Diversity of Benthic Organisms on Artificial Reef Structure

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Abstract. One of the methods of a marine rehabilitation program to accelerate the recovery of damaged coral reefs is to make artificial reefs as a new coral growth substrate. Interestingly, many benthic invertebrates overgrowth the artificial reef structures. The purpose of this study was to investigate the benthic organisms encrusting the artificial reefs including the cement and iron substrates. In June 2018, 10 artificial reef structures were deployed in 7-8 m depth around Putri Island, Belinyu, Bangka Regency. The artificial reef structures were made in the form of an iron frame with a cement concrete weight. Colonization of sessile benthic organisms is generally marine invertebrates; Scleractinia corals, sponges, bivalves, hydrozoa, bryozoa, soft corals, gastropoda, crinoid, ascidian, and gorgonian. Natural recruited coral Pocillopora sp. was found in all artificial reef structures with colony sizes 3-8cm and surprisingly only coral pocillopora found adhered in iron frames and sinkers. The other benthic organisms are sponge, crinoid, and bryozoa with the number of densities are 2 organism/m². Meanwhile, the lowest benthic density are groups of Mollusc and Ascidian with organism/m². The type of succession that occurs in this research was likely a primary succession. The preference of benthic organisms among reefs appeared to be related to the proximity of natural hard-bottom habitat and type of iron and coating materials.

1. Introduction
Coral reefs are an important ecosystem in the shallow water of the tropical and sub-tropical area, where they provide food and habitat for a wide range of marine organisms and support many ecological services [1]. The abundance and diversity of the marine organisms that make up a coral reef are linked to the health of surrounding environments. Furthermore, the resources derived from coral reefs are substantial to the food security of millions of people living within coastal communities. Unfortunately, coral reef ecosystems are threatened by natural change (e.g., global warming, cyclones, and disease) and anthropogenic pressures (e.g., sedimentation, pollution, and fisheries exploitation) [2]. An ecosystem has the capability to restore from degradation is eroded by any disturbance’s factors [1]. The declining coral cover will cause coral degradation and subsequent changes in the benthic community composition. The shift of the coral reef community includes stony corals composition, macroalgae, sponge, and other benthic organisms [3]. Even though these other benthic organisms are components of reef structures, stony coral domination is preferable for the reef health index.

This condition also occurs in Bangka Belitung Island, Indonesia, where the main cause of coral reef degradation is highly sedimented flows from tin mining activity in the terrestrial and shoreline region. The mining activities were spread out from terrestrial area to coastline leaving the impact on heavy metal pollution and high sedimentation. Most reef-building corals reef grows in clear and shallow water that is penetrated by the sunlight to help the symbiotic algae carrying out the photosynthetic cycles. Such mutual relationship involved with coral polyps provide the symbiotic algae a home, and in
exchange, the algae provide the coral polyps with the food they generate through photosynthesis. Thus, when the coral polyps are covered by sediment or rubbish, coral could not perform photosynthesis leaving the coral polyps devastated and leading to coral mortality in a long-term threat [4]. Stony corals are slow-growing marine invertebrates and have a weak expansion of hard skeletal structures. They also have to compete with other non-reef-building organisms for dominance [5,6]. Environmental disturbances on coral reefs may change the species composition of benthic organisms and lead to declining of reef-building species [7]. In the present research, we describe marine benthic communities collected from Putri Island, Bangka regency. The main objective of the study was to characterize the diversity, density, and variability of the marine benthic community to better understand and predict its dynamics. This study will also contribute to the establishment of a long-term monitoring program of the seabed communities and enhance the ability to detect changes in marine benthic organisms caused by natural and anthropogenic activities.

2. Research Methods
2.1 Location and Period
The study site was located in Putri Island in Bangka Region (coordinates: 105°41'46", 479" E; 1°31'49",630" S). Putri Island is free from tin mining activity but affected in receiving the sedimentation mainly from Kelabat Bay where the offshore tin mining activity was still carried out (distance 10km). This site has a sandy and rocky shoreline with sand and a mixture of silt substrate.

2.2 Data collection
The fringing reef was located in-depth 4-6 m while the artificial reef was drowned in 7m. Thirty artificial reef structure was drowned, but only 10 frames was measured for the study. The iron metal frame and concrete cement were chosen as the material of reef structure because inexpensive and locally available. The artificial reef was made from the iron frame in a half ball shape with the size 2x2x1.4 m, each artificial reef has 8 sinkers made from concrete cement on each side to keep them in balance. The iron frame was made with many holes to prevent sediment accumulation, penetrate the sunlight, and facilitate the fish movement. The artificial reef was drowned in June 2018 and the benthic data monitoring was taken in February 2020. The survey was performed by using SCUBA gear equipment and digital imaging.

2.3 Analysis data
In order to assess patterns of benthic community structure, we calculated the mean percent cover of each benthic category within each of the 10 frames. The sessile organisms adhered in iron frame and sinker was counted as benthic organisms including natural recruited coral, soft coral, algae, gorgonians, sponges, and any other benthic marine invertebrates. The substrate identity that occupied the most area within each frames was recorded for each of 3 major categories (stony corals, other sessile organisms, and non-living substrate) within 10 artificial reef structures. Other sessile organisms were classified in 5 groups: gorgonians (including soft corals and sea fans), sponges, sea anemones, or zoanthids (zoantharians), crinoids, hydroids, and bryozoans.

3. Result and Discussions
The artificial reef that was drowned in 2018 showed good results on benthic group association attached in the iron frame and the sinkers. The artificial reef structure was overgrown by some groups of marine invertebrates such as hard coral, soft coral, gorgonian, mollusk, sponge, ascidian, Crinoidea, hydroids, and bryozoa. One hard coral species from Genus Pocillopora was found attached in iron frame reef structure but not in cement sinkers, while Genus Nepthea of soft coral was also found hanging on the iron frame. Sea fans from the groups of Melithaeidae also found from colony form and individual size. Sponges from the Phylum Porifera include Haliclona, Desmapsamma, Aplysina, Hymeniacidon, and other unidentified sponges. The unidentified sponge was discovered in encrusting life form covering the iron frame from the short size 3cm until 10cm, the unidentified sponge was still counted for density
analysis. The encrusting sponge will overgrow the live tissues of corals in the northern Red Sea [5]. Sponges invasion may be enhanced under environmental conditions that are stressful to corals but preferable for sponges, such as low irradiance or high sedimentation levels, and following other decline causes as coral bleaching, disease, or predator attacks. Thus, process of coral competition with sponges and other sessile organisms may result in different outcomes than for coral–coral competition [8]. The competitive winner gained by non-reef builders under the above conditions can lead to reduced Scleractinian coral cover and eventual replacement by the alternate dominants. In the mollusk groups, only pectinia and drupella snail were found attached in the iron frame with a very low number. Other sessile invertebrates are ascidian (genus: botrylloides), Crinoidea, hydoid (genus: aglaophenia), and bryozoa (Triphyllozo0 inornatum). There were no macroalgae found in the iron frame, but turf algae and small sediment particles covering the whole reef structure. Turf algae were the dominant benthic organisms on many of the iron frames examined (87% cover) while other macroalgal types were rare. The complete taxa of marine benthic organisms found in 10 iron frames of artificial reef structure can be found in Table 1.

Table 1. Marine benthic organisms attached in iron frame of reef structure

| Taxa                      |                     |
|---------------------------|---------------------|
| Hard coral                | Bivalve             |
| *Pocillopora damicornis*  | Pectinia            |
| Gorgonian                 | Gastropod           |
| Melithaeidae              | Drupella            |
| Soft Coral                | Ascidian            |
| Nepthea                   | Botrylloides        |
| Sponge                    | Crinoidea           |
| Haliclonia                | Comatulidae         |
| Desmapsamma               | Hydroidea           |
| Aplysina                  | Aglaophenia sp.     |
| Hymeniacidon              | Bryozoa             |
| Other encrusting sponge   | *Triphyllozo0 inornatum* |

Figure 1 showed the density number of each benthic organisms per meter square. The density number of benthic organisms showed that hard coral from *Pocillopora damicornis* dominates the 10 iron structure frame with 3 colonies per meter square. The coral was naturally settled and be able to grow in a healthy colony. While the coral cover in the surrounding area was dominated by massive corals like porites and branching coral (e.g. acropora), but strangely no acropora colony was found in the iron frame. Another finding mention in their journal is that larvae of *P. damicornis* have greater adaptation into thermal stress than *Acropora tenuis* [9]. They also revealed that the adult colony of *P. damicornis* has a higher respiration rate than *A. tenuis* in all temperature range. Their previous study also revealed that *P.damicornis* harbor multiple Symbiodium types in their colony such as type A and C, while *A.tenuis* only harbor 1 Symbiodium type [10]. Multiple symbiont types will benefit the coral to survive especially during environmental stress by shuffling their existence Symbiodinium inside their tissue as most coral reefs harbor multiple symbionts in their gastrodermis layer [11,12]. The Symbiodinium shuffling will allow coral reefs to cope with an environmental stressor such as sedimentation near a mining location. The sediment’s particles from the tin mining residual and run off from the mainland will block the light and affecting the coral photosynthesis system, and gradually interfere with coral physiology leading to coral mortality [4].
Other fast-growing invertebrate groups are sponge, crinoid, and bryozoa with 2 colonies per meter square. Those fouling organisms attached in the iron frame during the early colonization stages form a minor benthic component but play an important role in elevating the structural complexity and making it suitable for coral settlement [13]. During the time of placement of artificial reef structure, organisms with larvae or spores in the water are likely to settle fast on the iron frame while some mobile organisms such as fish, gastropod, crustaceans might also encounter and colonize soon after placement. The succession and colonization of coral are faster than other invertebrate groups such as sponge, crinoid, and bryozoa, turf algae, and sediment particles appear to become abundant. [14] describe that different benthic colonization on different reef structures may be affected by the depth of placement, turbidity, geographical area (as some biogeographical locations are naturally richer/poorer in species), and structural complexity of the reef.

4. Conclusion
Future research is required especially on the processes of competition in sessile space occupiers other than Scleractinian corals, such as the sea anemones, zoanthids, ascidians, sponges, and algae that may replace corals on some reefs. Future research will advantage from interdisciplinary approaches that include both macro- and microscopic perspectives to reveal the complexity of competitive processes on coral reefs.

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