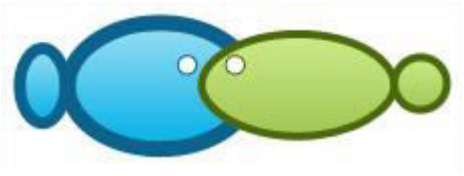

The effect of type and duration of substrate collector placement to the coral genus recruitment in Saleo Beach Area, Dampier Strait, Raja Ampat, Indonesia

[1]Jeremias R. Tuhumena, [2]Ricardo F. Tapilatu, [2]Paulus Boli

[1] Aquatic Resources Study Program, Postgraduate Program, University of Papua (UNIPA); [2] Teaching Staff of the Aquatic Resources Study Program Post Graduate Program at the University of Papua (UNIPA), Manokwari, West Papua Province, Amban Manokwari-Papua Barat, Indonesia. Corresponding author: R. F. Tapilatu, rf.tapilatu@unipa.ac.id

Abstract. The limitation of the substrate for the recruitment of coral species at the Saleo Beach Area is limited due to historic destructive practices such as fishing using explosives and the increase of rubble cover in particular between 2016 and 2017 caused by historical and current human activities. This research was conducted for 6 months using the Coral Recruitment Tile method. This method uses an artificial substrate for coral placement placed at 5-7 meter depth with slope of the substrate of 45°. The purpose of the study was to analyze the influence of the substrate types and its placement, duration, and diversity of attached coral. The results indicated that coral recruitments included the genus *Pocillopora*, *Porites*, *Seriatopora*, *Montipora*, *Stylophora* and *Goniastrea*. The highest coral abundance was recorded in genus Pocillopora with a value of 38.10% while Stylophora and Goniastrea showed the lowest abundance with 1% each. Species diversity was classified as moderate with a value of 1.5. The analysis showed that the placement duration of tiles at sea bottom influences the recruitment of coral species. The placement of substrate for a long time would facilitate new settlements from the reproduction of coral species.
Key Words: coral recruitment, rubble cover, coral placement, species diversity, coral abundance.

Introduction. Coral reefs have many biological functions as food incubator, fishery sites, organism spawning sites, laying eggs sites and shelter for various high-value marine biotas (Nybakken 1988). However, global warming and human activities can damage coral reef ecosystems (Westmacott et al 2000; Giyanto et al 2017).

Corals have both sexual and asexual forms of reproduction. Sexual reproduction involves the fertilization of female gametes, while asexual reproduction involving a number of processes where new colony formation occurs through partial removal of the tissue by fragmentation or bailout polyps. Coral gender is distinguished by hermaphrodite and gonocoric, where hermaphrodite produces male and female gametes in one colony, while gonocoric is a coral that produces male and female gametes individually throughout its life. Corals have two reproductive models namely spawning and brooding (containing larvae) (Richmond 1997).

Raja Ampat Regency has a total area of 4.6 million hectares (Mambrisaw et al 2006), and 553 coral species (Veron et al 2009). However, there have been signs of damage due to destructive fishing (McKenna et al 2002). The Dampier Strait Area is one of the regional aquatic conservation areas (KKPD) in Raja Ampat Regency that has a total area of 336,000 hectares (KEPMEN KP 2014). However, there has been damage to the coral reef ecosystem in this area due to minor illegal fishing activities as was reported by the communities near the sites (Pada et al 2016) and the MV Caledonian Sky grounding which caused damage to a total area of 18,882 m^2 with a significant damaged area of 13,270 m^2 (Tapilatu et al 2017).

Generally, coral transplants are often carried out because these kinds of actions are relatively easy to be done. Transplants are generally seen from a biological view with a survival rate of around 50-100%, when transplanted at the same location where coral fragment were taken (Harriott & Fisk 1988). However, this activity cannot play a role in improving damaged coral reef ecosystems, so that the main factors causing coral reef degradation are understood and addressed (Harriott & Fisk 1988; Ammar et al 2013). Recruitment is an important part of the process of forming and developing communities in a coral reef ecosystem in nature. In other words, recruitment guarantees community formation and provides assurance that this population will be sustainable (Erwin et al 2008). Coral recruitment can use natural substrates or artificial substrates. Research of Harriott & Fisk (1988) used natural substrate such as slices of massive *Porites* spp., slices of massive *Platygyra* spp., thick branches of *Isopora palifera,* the outer of *Platygyra* spp. and branches of *Pocillopora grandis*. Therefore, it is necessary to recruit coral species using artificial collector substrates as was previously done by Birkeland et al (1981) using PVC plates; concrete, gabbro, granite, and sandstone by Burt et al (2009); ceramic substrate by Maida et al (1992) and Mangubhai et al (2007) and concrete by Tioho et al (2001).

The present study aimed to analyze the effect of substrate and its laying duration on the recruitment of coral genus and the diversity of species of coral attached. The type of corals counted for abundance and diversity was the coral genus that attached to the surface of the substrate. Harriott & Fisk (1988) in his research used natural substrates like slices of massive *Porites* spp., slices of massive *Platygyra* spp., thick branches of *I. palifera,* the outer of *Platygyra* spp. and branches of *P. grandis*. But there are also experiments with usage of artificial substrates. The results showed that recruitment was higher on artificial substrates compared to natural substrates as they are hard and stable (Richmond 1997), has a rough surface (Harrison & Wallace 1990), therefore can be substrates for recruitment. Field et al (2007) reported that substrate size does not produce proportional levels of recruitment. Reproductive time and different larval planulae competition periods in each genus, can affect the time of laying the substrate.

Time of corals reproduction in Indonesia can be grouped into three types of seasons: spawning before the rainy season (October-November), spawning during or after rainy season (January-April) and spawning or planula release throughout the year. Coral spawning is generally influenced by lunar rotation that occurs after full moon while planulae release by brooding coral in the new moon to full moon (Munasik 2002). Research conducted by Harriott & Fisk (1988) approximately 20 weeks, during the time of the predominant seasonal spring/summer in two reef area (forereef and backreef) showed that the highest attachment was found in the backreef compared the forereef. Brooding coral normally release larvae that contain zooxanthellae and lipids for food reserves. As a result larvae have a competition period of approximately 100 days after release and before sticking to the substrate (Richmond & Hunter 1990). Conversely on coral broadcast-spawning (*Acropora tenuis*) has a period of only 20 days (Richmond & Hunter 1990). This finding is supported Mangubhai et al (2007) by its research conducted for 20 months, who showed 4294 recruitments consisted of Pocilloporidae (4024 ind.), Poritidae (139 ind.), Acroporidae (58 ind.), Faviidae (5 ind.), other (14 ind.) and unknown (54 ind.).

Material and Method

Description of the study sites. The study was conducted from August 2018 to February 2019 in the Saleo Beach Area, Raja Ampat District Dampier Strait Area, Indonesia (Figure 1).

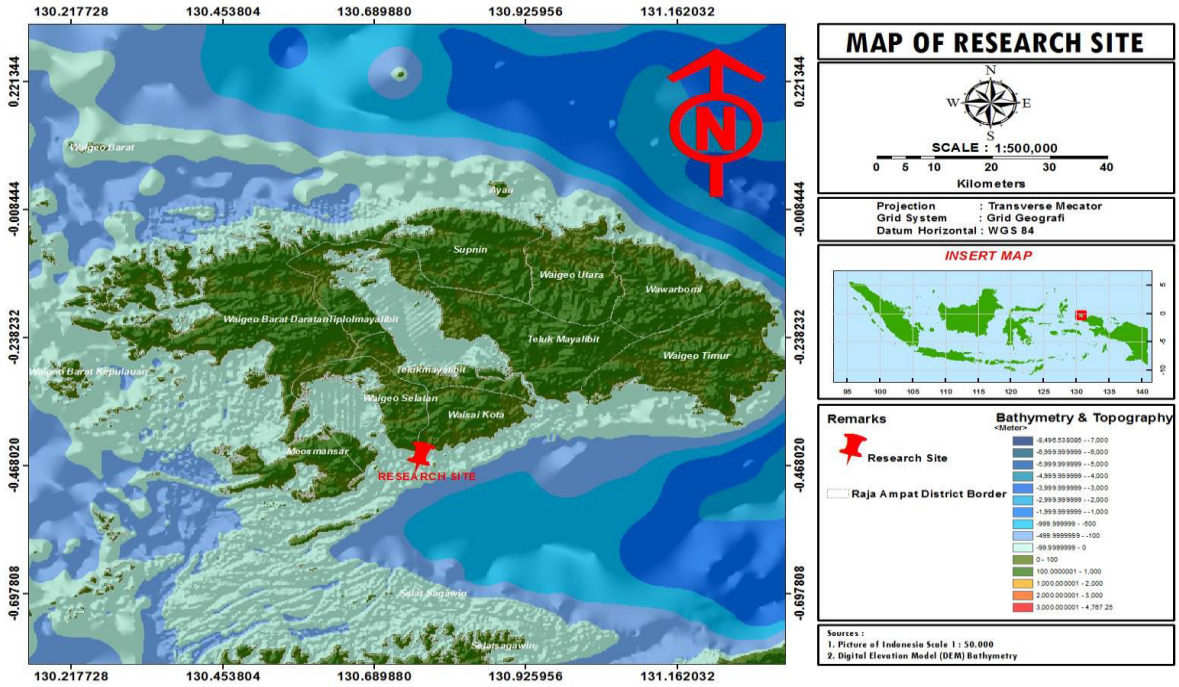

Figure 1. Map of research location.

Framing and substrate setup. In this study the substrates consisted of andesite stone, unglazed ceramic substrate and mild iron drum (Figure 2).

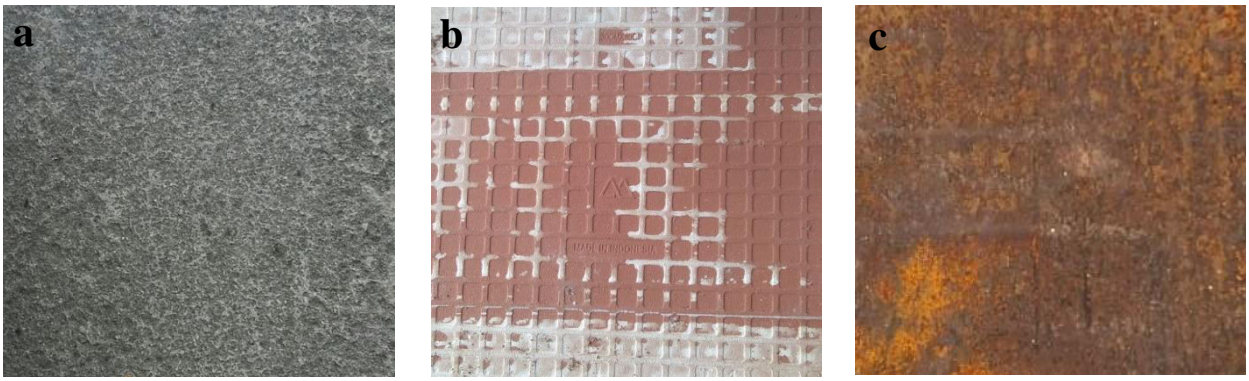

Figure 2. Type of substrate used. (a) Andesite stone; (b) Unglazed Ceramic; and (c) Plate of mild iron drum.

The substrate was in a square form with the size of 20 x 20 cm. The method used was Coral Recruitment Tiles (modified from Hill & Wilkinson 2004). The location of the study was determined by using purposive sampling method that determined the location of data collection based on the consideration of individuals or researchers at the research location. The substrate collector was placed on an iron frame used for one of the binding sites for the substrate to avoid excessive sedimentation of the substrate surface or lost due to sweeping currents and placed 10-15 meters apart from each other at a depth of 5–7 m. The collector substrates were tied to the frame three pieces per substrate type with a total of nine substrates (Figure 3). In addition, measurements of water physical parameters (temperature, salinity, depth and velocity of the current) were measured as well as the percentage of coral cover (Hill & Wilkinson 2004; Manuputty & Djuwariah 2009) as supporting data.

Samples were taken at 2 months, 4 months and 6 months after placement (MAP) on each frame where it was tied and then withdrawn to be observed at the Biology Laboratory of SMA Negeri 1 Raja Ampat in Waisai.

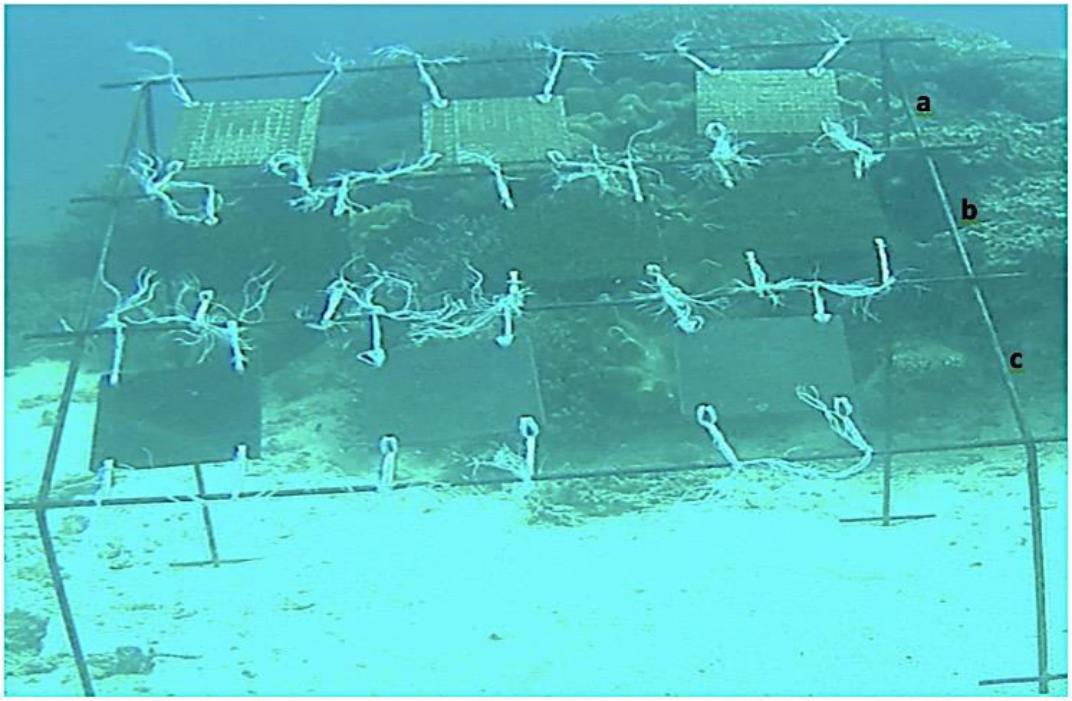

Figure 3. The placement of the collector substrates on the frame. (a) Ceramics; (b) Plate of mild iron drum; and (c) Andesite stone.

Formulas and statistical analysis. The formulas were used to calculate the abundance and diversity of coral larvae recruitment types as follows:

Abundance. The abundance of coral larvae was calculated using a formula adopted from Odum (1983) as follow:

$$KR = \frac{Ni}{N} \times 100\%$$

KR : Individual abundance
N : Total number of individuals
Ni : Number of individuals

Diversity. The diversity of coral larvae attached to the collector substrate was calculated using the Shannon & Wiener diversity index (Krebs 1989) as follow:

$$H' = -\Sigma \{(ni/n) \ln (ni/n)\}$$

H : Diversity Index
ni : Number of individuals
n : Total number of individuals
With criteria as follow:
H'<1 : shows a low level of diversity
1<H'<3 : shows a moderate level of diversity
H'>3 : shows a high level of diversity

Observation of the condition of coral reef cover was then processed by using the formula of percentage of coral cover (Manuputty & Djuwariah 2009) as follow:

$$\% \text{ Cover} = \frac{\text{number of each component}}{\text{total komponen (50)}} \times 100\%$$

Coral cover category was obtained (Giyanto et al 2017) as follow:

Bad or broken : 0-25%
Enough or moderate : 26-50%
Good : 51-75%
Very good : 76-100%

All data were tested for assumptions of normality and homogeneity of variance by the Levene test. In addition, the non-parametric analysis of the Kruskal-Wallis Rank test (<0.05) was performed to see the difference in number of coral genus attached in each substrate type at different exposition durations. Statistical analyses were performed using SPSS software version 25.

Results. Oceanographic parameters at the study site such as water temperature ranged from 29.7 to 33.2^{0}C (31.4±1.76), salinity from 26.9 to 30.2‰ (28.8±1.69), with 100% brightness and current velocity was between 81 and 125 mm/s (106.7±24.09) (Table 1).

Table 1

The oceanographic parameters at the study site

Parameter	*2 MAP*	*4 MAP*	*6 MAP*	*Mean ± SD*
Temperature (^{o}C)	31.2	33.2	29.7	31.4±1.76
Salinity (‰)	30.2	26.9	29.2	28.8±1.69
Visibility	100	100	100	100±0.00
Current (mm/s)	125	120	81	108.7±24.09

MAP – months after placement.

The attachment of coral species to the three types of substrate during the study period is presented in Table 2. In this study, six genus were found consisting of the genus: Pocillopora (8 ind./38.10%), Porites (5 ind./23.81%), Seriatopora (4 ind./19.05%), Montipora (2 ind./9.52%), Goniastrea (1 ind./4.76%) and Stylophora (1 ind./4.76%). The diversity was classified as moderate (1.5).

Table 2

Coral recruitment on the three substrates during the study

Genus	*Substrate*	*Individuals number*			*Mean*	*Total*
		2 MAP	*4 MAP*	*6 MAP*		
Pocillopora	Andesite substrate	2	1	2	1.67	5
Porites		0	1	3	1.33	4
Seriatopora		0	0	1	0.33	1
Stylophora		0	0	1	0.33	1
Subtotal		2	2	7	3.66	11
Pocillopora	Unglazed ceramics	0	1	1	0.67	2
Porites		0	0	1	0.33	1
Seriatopora		0	0	2	0.67	2
Subtotal		0	1	4	1.67	5
Pocillopora	Mild iron drum	1	0	0	0.33	1
Seriatopora		0	0	1	0.33	1
Montipora		0	0	2	0.67	2
Goniastrea		0	0	1	0.33	1
Subtotal		1	0	4	1.66	5
Total		3	3	15	6.99	21

The recruitment of coral genus during the observation on each substrate type is presented in Figure 4. The health of coral reefs in the research location was classified as poor, with a percentage of live coral cover of 14%. The analysis of the data shows that the coral recruitment was affected by the exposure time of substrate collector (<0.05), while the type of substrates did not affected the recruitment of coral species (>0.05).

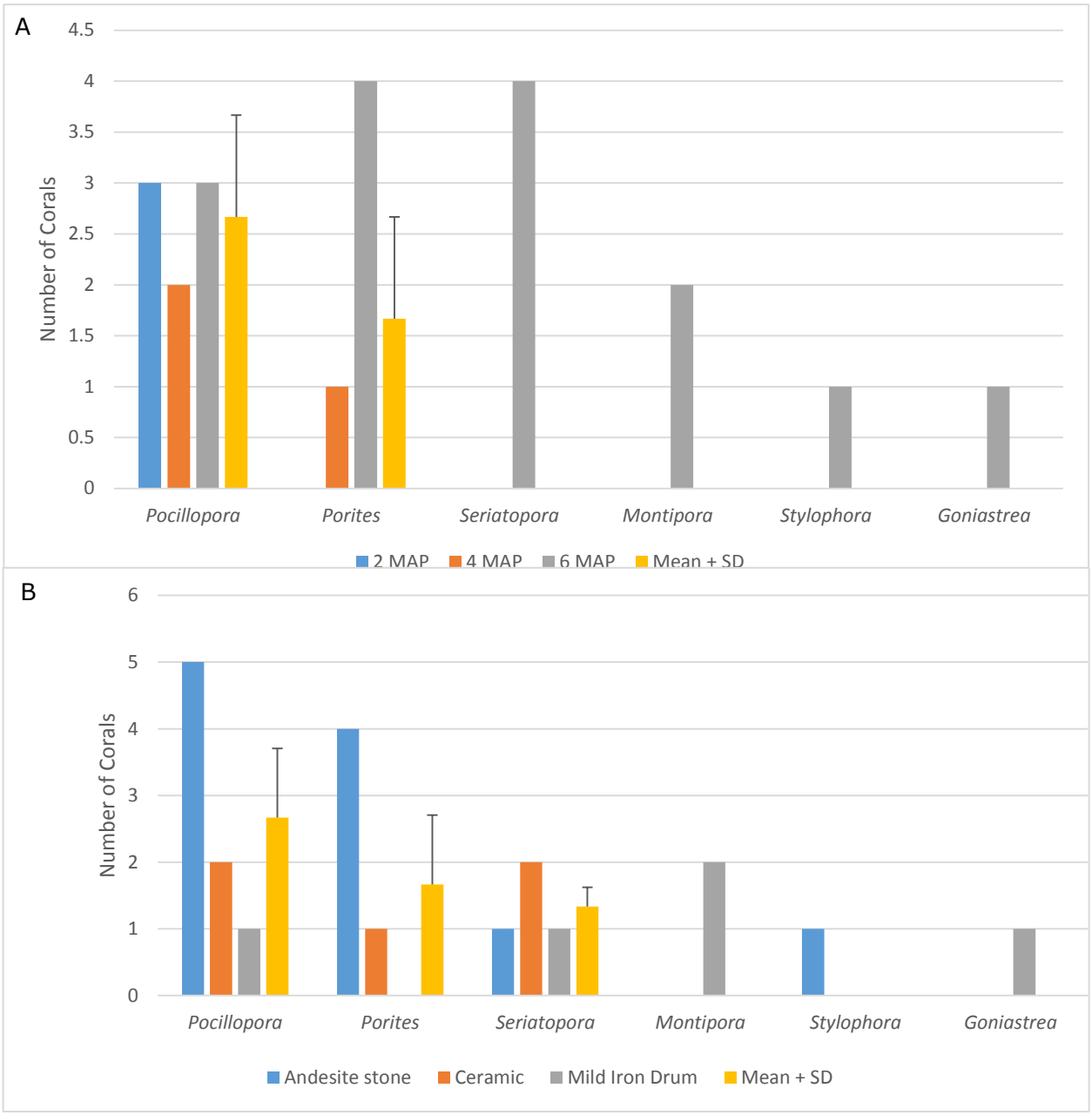

Figure 4. Recruitment of coral genus. (A). Months after substrates exposure and (B). Type of substrate.

Discussion. Coral reefs live at temperatures above 18°C in the temperature range between 23 to 30°C and at short-term can tolerate temperatures of 36-40°C (Nybakken 1988; Nontji 2005; Romimohtarto & Juwana 2007; Giyanto et al 2017). Richmond (1997) argues that good salinity for recruitment ranges from 32 to 40‰ and when water movement tends to be calm. Penetration of sunlight affects the photosynthesis process, which results from photosynthesis in the form of carbohydrate that contributes to the reproduction process (Abrar 2011).

Recruitment of coral planula larvae is influenced by several parameters including reproductive timing, planula larvae competition period, current pattern and velocity, substrate availability, predator density and competition (Richmond & Hunter 1990). The abundance of recruitment on andesite substrate had the highest attachment of 11 individuals (52.4%), unglazed ceramics and mild iron drum each of 5 individuals (23.8%). However, the analysis showed that the substrate had no effect on the recruitment of coral species (>0.05). Research conducted by Golbuu & Richmond (2007)

showed that biofilm layers might facilitate coral larvae attachment. Furthermore, Sneed et al (2014) explained that coral planula larvae would stick to the biofilm layer as a natural response. The existence of macro algae, barnacles and other organisms could create habitats that are less suitable for attaching coral species (Ritson-williams et al 2010).

In the present study, the existence of the substrate as the recruitment of coral species was very limited in the study location. The percentage of fault cover was higher in the study location with 24% with the percentage of live coral cover of 14% (bad/damaged category). The survey conducted and organized by Conservation International (CI) Indonesia reported that there is still a significant amount of coral rubble that increased significantly from 22.5% (2014) to 31.6% (2016). The abundance of coral species recruitment differed between observation periods (Table 1). In the 6 MAP (February 2019) there were attachments of 15 ind./71.4%, while the attachment in 2 MAP (October 2018) and 4 MAPs (December 2018) were similar at 3 ind./14.3%. The data analysis showed that the duration time of substrate collector laying affected the coral species recruitment (<0.05). The attachment was dominated by the Pocillopora genus as much as 8 ind./38.10%, while the genus Goniastrea and the genus Stylophora were represented by 1 ind./4.76%, respectively.

Veron (2000) in Rahman et al (2014) stated that corals from Pocilloporidae were one of the pioneering corals in coral reef ecosystems and their existence greatly determines the success of other types of coral recruitment. In addition, it can be seen from the reproductive period of the Pocillopora genus that it occurs throughout the year (Richmond 1997; Munasik 2002). Moreover, the study of Harii et al (2002) showed that the genus Pocillopora (*P. damicornis*) had a period of competition for 100 days. The study conducted by Mengubhai et al (2007) also found Pocillopora genus recruitment of 93.7% for 28 months (May 2003-August 2005). Goniastrea genus (*Goniastrea retiformis*) has a reproductive period in October after full moon (Munasik 2002). The Baird et al (2003) study showed that *Goniastrea retiformis* and *Coelastrea aspera* were predominantly attached to a depth of 2 meters. This is supported by Veron (2000) in Rahman et al (2014) that the genus Goniastrea is included in several genera that are tolerant of direct air exposure.

The Stylophora genus has a long reproductive period from December to July (Rinkevich & Loya 1987). This genus is spread in shallow areas (Suharsono 2008) and has a higher diversity in the western Pacific Ocean and Red Sea than in the central Indo-Pacific (Veron 2000 in Rahman et al 2014). Furthermore, Richmond (1997) explained further that the genus Goniastrea and the genus Stylophora have sequential hermaphrodite sexes where is a different sperm and egg maturity time. The diversity of coral species attached to the substrate during the study had a moderate diversity (1.5). Research of Phardana et al (2013) obtained a moderate diversity at a depth of 5 m and low to moderate diversity at a depth of 10 m. This is predicted due to spawning events that are less simultaneous due to a region's annual temperature range (Munasik 2002). The simultaneous occurrence of coral spawn in the GBR occurs in the range of the annual temperature of 12^0C (Babcock & Heyward 1986).

Conclusions. The highest abundance of coral larvae recruitment on the substrate collector was Pocillopora (38.10%), followed by Porites (23.81%), Seriatopora (19.05%), Montipora (9.52%) as well as Stylophora and Goniastrea (4.76% each). The diversity of coral species recruitment was in the medium category. The type of substrate used did not affect the recruitment of the coral species attached. The exposure time affects the recruitment of coral larvae. Recruitment of coral genus can guarantee the existence of coral reef ecosystems in nature that have an impact on the availability of fish resources for the needs of the community.

Acknowledgements. The first author would like to thank the Coremap monitoring team - CTI Raja Ampat, Mr. Ferdinan Bata (BK Ampara Kupang SAP Raja Ampat and Waigeo West) and Jecky Wader, as well as SMA Negeri 1 Raja Ampat for their assistance and

cooperation during the research. The first author also thanks Muhammad Abrar (LIPI-Jakarta) for his assistance in identifying the coral species in the present research.

References

Abrar M., 2011 Kelulusan Hidup Rekrutmen Karang (Scleractinia) di Perairan Gugus Pulau Pari, Kepulauan Seribu, Jakarta. Institute Pertanian Bogor. Retrieved from: https://repository.ipb.ac.id

Ammar M. S. A., El-gammal F., Nassar M., Belal A., Farag W., El-mesiry G., El-Hadad K., Orabi A., Abdelreheem A. Shaaban A., 2013 Review : Current trends in coral transplantation – an approach to preserve biodiversity. Biodiversitas 14(1):43–53.

Babcock R. C., Heyward A. J., 1986 Larval development of certain gamete-spawning scleractinian corals. Coral Reefs 5:111–116.

Baird A. H., Babcock R. C., Mundy C. P., 2003 Habitat selection by larvae influences the depth distribution of six common coral species. Marine Ecology Progress Series 252:289–293.

Birkeland C., Rowley D., Randall R. H., 1981 Coral recruitment patterns at Guam. In: Fourth International Coral Reef Symposium, pp. 339–344, Manila. https://www.researchgate.net/publication/284046708

Burt J., Bartholomew A., Bauman A., Saif A., Sale P. F., 2009 Coral recruiment and early benthic community development on several materials used in the construction of artificial and breakwaters. Journal of Experimental Marine Biology and Ecology 373:72–78.

Erwin P. M., Song B., Szmant A. M., 2008 Settlement behavior of *Acropora palmata* planulae: Effects of biofilm age and crustose coralline algal cover. In: International Coral Reef Symposium, pp. 1219–1224, Ft. Lauderdale, Florida: UNC, Wilmington, Center for Marine Science.

Field S. N., Glassom D., Bythell J., 2007 Effects of artificial settlement plate materials and methods of deployment on the sessile epibenthic community development in a tropical environment. Coral Reefs 26(2):279–289.

Giyanto G., Abrar M., Hadi T. A., Budiyanto A., Hafizt M., Salatalohy A., Iswari M. Y., 2017 Status Terumbu Karang Indonesia 2017. Suharsono S. (ed), Jakarta: Pusat Penelitian Oseanografi - Lembaga Ilmu Pengetahuan Indonesia. Retrieved from: https://www.oseanografi.;ipi.go.id

Golbuu Y., Richmond R. H., 2007 Substratum preferences in planula larvae of two species of scleractinian corals, *Goniastrea retiformis* and *Stylaraea punctata*. Marine Biology 152(3):639-644.

Harii S., Kayanne H., Takigawa H., Hayashibara T., Yamamoto M., 2002 Larval survivorship, competency periods and settlement of two brooding corals, *Heliopora coerulea* and *Pocillopora damicornis*. Marine Biology 141(1):39–46.

Harriott V. J., Fisk D. A., 1988 Coral transplantation as a reef management option. Proceedings of the 6th International Coral Reef Symposium, Australia, 2:375–379.

Harrison P. L., Wallace C. C., 1990 Reproduction, dispersal and recruitment of scleractinian corals. In: Coral reefs, Ecosystems of the world. Dubinsky Z. (ed), pp. 133-207, Elsevier, Amsterdam, Netherlands.

Hill J., Wilkinson C., 2004 Methods ecological monitoring of coral reefs. 1st edition, Townsville: Australian Institute of Marine Science.

Krebs C. J., 1989 Ecology the experiment analysis of distribution and abundance. Harper and Row Publisher, New York.

Maida M., Sammarco P. W., John C. C., 1992 Effects of soft corals on scleractinian coral recruitment. I: Direcional allelopathy and inhibition of settlement. Marine Ecology Progress Series 121:191–202.

Mambrisaw A., Wurlianty B., Liuw F., Hamel S., Lamatenggo Y., Rumbekwan I., Mujadi A. H., Sukmara A., Sumantri H., Omkarsba J., 2006 Atlas Sumberdaya Pesisir Kabupaten Raja Ampat Provinsi Irian Jaya Barat. (A. Firman & I. Azhar, Eds.). Raja Ampat: Conservation International Indonesia.

Mangubhai S., Harrison P. L., Obura D. O., 2007 Patterns of coral larval settlement on lagoon reefs in the Mombasa Marine National Park and Reserve, Kenya. Marine Ecology Progress Series 348:149–159.
Manuputty A. E. W., Djuwariah, 2009 Panduan Metode Point Intercept Transect (PIT) untuk Masyarakat: Studi baseline dan monitoring Kesehatan Karang di Lokasi Daerah Perlindungan Laut (DPL). Jakarta. Retrieved from: https://www.coremap.or.id/
McKenna S. A., Allen G. R., Suryadi S., 2002 A marine rapid assessment of the Raja Ampat Islands, Papua Province, Indonesia. RAP Bulletin on Biological Assessment. Washington.
Munasik, 2002 Reproduksi Seksual Karang di Indonesia: Suatu Kajian. In Bali (Ed.), Pengelolaan Sumberdaya Pesisir dan Lautan Indonesia (pp. 1–10). Bali. Retrieved from: https://eprints.undip.ac.id
Nontji A., 2005 Laut Nusantara, ed. rev. cet-4. Penerbit Djambatan, Jakarta, hal 115-126.
Nybakken J. W., 1988 Biologi Laut: Suatu Pendekatan Ekologis. (diterjemahkan oleh M. Eidman et al) cet-1. PT. Gramedia, Jakarta, hal. 325-363.
Odum E. P., 1983 Basic ecology. Saunders College Publ. Holt Saunder, Tokyo.
Pada D. N., Hidayat N. I., Pangulimang J., Hasan A. W., Mambrasar R., Dimara R., Mambraku E., Mofu I., Burdam A., 2016 Ecological Status of Dampier Strait MPA 2016 Technical Report. Raja Ampat. Retrieved from: http://blog.concervation.org/2016/06/amid-midespread-coral-bleaching-this-reef-is-thriving/
Phardana T., Suparno, Efendi Y., 2013 Kondisi dan Struktur Komunitas Rekruitmen Karang Batu (*Scleractinia*) di Taman Wisata Perairan (TWP) Pulau Pieh. FPIK Bung Hatta.
Rahman A., Haris A., Jamaluddin, 2014 Pola Rekrutmen Karang Scleractinia pada Kondisi Lingkungan Berbeda. Sains & Teknologi 14(3):209–219.
Richmond R. H., 1997 Reproduction and recruitment in corals: Critical links in the persistence of reefs: Life and death of coral reefs.). Chapman & Hall, New York, pp. 175–197.
Richmond R. H., Hunter C. L., 1990 Reproduction and recruitment of corals : Comparisons among the Caribbean, the Tropical Pacific, and the Red Sea. Marine Ecology Progress Series 60:185–203.
Rinkevich B., Loya Y., 1987 Variability in the pattern of sexual reproduction of the coral *Stylophora pistillata* at Eilat, Red Sea: a long-term study. Biological Bulletin 173(2):335–344.
Ritson-Williams R., Arnold S. N., Fogarty N. D., Steneck R. S., Vermeij M. J. A., Paul V. J., 2010 New perspectives on ecological mechanisms affecting coral recruitment on reefs. Smithsonian Contributions to the Marine Sciences, pp. 437-457. https://nsuworks.nova.edu/occ_facarticles/503.
Romimohtarto K., Juwana S., 2007 Biologi Laut : Ilmu Pengetahuan tentang Biota Laut (3rd ed.). Jakarta: PT. Djambatan.
Sneed J. M., Sharp K. H., Ritchie K. B., Paul V. J., 2014 The chemical cue tetrabromopyrrole from a biofilm bacterium induces settlement of multiple Caribbean Corals. Proceedings. Biological Sciences, DOI: 10.1098/rspb.2013.3086.
Suharsono, 2008 Jenis-Jenis Karang di Indonesia. Jakarta: LIPI Press, anggota Ikapi. Retrieved from: https://www.coremap.or.id/
Tapilatu R. F., Parenden D., Dimara R., Imbir R., Noor A., Hidayat N. I., 2017 The assessment of coral reef damage caused by the Caledonian sky grounding in cross-over reef, Dampier Strait of Raja Ampat-Papua Barat Provinse Indonesia. In The 7th Conference on Taxonomy and Systematics in Thailand (p. 7), Thailand: Faculty of Science, Ramkhamhaeng University.
Tioho H., Tokeshi M., Nojima S., 2001 Experimental analysis of recruitment in a scleractinian coral at high latitude. Marine Ecology Progress Series 213:79–86.
Veron J. E. N., Devantier L. M., Turak E., Green A. L., Kininmonth S., Stafford-Smith M., Peterson N., 2009 Delineating the coral triangle. Galaxea, Journal of Coral Reef Studies 11(2):91–100.

Westmacott S., Teleki K., Wells S., Henning J., 2000 Pengelolaan Terumbu Karang yang Telah Memutih dan Rusak Kritis. Inggris: Information Press, Oxford. Inggris. Retrieved from: http://iucn.org
*** KEPMEN Kelautan dan Perikanan Republik Indonesia, 2014 Kementerian Kelautan dan Perikanan Republik Indonesia Nomor 36/KEPMEN-KP/2014 Tentang Kawasan Konservasi Perairan Kepulauan Raja Ampat Kabupaten Raja Ampat di Provinsi Papua Barat, Jakarta 15 July 2014.

Received: 16 July 2019. Accepted: 30 September 2019. Published online: 08 October 2019.
Authors:
Jeremias Rumala Tuhumena, University of Papua (UNIPA), Postgraduate Program, Aquatic Resources Study Program, Indonesia, West Papua, Manokwari Province, 98314, Jln. Puncak Soribo, e-mail: jeremiastuhumena342@gmail.com
Ricardo Ferdinand Tapilatu, University of Papua (UNIPA), Research Center for Pacific Marine Resources, Indonesia, Papua Barat, 98314 Manokwari, Jl. Gunung Salju, e-mail: rf.tapilatu@unipa.ac.id
Paulus Boli, University of Papua (UNIPA), Research Center for Pacific Marine Resources, Indonesia, Papua Barat, 98314 Manokwari, Jl. Gunung Salju, e-mail: bolipaul@yahoo.com
This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.
How to cite this article:
Tuhumena J. R., Tapilatu R. F., Boli P., 2019 The effect of type and duration of substrate collector placement to the coral genus recruitment in Saleo Beach Area, Dampier Strait, Raja Ampat, Indonesia. AACL Bioflux 12(5):1643-1652.