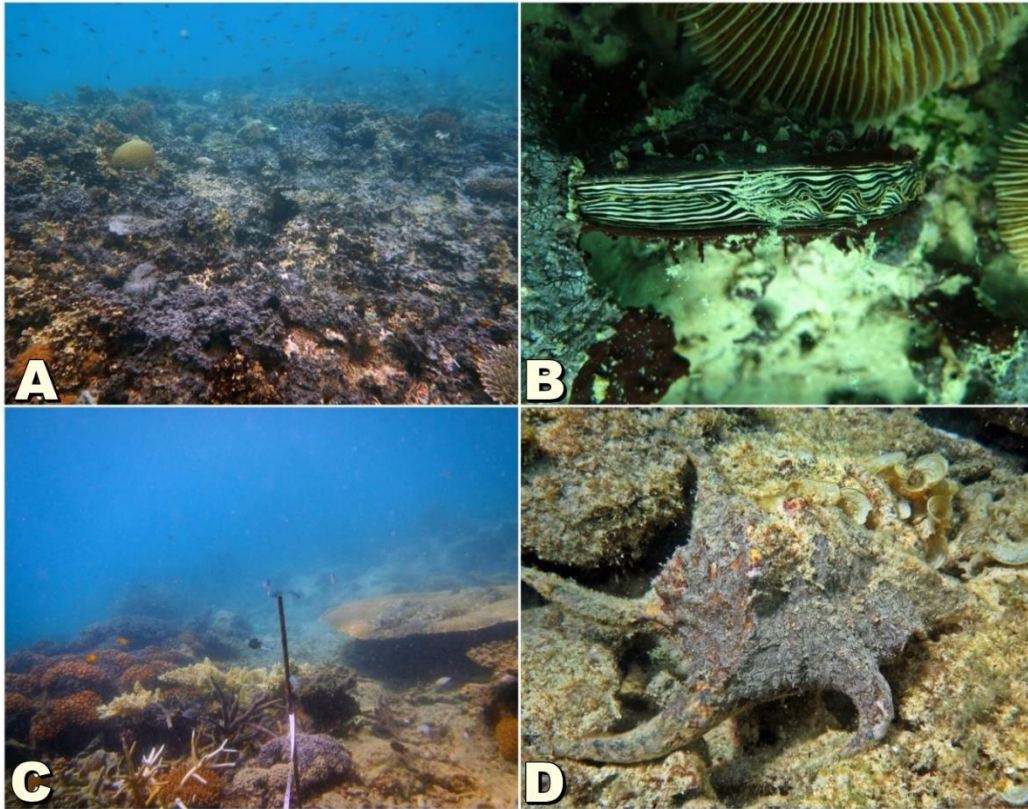


Figure 2. The condition of bottom cover in research location at Dapur Island (A), marine biota exposed by the sponge *T. hoshinota* in Dapur Island (B), the condition of bottom cover in research location at Belanda Island (C), the marine biota exposed by the sponge *T. hoshinota* in Belanda Island (D).

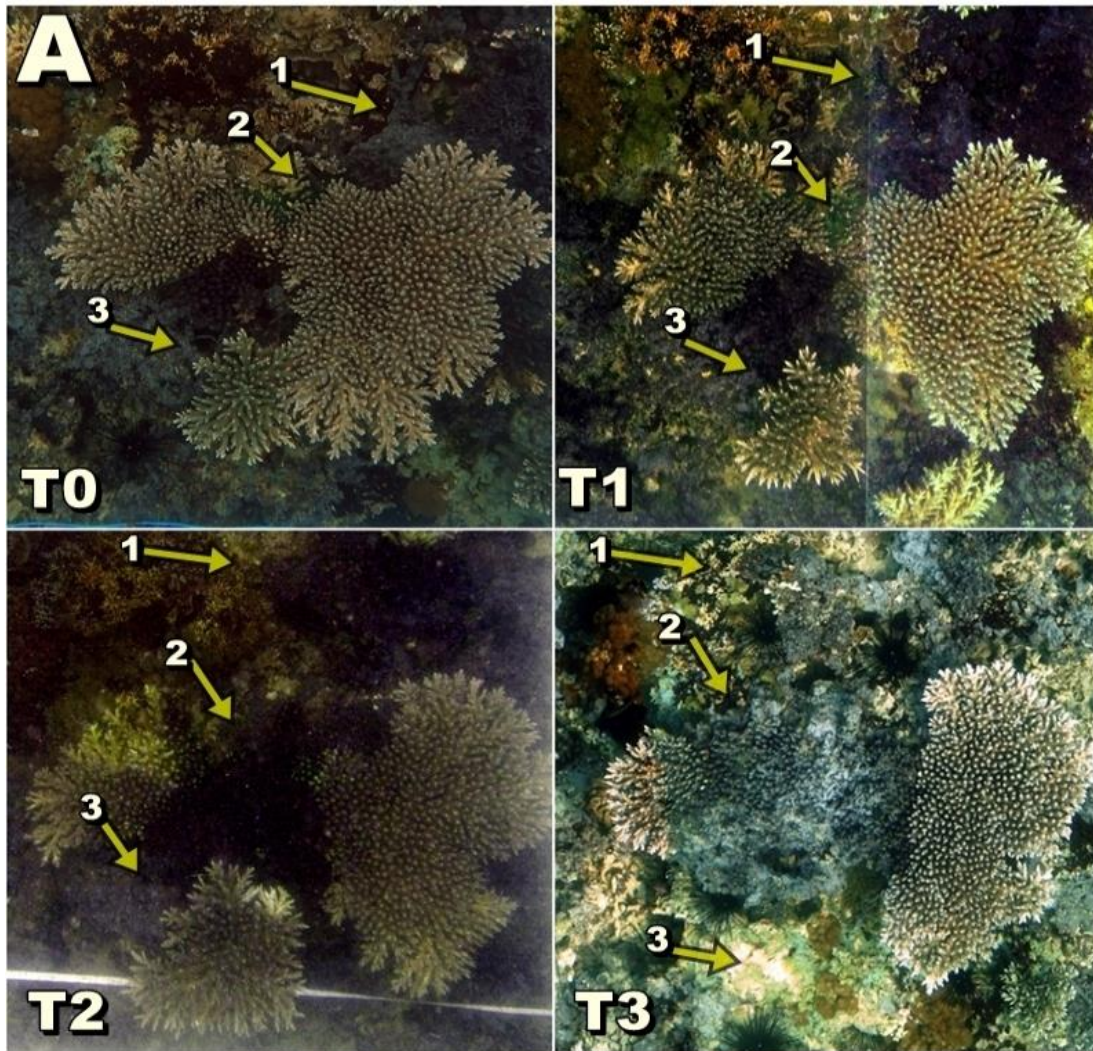
Table 3. Spatial and temporal variation of growth rate (cm<sup>2</sup>/month), growth area (cm<sup>2</sup>) and Total area of cover (cm<sup>2</sup>) of the sponge *T. hoshinota* in the coral reef ecosystem between Dapur Island and Belanda Island over 18 months (2016-2017) covering rainy and dry season.

Location	Transect	Time	Month/Season	Growth rate (cm <sup>2</sup> /month)	Growth area (cm <sup>2</sup> )	Total area of cover (cm <sup>2</sup> )
Dapur Island	1	T0/2016	Mar (rainy to dry)	-	-	49.076
		T1/2016	Jun (rainy to dry)	1.207	3.621	52.697
		T2/2016	Oct (dry to rainy)	1.641	6.564	59.261
		T3/2017	Aug (dry)	395	3.947	63.207
	2	T0/2016	Mar (rainy to dry)	-	-	4.953
		T1/2016	Jun (rainy to dry)	594	1.783	6.736
		T2/2016	Oct (dry to rainy)	410	1.639	8.375
		T3/2017	Aug (dry)	99	990	366
Total	T0/2016	Mar (rainy to dry)	-	-	54028	
	T1/2016	Jun (rainy to dry)	1.801	5.404	59.432	
	T2/2016	Oct (dry to rainy)	2.051	8.204	67.636	
	T3/2017	Aug (dry)	494	4937	72.573	



Location	Transect	Time	Month/Season	Growth rate (cm <sup>2</sup> /month)	Growth area (cm <sup>2</sup> )	Total area of cover (cm <sup>2</sup> )
Belanda Island	1	T0/2016	Mar (rainy to dry)	-	-	5.891
		T1/2016	Jun (rainy to dry)	n.a.	n.a.	n.a.
		T2/2016	Oct (dry to rainy)	129	906	6.797
		T3/2017	Aug (dry)	-585	-5.849	948
	2	T0/2016	Mar (rainy to dry)	-	-	5.333
		T1/2016	Jun (rainy to dry)	25	75	5.408
		T2/2016	Oct (dry to rainy)	354	1.415	6.822
		T3/2017	Aug (dry)	72	723	7.545
	Total	T0/2016	Mar (rainy to dry)	-	-	11.224
		T1/2016	Jun (rainy to dry)	25	75	11.299
		T2/2016	Oct (dry to rainy)	483	2.321	13.620
		T3/2017	Aug (dry)	-513	-5127	8.492

n.a.= not available.



(a)



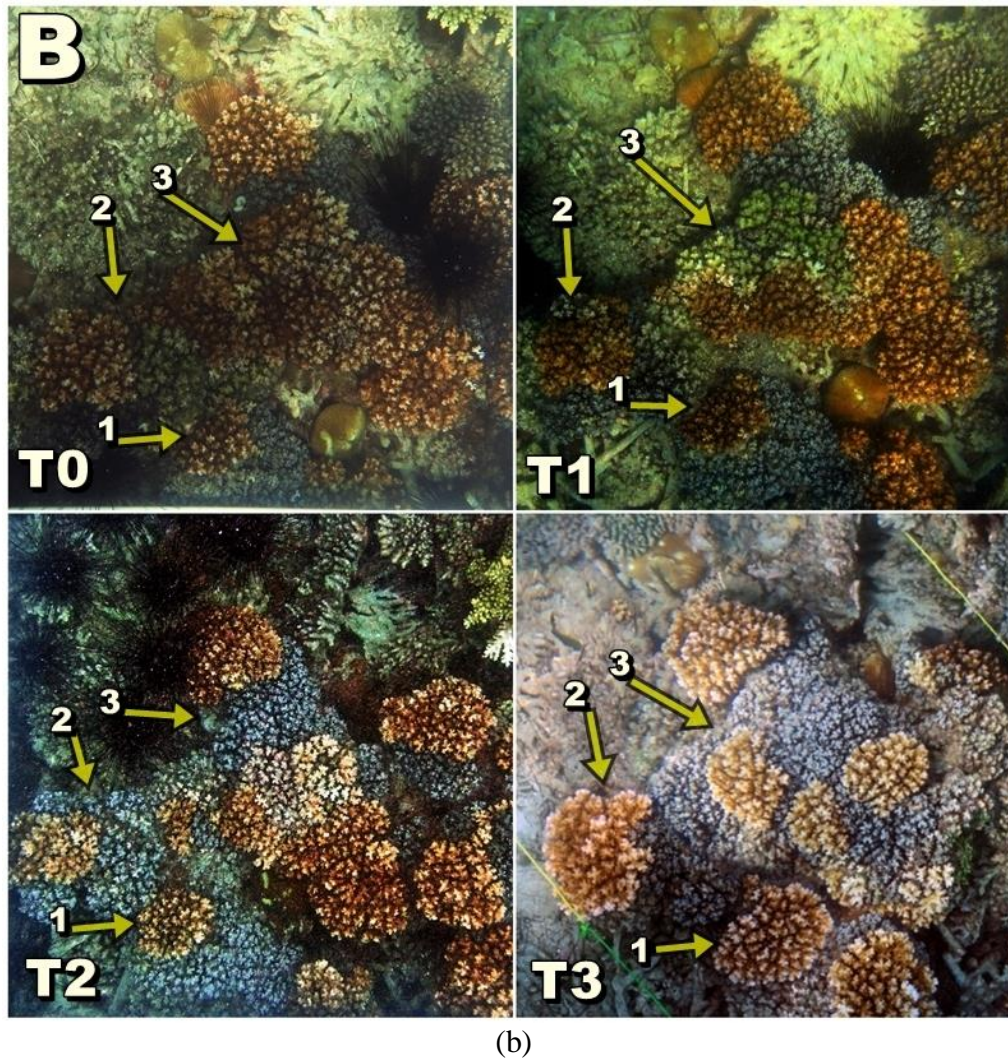


Figure 3. The movement pattern of the sponge within permanent transect at Dapur Island (a) and Belanda Island (b) on living coral substrate starts to exhibit a movement over 18 months in the observation.

black sponge cover has good spreading speed at the location of the Dapur Island with a hard substrate that has a density between the substrate very tightly (Figure 2.A) and within two months from the initial observation to the second observation an increase of  $5.404\text{cm}^2$ . Belanda Island itself is found in the northern part which leads to open sea waters having the condition of the dominant substrate of coral reefs with large separate colonies, the movement was limited to black sponge outbreaks with the best growth area of only  $2.321\text{cm}^2$  over an eight-month interval.

Its movement process in the research location of Dapur Island was dominated on the densely solid substrate in order to make easy its propagation to grow in the new areas (Figure 3.A), This location near the Mainland and in the Jakarta bay with murky enough waters as well as the basic substrate has the appropriate conditions of living coral growing massive and sub-massive. The movement pattern of this killer sponge is represented on the arrow number 1, the corals signify a competition for a growing space between the living corals and the sponge *T. hoshinota*, sponge outbreaks it



doesn't seem to reach the *Acropora* table reef that grew between the attacks of this black plague, to the time of this table coral building is destroyed starting there are separate parts that have been colonized by black sponges in arrow 2. While the conditions indicated by arrow 3, black sponges do not develop properly under the shade of table corals which are seen when the coral has been degraded.

Further, the observational location at Belanda Island, the sponge movement tended occurring on the living coral building forming a big colony, because this location is in the open waters so that the basic substrate conditions more dominated by living coral branching and has clear waters. In this station also points out the competition for space between the living coral and the sponge *T. hoshinota* is presented on arrow 1 and 2 which this time was won by the branchy coral *Pocillopora* from the early observation (T0) to the last observation (T3), is a coral competition against black sponges and algae for 3 arrows which only lasted for 3 months until the final observation. (T3) August 2017 and most have surrendered to the killer of the black sponge covered by *T. hoshinota*, also partially able to continue growth (Figure 3.B).

**3.3.4. Prevalence of Sponge *T. hoshinota***

The prevalence of black encrusting cyanosponge outbreaks is shown in Figure 4. The prevalence in Belanda Island was significantly higher than in Dapur Island at each period of observation. This is the third time exposed to black sponge outbreaks in two different locations and the outbreak begins to decrease simultaneously in the fourth observation. This condition shows the existence of coral reefs that are able to survive and grow more persistently than the plague of black sponge killer *T. hoshinota*. However, this black sponge will be an epidemic that threatens the health of hard corals in this region, proven for 18 months of observation the existence of this sponge can survive in all weather conditions during the observation period.

The increase in prevalence at the two observation sites increased much higher in October 2016 (T2) by 14.21% from 8.70% on Dapur island and 33.11% from 28.97% on the Belanda island. This added to the death of coral reef colonies at the location of the outbreak. As the increase in prevalence results in *Pocillopora* branched coral genera experiencing the highest increase in exposure to death by 5.053 cm<sup>2</sup> (T3) from 2.085 cm<sup>2</sup> (T0) and the *Acropora* table

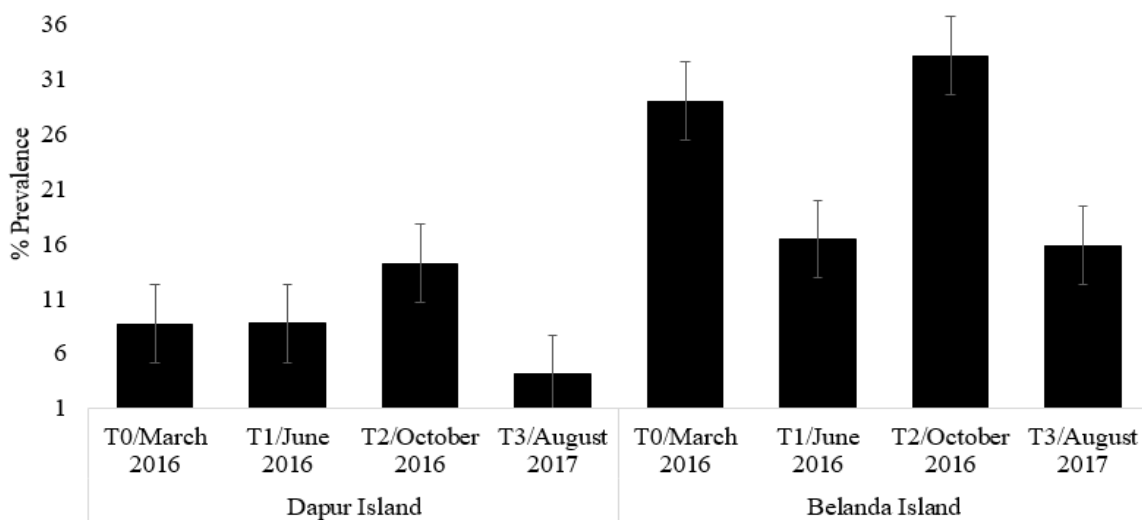


Figure 4. The prevalence (%) causing by the sponge *T. hoshinota* at each study sites over period of observation.

genera from 737 cm<sup>2</sup> (T0) to 1.575 cm<sup>2</sup> (T2) by observing T3 of this coral genera in part a large number of *T. hoshinota* outbreaks were destroyed by other factors

### 3.4. Discussion

#### 3.4.1. Coral Reefs Condition in the Surrounding Areas of *T. hoshinota* Outbreaks

The coral reef is a threatened ecosystem icon that has been existing since 500 million years, but its ecological persistence still continuing is seemingly doubtful currently (Riegl *et al.*, 2009). The lowering health condition of this ecosystem has various causes from physical factors such as an increasing number of components composing abiotic which is resulted by a very common happening activity like fishing in the coral reef area and eventually physical damages on the coral buildings. Then rising some coral inhabitant communities that are harmful and impact on the living coral cover condition as one of causing natural factors. However, many coral reef areas in around the world are getting threatened, mainly caused by overfishing, pollution, hurricane, global warming and increasing coral predators such as the *Acanthaster planci* (Teruya *et al.*, 2001; Teruya *et al.*, 2004). Our results obtained the amount of cover from the percentage of live coral on the two islands where this observation was in poor condition, only on the Belanda Island which had a higher live coral cover value than the Dapur Island. Showing the percent of live coral cover deteriorating from the results of previous studies. For Dapur island under good cover conditions and the Belanda island in a quite poor condition. (Cleary *et al.*, 2008). Belanda Island which is one of the Core Zones should have a tendency to change the percentage of hard coral cover in a positive direction. The remote location of Belanda Island might lead to less intensive supervision resulting in a decrease in the percentage of closure (Fadila & Idris, 2009). Sponge *T. hoshinota* is one of the natural

impacts of coral reef damages currently. It makes solid substrates, including living corals, and often experiencing a huge plague which is able to cover a very large area that is resulted in the mass death of corals and inhabiting organisms of coral reefs (Rutzler & Muzik 1993; Fujii *et al.*, 2011).

Rising the plague which is harmful on the coral reef ecosystem in the Seribu Islands is able to magnify problems causing coral damages in this area. The identification based on the results of molecular DNA exhibits that the sponge species actually is *T. hoshinota*, a study conducting in the areas of Belanda Island and Dapur Island of Seribu Islands (Utami *et al.*, 2018). Coral reefs become vulnerable due to one type of threat can be pushed towards ecological destruction if coupled with a second threat (Burke *et al.*, 2012). Based on research conducted by Costantino *et al.* (2008) *T. hoshinota* sponges that grow rapidly in coral reef ecosystems, often causing death on corals, *T. hoshinota* sponges are the most important cause of coral reef destruction.

#### 3.4.2. Growth rate of Sponge *T. hoshinota*

Based on Table 3, namely the period from March 2016 to October 2016 means that for 7 months the observation resulted in a value of 2.051 cm<sup>2</sup> for Dapur Area Island and 483 cm<sup>2</sup> Belanda Islands area. The high growth rate of these sponges, around 1-2mm/day, has caused the death of many corals, and steps to reduce or prevent further sponging of the crust have become a top priority (Tang *et al.*, 2011). The fast growth rate of *T. hoshinota* is an asset that allows it to be a space competitor effective against scleractinian corals, a comparison of sponge growth rates with coral growth rates at least twice as high as *Acropora* branching corals 4-10 times higher (Elliott *et al.*, 2015). Sponge *T. hoshinota* grows through lateral propagation, extending fine tendrils and crossing short slits to new substrates (Rutzler & Muzik 1993). Expansion of this

sponge was greatly aggressive in a span of four months from June 2016 to October 2016 during dry season. During the observation on the Maritus Island, sponge recruitment was low during the winter until the end of spring (Elliott *et al.*, 2016). This sponge coats the living coral building to be death rapidly in tropical climate and it continues to explore other hard coral substrates in the adjacent areas. The first study report in Palk Bay evidences a fast coral death and increasingly is due to the invasion of *T. hoshinota* in two years (Thinesh *et al.*, 2017a). The shaded substrate under the shade of a table reef is not covered by the black sponge outbreak, and table corals grow well above the substrate with an uninterrupted black sponge outbreak. So that the destruction of the coral building was attacked because some of it was separated from the support of the table corals falling into the area of this black plague (Figure 3.A). An observation conducted in Tioman Island, Malaysia, point outs that the sponge *T. hoshinota* possesses a preference on corals exposed to sunlight and it is able to grow excessively. Further, the shallow coral that has been exposed to this sponge plague is looked as though being killed, however, beneath the coral building still has a living part and far away from sunlight. This finding is looked consistently with the experiment results that shade can protect corals towards the sponge growth excessively (Soong *et al.*, 2009; Hoeksema *et al.*, 2014). There is a coral resistance from the *Pocillopora* genera capable of maintaining its growth around the attack of black sponges killing *T. hoshinota* on the location of the Belanda Island. Coral colonies of the types *Acropora digitifera* have retained the same boundaries with *T. hoshinota* for over a year without any progress or regression (Wang *et al.*, 2012).

### 3.4.3. Spatial and Temporal Variation of Sponge *T. hoshinota*

Almost all components of hard bottom substrates not covering by sands are

able to be used as the growing media of the sponge *T. hoshinota*, for species and life forms of exposing this sponge plague depend on the structures of coral colonies in each location. The tighter the hard substrates and side by side to the living corals, the easier this sponge broadens to the new areas. The preference of finalizing a test implies that the sponge *T. hoshinota* might not directly attack the healthy living corals, but settles on other hard substrates close to the corals (Hsu *et al.*, 2013). The location of a Dapur Island near the Jakarta Bay area in the southern part of the Seribu Islands was found in more black sponges *T. hoshinota* from the northern region, the Belanda Island. The competition for space between the sponge *T. hoshinota* and the living corals was very fierce. The coral reefs with an unhealthy condition and commonly in pale color or looked different in a colony, the sponge is able to reign a part of the coral building. Looked a wide difference of the measured sponge plague in the two research locations emphasizes that the different bottom characteristics affect highly the distribution pattern of this sponge, and these locations are no more than 6m depth. The four different found locations of *T. hoshinota* are varied each other in a benthic community structure. The sponge is found in two sites highly, unstable, and low living corals, algae, coral ruins, and sand (Esther *et al.*, 2015).

From a distance of three months the black sponge outbreak shows its nervousness increasing dramatically when entering the high dry season in both different locations, this condition is erratic when the coverage area of black sponges at the end of the fourth observation spans nine months decreases and enters different years, where the results of recording several images show a good increase in the growth of living coral reefs from sponge growth. *T. hoshinota* reproductive season occurs during the summer. (Hirose & Murakami, 2011; Nozawa *et al.*, 2016). Also, some transect

locations on the kitchen island have increased coral cover covering the sponge outbreak. Research conducted by Shi *et al.* (2012) they observed that coral had previously been covered with black crust sponges. It was difficult to assess whether there would be an appearance of algae. We found corals which were the growth media for black sponges physically damaged (fractures) and their surfaces with turfs algae growing slowly on the location of the Belanda Island. However, the *Terpios* outbreak sometimes shows setbacks (negative growth) and can even be overgrown by some coral organisms (*Montipora* and *Porites*) or red calcareous algae (Plucer, 1987; Wang *et al.*, 2012). Although there was a decrease in the extent of the outbreak during this period of observation it did not cause the outbreak to disappear completely. Obviously, these sponges are very persistent on coral reefs, and once they have invaded a new area, they will remain there permanently (Reimer *et al.*, 2011; Esther *et al.*, 2015).

The location of the distance of the Dapur and Belanda islands is so far away, the basic characteristics of the islands are certainly different. Dapur islands that are still affected by the bad condition of Jakarta Bay and the rather turbid waters of the Belanda island make the dominant coral that grows is the massive and sub-species of *Porites*. The *T. hoshinota* outbreak in Palk Bay is likely to be higher due to the impact of anthropogenic activities (Thinesh *et al.*, 2017b). Likewise, the results of this study show the appearance of many *T. hoshinota* sponges on Dapur Island. Turbid waters that cause not all types of rock can grow well, without distinguishing the type, found that rock corals that have massive forms of growth have a high tolerance to environmental changes (Giyanto & Sukarno, 1997; Tuti *et al.*, 2010). So that the density between coral colonies is better than the Belanda islands which are predominantly branching corals of *Acropora* and

*Pocilopora* species. This is the positive and negative value that exists on each island against the spread of black sponge outbreaks that are often seen creeping in on the surface of solid substrates. That the direction of overgrowth by a sponge may be associated with the level of compactness coral, indicating that health status corals can also be a determining factor in *Terpios* infection. (Averts, 2000; Wang *et al.*, 2012). The condition of coral reef ecosystems in the Thousand Islands tends to resemble inter-islands, except for a few islands that are located near or located in Jakarta Bay (Untung Jawa island) (Estradivari *et al.*, 2009). Dapur Island near the southern part of Untung Jawa.

#### 3.4.4. Prevalence of Sponge *T. hoshinota*

Dapur Island has a lower prevalence of black sponges for corals from Belanda Island. In Dapur Island, the exposure of small coral substrates that live here and black sponges are found on the basic substrate of rocks and coral reefs. Conversely, Belanda Island was observed with a high prevalence value because of the high percentage of live coral substrates. So that this black sponge outbreak predominantly moves on the coral reef substrate. After this outbreak of black disease, it can last up to a decade occupying the substrate and preventing the emergence of young coral recruitment (Liao *et al.*, 2007). The Belanda Island which has a high prevalence rate at the beginning of the observation, from the second observation occurs because the outbreak data calculation is incomplete on the observation transect 1. but basically, there was an increase shown by the same location on transect 2 also at the same time on different island locations from the total area cover of the black sponge outbreak (Table 3) and the photo recording portion of growth T0 and T1 (Figure 3). At the end of the observation of the black sponge outbreak rate that killed corals in both locations declined, this was like being



challenged by coral reefs and some areas of the outbreak were also covered by soft coral colonies. In most cases, these two competitors can alternately lose and gain tissue and space to grow during 15-month intervals. (Chornesky, 1989; Lisanne, 2000). Almost similar to what was found by Rocktim *et al* (2020) scenario at stations 5 and 6 after the *T. hoshinota* outbreak attacked the reef and killed the reef death here by sponsoring *T. hoshinota* sponsors and grass algae took over. Highlighting the long-term symptoms of the *T. hoshinota* outbreak should be seen as a threat to coral disease and might be one of the most important disturbances affecting coral reefs (Liao *et al.*, 2007). Prevalence values dropped at some time observations did not cover up the black outbreak will stop developing, and the outbreak disappeared from its area of existence.

All observing areas, there are two coral categories becoming victims of the sponge *T. hoshinota* outbreak ferocity namely the *Acropora* and branchy non-*Acropora* like *Porites* and *Pocillopora*, and *Porites* and non-branchy *Fungia*. During a biodiversity survey recently in Faafu Atoll, Maladewa, the sponge *T. hoshinota* was observed growing excessively in the living corals such as *Porites*, *Acropora*, *Cyphastrea*, *Montipora* and coral colonies of *Pavona* in 13 different locations in a range depth of 7 to 24 m (Montano *et al.*, 2015). Based on genera, there are 2 corals, namely *Acropora* and *Pocillopora* which experienced the most striking increase in mortality when the prevalence increased. According to Tinnesh *et al* (2017) on the Palk Bay reef, Southeast coast of India. From 1930 colonies examined, 25.4% (n= 492) were effects shaded by *T. hoshinota* sponges during the study period, where the percentage has increased from the initial amount of 1.3% (n= 25).

#### IV. CONCLUSIONS

This study reveals the sponge *Terpios hoshinota* able to overgrown almost all hard substrate buildings and densities between solid substrates determine the fast or slow deployment process in one area of the coral reef ecosystem. The highest growth level was observed in Dapur Island (the closest site to Jakarta) during transitional season from rainy season to dry season. While the lowest growth rate of sponge was observed during transitional season from the dry season to rainy season. In general, prevalence percentage was higher in Belanda Island than in Dapur Island. This study showed a persistence of *T. hoshinota* proliferation.

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