Assembled concrete reefs as a stand for coral transplantation on the seabed

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Abstract. Corals are cultured as a multiplication effort to conserve the recovery of coral reef ecosystems in natural habitat or sold as ornamental biota for saltwater aquariums. Coral cultured requires a substrate for the enlargement of transplanted coral tillers, where the substrate must be in accordance with the needs and conditions of the aquatic environment. This assembled concrete reefs as a stand is designed to be resistant to the conditions of the monsoon season sea waters. Artificial reefs made of concrete designed with concrete beam where each beam has a dimension of 1 m in length, 10 cm in width and 10 cm in height are arranged in specific form so that it is easy to assemble to place on the seabed. The test results shown that this structure for 12 months on the seabed is still intact, the position of the structure has not shifted, the transplanted coral has remained attached, natural epiphytes already attached after 1 month and are attached until next 11 months.

1. Introduction
Reefs are also known as a ridge of jagged rock below the surface of the sea, which are places where coral attaches [1], so reefs that are overgrown with coral are called coral reefs which are one of the ecosystems in the sea [2]. Coral is a group of animals that are protected as well as of high economic value, so corals are cultivated as an attempt to multiply conservation of coral reef ecosystems in nature or sold as ornamental biota for sea water aquariums. Coral cultivation requires a substrate for the enlargement of transplanted coral fragment [3], where the substrate must be in accordance with the needs and conditions of the aquatic environment. This Assembled Concrete Reefs [4] is designed to be resistant to the conditions of the monsoon season sea waters.

The concrete material as patented artificial coral [5] forms from a single artificial coral concrete in the form of a tetrapod form [6, 7], a structure with a spatial shape [8] and a semicircle [9] exists, then an artificial reef with blocks that can be combined [10], then from the combined polyethylene pipe
This research goal is to design the artificial reef that can be efficiently assembled and function effectively.

2. Materials and Methods
This research is design and testing the Assembled Concrete Reefs, using custom made concrete beam where each beam has a dimension of 1 m in length, 10 cm in width, 10 cm in height and weigh 23 kg are arranged in specific form so that it is easy to assemble (Figure 1). The concrete beam was connected each other with metal bolt and lock with it nut. In each concrete beam the coral fragment was attached to the metal pole and glued with epoxy [13] (figure 2). The Assembled Concrete Reefs were tested at depth 6 m in the seabed for 12 months (figure 3).

Figure 1. The structure of Assembled Concrete Reefs, consist of 20 beam concrete

Figure 2. A = Metal Pole; B = Metal bolt; C = Coral fragment; D = Epoxy glue
Figure 3. Testing site

2.1. Coral species that become test subject attached to the structure
   a. *Isis hippuris* 25 fragments
   b. *Acropora millepora* 25 fragments

2.2. The parameter was observed once a month for 12 months
   a. The structure intact, using visual observation, the structure positions, and using visual observation
   b. The status of coral transplant fragment attachment, using visual observation
   c. The status of epiphytes attachment, using visual observation
   d. Surface temperature (Celsius), using multiparameter water quality checker with 3 replications
   e. Salinity (ppt), using digital multiparameter water quality checker with 3 replications
   f. Wave height (m), analog scale stick with 3 replications
   g. Current velocity (m/s), using digital water current meter with 3 replications

2.3. The analysis by describing the condition
   a. Structure Condition
   b. For the structure condition the parameter that observed were the structure intact and the structure position due to the wave height (m) and Current velocity (m/s) each month for 12 months.

2.4. Biology condition
For the biology condition the parameter that observed were the status of coral transplant fragment attachment and the status of epiphytes attachment due to the pH, Salinity (ppt) and surface temperature (Celsius) each month for 12 months.

3. Results and Discussions
The result shown that this structure for 12 months on the seabed is still intact, the position of the structure has not shifted, the transplanted coral has remained attached, natural epiphytes already
attached after 1 month and are still attached to 12 months (table 1). The structure can withstand the monsoon season in November 2017 to January 2018.

Table 1. The structure intact

| No | Observation period (month/year) | The structure intact |
|----|---------------------------------|----------------------|
|    |                                 | Not intact | Intact |
| 1  | November 2017                   | ✔          |        |
| 2  | December 2017                   | ✔          |        |
| 3  | January 2018                    | ✔          |        |
| 4  | February 2018                   | ✔          |        |
| 5  | March 2018                      | ✔          |        |
| 6  | April 2018                      | ✔          |        |
| 7  | May 2018                        | ✔          |        |
| 8  | June 2017                       | ✔          |        |
| 9  | July 2018                       | ✔          |        |
| 10 | August 2018                     | ✔          |        |
| 11 | September 2018                  | ✔          |        |
| 12 | October 2018                    | ✔          |        |

Table 2. The structure positions

| No | Observation period (month/year) | The structure positions |
|----|---------------------------------|-------------------------|
|    |                                 | Shifted | Not shifted |
| 1  | November 2017                   | ✔          |            |
| 2  | December 2017                   | ✔          |            |
| 3  | January 2018                    | ✔          |            |
| 4  | February 2018                   | ✔          |            |
| 5  | March 2018                      | ✔          |            |
| 6  | April 2018                      | ✔          |            |
| 7  | May 2018                        | ✔          |            |
| 8  | June 2017                       | ✔          |            |
| 9  | July 2018                       | ✔          |            |
| 10 | August 2018                     | ✔          |            |
| 11 | September 2018                  | ✔          |            |
| 12 | October 2018                    | ✔          |            |

Table 3. The status of coral transplant fragment attachment

| No | Observation period (month/year) | The status of coral transplant fragment attachment |
|----|---------------------------------|-----------------------------------------------|
|    |                                 | Not attached | Attached |
| 1  | November 2017                   | ✔            |         |
| 2  | December 2017                   | ✔            |         |
| 3  | January 2018                    | ✔            |         |
| 4  | February 2018                   | ✔            |         |
| 5  | March 2018                      | ✔            |         |
| 6  | April 2018                      | ✔            |         |
| 7  | May 2018                        | ✔            |         |
| 8  | June 2017                       | ✔            |         |
| 9  | July 2018                       | ✔            |         |
| 10 | August 2018                     | ✔            |         |
| 11 | September 2018                  | ✔            |         |
Table 4. The status of epiphytes attachment

| No | Observation period (month/year) | The status of epiphytes attachment |
|----|---------------------------------|-----------------------------------|
| 1  | November 2017                   | ✔                                 |
| 2  | December 2017                   | ✔                                 |
| 3  | January 2018                    | ✔                                 |
| 4  | February 2018                   | ✔                                 |
| 5  | March 2018                      | ✔                                 |
| 6  | April 2018                      | ✔                                 |
| 7  | May 2018                        | ✔                                 |
| 8  | June 2017                       | ✔                                 |
| 9  | July 2018                       | ✔                                 |
| 10 | August 2018                     | ✔                                 |
| 11 | September 2018                  | ✔                                 |
| 12 | October 2018                    | ✔                                 |

Table 5. The result of average water parameter

| No | Observation period (month/year) | Surface temperature (Celsius) | Salinity (ppt) | Wave height (m) | Current velocity (m/s) |
|----|---------------------------------|------------------------------|---------------|----------------|------------------------|
| 1  | November 2017                   | 29.240                       | 30.35         | 0.67           | 0.36                   |
| 2  | December 2017                   | 29.240                       | 30.35         | 0.67           | 0.36                   |
| 3  | January 2018                    | 29.240                       | 30.31         | 0.67           | 0.37                   |
| 4  | February 2018                   | 29.237                       | 30.28         | 0.65           | 0.36                   |
| 5  | March 2018                      | 29.237                       | 30.28         | 0.65           | 0.36                   |
| 6  | April 2018                      | 29.237                       | 30.28         | 0.64           | 0.36                   |
| 7  | May 2018                        | 29.233                       | 30.26         | 0.64           | 0.36                   |
| 8  | June 2017                       | 29.233                       | 30.26         | 0.64           | 0.36                   |
| 9  | July 2018                       | 29.233                       | 30.26         | 0.64           | 0.37                   |
| 10 | August 2018                     | 29.229                       | 30.25         | 0.66           | 0.38                   |
| 11 | September 2018                  | 29.237                       | 30.28         | 0.66           | 0.37                   |
| 12 | October 2018                    | 29.233                       | 30.29         | 0.66           | 0.37                   |

3.1. Structure condition

The structure is intact and not shifted because at the depth of 6 m the wave energy become decreased from deep to rather shallow waters [14]. The dimension of the structure that form rectangular shape can distribute the wave that make it not shifted [15]. The horizontal wide structure 3 m and total height 20 cm and total weigh 230 kg (figure 1) give hydrodynamic advantage due the wave force [16].

Waves greatly affect the structure of artificial reefs and higher of significant wave height disrupt the structure of artificial reefs efficiently. Water depth additionally affects the wave impact on artificial reefs, in some case the shallow water on artificial reef were found to be unstable [17]. Tseng et al [18] recommend that the deployment of artificial reef at more deeper water than shallow water to avoid impending shipping cruise and the possibly destroying effects of waves. This is also reinforced by research conducted from Miao and Xie [19] the amplitudes of the hydrodynamic force increase with the decrease of water-depth for different wave-direction angle in shallow water, but the peak values appear when the wave-direction is 90° and this condition give the significant impact in the ultra-shallow water the hydrodynamic force increase very evidently with the decrease of water-depth and hydrodynamic force is 3 times larger when than those of deep water and this will affect artificial reef [19]. The impact of waves and currents on artificial reefs in shallow areas is caused by changing...
in energy concentration, as well know transforming occur the wave shoaling. The wave shoaling is an increase in wave height as the wave enters shallow water. The wave shoaling is an increase in wave height when waves enter the shallow water [20]. Reflective coefficient waves on artificial reefs can be used as an alternative to determining the resistance of reefs to waves. Schlurmann et al [21] has proven that in shallow waters the value of reflection coefficient is higher in artificial reef and shallower the water depth over the reef, the better the damping performance of the artificial reef as the transmission coefficient notably decreases and, therefore, the dissipation coefficient and the reflection coefficient significantly increases [22].

3.2. Biology condition
The coral transplant fragment is 100% attached and because it attached using epoxy that can make strong attachment and lasting longer [13]. The coral fragment can tolerate the current velocity 0.36-0.38 m/s that below 0.8 m/s [23], the water temperature in range 29.229 °C - 29.240 °C and salinity in range 30.25 ppt - 30.35 ppt is in the range of annually averaged tolerance limits for coral reefs [24]. The epiphytes attachment to the concrete structure commonly after 1 month [25, 26] and keep growing to cover the concrete surface.

4. Conclusions
The assembled concrete reefs can be a good stand for coral transplantation on the seabed because the structure is intact, the position of the structure has not shifted and the transplanted coral has remained attached and natural epiphytes already attached after 1 month and remained attached.

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