Conditions of Megabenthos on Coral Reef Ecosystem in Seribu Islands National Park, Jakarta, Indonesia

Dedy Kurniawan[1,*], *Risandi Dwirama* Putra[2], *Rikoh Manogar* Siringoringo[3], *Ni Wayan Purnama* Sari[3], *Muhammad* Abrar[3], *Jumsurizal* Jumsurizal[1], *Try* Febrianto[1], and *Hasnarika* Hasnarika[4]

[1]Faculty of Marine Science and Fisheries, University of Maritim Raja Ali Haji, 29111 Tanjungpinang, Indonesia
[2]Faculty of Engineering, University of Maritim Raja Ali Haji, 29111 Tanjungpinang, Indonesia
[3]Research Centre for Oceanography, National Research and Innovation Agency, 14430 DKI Jakarta, Indonesia
[4]Department of Accounting, Institute of Economic Science Pembangunan Tanjungpinang, 29124 Tanjungpinang, Indonesia

Abstract. Seribu Islands National Park is located off the north coast of Jakarta and consists of 110 islands. This study aims to determine the distribution and density of megabenthos in coral reef ecosystems in the Seribu Islands National Park. This research was conducted in November 2021 in the Seribu Islands National Park waters. Megabenthos observations were carried out using the Benthos Belt Transect method, a development of the Belt Transect Method for monitoring megabenthos combined with the Reef Check Benthos method. Based on observations in the waters of the Seribu Islands National Park, five types of megabenthos were found, including clams (*Tridacna* sp.), lola (*Trochus* sp.), Crown-of-torns starfish (*Acanthaster planci*), drupella (*Drupella* sp.), and sea urchins (*Diadema* sp.). The highest density of megabenthos was found on Kayuangin Genteng Island, with a density of 8,786 ind/ha, while the lowest was on Peteloran Barat Island, with 429 ind/ha. Based on the type of megabenthos at all observation stations, the most abundant megabenthos found was *Diadema* sp., with a density of 43,397 ind/ha. In comparison, the least was *Acanthaster planci* of 214 ind/ha. Megabenthos in the Seribu Islands National Park waters are in various conditions.

1 Introduction

Seribu Islands National Park is located off the north coast of Jakarta and consists of 110 islands with an area of 108,000 hectares, with an extended position from north to the south marked by small white sandy islands and coral reefs. The geomorphology of small islands in the Seribu Islands includes lowland islands with uplifted coral types formed from massive coral rock deposits [1].

* Corresponding author: dedykurniawan@umrah.ac.id

Based on the research results, islands in the Seribu Islands are mostly surrounded by coral reefs, so the dominant ecosystem is the coral reef ecosystem, followed by the mangrove ecosystem and seagrass ecosystem. Coral reef ecosystems have an area of 3,147.93 Ha, mangrove ecosystems cover an area of 575.09 Ha, and seagrass ecosystems cover an area of 277.01 Ha [1].

Coral reefs are the habitat of various groups of marine biota, both permanent and temporary. One of the constituents of coral reef ecosystems is a group of benthic fauna, namely groups of fauna that live in the bottom waters (benthos) [2]. Echinoderms, Molluscs, and Crustaceans are a group of benthic fauna that are often found living on coral reefs. Benthic fauna group (megabenthos), which is relatively large and has a high population, has an important role in the condition and stability of the ecosystem [3-4].

Megabenthos is the largest marine biota group that has an important role in the ecosystem [5]. Suggested that benthic animals play a role in the nutrient cycle in waters [6]. The nutrient cycle is an essential process in aquatic ecology because it is a source of energy for producers. On the other hand, macrobenthos is also a biological component that is often used as an indicator of pollution because it has a different sensitivity to pollutants and has low mobility so that it can be directly affected and easily captured for analysis [7]. Benthic fauna that is easily recognizable and sensitive to changes in the aquatic environment is the megabenthic group. Megabenthos has a wide distribution, relatively large size, and a rather long life cycle, causing this organism to have a relatively slow movement so that it can continuously respond to water quality conditions [8-9].

This makes the megabenthos group of potential value to be used as an object for monitoring coral reef health. This study aims to determine the distribution and density of megabenthos in coral reef ecosystems in the Seribu Islands National Park, Jakarta.

2 Materials and Methods

The research activity was carried out on November 2-12, 2021. This activity was carried out in the Seribu Islands National Park area, with 14 monitoring stations. In detail, the monitoring stations in the waters of the Seribu Islands National Park can be seen in Table 1 and Figure 1.

Table 1. Location and Geographical Position of Megabenthos Condition Monitoring Station in the Waters of the Seribu Islands National Park

Nu.	Location	Station Name	Coordinate Point	
			SL	EL
1.	Peteloran Barat Island	KSBC01	-5.4632	106.5466
2.	Penjaliran Barat Island	KSBC02	-5.4630	106.5519
3.	Sebaru Besar Island	KSBC03	-5.5061	106.5420
4.	Melinjo Island	KSBC04	-5.5698	106.5428
5.	Genteng Besar Island	KSBC05	-5.6137	106.5506
6.	Bira Besar Island	KSBC06	-5.6151	106.5779
7.	Kayuangin Genteng Island	KSBC07	-5.6190	106.5632
8.	Belanda Island	KSBC08	-5.6033	106.6053
9.	Pamagaran (Timur) Island	KSBC09	-5.6359	106.6043
10.	Pamagaran Selatan Island	KSBC10	-5.6389	106.5909
11.	Karya Island	KSBC11	-5.7320	106.6035

Nu.	Location	Station Name	Coordinate Point	
			SL	EL
12.	Pramuka Island	KSBC12	-5.7517	106.6114
13.	Payung Island	KSBC13	-5.8177	106.5596
14.	Pari Island	KSBC14	-5.8513	106.6127

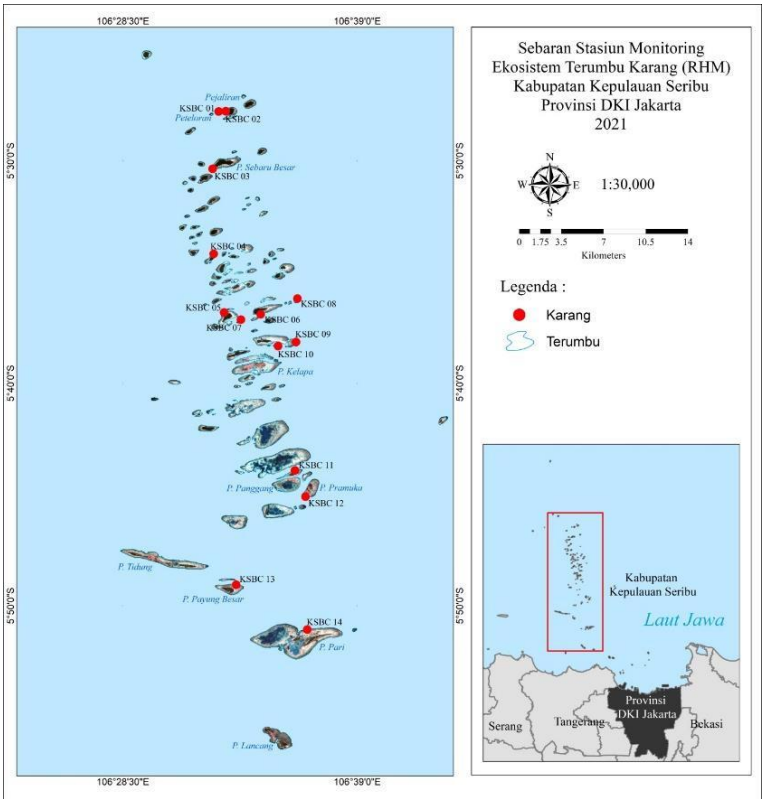

Fig 1. Megabenthos Condition Monitoring Station in the Waters of the Seribu Islands National Park

Megabenthos observations were carried out using the Benthos Belt Transect (BBT) method, which is a development of the Belt Transect Method for monitoring megabenthos [10] combined with the Reef Check Benthos method at fourteen stations with the help of SCUBA diving equipment [11]. Observations were made using SCUBA equipment. Transects were synchronized for coral and reef fish observations on permanent transects. This method is done by pulling a scale tape (roll meter) parallel to the shoreline at a depth of 4-7 meters with a transect length of 70 meters, and the shoreline is always on the diver's left when pulling the transect tape. After the tape transect was installed, observations and records were made of the type and number of target megabenthos from 0 meters to 70 meters with an observation width of 1 meter to the left and 1 meter to the right of the transect line so that the observation area became 140 m^2 (2 x 70 m) (Figure 2). There are eight species or groups of megabenthos fauna species monitored, namely Sea Cucumber (Holothurians), Clams (*Tridacna* sp. and *Hippopus* sp.), Lobster (*Panulirus* spp.), Lola (*Trochus* spp.), *Crown-of-torns starfish* (*Acanthaster planci*), drupella snail (*Drupella* spp.), sea urchin (*Diadema* sp.), and Blue Starfish (*Linckia laevigata*) (Table 2).

All types of megabenthos that were targeted by transects were recorded for the number of species and the number of individuals. Megabenthos targets are biota that has high economic value and play an important role in coral health, consisting of seven groups of megabenthos indicator biota. Identification refers to [12].

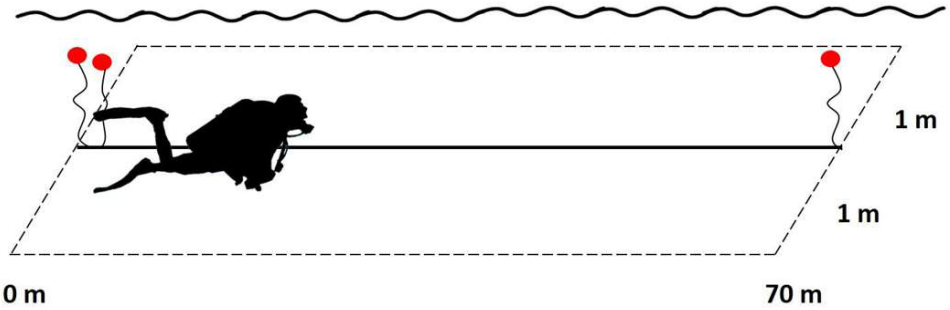

Fig 2. Megabenthos Transect Simulation with Modified Benthos Belt Transect (BBT) Method [12]

Table 2. Types of Megabenthos Targets Observed

Nu.	Megabenthos	Common Name / Species Name
1.	Sea Cucumbers	Sea Cucumbers, Holothurians
2.	Giant Clams	Giant Clams / Tridacna spp. dan Hippopus spp.
3.	Lobsters	*Panulirus* spp.
4.	Lola	*Trochus* spp.
5.	Crown-of-torns starfish	Crown-of-torns starfish */ Acanthaster planci*
6.	Drupella Snails	Coral eating snails */ Drupella cornus dan D. rugosa*
7.	Sea Urchin	Sea Urchin */ Diadema* sp.
8.	Blue starfish	Blue starfish */ Linckia laevigata*

After the observation data is collected, the information is transferred into a spreadsheet, for example, by using Microsoft Excel, including the type, number of individuals of each species, and abundance. Megabenthos density can be calculated using the following formula [13].

3 Materials and Methods

Presence and Composition of Megabenthos

At the location for observing the condition of megabenthos at fourteen observation stations in the waters of the Seribu Islands National Park, five types of megabenthos were found that became the object of observation. The following is the presence of the megabenthos target group and the number of megabenthos species at each observation station in the waters of the Seribu Islands National Park, which are presented in Table 3.

Table 3. Presence and Number of Megabenthos Species at Each Station in the Waters of the Seribu Islands National Park

	Megabenthos	Observation Station (KSBC)													Presence (%)
		01	02	03	04	05	06	07	08	09	10	11	12	13	14	
1	Sea Cucumbers															
2	Clams		+	+			+	+	+		+		+			**50.00**
3	Lobsters															
4	Lola				+	+	+				+		+	+	+	**50.00**
5	*Acanthaster planci*		+		+											**14.29**
6	*Drupella* Snails	+	+		+	+	+		+					+	+	**57.14**
7	Sea Urchin	+	+	+	+	+	+	+	+	+	+	+	+	+	+	**100.00**
8	*Linckia laevigata*															
Species		**2**	**4**	**3**	**4**	**3**	**4**	**2**	**3**	**1**	**3**	**1**	**3**	**3**	**3**	

Based on observations in the waters of Seribu Islands National Park, five types of megabenthos were found that were the target of observation, including clams (Tridacna sp.), Lola (*Trochus* sp.), spiny starfish (*Acanthaster planci*), drupella. Snails (*Drupella* sp.), and sea urchins (*Diadema* sp.), while sea cucumbers (Holothurians), lobsters (*Panulirus* spp.), and blue starfish (*Linckia laevigata*) were not found at the observation station. The megabenthos species that dominate the waters of Seribu Islands National Park are sea urchins (*Diadema* sp.) as much as 100%, followed by drupella snails (*Drupella* sp.) 57.14%, clams (Tridacna sp.) and Lola (Trochus sp.) respectively 50% each, and the Crown-of-torns starfish (*Acanthaster planci*) at 14.29%. Based on the number of species at each observation station, the highest number of species was found on West Penjaliran Island (KSBC02), Melinjo Island (KSBC04), and Bira Besar Island (KSBC06), while the lowest was on Pamagaran Island. (East) station (KSBC09) and Pulau Karya (KSBC11).

Megabenthos Density

Based on the calculation of the density of each type of megabenthos found at each observation station, the density of the type of megabenthos is quite varied, ranging from 429 – 8,786 ind/ha. For the total density of megabenthos from each observation station, the highest is at Pulau Kayuangin Genteng station (KSBC07), with a megabenthos density of 8,786 ind/ha, while the lowest is at Pulau Peteloran Barat station (KSBC01) of 429 ind/ha. The results of the calculation of the density of megabenthos found at each observation station in the waters of the Seribu Islands National Park are presented in Figure 3.

Based on the type of megabenthos at all observation stations, the most abundant megabenthos found was sea urchin (*Diadema* sp.) with a total density of 43,397 ind/ha, while the least was *Acanthaster planci* at 214 ind/ha. For sea cucumber megabenthos, lobster and blue starfish (*Linckia laevigata*) were not found at all observation sites. The results of the calculation of megabenthos density for each species in the waters of the Seribu Islands National Park are presented in Figure 4.

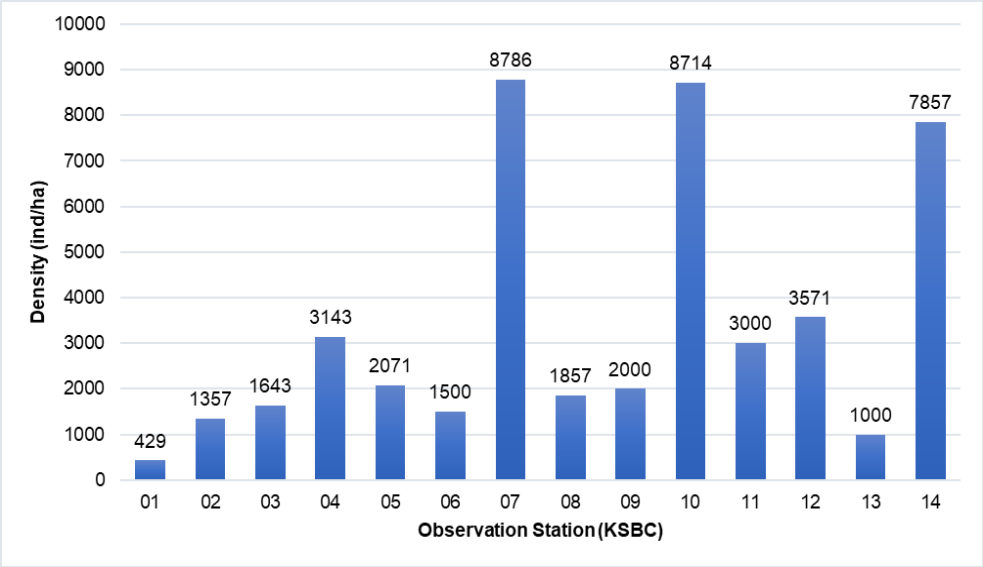

Fig 3. The density of megabenthos species (ind/ha) at each station in the waters of the Seribu Islands National Park

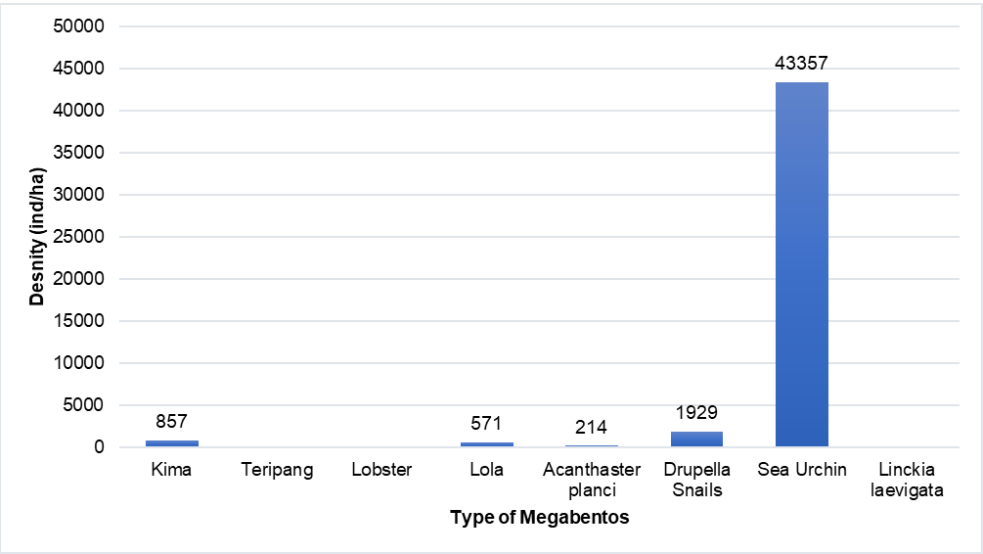

Fig 4. The density of megabenthos species (ind/ha) by type in the waters of the Seribu Islands National Park

Clams (Tridacna sp.)

Clams (*Tridacna* sp.) was found at seven observation stations with densities ranging from 71 – 214 ind/ha, with a total of 857 ind/ha. Based on the types of clams found, there was hole clams (*Tridacna corcea*) and giantsclams (*Tridacna maxima*). The size of the hole clams (Tridacna corcea) found ranged from 7-13 cm, while the giants clams (*Tridacna maxima*) was >20 cm. The types of clams found at the observation station can be seen in Figure 5.

Tridacna corcea *Tridacna maxima*

Fig 5. Types of Clams Found at the Water Observation Station of the Seribu Islands National Park

Based on data on the density of clams in the waters of the Seribu Islands National Park, the value of clams density is relatively low. This is because the clams is a type of megabenthos that is used by the community (economically significant). The meat and shells can be used for various purposes. Clams meat is prevalent in the non-fish fisheries trade because of its delicacy, while the shell is often used as a raw material for handicrafts for souvenirs. These shells continue to be the target of the fishing community. These conditions can cause the population and its existence in the coral reef ecosystem of the Seribu Islands National Park to be threatened. Overfishing of economic biota will disrupt the balance of the ecosystem, where the absence of this biota will disrupt the web and food chain [3].

Lola (Trochus sp.)

Lola (*Trochus* sp.) was found at seven observation stations in the waters of the Seribu Islands National Park, including stations KSBC04, KSBC05, KSBC06, KSBC10, KSBC12, KSBC13 and KSBC14, with densities ranging from 71 to 143 ind/ha, with as many as 571 ind/Ha. Lola is relatively difficult to find because it usually lives hidden behind corals during the day. This follows the nature of his life, which is more active at night or nocturnal. This species usually lives among coral fractures, dead coral and coral crevices on coral reefs in intertidal to shallow subtidal areas [14]. Another factor that makes it difficult to find this biota is the fishing factor. Based on the information, local fishermen make this biota a bycatch target for fishermen because it has a relatively high price. The types of lola found at the observation station can be seen in Figure 6.

Fig 6. Types of Lola Found at the Water Observation Station of the Seribu Islands National Park

Crown-of-Torns Starfish (Acanthaster planci)

Crown-of-torns starfish (*Acanthaster planci*) is one of the biotas that eats coral polyps. This species is quite popular because the impact of coral death it causes is quite severe. The spiny starfish (*Acanthaster planci*) was found at two observation stations, namely Penjaliran Barat Island (KSBC02) with a density of 143 ind/ha and Melinjo Island (KSBC04) with a density of 71 ind/ha, with a total density of 214 ind/ha. The spiny starfish (*Acanthaster planci*) found at the observation station can be seen in Figure 7.

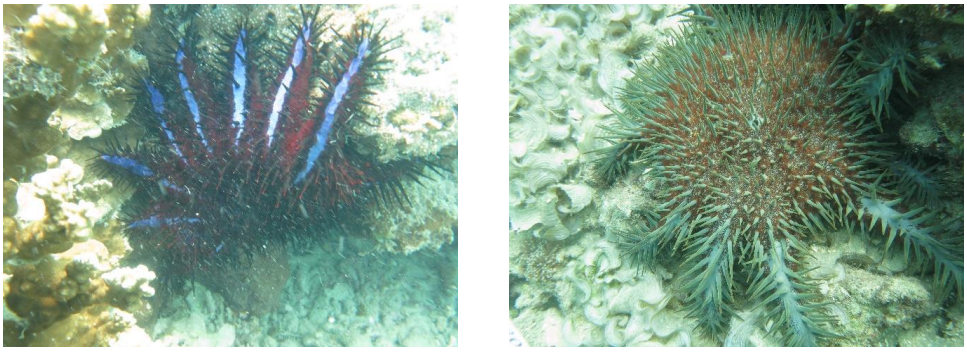

Fig 7. Types of Crown-of-torns starfish (*Acanthaster planci*) Found at the Water Observation Station of the Seribu Islands National Park

In this monitoring activity, the Crown-of-torns starfish (*Acanthaster planci*) was only found in a small number of individuals, but its presence needs to be watched out for considering the reproductive strategy of this species. Under stress conditions, *Acanthaster planci* will accelerate the process of gonad maturation and immediately lay eggs by releasing large numbers of eggs [15]. In addition, the relatively long lifespan of planktonic larvae allows for a reasonably wide dispersal following the pattern of water currents. It will eventually grow and reproduce after finding suitable habitat. The absence of natural predators of this species is also a factor to worry about.

Drupella* Snails *(Drupella sp.)

Drupella snails (*Drupella* sp.) are found between dead and live corals. *Drupella* snails (*Drupella* sp.) were found at eight observation stations in the waters of the Seribu Islands National Park. The density of drupella snails (*Drupella* sp.) ranged from 71 – 429 ind/ha, with the highest density being on Bira Besar Island (KSBC06). The total density of drupella snail (*Drupella* sp.) was 1,929 ind/ha. The density of drupella snails (*Drupella* sp.) below 1,400 to 6,400 ind/ha is not endemic [16]. *Drupella* sp. is a golden snail who habitually eats coral polyps, especially on branching and massive corals [14]. In small quantities, this type of gold snail does not significantly impact the corals' condition. Still, if there is a population explosion (epidemic), this gold snail can be fatal to coral damage. Ecologically, this coral polyp-eating snail acts as a natural controller of the balance of the coral reef ecosystem. However, the effect will be pretty significant in killing corals if it is present in relatively large aggregations [17]. The types of *Drupella* snails found at the observation station can be seen in Figure 8.

Fig 8. Types of *Drupella* snails Found at the Water Observation Station of the Seribu Islands National Park

Sea urchins (Diadema sp.)

Sea urchins megabenthos (*Diadema* sp.) is the most common megabenthos found in bottom waters where algae, coral debris, live coral, and rocks are found. Sea urchins (*Diadema* sp.) were found in all observation stations in the waters of the Seribu Islands National Park. The highest density was found at Pulau Kayu Angin Genteng station (KSBC07) with a density of 8,719 ind/ha, while the lowest was at Pulau Peteloran Barat (KSBC01) with a density of 357 ind/ha. The total density of sea urchins (*Diadema* sp.) was 43,357 ind/ha. In a study conducted by, in five locations, the difference in density of sea urchins (*Diadema* sp.), namely: in Uyombo, as many as 8,250 ind/ha, in Kanani, as many as 4,710 ind/ha, in Lambis as many as 2,125 ind/ha. In addition, 690 ind/ha in Coral Gardens and 785 ind/ha in Bennets, but no statistically significant difference but had little effect on the coral cover. It is estimated that 30% of macroalgae cover changes can be caused by sea urchins (*Diadema* sp.) [18]. Several types of sea urchins (*Diadema* sp.) found at the observation station can be seen in Figure 9.

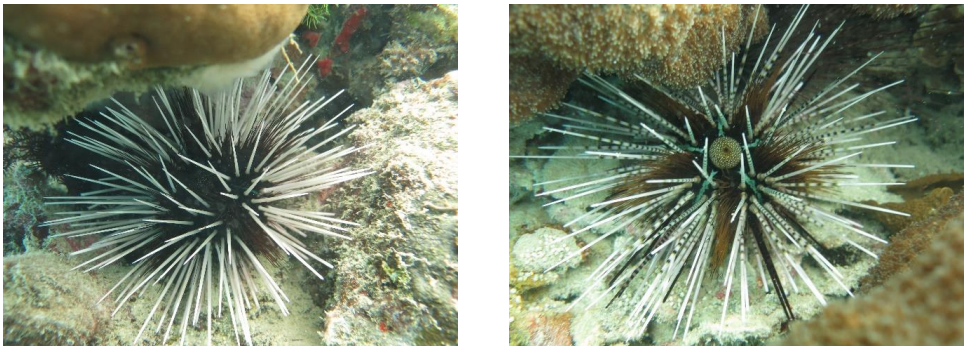

Fig 9. Types of Sea urchins (*Diadema* sp.) Found in the Water Observation Station of the Seribu Islands National Park

Sea urchin (*Diadema* sp.) is one of the bioindicators of coral health, where its presence in large numbers indicates unhealthy corals [19]. Furthermore, *Diadema setosum* in coral reef ecosystems plays a role in cleaning algae that grow on dead coral that has been overgrown with algae, according to its nature in terms of foraging as algae eaters. Therefore, this black sea urchin has a beneficial role for coral reef ecosystems because it helps clean algae, thus allowing corals to grow properly after the substrate is cleaned by *Diadema setosum* from the presence of algae [17].

Conclusion

Megabenthos in the Seribu Islands National Park waters are in various conditions. Groups of clams megabenthos (*Tridacna* sp.) and lola (*Trochus* sp.), which have significant economic value, can still be found in several observation stations with relatively few individuals. The existence of megabenthos Crown-of-torns starfish (*Acanthaster planci*), sea urchins (*Diadema* sp.), and drupella snails (*Drupella* sp.) have not endangered coral life in the waters of the Seribu Islands National Park.

Acknowledgement

We would like to acknowledge the contributions the funding research from COREMAP-CTI and Research Centre for Oceanography, National Research and Innovation Agency, Indonesia.

References

1. R.M. Siringoringo, M. Abrar, N.W.P. Sari, D. Nurdiansah, L.O. Alivatri, R.D. Putra, I.P. Putra, & D. Kurniawan. *Monitoring Kondisi Terumbu Karang dan Ekosistem Terkait di Kepulauan Seribu dan Sekitarnya Tahun 2021*. Pusat Riset Oseanografi Badan Riset dan Inovasi Nasional (2021)
2. T. Febrianto, R.M. Siringoringo, R.D. Putra, D. Kurniawan, N.W.P. Sari, Jumsurizal, Khairunnisa, M. Firdaus, & M. Abrar. *The condition of the coral reef ecosystem in Natuna Island*. IOP Conf. Ser.: Earth Environ. Sci., **744**, 012019. (2021) https://doi.org/10.1088/1755-1315/744/1/012019
3. Suharsono & O.K. Sumadhiharga (ed). *Panduan Monitoring: Kesehatan Terumbu Karang*. COREMAP – CTI, Lembaga Ilmu Pengetahuan Indonesia (LIPI). Jakarta. (2014)
4. D. Kurniawan, T. Febrianto, Jumsurizal, & R.D. Putra. *The coral reef health index in Teluk Sebong, Bintan Island*. IOP Conf. Ser.: Earth Environ. Sci., **763**, 012066. (2021) https://doi.org/10.1088/1755-1315/763/1/012066
5. T. Ganesh, & A.V. Raman. Macrobenthic community structure of the Northeast Indian Shelf Bay of Bengal. Mar. Ecol. Prog. Ser, **341**: 59-73 pp. (2007)
6. J.M. Teal. *Primary production of benthic and pringing plant communities*. in: Barnes, R.S.K. & K.H. Mann (eds). *Biology of polluted waters*. Blackwell Scientific Publications. Oxford, London. (1980)
7. J.F. Wilhm. *Biological indicator of pollution*. in: Whitton, B.A. (ed.). *River ecology*. Blackwell Scientific Publications. Oxford, London. (1975)
8. H. Zulkifli, & D. Setiawan. Struktur Komunitas Makrozoobentos di Perairan Sungai Musi Kawasan Pulokerto sebagai Instrumen Biomonitoring. J. Natur Indonesia. **14(01)**: 95–99. (2012) https://doi.org/10.31258/jnat.14.1.95-99
9. B.W. Mutaqin, E.P. Yuendini, B. Aditya, I.N. Rachmi, M.I. Fathurrizqi, S.I. Damayanti, S.N. Ahadiah, & N.N.A. Puspitasari. Kelimpahan Megabentos sebagai Indikator Kesehatan Karang di Perairan Bilik, Taman Nasional Baluran, Indonesia. J. Enggano, **5(2)**:181-194. (2020) https://doi.org/10.31186/jenggano.5.2.181-194
10. Y. Loya. *Plotless and Transect Methods*, in: Stoddard, D.R., and R.E. Johannes, Coral Reef Research Methods, Paris (UNESCO): 22–32. (1978)
11. J.E. Brower, J.H. Zar, & C.N. von Ende. *Field and laboratory methods for general ecology*. WCB McGraw-Hill, Boston. (1998)
12. U.Y. Arbi, H.A.W. Cappenberg, & H.F. Sihaloho. *Monitoring Megabenthos*. Panduan Kesehatan Terumbu Karang. Pusat Penelitian Oseanografi LIPI. Jakarta. (2014)

13. J.T. Harvey. *Abundance. Encyclopedia of Ecology* (ed. by S.E.J. Fath and D. Brian), pp. 4-10. Academic Press, Oxford. (2008)
14. U.Y. Arbi. Drupella spp. (Muricidae: Mollusca): Siput pemakan karang. OSEANA. **XXXIV(3)**: 19-24. (2009)
15. A. Setyastuti. Biologi dan Ekologi Bintang Laut Mahkota Duri, (*Acanthaster planci*). (2009). OSEANA. **XXXIV(4)**. 17-24. (2009)
16. R.L. Cumming. *Population outbreaks and large aggregations of Drupella on the Great Barrier Reef*. Great Barrier Reef Marine Park Authority. (2009)
17. M. Abrar, Giyanto, R.M. Siringoringo, I.N. Edrus, U.Y. Arbi, H.F. Sihaloho, A. Salatalohi, and Sutiadi. *Baseline Survei Kesehatan Terumbu Karang dan Ekosistem Terkait di TWP Pulau Pieh dan Laut di Sekitarnya*. Pusat Penelitian Oseanografi LIPI. Jakarta. (2014)
18. S. Tyrrell. *The Distribution and impact of Sea urchins on Coral reefs in Watamu, Kenya*. Dissertation. Faculty of Geography. University of Exeter. (2014)
19. I.B. Vimono. Sekilas Mengenai Landak Laut. OSEANA. **XXXII(3)**: 15-21. (2007)