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Research Article

Inventory of Marine Fauna on Reef Balls Structures of Selingan Island, Sandakan, Sabah, Malaysia

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Abstract

Selingan Island is well known as a turtle sanctuary in Sandakan, Sabah. However, beach erosion has affected both infrastructure and turtle nesting grounds on the island. As one of the solutions, stone revetment and reef ball structures were deployed at the southeast part of the island in 2005 and 2007, respectively. The uneven stony surface of reef ball structures creates tiny pockets of space for attachment and colonization of coral larvae and sessile invertebrates. The objectives of this study are to determine the condition of the reef ball structures and to identify the types of marine fauna within these structures. The field surveys were carried out in May and December 2017. The survey area covered the 120 m length of balls structures for inventory of marine fauna using random quadrat sampling and observation of the reef balls condition. The survey areas were divided into Part 1 (1-40 m), Part II (40-80 m) and Part III (80-120 m) from the shoreline of the island. There was only one reef ball unit damaged and others were intact with encrusting marine invertebrates and other associated marine life. The structures of the reef balls play an important role as an artificial marine habitat. A total of 3,583 individual (298 inv/m^{-2}) of invertebrates (barnacles, bivalves, limpets and gastropods) were identified and 26 marine fauna species comprising of fishes, algae and corals associated with the reef balls structures. The marine fauna was expected to be higher if the survey could be done at the different tidal cycles, weather conditions and increase number of the survey. The findings provide insight of marine fauna at the reef balls structure in Selingan Island and enhance baseline data for marine resources management in the marine protected area of Turtle Island Parks.

Keywords: reef balls, habitat, fauna, marine protected area, Selingan Island

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Introduction

The shoreline protection such as submerged breakwater, sea walls, stone revetment and artificial reefs are installed along the shoreline to protect the beach and property from erosion. These structures act as additional physical substrate for various marine fauna and enhance biodiversity in the coastal areas (Harris, 2001; Sherman et al., 2002). For example, encrusting invertebrates are commonly found organisms on a man-made structure such as sea wall (Lee et al., 2009; Lai et al., 2018) and reef balls (Barber & Barber, 1996) and further improve the attenuation of wave energy, enhance water quality and as food sources for humans (Nelson, 2004).

Selingan Island is one of the three Turtle Islands, located about 40km from Sandakan (Sabah) on the edge of the Malaysia-Philippines international border. This island is very important as it provides nesting beaches for the endangered green turtle (*Chelonia mydas*) and the critically endangered hawksbill turtle (*Eretmochelys imbricata*). The annual nesting recorded for the green and hawksbill turtles range between 3000 to 8000, and 50 - 179, respectively (Joseph, 2017). Selingan Island has a long history of sea turtle conservation, where it was started in the 1930s by the North Borneo British Company, and in 1977 Selingan together with the other two islands (Gulisaan & Bakkungaan Kecil) was gazetted as the Turtle Islands Park (Chan & Liew, 1997), currently under the management of the Sabah Parks. However, beach erosion in the southern part of the island is the biggest challenge faced by the local authority. This contributes to loss of the turtle's nesting area and damages on infrastructure such as the Sabah Park's office and jetty (Razak et al., 2015). As a solution, Sabah Parks has deployed two types of shoreline protection; the stone revetment and reef balls.

The Sabah State Government allocated about RM1, 880,000.00 to install 290 units of reef balls (Goliath balls) at the southeast part of Selingan Island in 2007. These reef balls were set up as a submerged breakwater and as an additional structure to the stone revetment deployed in 2005. Most reef balls used as shoreline protection are deployed in deeper water, are constantly submerged and located further offshore (Sherman et al., 2002; Harris, 2009). Reef balls were identified as the best option for this island after considering the turtles' access to the beach, aesthetics, and tidal range condition. Based on the Sabah Parks information, the length of the reef balls is estimated at 470 m. However, a satellite image from Google Earth (2020) indicates that the length of the exposed reef ball was only 180 m and the others in the area are probably buried by the sand at the south of the island. The objectives of this study are to

determine the condition of the reef balls as shoreline protection and to identify marine fauna present within the reef ball's structures.

Materials and Methods

The reef ball layout at Selingan Island ($6^0$10'20.63" N, $118^0$03'37.32" E) is in L mirror shape arrangement and built almost parallel to the beach at the south of the stone revetment (Figure 1). The reef balls were supplied by Reef Ball Asia Sdn. Bhd. to Sabah Parks to tackle beach erosion by reducing current and wave action to the beach. The reef balls were set up into three segmented breakwater sections and use three rows of Reef Ball ™ units for each segment. Reef balls imitate a natural system with varying size of holes. The holes in the interior cavity are smaller than the exterior to create a whirlpool and upwelling effect to nourish marine life attached to the reef (Banerjee, 1994; Reef Ball Foundation, 2017).

The field surveys were carried out on 23 to 24 May 2017 and 27 to 28 December 2017. The survey area was divided into three parts (Figure 1); Part 1 (1- 40 m), Part II (40-80 m) and Part III (80-120 m) of the island. The reef balls survey area started from the shoreline towards the offshore covering about 120m length of the reef balls. The condition of the reef balls was recorded and compared with a survey done in 2011 (Sabah Parks & UMS, 2013). A total of 24 quadrats (50 cm x 50 cm) were randomly placed on the top and middle part of the reef balls to estimate the total number of individual marine fauna. At the same time, gliding and snorkelling for other associated marine fauna around the reef balls structures were carried out by taking photographs for further identification to the lowest taxa (Calumpong & Menez, 1997; Wood & Aw, 2002). No sample was taken as this study site is located at a marine protected area.

Results and Discussion

The 11 years of reef balls deployment in Selingan Island has played an important role in shoreline protection and preserved the turtle nesting areas for the island (Chen et al., 2018). During low tide, the reef ball structures are totally exposed, partially exposed and submerged at Part 1, Part II and Part III, respectively. The reef balls provide a physical structure and substrate to support primary and secondary production (Lee et al., 2009; Harris, 2001; Lai et al., 2018). Throughout the surveys, the reef balls installed in the Turtle Islands Parks were intact and in good conditions except for one broken reef ball unit encountered at Part II.

Reef ball structures and marine fauna at Part I

The most dynamic area of Selingan Island is located at the south of the island where the formation of a sandbar was periodically observed (Chen et al., 2018). Sand accumulated on the reef balls changed based on the direction of wind-waves and local currents. In 2011, the reef balls at part I was buried by sand (Figure 2a) and connected to the island (Sabah Parks & UMS, 2013).

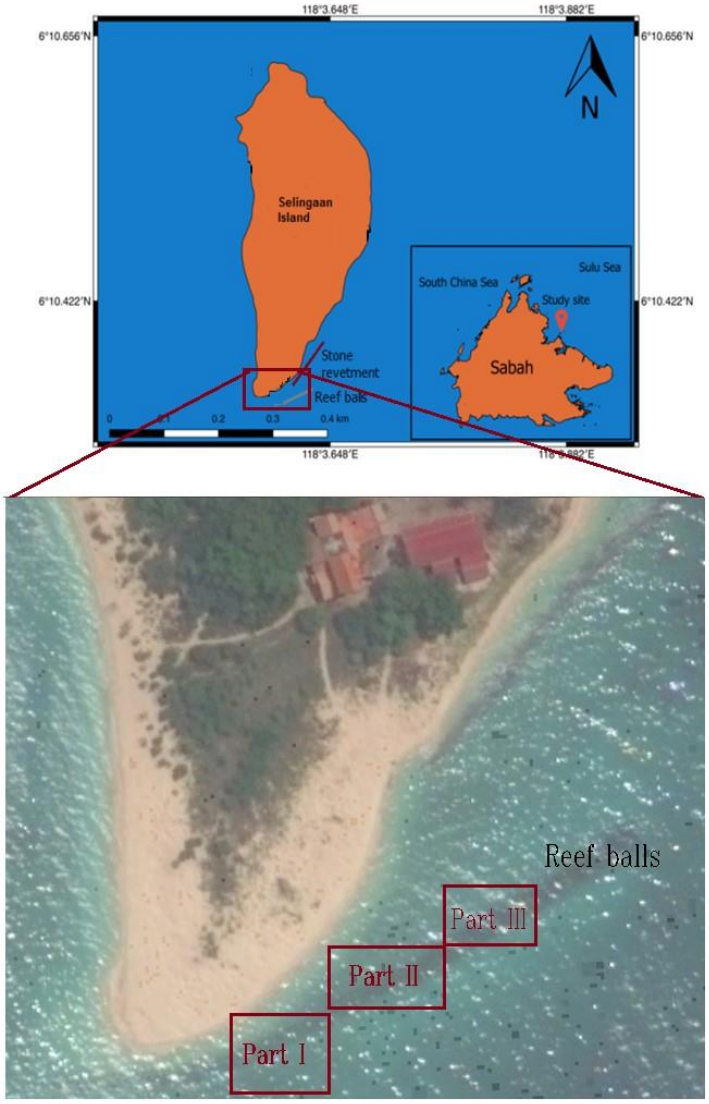

Figure 1. Location of the reef balls and survey area at southeast of Selingan Island (Source: Google Earth 2020)

In in 2017, half of the reef balls structures in Part I were exposed and separated about 5 m from the shoreline during the survey (Figure 2b). The submerged crevices top of the reef balls provides a hiding habitat for snails (Figure 2c) while oysters and barnacles dominated the bottom part of the reef balls (Figure 2d). Part I of the survey area has a lower number of marine fauna as the reef balls have longer exposure time to the sun during low tide. The level of the exposure is dependent on the tidal condition, local currents influencing the sediment transport and seasonal monsoons (Saleh et al., 2013).

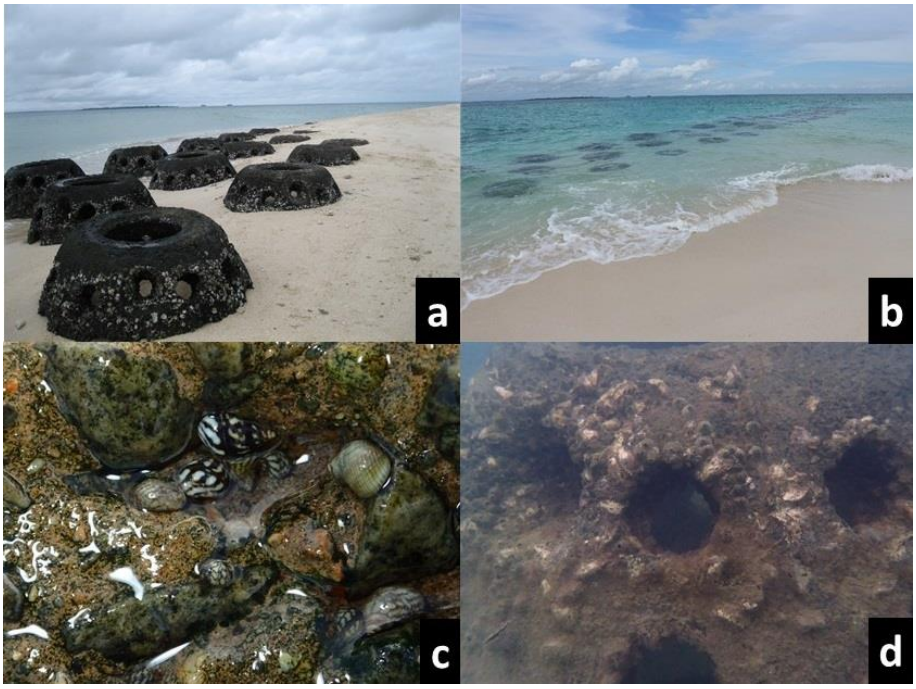

Figure 2. Reef balls in Part I partially covered by sand, (a) exposure during love tide, and (b) submerged during high tide. Various types of sea snails found on the top area of the reef balls (c), and oysters found on the submerged area of the reef balls (d).

Reef balls structures and marine fauna at Part II

Strong waves during storms and exposed to the air during low tide may limit marine organisms occupying the upper part of the reef ball structures in Part II. Both the outer and inner surfaces of reef balls were occupied with oysters, barnacles and limpets (Figure 3a). Most oysters and barnacles were dominated at the top and middle of the reef ball structures while re-suspended sand buried the base (lower part) of the reef balls. Limpet and sea snail species play a major

role in controlling the algal community since algae are their main diet (Dayton, 1971; Lubchenco, 1978; Nicotri, 1977).

The sand can be transported elsewhere if the surrounding current pattern and wave actions change. The damaged reef ball (Figure 3b) and small coral colonies were covered by sand at the base of the reef balls (Figure 3c). School of juvenile fish were observed swimming within reef balls structures (Figure 3d).

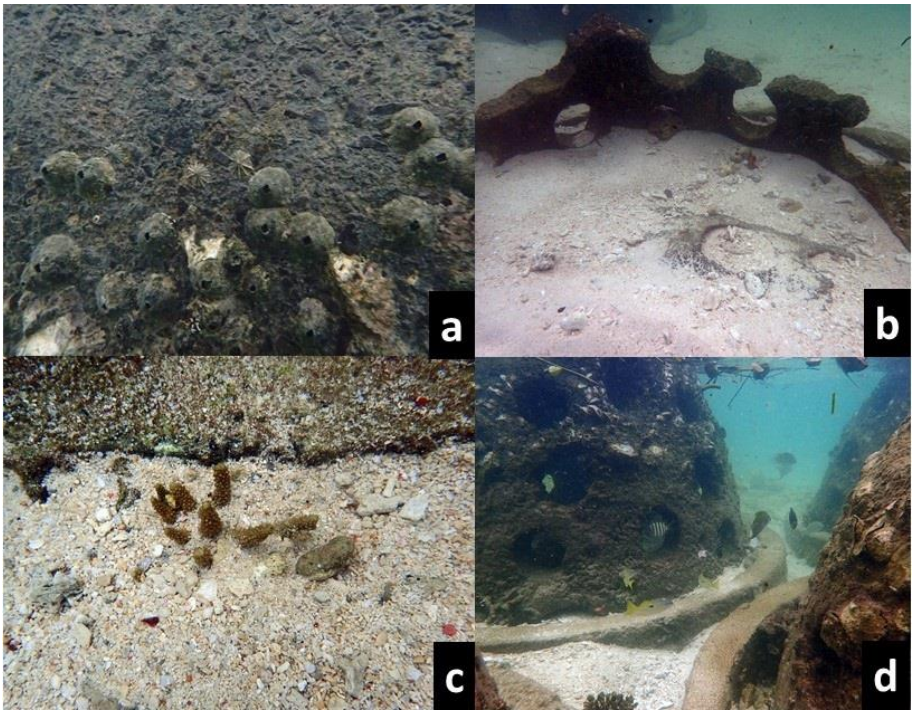

Figure 3. Reef balls in Part II. (a) reef balls structures dominated by barnacles and (b) only one unit of reef ball was damaged. (c) Small coral colonies growing on the base and partially covered by sand and (d) juvenile fish from various species swimming within reef balls.

Reef ball structures and marine fauna at Part III

Full structures of the reef balls were observed at Part III. Several reef balls have signs of scouring processes at the base of the reef balls and provide a larger substrate area for epiphytic species (algae, cyanobacteria, biofilm and diatoms) to growth. Present of epiphytic species increase food availability and promote settlement of the other associated marine fauna such as rabbitfish and butterflyfish (Figure 5a) which is a health indictor of coral colonies and to

support the population of corallivores (Hourigan et al., 1988). The water is clear where algae and corals (Figure 5b) adapt with the surrounding environment. The highest abundance and diverse marine life are found in Part III compared to Part Iand Part II (Figure 4). Most of the species listed in Table 2 are found in Part III.

The highest associated marine fauna species identified at the reef balls belong to the class of Actinopterygii (ray-finned fish) such as damselfishes, parrotfish, wrasses and butterflyfish with estimated average size less than 12 cm in length. Other species are blenny fish that live within crevices or soft corals (Figure 4c) while black damselfish known as territorial marine fish swim around reef balls. Echinoidea (*Diadema* sp and *Heterocentrotus* sp) were spotted hiding among the reef ball's crevices in Part II and Part III (Figure 4d).

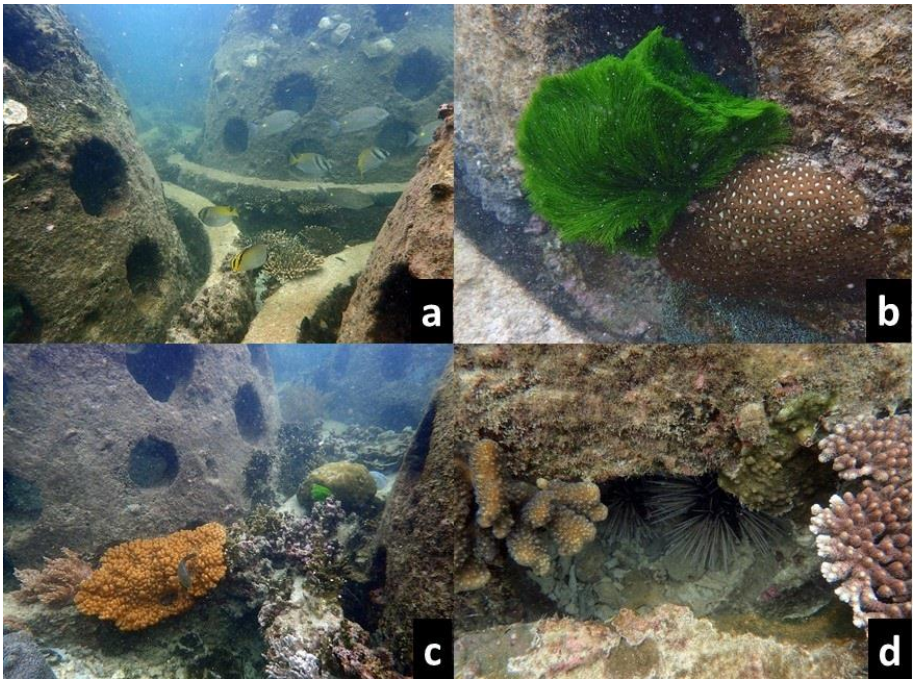

Figure 4. Diverse of organism living among reef balls at Part III. (a) Rabbitfish and butterflyfish swimming within the reef ball. The surface of reef balls provided a substrate for (b) green algae, hard corals and (c) soft coral to settle and thrive. Reef ball provides a structural hideout for invertebrate such as (d) sea urchin.

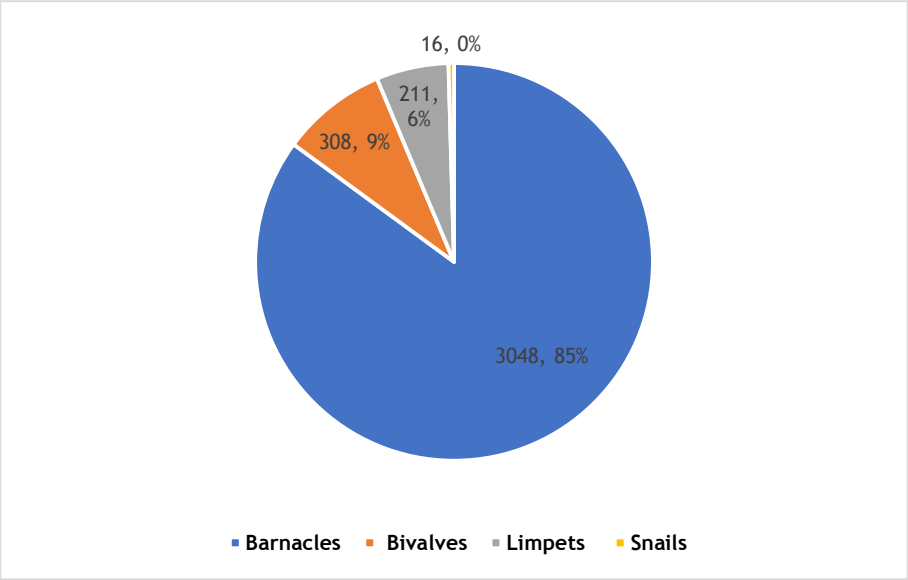

Figure 5. Percentage and number of individual of invertebrates found on reef balls from 24 quadrats.

Inventory of the marine fauna at reef balls area

Marine fauna on hard structures can be ranked according to their ability to colonise and compete for space which are greatly influenced by the historical components, predation, reproduction and abundance of settling larvae (Osman, 1977). During their larval stage, the survival, growth and colonization depends on the ability to cope with the surrounding environment (Garland & Zimmer, 2002). These species also prefer sand-rock or seawalls as substrate areas (Batomalaque et al., (2010) Lee et al., 2009; Lai et al., 2018). A total of 3,583 individual marine fauna were counted within the 24 quadrats (Table 1). A total of 3,048 individuals (83.57%) from the total fauna identified are barnacles (*Tetraclita multicostata*, *Tetraclita porosa* and *Tetraclita* sp.) (Table 1: Figure 5). On the other hand, 308 individuals (8.60%) of bivalves, consist of *Saccostrea cucullata*, *Xenostrobus* sp. and *Isognomon perna*. Limpets consist of 22 individuals (5.89 %) from the genus of *Cellana, Patelloida*, *Siphonaria* while 16 (0.33%) individuals of snails from the genus of *Nodilittorina* sp., *Tubro* sp. There were also unidentified species from the group of limpet and snails (Figure 5; Table 1).

Table 1. Inventory of invertebrates from 24 quadrats on the reef balls structure

Class	Common name	Species	No of organisms
Maxillopoda	Barnacles	*Tetraclita multicostata*	2593
		Tetraclita porosa	447
		Tetraclita sp.	8
Bivalvia	Oysters	*Isognomon perna*	27
		Saccostrea cucullata	171
		Xenostrobus sp.	110
Gastropod	Limpets	*Cellana rota*	1
		Cellana sp.	25
		Patelloida saccharinoides	20
		Patella sp. (1)	22
		Patella sp. (2)	3
		Siphonaria atria	13
		Siphonaria javanica	45
		Siphonaria sp. (1)	19
		Siphonaria sp. (2)	36
		Unidentified (1)	26
		Unidentified (2)	1
	Sea snails	*Nodilittorina* sp.	2
		Turbo sp.	5
		Unidentified genus (1)	7
		Unidentified genus (2)	2

A total of six classes (Gastropod, Holothuroidea, Bivalvia, Actinopterygii, Anthozoa and Echinoidea) of associated marine fauna were identified (Table 2). Bivalvia (*Tridacna* sp) and various types of Anthozoa (hard and soft corals) were found on the base of the reef balls as this area is constantly submerged and less exposed to wave actions (Figure 3c). A variety branching, tabletop and massive corals grow on the reef balls that may create a microhabitat for juveniles of rabbitfish, parrotfish snapper, silver pomfret and butterflyfish (Figure 4a and Table 2). Some corals that grow inside the reef balls provide extra habitat within the reef balls. Reef balls also provide hard substrate surface to colourful anemone species and macroalgae such as red and green algae (Figure 4b). The marine fauna identified (Table 2) are generally small in size. These indicate that the reef ball structures may provide a temporal or nursery habitat in Turtle Island Parks.

Table 2. Inventory of associated marine fauna within reef balls

Class	Common name	Genus / Species	Malay name
Bivalvia	Giant clam	*Tridacna maxima*	Kima
	Giant clam	*Tridacna crocea*	Kima
Gastropod	Cowrie	*Cypraea* sp	siput
Holothuroidea	Black sea cucumber	*Holothuria atra*	Timun laut
	Black sea cucumber	*Halothuria leucospilota*	Timun laut
Echinoidea	Long spine sea urchin	*Diadema setosum*	Landak laut
	Pencil urchin	*Heterocentrotus* sp	Landak laut
Actinopterygii	Indo-Pacific sergeant	*Abudefduf vaigiensis*	
	Silver pomfret	*Pampus argenteus*	Bawal perak
	Ocellaris clown fish	*Amphiprion ocellaris*	Nemo
	Golden spot rabbit fish	*Siganus guttatus*	belais
	Two bar rabbit fish	*Siganus doliatus*	belais
	Parrotfish	*Scarus* sp	bayan
	Longfin damselfish	*Stegastes diencaeus*	
	Black spot snapper	*Lutjanus fluviflamma*	Pisang-pisang
	Copper band butterflyfish	*Chelmon rostratus*	
	Lined butterflyfish	*Chaetodon* sp	
	Cleaner wrasse	*Labroides dimidiatus*	
	Moon wrasse	*Thalassoma lunare*	
	Blenny	*Salarias* sp	
	Saw jawed monocle bream	*Scolopsis ciliata*	
Anthozoa	Table coral	*Acropora* sp	
	Coral	*Montipora* sp	
	Stony coral	*Oxypora* sp	
	Leather coral	*Sinularia* sp	
	Sea anemone	*Heteractis* sp	

Conclusion

There was no major change of the reef ball physical structure in Selingan Island between 2011 and 2017 except for encrusting invertebrates on reef balls. The dynamics of sand at southern part of the island affect the reef ball structures and the distribution of marine fauna. Reef ball structures located closer to the beach (Part I) was partially buried by sand as a scouring process occurs further offshore (Part III). Temporally accumulation of sand occurs in this area as several marine fauna were buried alive while the scouring process creates a hiding space for many marine life at the base of the reef balls.

The reef balls at Selingan Island play an important role as a refuge site, food source, settling substrate and habitat of various marine fauna. A total of 3,583 individual invertebrates on the reef ball structures and 6 classes of associated marine fauna were recorded during this survey. The most abundant species are

barnacles followed by bivalves, limpets and snails. Diversity of marine fauna increased from Part I to Part III of the survey areas.

The reef balls in Selingan Island provide shoreline protection and enhance the marine habitat for Turtle Island Marine Park. The presence of butterflyfish indicates a healthy habitat condition within the reef ball structures. The finding provides baseline data and an insight of marine fauna within the reef ball structures. A number of fauna could not be identified to the lower taxa due to poor pictures quality for species identification. The inventory of the marine fauna can be improved by increasing survey areas and time of observation. Tidal cycles and seasonal monsoons need to also be considered for the next survey.

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