The existence of estuarine coral reef at eastern front of Mahakam Delta, East Kalimantan, Indonesia: a first record

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Abstract. The coral reef existence at eastern front of Mahakam Delta has never been investigated, since the water condition and bottom substrate have been considered unsuitable for the coral reef development. Interestingly, thirty genera of hard coral in eleven families and eleven genera of soft coral in six families were found from this research. Video belt transect methods discovered poor/bad to fair/moderate of coral cover condition. These results confirmed that coral reef does exist at eastern front of Mahakam Delta, Tani Baru Village, Anggana Sub-district, Kutai Kartanegara District, East Kalimantan Province.
Key Words: percent cover, genera, video belt transect, Anggana, Kutai Kartanegara.

Introduction. Coral reefs or often called as “rain forests of the sea” are one of the most biologically rich and highly productive ecosystems on earth (Burke et al 2011). Coral reefs found around the world and the global center of maximum marine biodiversity is an area that encompasses parts of Southeast Asia and the Western Pacific known as the “Coral Triangle” (Veron et al 2009; Veron et al 2015; Burke et al 2012). Indonesia is the country with the largest area of coral reefs (Tomascik et al 1997; Spalding et al 2001), located within the Coral Triangle particularly the central to the eastern region which is east coast of Kalimantan Island across to Papua (Burke et al 2011).

The Mahakam Delta is located at the east coast of Kalimantan Island, at the mouth of one of the largest rivers in Indonesia, named the Mahakam River and administratively included in Kutai Kartanegara District, East Kalimantan Province. This delta was formed by the sedimentation processes of the Mahakam River, it is symmetrical with a radius to the delta shore c.a. 50 km, covering an area of 1800 km^2 and comprising 42 islands with total land surface about 1100 km^2 (Allen & Chambers 1998; Storms et al 2005; Budiyanto & Lestari 2013; Persoon & Simarmata 2014; Pham Van et al 2016).

The Mahakam River discharge carries out high quantities of suspended solid to the delta area causing very low water transparency or very turbid water, further the deposition and accumulation causing the bottom substrate characterized by mud or high silt and clay contents (Allen et al 1976; Allen & Chambers 1998; Creocean 2000; Storms et al 2005; Budhiman et al 2004, 2012). As a coastal environment, it is also characterized by a wide fluctuation of salinity due to the freshwater-seawater influence (Mackinnon et al 2000; Blanton et al 2001; Davila et al 2002; Piola et al 2005; Lane et al 2007; Möller Jr et al 2008; Salisbury et al 2011; Wikner & Andersson 2012). Generally, this condition of delta environment or estuarine waters negatively influenced the coral reef condition and, thus, suggested as unsuitable environment for coral reef development (Rogers 1990; Tomascik et al 1997; Fabricius & De'ath 2001; Fabricius 2005; Golbuu et al 2008; Jokiel et al 2014).

Despite none of coral reef visual prove had ever been published from eastern front area of Mahakam Delta, there was a rational idea to perform the search for coral reef existence in this area due to some available linked indicators. Several studies show

evidences of coral reef existence associated to Mahakam Delta from the earlier epoch (Wilson 2005; Marshall et al 2015; Rosler et al 2015; Santodomingo et al 2015a, b). The studies also revealed that the 'ancient' coral reefs adapted to turbid waters and soft substrates, which probably resemble the present waters condition. Nevertheless, the palaeoecologycal study has informed the correlation of past-present coral reef communities (Pandolfi 2011; Rosler et al 2015; Weiss & Martindale 2017). Thus, the possibility of 'present day' coral reef existence in this area is considerable. Even till present, there remain few studies about coral reef existence related to the Mahakam Delta. Tomascik et al (1997) described the nearest coral reef existence which was about 75 km south of the Delta to coast of Balikpapan and 20 km north of Mahakam Delta to Tanjung Santan. Suyatna et al (2017) from the research of 2011 and 2013 found the coral reef developed closer to the Delta Mahakam, i.e. 8.7 km to the north (included to Muara Badak Sub-district) and 11.9 km to the south (included to Samboja Sub-district) of Mahakam Delta. However, there is no evidence whether the coral reef also settled along the eastern front area of Mahakam Delta.

Based on the fish catch studies that were conducted in both onshore and offshore of the eastern front area of Mahakam Delta by TotalFinaElf E&P Indonesie (2002), Total E&P Indonesie (2006), and Suyatna (2011), the presence of reef fishes within the area was indicated. Several species of the catch such as goatfish (*Upeneus*, Mullidae), snapper (*Lutjanus*, Lutjanidae), monocle bream (*Scolopsis*, Nemipteridae), razorfish (*Centriscus*, Centriscidae), scorpionfish (*Pterois*, Scorpaenidae), bannerfish (*Heniochus*, Chaetodontidae) and butterflyfish (*Chaetodon*, Chaetodontidae), were identified as reef fishes (Allen & Steene 1994; Randal et al 1997; Allen 2000; Bergbauer & Kirschner 2014). The catch has become the indicator of coral reefs community existence around the area due to the coral reef's ecological role as the fishes habitat (Sale 1991; Tomascik et al 1997; Mora 2015; Graham & Nash 2013; Honda et al 2013).

Moreover, there used to be a rumor for many years among fishermen in Mahakam Delta about rocks-like objects in the seabed of their fishing ground at the delta eastern front area, Anggana Sub-district, Kutai Kartanegara District. This common term of 'rocks-like' possibly lead to coral reef, but unfortunately this has never been investigated. Therefore, this research was conducted in order to obtain the evidence of existence and 'first sight' of condition of coral reef in this sub-district.

Material and Method. Administratively, Delta Mahakam includes five sub districts in Kutai Kartanegara regency i.e. Muara Badak, Sanga-Sanga, Anggana, Muara Jawa and Samboja (Nursigit et al 2013). Anggana is located at the center area of the delta and the most eastward to the Makassar Strait (Figure 1).

Spotting the reef has encountered difficulties in this research due to the high turbid waters, both by direct visual from the water surface or through the common satellite image. However, since seabed roughness and hardness differences are detectable by acoustic technology (Lawrence & Bates 2001; Kagesten 2008; D'Elia et al 2009), therefore, Garmin GPSMap 585 echosounder was used for the water depth measurement and also to assist distinguishing the soft-hard bottom substrate type (Garmin 2011). The spotted area of hard substrate bottom was further cross-checked through scuba diving. The research area was taken at the eastern coast of Anggana Sub-district at July 2017. Several spots had been checked during the field survey, however, only spots with observed coral reef are presented in this report, i.e. four spots. The coordinates of the observation spots are: 1) S.00^{o}30'09.0", E.117^{o}41'16.9"; 2) S.00^{o}30' 19.0", E.117^{o}41'26.8"; 3) S.00^{o}29'58.6", E.117^{o}40'39.7"; 4) S.00^{o}30'05.4", E.117^{o}41' 16.2".

The coral coverage was observed by video belt transect. A set of video was recorded along 50 m track in the perpendicular position with height about 0.4 m to the reef (Hill & Wilkinson 2004; PERSGA/GEF 2004; Lam et al 2006). Coral colony groups are classified in lifeform category based on English et al (1994).

Percent cover of hard corals (HC) is the total of both coverage of lifeform Acropora and non-Acropora. Live coral (LC) coverage is the total of hard coral (HC) and soft coral (SC) coverage (LC = HC + SC). The coral condition was indicated by percentage of live

corals, classified into following categories: LC < 25% as poor/bad, LC 25 - <50% as fair/moderate, LC 50 - <75% as good, and LC ≥75% as excellent (Gomez & Yap 1988; Gomez et al 1994; Jompa & Pet-Soede 2002; Hill & Wilkinson 2004).

The HC colony was identified to genus level by in-situ (Kelley 2009) and/or ex-situ (Veron 2000; Veron & Stafford-Smith 2002) with the taxonomy referring to updated systematics, e.g. Gittenberger et al (2011), Budd et al (2012), Arrigoni et al (2014), Huang et al (2014a, 2014b, 2016), Kitano et al (2014), Kitahara et al (2016), Richards (2016) and WoRMS Editorial Board (2017). The SC genera were identified referring to Fabricius & Alderslade (2001), Sánchez & Wirshing (2005) and Yogesh Kumar et al (2014).

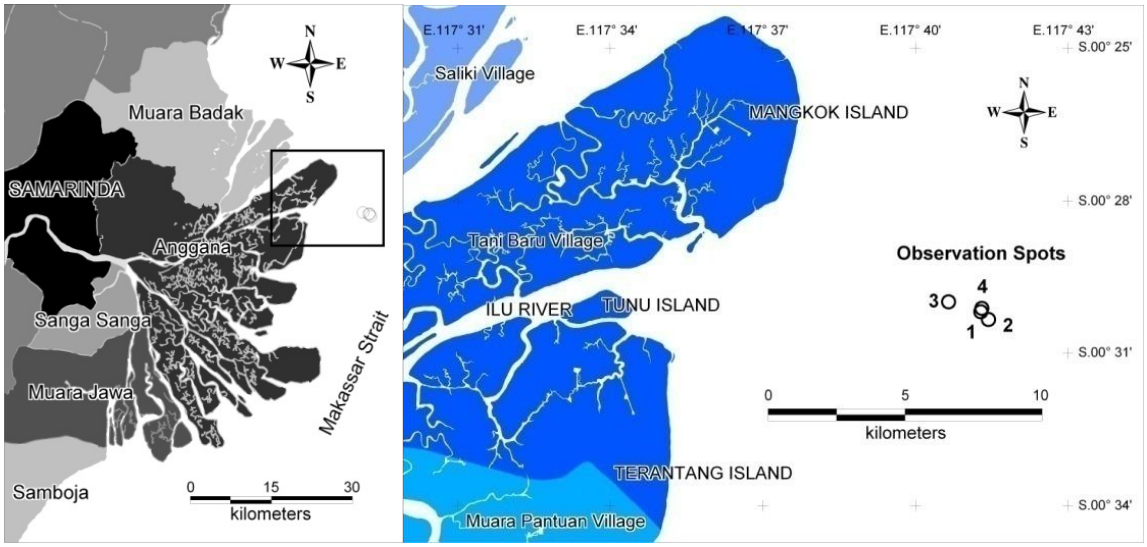

Figure 1. Position of observation spots in Mahakam Delta.

Results and Discussion. Coral reefs community at eastern front area of Mahakam Delta, Anggana Sub-district, Kutai Kartanegara District, all were observed within Tani Baru Village area. It is located in front of Ilu River mouth or known as Muara Ilu, about 11 km eastward. This river flows between two main islands of Mahakam Delta, i.e. Mangkok Island at the north side and Terantang Island at the south side (Figure 1). The found coral reef was developed on a relatively flat contoured seabed. The measured depth at each observation spots was: 7-9 m, 10-11 m, 5-6 m, and 6-7 m, respectively.

Across all observation spots, 11 families (including 1 family of *Incertae Sedis*) comprising 30 genera of HC were identified, while from SC group we identified 6 families comprising 11 genera (Table 1).

The highest number of HC genera was found in observation spot 4 with 21 genera from 8 families, then a lower number was found in spot 1 with 15 genera from 7 families, spot 3 with 6 genera from 5 families, and spot 2 with 3 genera from 3 families. The observation spot with highest to lowest number of SC genera consecutively was: spot 3 (6 genera from 5 families), 4 (4 genera from 4 families), 1 (4 genera from 3 families) and 2 (1 genus from 1 family).

Table 1

List of corals genera from Delta Mahakam eastern front, Anggana Sub-district

No	Family	Genus	Observation spot			
			1	2	3	4
	Hard Coral					
1	Acroporidae	*Alveopora*	+	+	+	
2	Agariciidae	*Leptoseris*				+
3	Euphylliidae	*Euphyllia*				+
4	Euphylliidae	*Galaxea*	+			
5	Fungiidae	*Ctenactis*	+			
6	Fungiidae	*Cycloseris*	+			+
7	Fungiidae	*Danafungia*	+			+
8	Fungiidae	*Halomitra*	+			+
9	Fungiidae	*Heliofungia*	+			+
10	Fungiidae	*Herpolitha*	+			+
11	Fungiidae	*Lithophyllon*	+			
12	Fungiidae	*Pleuractis*				+
13	Fungiidae	*Polyphyllia*	+			
14	*Incertae sedis*	*Physogyra*				+
15	Lobophylliidae	*Echinophyllia*				+
16	Lobophylliidae	*Lobophyllia*	+			
17	Lobophylliidae	*Oxypora*				+
18	Meandrinidae	*Eusmilia*			+	
19	Merulinidae	*Caulastrea*	+			
20	Merulinidae	*Cyphastrea*			+	+
21	Merulinidae	*Dipsastraea*				+
22	Merulinidae	*Favites*		+		+
23	Merulinidae	*Goniastrea*				+
24	Merulinidae	*Mycedium*				+
25	Merulinidae	*Platygyra*				+
26	Merulinidae	*Trachyphyllia*				+
27	Pocilloporidae	*Stylophora*				+
28	Poritidae	*Goniopora*	+	+	+	+
29	Poritidae	*Porites*	+			+
30	Siderastreidae	*Pseudosiderastrea*	+		+	
	Soft Coral					
1	Alcyoniidae	*Lobophytum*	+		+	+
2	Alcyoniidae	*Sarcophyton*	+			
3	Ellisellidae	*Ellisella*			+	
4	Ellisellidae	*Junceella*	+		+	
5	Gorgoniidae	*Pseudopterogorgia*				+
6	Melithaeidae	*Melithaea*			+	
7	Nephtheidae	*Lemnalia*	+			
8	Nephtheidae	*Litophyton*		+		
9	Nephtheidae	*Nephthya*				+
10	Nephtheidae	*Scleronephthya*			+	
11	Xeniidae	*Xenia*			+	+

Fungiidae, members of HC groups, was most abundance with 9 genera in spots: 1 (8 genera) and 4 (6 genera). Worldwide, this family formerly consist of 13 genera according to Veron (2000), after revised by Gittenberger et al (2011) recently become 15 genera. Fungiids or also known as mushroom corals are initially attached to a hard substratum, but at their life phase as adult mostly detached and become free-living (Hoeksema 1989; Hoeksema & Yeemin 2011). Fungiids are found under different degrees of environmental disturbances (Kramarsky-Winter & Loya 1996), they were reported being able to survive and disperse over various kinds of substrata and depths (Chadwick-Furman & Loya 1992;

Goffredo & Chadwick-Furman 2000; Hoeksema 2009, 2012; Hoeksema et al 2014). The abundance and survival of Fungiidae group are related with their capability in adaptation strategy, e.g. asexual reproduction in form of cloning through the budding and fragmentation (Kramarsky-Winter & Loya 1996; Hoeksema 2004; Harrison 2011; Hoeksema & Waheed 2011; Hoeksema & Yeemin 2011), ability to repair and regenerate their damaged tissues and skeleton (Kramarsky-Winter & Loya 1996), capability of 'moved-away' or mobilization (Hoeksema 1988; Chadwick-Furman & Loya 1992; Hoeksema 2004; Hoeksema & de Voogd 2012), they can flip-over or self-righting whenever their body are suffering upside-down (Hoeksema & Bongaerts 2016), and they are capable to excavate and freed themselves from sediment burial (Bongaerts et al 2012).

Other members of HC group, Merulinidae and Poritidae, were recorded from all observation spots. Within Merulinidae family, there were 8 genera recorded from this research. Merulinidae is the most genus-rich family of reef-building corals occurring in the Indo-Pacific, including the Red Sea (Veron 2000), with 25 genera included into the family (Huang et al 2014a, 2014b). Meanwhile, there were only two genera recorded from family Poritidae, i.e. *Porites* and *Goniopora*. These genera are characteristic groups in turbid coastal areas and common in areas that are influenced by river runoff (Tomascik et al 1997). In many studies, coral species in Merulinidae and Poritidae are found to be tolerant, recovered and surviving from bleaching events and mortality in 'atypical' environments with high sedimentation, turbidity, thermal stress and periods of exposure (Edwards et al 2001; Torres & Morelock 2002; Hennige et al 2010; Chou et al 2012; Sutthacheep et al 2013; Ferns 2016).

Overall, coral reef in the research area included the condition of fair/moderate category with LC cover of 26.25%. The coverage comprised by HC was 16.1% and by SC 10.15%. Most colonies of HC were in encrusting lifeform. No acropora group lifeform was observed, hence all HC cover was composed by non-acropora corals (Figure 2).

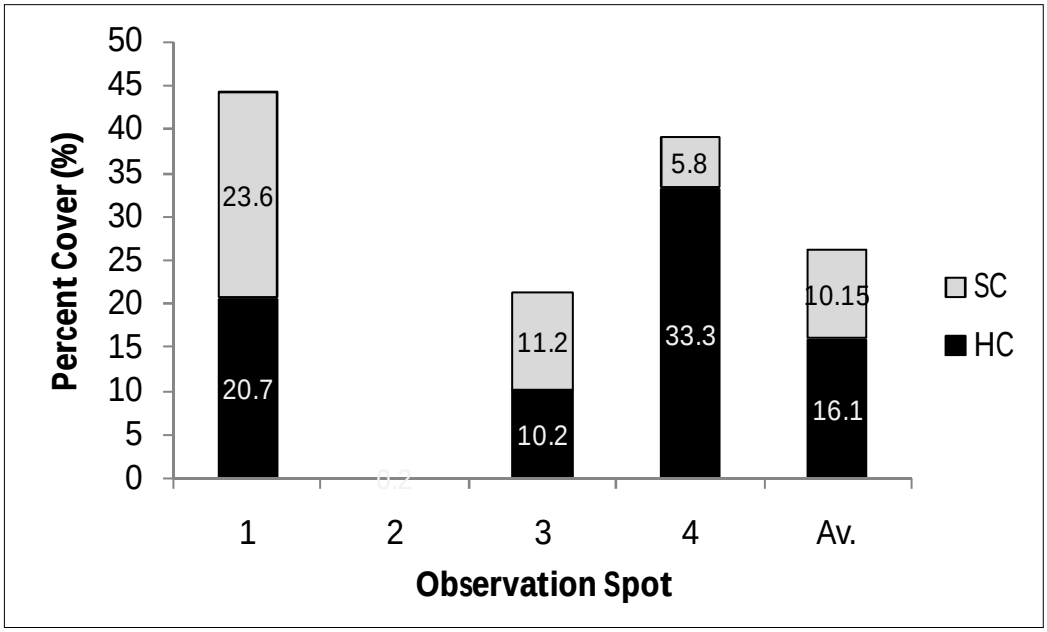

Figure 2. Percent cover of LC (HC + SC) in each observation spot and the overall average (Av = average).

Despite the observation spots are considered nearby one to another, particularly spot 1 and 4, each spot showed different coral coverage composition (Figure 3).

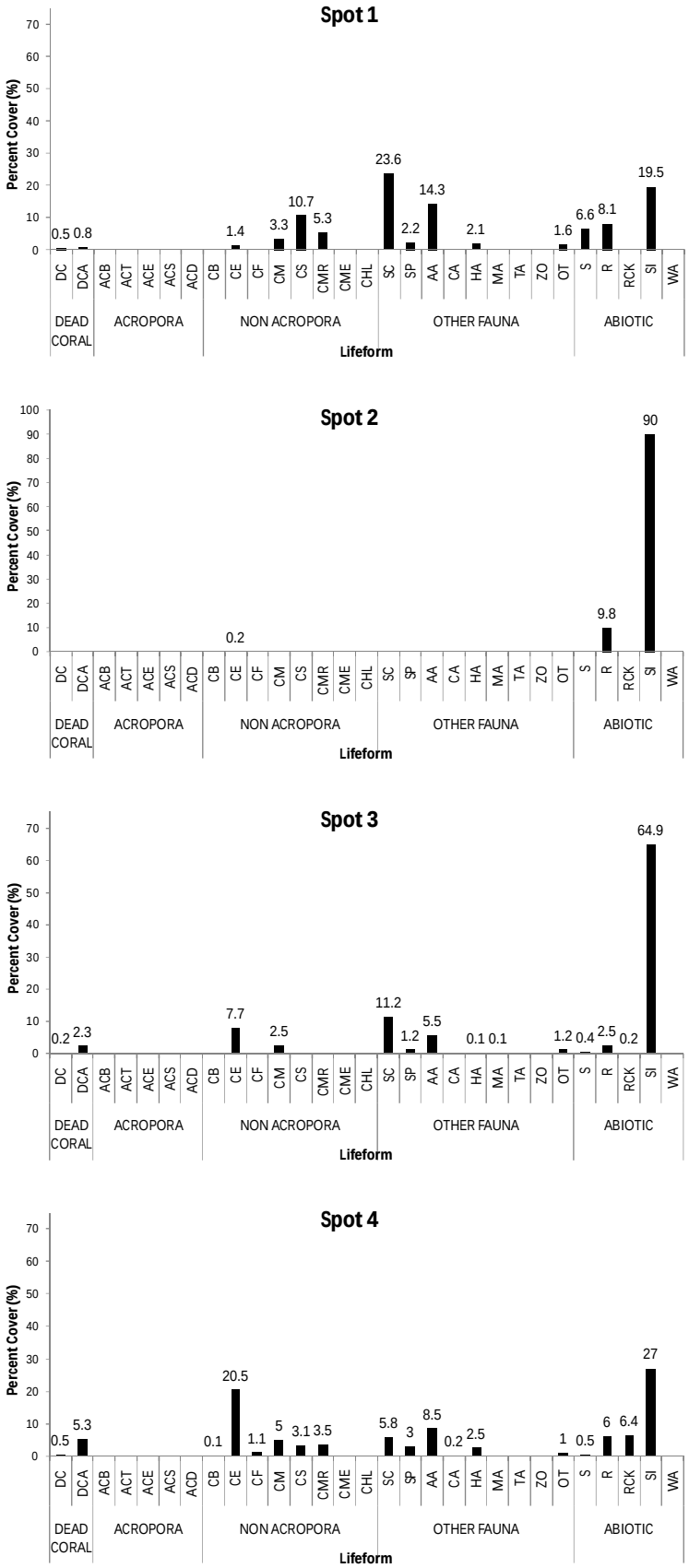

Figure 3. Percent cover of coral lifeform in each observation spot. The codes of coral lifeforms were referring to English et al (1994).

The highest LC cover was observed in spot 1 with LC 44.3%, consisting in 20.7% of HC and 23.6% of SC. The coverage of SC was higher than HC, which is mostly due to the contribution of monospecific colonies of *Sarcophyton* that were observed densely developed at a certain part of this spot (Figure 4a & 4b). These results were consistent with the previous studies that showed the most abundant genera from soft coral Alcyoniidae was *Sarcophyton* (Fabricius et al 2007; Goh et al 2009; Chanmethakul et al 2010; Aratake et al 2012; Baum et al 2016). *Sarcophyton* species are very hardy and dominant in many coral reef areas; they are characterized by a distinct sterile stalk, a broad, flared, smooth, mushroom shaped top called capitulum (Aratake et al 2012). In order of competition for space and survival, as an octocorallian, they are also known to produce and releasing a kind of chemical substance into the water. The chemical substance is toxic and causing allelopathic effects (Coll et al 1982; Sammarco et al 1983; La Barre et al 1986; Tomascik et al 1997; Fleury et al 2006).

Concurrently, the coverage of HC in spot 1 was mostly composed by *Galaxea* and various genera of Fungiidae. *Galaxea* coral was observed in the form of a wide submassive colony (Figure 4c). The coral colonies of *Galaxea* are known to grow in massive, submassive, laminar, encrusting, and arborescent forms, as well as by the width of the colony up to several meters (Veron 2000). The presence of dominant *Galaxea* colonies in the delta area with high turbidity and sedimentation is possible due to the mixed massive-columnar morphology, since the morphological growth is known as a stress-tolerator in high sedimentation and/or eutrophication (Rogers 1990; Edinger & Risk 2000).

Figure 4. Coral reef in observation spot 1: a) and b) dense colonies of *Sarcophyton*; c) a large colony of *Galaxea*.

The lowest cover of LC was observed in spot 2 with seabed mostly covered by silt and only one small group of the LC colonies was observed growing close together at a narrow spot. Ten colonies of coral were found from 3 genera of HC and 1 genus of SC. HC group was found as 7 coral colonies of genus *Goniopora* (Figure 5b), and single colony each of *Alveopora* and *Favites* (Figure 5a), while SC group was detected as only one coral colony of genus *Lithophyton*. Fragments of HC or rubble with mixed of some shell fractions also were found at the certain parts, particularly nearby the observed LC (Figure 5c). The presence of a rubble form of hard substrate may play roles to provide a suitable attachment object for coral colonies, which is an important part of recruitment and sustainability of growth for many sessile invertebrates (Hughes 1999; Rasser & Riegl 2002; Fox et al 2003; Duckworth & Wolff 2011; Wahab et al 2014).

Bottom substrate in observation spot 3 was characterized by vast cover of silt (64.4%). The coral condition was in poor/bad category with LC cover of 21.4%. Similar to the coral cover of spot 1, dense coverage of SC was also observed at the certain part of the study area in spot 3. Percent cover of SC group was 11.2% that dominated by *Junceella* and *Ellisella* genera, belonging to the Ellisellidae family (Figure 6a & b). *Junceella* or commonly known as sea-whip, has whip-like character state, while *Ellisella* is candelabrum (Bilewitch et al 2014). Ellisellidae family constitute a diverse and widely distributed family, which recorded throughout the Indo-Pacific and Atlantic region, Mediterranean and Red Sea (Grasshoff 2000; Fabricius & Alderslade 2001; Sánchez & Wirshing 2005; Cairns 2007; Fabricius et al 2007; Ben & Dautova 2010; Yogesh Kumar et al 2014, 2016), although the origins of this family is likely occurred in the Indo-Pacific

region (Bilewitch et al 2014). Meanwhile, percent cover of HC was lower than SC i.e. 10.2%. The dominant colony of HC was from genera of *Alveopora* and *Goniopora*. They were often observed grow in a group of several small colonies. Another frequently observed colony of HC was *Pseudosiderastrea* (Figure 6f) that grows in sparse and small size colony, commonly less than 25 cm wide, while the large colonies of HC was encrusted *Chypastrea* and *Favites* (Figure 6d & e).

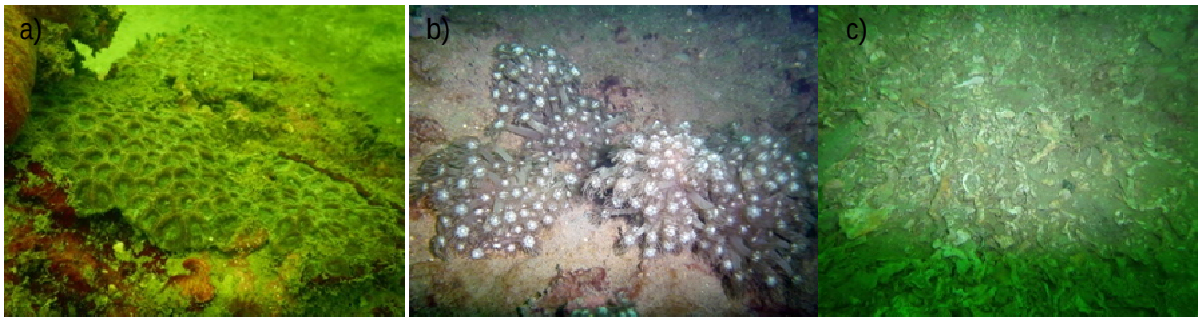

Figure 5. Coral reef of observation spot 2: a) colony of *Favites*; b) colony group of *Goniopora*; c) rubble.

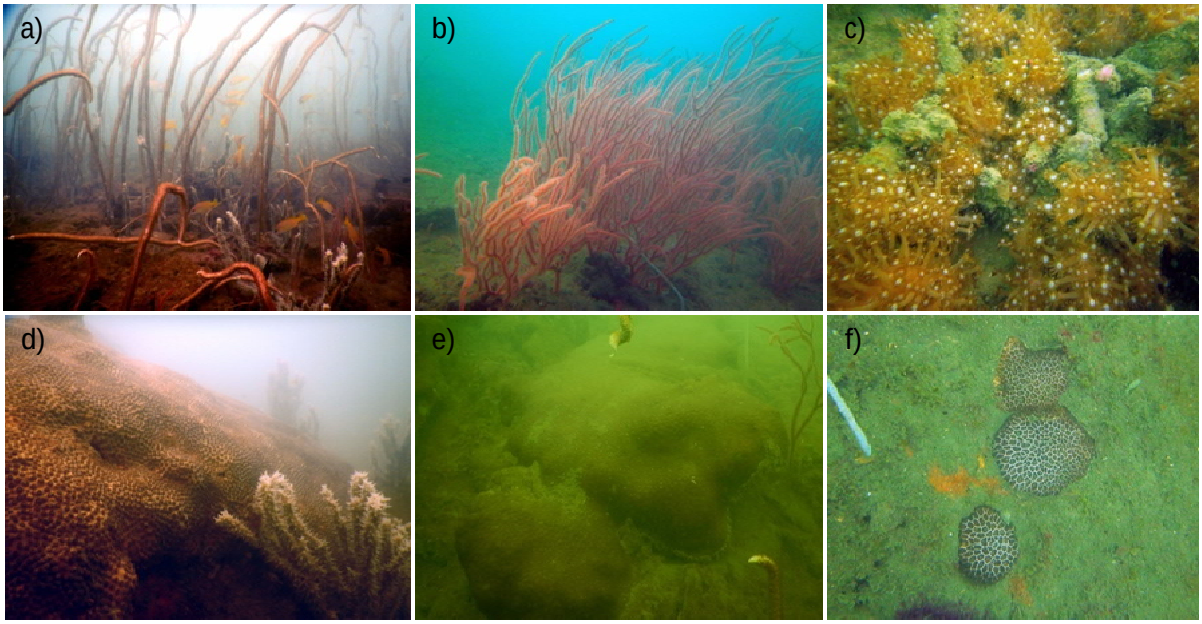

Figure 6. Coral reef of observation spot 3: a) *Junceella*; b) *Ellisella*; c) *Alveopora*; d) *Cyphastrea*; e) *Favites*; f) *Pseudosiderastrea*.

In general, higher percent cover of SC toward HC is a common case since Octocorallia groups in many reefs area have better ability to grow and compete with HC in dominating certain areas (Fabricius 1997; Schleyer & Celliers 2003; Schleyer & Benayahu 2008; Nababan et al 2015; Syahrir et al 2015; Baum et al 2016; Shahbudin et al 2017). Octocorals are the second most common and widely distributed group after HC which are able to tolerate large variations of ecological conditions (Yongesh Kumar et al 2016). They have been reported occur in various types of coral reefs in wide ecological range of marine, from tropical to subtropical, shallow waters to abyssal depths and hard to soft substrates (Fabricius & Alderslade 2001; Cairns 2007; Fabricius et al 2007; Chanmethakul et al 2010; Bryce & Sampey 2014; Perez et al 2016). They are adaptable and can survive under heavy loads of sedimentation (Schleyer & Celliers 2003), overgrow and smother the HC colonies (Alino et al 1992), compared to the HC group they are more resistant (up to four times) toward the density deflation due to the turbidity influences (Fabricius et al 2012), and competitively damage many stony corals and may become

dominant on the reefs due to the alteration of the environmental conditions (Chadwick & Morrow 2011).

The coral reef condition of spot 4 was categorized into fair/moderate with 39.1% of LC cover, comprised of 33.3% cover of HC and 5.8% cover of SC. This spot was also recorded as the highest coral coverage of HC group among the spots, as well revealed the highest genera of coral, mostly contributed by encrusting corals (CE) with 20.5% of coral cover. The CE was particularly large colonies of *Dipsastraea* genera (formerly known as *Favia* genera of Indo-Pacific before Budd et al (2012) and Huang et al (2014b)) from Merulinidae family (Figure 7a). In addition, other genera of HC also observed growing in wide colonies are *Favites, Leptoseris, Platygyra, Physogyra* and *Porites* (Figure 7b-f). The encrusting colonies were observed mainly growing over the rock or dead coral. Six genera of Fungiids (Table 1) were recorded from this spot (Figure 7g).

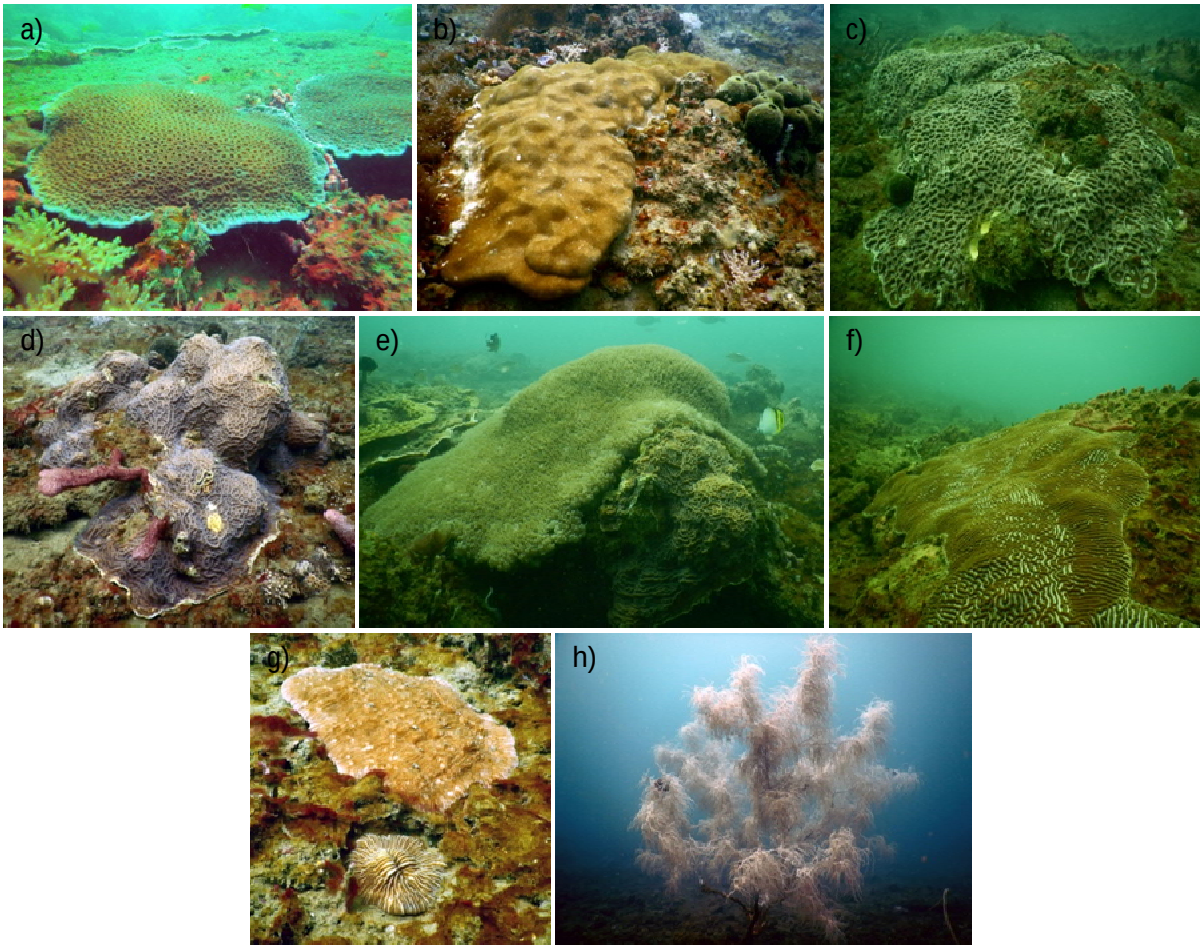

Figure 7. Coral reef of observation spot 4; a) *Dipsastraea*; b) *Porites*; c) *Favites*; d) *Leptoseris*; e) *Leptoseris* & *Physogyra*; f) *Platygyra*; g) *Halomitra* (upper) & *Cycloseris* (below); h) *Pseudopterogorgia*.

The present study successfully reported the coral presence in the Mahakam Delta area. It was surprising that we found a significant community of corals in the delta area, an atypical environment for the coral reefs development. Suyatna et al (2017) also found corals distributed in the Mahakam Delta. The presence of these new discoveries of corals in this area will aid to complete the databases of the coral reef in Mahakam Delta. Therefore, it opens up a wider idea of the possibility of another undiscovered coral reef that is still hidden and 'unseen' under the turbid conditions of the murky Mahakam Delta. Furthermore, this discovery may raise the question of how these reefs can adapt and survive in the unsuitable conditions of the deltaic environment, and whether they are associated with the ancient reefs from several previous studies (e.g. Storms et al 2005; Wilson 2005; Marshall et al 2015; Novak et al 2013; Kusworo et al 2015; Renema et al

2015; Santodomingo et al 2015a, 2015b; Pretkovic et al 2016). Finally, this study implication expected to increase our understanding of high aquatic biodiversity and complex ecosystem of the Mahakam Delta.

Conclusions. The coral reefs are found to exist in the eastern front of the Mahakam Delta, Tani Baru Village, Anggana Sub-district, Kutai Kartanegara District, East Kalimantan Province. Thirty (30) hard coral genera from 11 families and 11 soft coral genera from 6 families were recorded. The measured coral reef condition varies from poor/bad to fair/moderate category.

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References

Alino P. M., Sammarco P. W., Coll J. C., 1992 Competitive strategies in soft corals (Coelenterata, Octocorallia). IV. Environmentally induced reversals in competitive superiority. Marine Ecology Progress Series 81:129-145.

Allen G., 2000 Marine fishes of South-East Asia: a field guide for anglers and divers. Periplus Editions (HK) Ltd., Singapore, 292 pp.

Allen G. P., Chambers L. C. C., 1998 Sedimentation in the Modern and Miocene Mahakam delta. Indonesian Petroleum Association, Jakarta, Indonesia. Field Trip Guide Book, 236 pp.

Allen G. P., Laurier D., Thouvenin J., 1976 Sediment distribution patterns in the Modern Mahakam delta. Indonesian Petroleum Association, 5th Annual Convention Proceedings, Jakarta, pp. 159-178.

Allen G. R., Steene R., 1994 Indo-Pacific coral reef field guide. Tropical Reef Research, Singapore, 378 pp.

Aratake S., Tomura T., Saitoh S., Yokokura R., Kawanishi Y., Shinjo R., Reimer J. D., Tanaka J., Maekawa H., 2012 Soft coral Sarcophyton (Cnidaria: Anthozoa: Octocorallia) species diversity and chemotypes. PLoS ONE 7(1):e30410.

Arrigoni R., Terraneo T. I., Galli P., Benzoni F., 2014 Lobophylliidae (Cnidaria, Scleractinia) reshuffled: pervasive non-monophyly at genus level. Molecular Phylogenetics and Evolution 73:60-64.

Baum G., Januar I., Ferse S. C. A., Wild C., Kunzmann A., 2016 Abundance and physiology of dominant soft corals linked to water quality in Jakarta Bay, Indonesia. PeerJ 4:e2625.

Ben H. X., Dautova T. N., 2010 Diversity of soft corals (Alcyonacea) in Vietnam. In: Proceedings of International Conference: Marine Biodiversity of East Asia Seas: Status, Challenges and Sustainable Development. Dautova T. N., Lutaenko K. A. (eds), Nha Trang, Vietnam, pp. 82-87.

Bergbauer M., Kirschner M., 2014 Reef fishes of the Indo-Pacific. John Beaufoy Publishing Limited, United Kingdom, 352 pp.

Bilewitch J. P., Ekins M., Hooper J., Degnan S. M., 2014 Molecular and morphological systematics of the Ellisellidae (Coelenterata: Octocorallia): parallel evolution in a globally distributed family of octocorals. Molecular Phylogenetics and Evolution 73: 106-118.

Blanton J., Alber M., Sheldon J., 2001 Salinity response of the Satilla River estuary to seasonal changes in freshwater discharge. In: Proceedings of the 2001 Georgia Water Resources Conference. Hatcher K. J. (ed), Institute of Ecology, University of Georgia, Athens, Georgia, pp. 619-622.
Bongaerts P., Hoeksema B. W., Hay K. B., Hoegh-Guldberg O., 2012 Mushroom corals overcome live burial through pulsed inflation. Coral Reefs 31:399.
Bryce M., Sampey A., 2014 Kimberley marine biota. Historical data: soft corals and sea fans (Octocorallia). Records of the Western Australian Museum, Supplement 84: 101-110.
Budd A. F., Fukami H., Smith N. D., Knowlton N., 2012 Taxonomic classification of the reef coral family Mussidae (Cnidaria: Anthozoa: Scleractinia). Zoological Journal of the Linnean Society 166:465-529.
Budhiman S., Hobma T. W., Vekerdy Z., 2004 Remote sensing for mapping TSM concentration in Mahakam delta: an analytical approach. Presented at 13th OMISAR Workshop on Validation and Application of Satellite Data for Marine Resources Conservation, Kuta, Bali, Indonesia, 5-6 October, 14 pp.
Budhiman S., Salama M. S., Vekerdy Z., Verhoef W., 2012 Deriving optical properties of Mahakam delta coastal waters, Indonesia using in situ measurements and ocean color model inversion. ISPRS Journal of Photogrammetry and Remote Sensing 68: 157-169.
Budiyanto F., Lestari, 2013 Study of metal contaminant level in the Mahakam delta: sediment and dissolved metal perspectives. Journal of Coastal Development 16(2): 147-157.
Burke L., Reytar K., Spalding M., Perry A., 2011 Reefs at risk revisited. World Resources Institute, Washington DC., 114 pp.
Burke L., Reytar K., Spalding M., Perry A., 2012 Reefs at risk revisited in the coral triangle. World Resources Institute, Washington DC., 72 pp.
Cairns S. D., 2007 Studies on western Atlantic Octocorallia (Gorgonacea: Ellisellidae). Part 7: The genera *Riisea* Duchassaing & Michelotti, 1860 and *Nicella* Gray, 1870. Proceedings of the Biological Society of Washington 120:1-38.
Chadwick N. E., Morrow K. M., 2011 Competition among sessile organisms on coral reefs. In: Coral reefs: an ecosystem in transition. Dubinsky Z., Stambler N. (eds), Springer, Netherlands, Dordrecht, pp. 347-371.
Chadwick-Furman N., Loya Y., 1992 Migration, habitat use, and competition among mobile corals (Scleractinia: Fungiidae) in the Gulf of Eilat, Red Sea. Marine Biology 114:617-623.
Chanmethakul T., Chansang H., Watanasit S., 2010 Soft coral (Cnidaria: Alcyonacea) distribution patterns in Thai waters. Zoological Studies 49(1):72-84.
Chou L. M., Toh K. B., Tay Y. C., Phang V. X. H., 2012 Coral reefs in Singapore: past, present and future. The Asian Conference on Sustainability, Energy and the Environment: Conference Proceedings 2012, pp. 431-436.
Coll J. C., Bowden B. F., Tapiolas D. M., Dunlap W. C., 1982 In situ isolation of allelochemicals released from soft corals (Coelenterata: Octocorallia): a totally submersible sampling apparatus. Journal of Experimental Marine Biology and Ecology 60:293-299.
Creocean, 2000 Mahakam Delta 1999 Environmental Baseline Survey. Final Report to Total Indonesie, Creocean, Montpellier, 132 pp.
D'Elia M., Patti B., Sulli A., Tranchida G., Bonanno A., Basilone G., Giacalone G., Fontana I., Genovese S., Guisande C., Mazzola S., 2009 Distribution and spatial structure of pelagic fish schools in relation to the nature of the seabed in the Sicily Straits (Central Mediterranean). Marine Ecology 30:151-160.
Davila P. M., Figueroa D., Muller E., 2002 Freshwater input into the coastal ocean and its relation with the salinity distribution off austral Chile (35-55^{o}S). Continental Shelf Research 22:521-534.
Duckworth A. R., Wolff C. W., 2011 Population dynamics and growth of two coral reef sponges on rock and rubble substrates. Journal of Experimental Marine Biology and Ecology 402:49-55.

Edinger E. N., Risk M. J., 2000 Reef classification by coral morphology predicts coral reef conservation value. Biological Conservation 92:1-13.
Edwards A. J., Clark S., Zahir H., Rajasuriya A., Naseer A, Rubens J., 2001 Coral bleaching and mortality on artificial and natural reefs in Maldives in 1998, sea surface temperature anomalies and initial recovery. Marine Pollution Bulletin 42(1):7-15.
English S., Wilkinson C., Baker V., 1994 Survey manual for tropical marine resources. Australian Institute of Marine Science, Townsville, Australia, 368 pp.
Fabricius K. E., 1997 Soft coral abundance on the central Great Barrier Reef: effects of *Acanthaster planci*, space availability, and aspects of the physical environment. Coral Reefs 16:159-167.
Fabricius K. E., 2005 Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis. Marine Pollution Bulletin 50:125-146.
Fabricius K., Alderslade P., 2001 Soft corals and sea fans: a comprehensive guide to the tropical shallow water genera of the central-west Pacific, the Indian Ocean and the Red Sea. Australian Institute of Marine Science, Townsville, 264 pp.
Fabricius K. E., De'ath G., 2001 Environmental factors associated with the spatial distribution of crustose coralline algae on the Great Barrier Reef. Coral Reefs 19:303-309.
Fabricius K. E., Alderslade P., Williams G. C., Colin P. L., Golbuu Y., 2007 Octocorallia in Palau, Micronesia: effects of biogeography and coastal influences on local and regional biodiversity. In: Coral reefs of Palau. Kayanne H., Omori M., Fabricius K., Verheij E., Colin P., Golbuu Y., Yukihira H. (eds), Palau International Coral Reef Centre, Palau, pp. 79-92.
Fabricius K. E., Cooper T. F., Humphrey C., Uthicke S., De'ath G., Davidson J., LeGrand H., Thompson A., Schaffelke B., 2012 A bioindicator system for water quality on inshore coral reefs of the Great Barrier Reef. Marine Pollution Bulletin 65(4-9):320-332.
Ferns L. W., 2016 Coral communities in extreme environmental conditions in the Northern Territory, Australia. Northern Territory Naturalist 27:84-96.
Fleury B. G., Coll J. C., Sammarco P. W., 2006 Complementary (secondary) metabolites in a soft coral: sex-specific variability, inter-clonal variability, and competition. Marine Ecology 27:204-218.
Fox H. E., Pet J. S., Dahuri R., Caldwell R. L., 2003 Recovery in rubble fields: long-term impacts of blast fishing. Marine Pollution Bulletin 46:1024-1031.
Garmin, 2011 GPSMap 580/585 Chartplotter/Combo Fish Finder Owner's Manual. Garmin Ltd., 124 pp.
Gittenberger A., Reijnen B. T., Hoeksema B. W., 2011 A molecularly based phylogeny reconstruction of mushroom corals (Scleractinia: Fungiidae) with taxonomic consequences and evolutionary implications for life history traits. Contributions to Zoology 80(2):107-132.
Goffredo S., Chadwick-Furman N. E., 2000 Abundance and distribution of mushroom corals (Scleractinia: Fungiidae) on a coral reef at Eilat, northern Red Sea. Bulletin of Marine Science 66(1):241-254.
Goh B. P. L., Tan G. E., Tan L. T., 2009 Diversity, distribution and biological activity of soft corals (Octocorallia, Alcyonacea) in Singapore. Journal of Coastal Development 12(2):89-98.
Golbuu Y., Fabricius K., Victor S., Richmond R. H., 2008 Gradients in coral reef communities exposed to muddy river discharge in Pohnpei, Micronesia. Estuarine, Coastal and Shelf Science 76:14-20.
Gomez E. D., Yap H. T., 1988 Monitoring reef conditions. In: Coral reef management handbook. Kenchington R. A., Hudson B. E. T. (eds), UNESCO Regional Office for Science and Technology for Southeast Asia (ROSTSEA), Jakarta, pp. 187-195.
Gomez E. D., Alino P. M., Yap H. T., Licuanan W. Y., 1994 A review of the status of Philippine reefs. Marine Pollution Bulletin 29(1-3):62-68.
Graham N. A. J., Nash K. L., 2013 The importance of structural complexity in coral reef ecosystems. Coral Reefs 32:315-326.

Grasshoff M., 2000 The gorgonians of the Sinai coast and the Strait of Gubal, Red Sea (Coelenterata, Octocorallia). Courier Forschungsinstitut Senckenberg 224:1-125.
Harrison P. L., 2011 Sexual reproduction of scleractinian corals. In: Coral reefs: an ecosystem in transition. Dubinsky Z., Stambler H. (eds), Springer, Netherlands, pp. 59-85.
Hennige S. J., Smith D. J., Walsh S. J., McGinley M. P., Warner M. E., Sugget D. J., 2010 Acclimation and adaptation of scleractinian coral communities along environmental gradients within an Indonesian reef system. Journal of Experimental Marine Biology and Ecology 391:143-152.
Hill J., Wilkinson C., 2004 Methods for ecological monitoring of coral reefs, Version 1. A resource for managers. Australian Institute of Marine Science, Australia, 117 pp.
Hoeksema B. W., 1988 Mobility of free-living fungiid corals (Scleractinia), a dispersion mechanism and survival strategy in dynamic reef habitats. Proceedings of the 6th International Coral Reef Symposium, Townsville, Australia 2:715-720.
Hoeksema B. W., 1989 Taxonomy, phylogeny and biogeography of mushroom corals (Scleractinia: Fungiidae). Zoologische Verhandelingen Leiden 254:1-295.
Hoeksema B. W., 2004 Impact of budding on free-living corals at East Kalimantan, Indonesia. Coral Reefs 23:492.
Hoeksema B. W., 2009 Attached mushroom corals (Scleractinia: Fungiidae) in sediment-stressed reef conditions at Singapore, including a new species and a new record. The Raffles Bulletin of Zoology 22:81-90.
Hoeksema B. W., 2012 Distribution patterns of mushroom Ccorals (Scleractinia: Fungiidae) across the Spermonde Shelf, South Sulawesi. The Raffles Bulletin of Zoology 60(1):183-212.
Hoeksema B. W., Waheed Z., 2011 Initial phase of autotomy in fragmenting *Cycloseris* corals at Semporna, eastern Sabah, Malaysia. Coral Reefs 30:1087.
Hoeksema B. W., Yeemin T., 2011 Late detachment conceals serial budding by the free-living coral *Fungia fungites* in the Inner Gulf of Thailand. Coral Reefs 30:975.
Hoeksema B. W., de Voogd N. J., 2012 On the run: free-living mushroom corals avoiding interaction with sponges. Coral Reefs 31:455-459.
Hoeksema B. W., Bongaerts P., 2016 Mobility and self-righting by a free-living mushroom coral through pulsed inflation. Marine Biodiversity 46:521-524.
Hoeksema B. W., Dekker F., de Voogd N. J., 2014 Free-living mushroom corals strike back by overtopping a coral-killing sponge. Marine Biodiversity 44:3-4.
Honda K., Nakamura Y., Nakaoka M., Uy W. H., Fortes M. D., 2013 Habitat use by fishes in coral reefs, seagrass beds and mangrove habitats in the Philippines. PLoS ONE 8(8):e65735.
Huang D., Benzoni F., Arrigoni R., Baird A. H., Berumen M. L., Bouwmeester J., Chou L. M., Fukami H., Licuanan W. Y., Lovell E. R., Meier R., Todd P. A., Budd A. F., 2014a Towards a phylogenetic classification of reef corals: the Indo-Pacific genera *Merulina*, *Goniastrea* and *Scapophyllia* (Scleractinia, Merulinidae). Zoologica Scripta 43(5):531-548.
Huang D., Benzoni F., Fukami H., Knowlton N., Smith N. D., Budd A. F., 2014b Taxonomic classification of the reef coral families Merulinidae, Montastraeidae and Diploastraeidae (Cnidaria: Anthozoa: Scleractinia). Zoological Journal of the Linnean Society 171:277-355.
Huang D., Arrigoni R., Benzoni F., Fukami H., Knowlton N., Smith N. D., Stolarski J., Chou L. M., Budd A. F., 2016 Taxonomic classification of the reef coral family Lobophylliidae (Cnidaria: Anthozoa: Scleractinia). Zoological Journal of the Linnean Society 178(3):436-481.
Hughes T. P., 1999 Off-reef transport of coral fragments at Lizard Island, Australia. Marine Geology 157:1-6.
Jokiel P. L., Rodgers K. S., Storlazzi C. D., Field M. E., Lager C. V., Lager D., 2014 Response of reef corals on a fringing reef flat to elevated suspended-sediment concentrations: Moloka'i, Hawai'i. PeerJ 2:e699.

Jompa H., Pet-Soede L., 2002 The coastal fishery in East Kalimantan: a rapid assessment of fishing patterns, status of reef habitat and reef fish stocks and socio-economic characteristics. WWF Indonesia – Wallacea Program Report, 83 pp.
Kagesten G., 2008 Geological seafloor mapping with backscatter data from a multibeam echo sounder. Department of Earth Sciences, Gothenburg University, Gothenburg, Sweden, 38 pp.
Kelley R., 2009 Indo Pacific Coral Finder. BYO Guides. Townsville, Australia, 34 pp.
Kitahara M. V., Fukami H., Benzoni F., Huang D., 2016 The new systematics of Scleractinia: integrating molecular and morphological evidence. In: The Cnidaria, past, present and future: the world of Medusa and her sisters. Goffredo S., Dubinsky Z. (eds), Springer, Switzerland, pp. 41-59.
Kitano Y. F., Benzoni F., Arrigoni R., Shirayama Y., Wallace C. C., Fukami H., 2014 A phylogeny of the family Poritidae (Cnidaria, Scleractinia) based on molecular and morphological analyses. PLoS ONE 9(5):e98406.
Kramarsky-Winter E., Loya Y., 1996 Regeneration versus budding in fungiid corals: a trade-off. Marine Ecology Progress Series 134:179-185.
Kusworo A., Reich S., Wesselingh F. P., Santodomingo N., Johnson K. G., Todd J. A., Renema W., 2015 Diversity and paleoecology of Miocene coral-associated mollusks from East Kalimantan (Indonesia). Palaios 30:116-127.
La Barre S. C., Coll J. C., Sammarco P. W., 1986 Competitive strategies of soft corals (Coelenterata: Octocorallia): III. Spacing and aggressive interactions between alcyonaceans. Marine Ecology Progress Series 28:147-156.
Lam K., Shin P. K. S., Bradbeer R., Randall D., Ku K. K. K., Hodgson P., Cheung S. G., 2006 A comparison of video and point intercept transect methods for monitoring subtropical coral communities. Journal of Experimental Marine Biology and Ecology 333:115-128.
Lane R. R., Day Jr. J. W., Marx B. D., Reyes E., Hyfield E., Day J. N., 2007 The effects of riverine discharge on temperature, salinity, suspended sediment and chlorophyll *a* in a Mississippi delta estuary measured using a flow-through system. Estuarine, Coastal and Shelf Science 74:145-154.
Lawrence M. J., Bates C. R., 2001 Acoustic ground discrimination techniques for submerged archaeological site investigations. Marine Technology Society Journal 35(4):65-73.
MacKinnon K., Hatta G., Halim H., Mangalik A., 2000 [The ecology of Indonesia series. Vol. III; Ecology of Kalimantan]. Kartikasari S. N. (ed), & Tjitrosoepomo G., Kartikasari S. N., Widyantoro A. (Trans), Prehalindo, Jakarta, 972 pp. [in Indonesian]
Marshall N., Novak V., Cibaj I., Krijgsman W., Renema W., Young J., Fraser N., Limbong A., Morley R., 2015 Dating Borneo's deltaic deluge: middle Miocene progradation of the Mahakam delta. Palaios 30:7-25.
Möller Jr. O. O., Piola A. R., Freitas A. C., Campos E. J. D., 2008 The effects of river discharge and seasonal winds on the shelf off southeastern South America. Continental Shelf Research 28(13):1607-1624.
Mora C. (ed), 2015 Ecology of fishes on coral reefs. Cambridge University Press, 374 pp.
Nababan S. M. P., Ruswahyuni, Suryanti, 2015 [Closure soft coral on reef flat areas with the reef slope areas in Cemara Kecil Island, Kepulauan Karimun Jawa]. Diponegoro Journal of Maquares, Management of Aquatic Resources 4(3):164-169. [in Indonesian]
Novak V., Santodomingo N., Rosler A., Di Martino E., Braga J. C., Taylor P. D., Johnson K. G., Renema W., 2013 Environmental reconstruction of a late Burdigalian (Miocene) patch reef in deltaic deposits (East Kalimantan, Indonesia). Palaeogeography, Palaeoclimatology, Palaeoecology 374:110-122.
Nursigit L., Sya'rani, Suryanto A., 2013 Zonation compatibility on forest mangrove area in Delta Mahakam, East Kalimantan Indonesia. International Journal of Waste Resources 3(1):47-45.

Pandolfi J. M., 2011 The palaeoecology of coral Rreefs. In: Coral reefs: an ecosystem in transition. Dubinsky Z., Stambler N. (eds), Springer, Netherlands, Dordrecht, pp. 13-24.
Perez C. D., De Moura Neves B., Cordeiro R. T., Williams G. C., Cairns S. D., 2016 Diversity and distribution of Octocorallia. In: The Cnidaria, past, present and future: the world of Medusa and her sisters. Goffredo S., Dubinsky Z. (eds), Springer, Switzerland, pp. 109-123.
PERSGA/GEF, 2004 Standard survey methods for key habitats and key species in the Red Sea and Gulf of Aden. PERSGA Technical Series No. 10, PERSGA, Jeddah, 310 pp.
Persoon G. A., Simarmata R., 2014 Undoing 'marginality': the islands of the Mahakam delta, East Kalimantan (Indonesia). Journal of Marine and Island Cultures 3(2):43-53.
Pham Van C., de Brye B., Deleersnijder E., Hoitink A. J. F., Sassi M., Spinewine B., Hidayat H., Soares-Frazao S., 2016 Simulations of the flow in the Mahakam river-lake-delta system, Indonesia. Environmental Fluid Mechanics 16(3):603-633.
Piola A. R., Matano R. P., Palma E. D., Möller Jr. O. O., Campos E. J. D., 2005 The influence of the Plata River discharge on the western south Atlantic shelf. Geophysical Research Letters 32:L01603.
Pretkovic V., Braga J. C., Novak V., Rosler A., Renema W., 2016 Microbial domes and megaoncoids in Miocene reefs in the Mahakam delta in East Kalimantan, Indonesia. Palaeogeography, Palaeoclimatology, Palaeoecology 449:236-245.
Randall J. E., Allen G. R., Steene R. C., 1997 Fishes of Great Barrier Reef and Red Sea. Revised and expanded edition, Periplus Edition (HK) Ltd., Singapore, 557 pp.
Rasser M. W., Riegl B., 2002 Holocene coral reef rubble and its binding agents. Coral Reefs 21:57-72.
Renema W., Warter V., Novak V., Young J. R., Marshall N., Hasibuan F., 2015 Age of Miocene fossil localities in the northern Kutai basin (East Kalimantan, Indonesia). Palaios 30:26-39.
Richards Z., 2016 The coral compactus: westrern Australia hard coral genus identification guide, Version 1.1. Western Australian Museum, 21 pp.
Rogers C. S., 1990 Responses of coral reefs and reef organisms to sedimentation. Marine Ecology Progress Series 62:185-202.
Rosler A., Pretkovic V., Novak V., Renema W., Braga J. C., 2015 Corraline algae from the Miocene Mahakam delta (East Kalimantan, Southeast Asia). Palaios 30:83-93.
Sale P. F. (ed), 1991 The ecology of fishes on coral reefs. Academic Press Inc., 754 pp.
Salisbury J., Vandemark D., Campbell J., Hunt C., Wisser D., Reul N., Chapron B., 2011 Spatial and temporal coherence between Amazon River discharge, salinity, and light absorption by colored organic carbon in western tropical Atlantic surface waters. Journal of Geophysical Research 116:C00H02.
Sammarco P. W., Coll J. C., La Barre S. C., Willis B. L., 1983 Competitive strategies of soft corals (Coelenterata: Octocorallia): allelopathic effects on selected scleractinian corals. Coral Reefs 1:173-178.
Sánchez J. A., Wirshing H. H., 2005 A field key to the identification of tropical western Atlantic zooxanthellate octocorals (Octocorallia: Cnidaria). Caribbean Journal of Science 41(3):508-522.
Santodomingo N., Novak V., Pretkovic V., Marshall N., Di Martino E., Cappelli E. L. G., Roesler A., Reich S., Braga J. C., Renema W., Johnson K. G., 2015a A diverse patch reef from turbid habitats in the Middle Miocene (East Kalimantan, Indonesia). Palaios 30:128-149.
Santodomingo N., Wallace C. C., Johnson K. G., 2015b Fossils reveal a high diversity of the staghorn coral genera *Acropora* and *Isopora* (Scleractinia: Acroporidae) in the Neogene of Indonesia. Zoological Journal of the Linnean Society 175(4):677-763.
Schleyer M. H., Celliers L., 2003 Coral dominance at the reef-sediment interface in marginal coral communities at Sodwana Bay, South Africa. Marine and Freshwater Research 54:967-972.

Schleyer M. H., Benayahu Y., 2008 Soft coral biodiversity and distribution in East Africa: gradients, function and significance. Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida, 7-11 July 2008, pp. 1388-1391.
Shahbudin S., Fikri Akmal K., Faris S., Normawaty M. N., Mukai Y., 2017 Current status of coral reefs in Tioman Island, Peninsular Malaysia. Turkish Journal of Zoology 41: 294-305.
Spalding M. D., Ravilious C., Green E. P., 2001 World atlas of coral reefs. UNEP-WCMC, University of California Press, 424 pp.
Storms J. E. A., Hoogendoorn R. M., Dam R. A. C., Hoitink A. J. F., Kroonenberg S. B., 2005 Late-Holocene evolution of the Mahakam delta, East Kalimantan, Indonesia. Sedimentary Geology 180:149-166.
Sutthacheep M., Yucharoen M., Klinthong W., Pengsakun S., Sangmanee K., Yeemin T., 2013 Impacts of the 1998 and 2010 mass coral bleaching events on the Western Gulf of Thailand. Deep-Sea Research Part II 96:25-31.
Suyatna I., 2011 [A study on distribution of demersal fishes caught around the mangrove area of the Mahakam delta]. PhD thesis, Faculty of Forestry, Mulawarman University, Samarinda, Indonesia, 177 pp. [in Indonesian]
Suyatna I., Hanjoko T., Adnan A., Yasser M., Efendi M., Budiarsa A. A., Eryati R., Rafii A., Sidik A. S., 2017 First record of coral reefs in the delta front of Mahakam Delta, East Kalimantan, Indonesia. AACL Bioflux 10(4):687-697.
Syahrir M. R., Jayadi A., Adnan A., Yasser M. F., Hanjoko T., 2015 Condition of coral reef at Teluk Pandan sub-district East Kutai district. International Journal of Science and Engineering 8(1):60-64.
Tomascik T., Mah A. J., Nontji A., Moosa M. K., 1997 The ecology of Indonesian series, Vol VII; The ecology of Indonesian seas. Periplus Editions (HK) Ltd., Republic of Singapore, 1388 pp.
Torres J. L., Morelock J., 2002 Effect of terrigenous sediment influx on coral cover and linear extension rates of three Caribbean massive coral species. Caribbean Journal of Science 38(3-4):222-229.
Total E&P Indonesie, 2006 Tunu high resolution site 3D seismic monitoring Mahakam delta, Kutai Kartanegara, East Kalimantan: study on the water quality and fish catch offshore and onshore. Final Report, Total E&P Indonesia, Balikpapan cooperation with Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, University of Mulawarman, 152 pp.
TotalFinaElf E&P Indonesie, 2002 [Monitoring on fish catch of fisherman in Mahakam delta area East Kalimantan]. Final Report, TotalFinaElf E&P Indonesia, Balikpapan cooperation with Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, University of Mulawarman, 129 pp. [in Indonesian]
Veron J. E. N., 2000 Corals of the world, Vols. 1-3. Stafford-Smith M. (ed), Australian Institute of Marine Science, Townsville, Australia, 1382 pp.
Veron J. E. N., Stafford-Smith M., 2002 Coral ID: an electronic key to the scleractinian corals of the world. Australian Institute of Marine Science and CRR Qld Pty Ltd. Australia, 17 pp.
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 11:91-100.
Veron J., Stafford-Smith M., DeVantier L., Turak E., 2015 Overview of distribution patterns of zooxanthellate Scleractinia. Frontiers in Marine Science 1:81.
Wahab M. A. A., de Nys R., Webster N., Whalan S., 2014 Larval behaviours and their contribution to the distribution of the intertidal coral reef sponge *Carteriospongia foliascens*. PLoS ONE 9(5):e98181.
Weiss A., Martindale R. C., 2017 Crustose coralline algae increased framework and diversity on ancient coral reefs. PLoS ONE 12(8):e0181637.
Wikner J., Andersson A., 2012 Increased freshwater discharge shifts the trophic balance in the coastal zone of the northern Baltic Sea. Global Change Biology 18:2509-2519.

Wilson M. E. J., 2005 Development of equatorial delta-front patch reefs during the Neogene, Borneo. Journal of Sedimentary Research 75(1):114-133.
WoRMS Editorial Board, 2017 World Register of Marine Species. Available at: http://www.marinespecies.org at VLIZ. Accessed: August, 2017.
Yogesh Kumar J. S., Raghunathan C., Raghuraman R., Sreeraj C. R., Venkataraman K., 2014 Handbook on gorgonians (Octocorallia) of Andaman and Nicobar Islands. Publication Division by the Director, Zoological Survey of India, 119 pp.
Yogesh Kumar J. S., Geetha S., Sornaraj R., 2016 Studies on the shallow water octocorals from the coast of Gulf of Mannar, India. Scholars Academic Journal of Biosciences 4(11):1045-1053.

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