Mar. Res. Indonesia Vol. 38, No. 1, 2013: 9−19

DIVERSITY OF STONY CORALS IN BANGGAI WATER

Rikoh Manogar Siringoringo and Tri Aryono Hadi

[1]Research Center for Oceanography-Indonesian Institute of Sciences
Jln. Pasir Putih I Ancol Timur, Jakarta 14430, Indonesia
E-mail: rikoh_ms@yahoo.com

Received: November 2012 Accepted: February 2013

ABSTRACT

Banggai waters, located in Central Sulawesi Province, is part of the world's coral triangle area which is well–known to have the highest diversity on stony corals (Scleractinia). A research on stony corals has been carried out at 9 study sites between June–July 2011, practicing line transect methods and free collection in order to determine the recent condition and diversity of the given coral group. The average of live corals coverage was recorded at 46% (ranging between 24–77%), and categorized as fair condition. The number of coral species found was 194, distributed in 54 genera. The Banggai waters condition was considered good and potential to sustain the corals'growth. Even though so, in several particular areas, there were still threats on coral reefs.

Keywords: diversity, stony corals, covering percentage, Banggai waters.

INTRODUCTION

Coral reef is a tropical aquatic ecosystem which has high productivity and plays important roles for human being (Supriharyono, 2000). Coral reefs offer coastal protection and are center of high biodiversity and provide essential habitats to a wide range of recreational and commercially important species of fishes and invertebrates (Johnson and Marshall, 2007). To support the roles, it is necessary to accumulate basic data related to the condition of coral reef ecosystem. The data will enable the government to make feasible plans to be implemented.

A significant global decline in living coral communities has occurred in recent decades as a response to many anthropogenic and environmental disturbances (Grimsditch and Salm, 2006). It has been the anthropogenic factors including plenty of activities which have influences in determining the ecosystem condition, rather than natural disasters. Some anthropogenic factors such as environmentally unfriendly fishing methods are apparently destructive. For such reason, more efforts are needed to protect the ecosystem condition from deteriorations by developing monitoring system over coral reefs, especially in remote and isolated areas.

In this study, observation on coral reef conditions was carried out in Banggai waters, central Sulawesi Province, Indonesia. This area is part of the world's coral triangle region which is well–known as the world's highest diversity of corals. According to Veron (2000a), in Indonesian waters especially in the western part, the coral diversity can reach 590 species. Other area in Indonesia, such as the Raja Ampat Islands, contributes 465 species belonging to 77 genera. Recently, coral studies have been conducted in Banggai waters, to determine the condition of coral reef. This research was to reveal the potential resources of corals and their health condition by examining several diversity indexes based on the number of individuals and species.

MATERIAL AND METHODS

Field observation was carried out between June and July 2011 by setting up nine study sites in Banggai waters (Fig. 1). At each site, the biota and types of substrates were investigated using Line Intersect Transect (LIT) method (English et

DOI : 10.14203/mri.v38i1.52

al., 1997) with some modifications.The Transect was 70 meters in length parallel to the coast line at 5−10 meters in depth. Biota and types of substrates were recorded exactly beneath the line, at 0−10 meters, 30−40 meters and 60−70 meters. The covering percentage of living corals was categorized into 4 ranks, i.e., poor, fair, good and excellent, adopted from Gomez and Yap (1988). Species of the corals beneath the line was identified. The diversity indexes, including Shannon's diversity index (H') (Shannon, 1948; Zar, 1996) and Pielou's evenness index (J') (Pielou, 1966; Zar, 1996) were calculated using software "Primer 5" (Clarke and Warwick, 2001). Further statistical analyses were conducted i.e. clustering analysis and multidimensional scaling (Clarke and Warwick, 2001).

The abundance of stony corals of family Fungiidae was assessed through a belt transect as long as 100 meters with 1,75 meters wide, using the same line with LIT. The number of colonies of Fungiids and their species found in the belt transect were recorded (Eleftheriou and Mclntyre, 2005). Free collection was also conducted from 5 meters down to a particular depth where stony corals still could be rarely found, completing the data taken from the belt transect. Some of the Fungiids were collected to be identified later in the laboratory under a microscope. We referred to Veron (2000a, b and c) in identifying the stony corals.

RESULTS

Biota and substrates

The visibility on the study sites was 10–20 meters. However, the bottom was dominated by unstable substrates such as sand and rubbles, and overgrown by hydroids and soft corals (Figure 2A). Stony corals occurred from reef flat to slope and were found in patches.

Coverage of live corals and conditions of corals

Based on the LIT data, the covering percentage of living stony corals averaged 46%, ranging

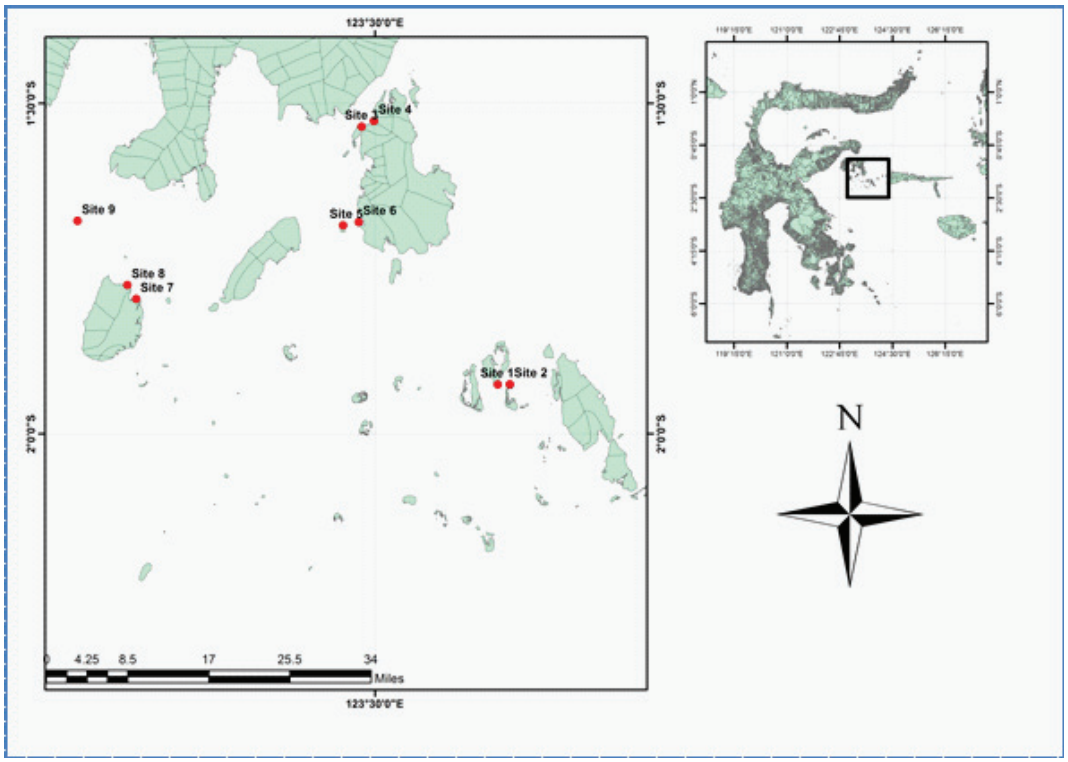


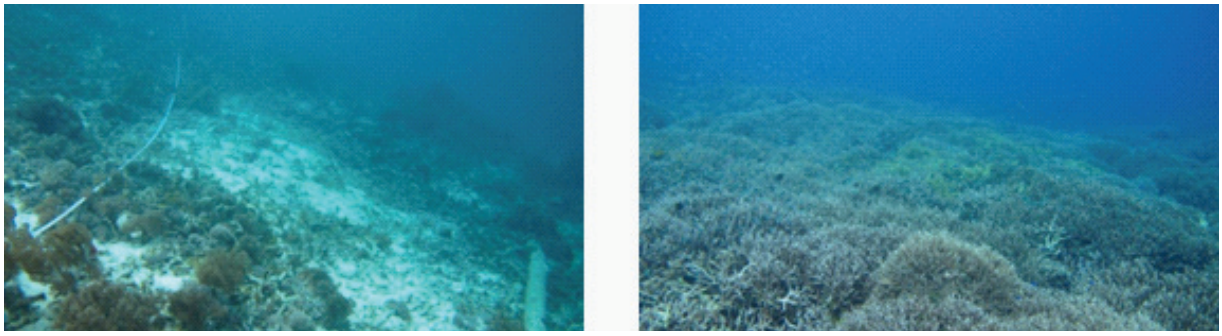
Figure 1. Location of study sites in Banggai waters. Site 1: Kokudan Island, Site 2: Melilis Island, Site 3: Toulon Island, Site 4: North Banggai Island, Site 5: Bandang Besar Island, Site 6: South Banggai Island, Sites 7 and 8: North Bengkulu Island, Site 9: Karang Merpati.

from 24% to 77% and was classified into fair condition (Table 1). The highest percentage occurred in Site 9, whereas the lowest was in Site 2. Sites 3 and 6 were categorized poor, whereas Sites 1 and 4 were fair, Sites 5 and 8 were good and Sites 7 and 9 were excellent.

Distribution and diversity of corals

Based on the observation utilizing LIT and free collection, 194 species of 54 genera of stony corals were found, and 11 of those species were distributed at all research sites (Table 2). Among the nine research sites, Site 9 demonstrated the largest number of species (128 species), followed by Site 7 (101 species). On the other hand, the smallest number of species (48 species) was observed at Site 3. Acroporidae and Faviidae were the most diverse families found in Banggai waters, having 55 and 45 species, respectively. The corals became more diverse as the depth increased up to 20 meters. Corals were still found at 25 meters in depth.

Acropora was widely spread at the research sites and dominated at Sites 7, 8 and 9 with coverage as much as 58%, 37% and 59% (Table 1). Many corals were found in small patches, but at Site 5, *Anacropora* was quite dominant, covering 55.1 percent of total LIT transect (Figure 2B). While at Site 2, the coverage of *Acropora* was quite low and that of rubbles was high, indicating the influence of human activities.



A **B**

Figure 2. Biota and substrates. A: unstable substrates; B: domination of *Anacropora*.

Table 1. The covering percentage of living corals, other organisms and substrates at each site.

Substratum	Site1	Site2	Site3	Site4	Site5	Site6	Site7	Site8	Site9
Total living coral	34.7	24.3	24.5	40.2	59.2	26.6	74.1	52.0	76.8
Acropora	13.5	10.7	0.1	7.4	4.1	1.9	58.3	37.1	58.8
non *Acropora*	21.2	13.6	24.4	32.8	55.1	24.7	15.8	14.9	18.0
Dead corals	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0
Dead coralline algae	0.0	0.0	0.0	0.0	0.8	0.0	1.1	4.6	1.6
Halimeda	0.0	8.6	0.0	0.0	0.7	0.0	1.1	6.8	2.0
Macroalgae	0.8	0.0	0.0	0.0	0.0	0.0	3.5	2.6	1.2
Soft coral	26.0	1.1	14.6	7.5	0.0	3.0	0.0	2.8	0.3
Sponge	0.0	0.7	7.0	10.7	0.5	5.9	0.1	0.0	0.0
Turf algae	11.0	19.3	23.6	15.9	4.6	18.7	16.2	17.4	16.6
Other organisms	2.8	4.7	8.2	7.1	0.2	2.8	0.0	0.5	0.0
Rubble	8.4	32.7	3.5	6.6	31.1	24.3	2.6	10.9	1.6
Rock	0.0	0.0	8.5	0.0	0.0	0.0	0.0	0.0	0.0
Sand	16.3	8.6	10.1	12.1	2.7	18.7	1.2	2.2	0.0

The diversity indices and cluster analysis

The Shannon's diversity index of living corals was highest (3.36) at Site 2 (Table 3) with 31 species from 41 sample corals. On the other hand, Site 9, in which the living coral percentage was the highest, showed the lowest Shannon's diversity index (2.12), indicating that the dominance of particular living coral, especially *Acropora*, occurred and resulted in the lowest Pielou's evenness index (0.75).

The cluster analysis in species composition of stony corals illustrated two major clusters of study sites (Figure 3). The first cluster comprised of Sites 7, 8 and 9. The most similar sites were Site 3 and 4, having approximately 60 percent of similarity.

DISCUSSIONS

The condition of coral reefs in Banggai waters was generally fair. Sri et al. (2006) and Suhendra et al. (2007) reported similar results in covering percentage of living corals, and the status of coral reefs condition has been constant over six years. Site 9 was categorized excellent by having the high covering percentage around 77%. This site was a wide reef flat, which was always immersed in sea water. There was no fresh water input or sedimentation. Furthermore, the water current was strong enough to enhance the corals' growth. Fast water flow conditions could protect corals from bleaching by removing harmful oxygen radicals and improve coral reef resiliency by preventing shifts to macroalgae-dominated reefs (Grimsditch and Slam, 2006; MacClanahan et al., 2002).

Based on the cluster analysis, there were two major cluster grouped by the presence of living corals (Figure 3). Sites 7, 8 and 9 which were clustered in one group were located in the western part of Banggai waters which had good visibility of water; that is, between 15–30 meters. The good water visibility seemed to enable branching corals, such as *Acropora* and *Anacropora*, to grow faster and be dominant among stony corals (Table 1). Johnson et al. (2012) showed that the optimal condition for the growth of *Acropora* is high visibility and well-circulation with low sedimentation.

Sites 3 and 4 had the highest similarity, but they were not close to each other. These sites were characterized by the dominance of non *Acropora*, especially massive corals, although the environmental conditions between them were different.

The diversity index ranged from 2.12 to 3.36 with the evenness index from 0.75 to 0.98 (Table 2). This suggests that stony corals were relatively diverse. However, Site 7 and 9 were dominated by *Acropora* (Table 1), generated by high visibility and enough current which made *Acropora* grow faster. Generally, good water condition found in Banggai enabled to sustain coral growth, therefore many corals could be found.

There were 11 species distributed in all observed sites. These species belong to the families Pocilloporidae, Poritidae, Fungiidae, Ocilinidae, Mussidae and Merulinidae (Table 2). One of those, i.e. Poritidae, was often classified as resistant coral which was characterized by massive growth

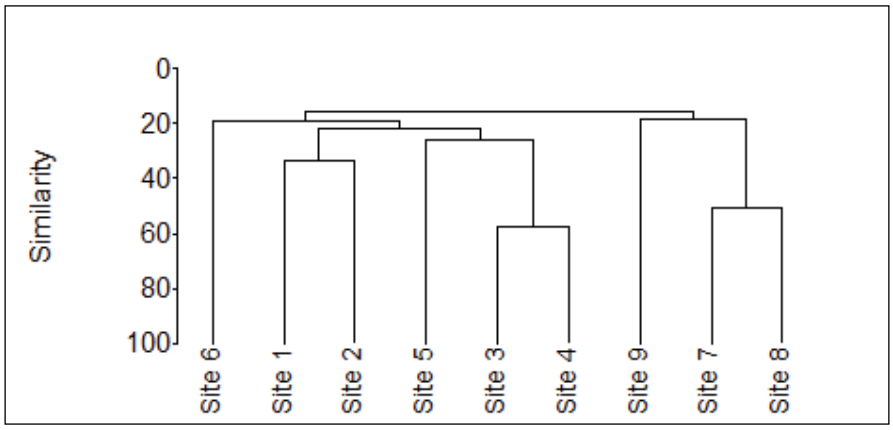


Figure 3. Cluster analysis of the study sites based on the species composition of live corals.

forms and slow growth rates and more resistant to bleaching and thermal stress (MacClahan, 2004; Marshall and Scuttenberg, 2006). However, most of the corals found in Banggai water such as *Acropora* and *Montipora*, were branching and foliose and they seemed less resistant judged from their morphology. Some resistant corals appeared only at some particular sites, with high sedimentation.

Reproductive strategy is different among families. Ocilinidae, Mussidae, Merulinidae, and most of Pocilloporidae are spawners, having larvae which can swim for long distance before settling (Richmond and Hunter, 1990). Furthermore, spawners are known for its high fecundity (Fadlalah, 1983) whereas Fungiidae utilizes also their free living stage for their dispersal and reproduces both asexually by budding and sexually (Hoeksema, 2012).

ACKNOWLEDGMENTS

We acknowledge Research Center for Oceanography for the financial support so that the research could be eventually conducted successfully and JSPS ACORE-COMSEA and LIPI for creating the opportunity to present this study. We also thank to crews of Baruna Jaya VIII research vessel who facilitated the research in the field.

Table 2. List of coral species found at Banggai waters (**+:** present)

No.	Family Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
	Number of species	**79**	**52**	**48**	**62**	**84**	**85**	**101**	**88**	**128**
I	ASTROCOENIIDAE									
1	*Stylocoeiniella armata*								+	+
II	POCILLOPORIDAE									
2	*Pocillopora damicornis*	+	+			+	+	+	+	+
3	*P. meandrina*								+	
4	*P. verrucosa*	+	+	+	+	+	+	+	+	+
5	*Seriatopora caliendrum*		+					+	+	+
6	*S. hystrix*	+	+	+	+	+	+	+	+	+
7	*Stylophora pistillata*	+	+	+	+	+	+	+	+	+
8	*S. subseriata*	+	+	+	+	+	+	+	+	+
9	*Palauastrea ramosa*					+				
III	ACROPORIDAE									
10	*Montipora aequituberculata*	+			+	+	+	+	+	+
11	*M. capricornis*									+
12	*M. confuse*		+							
13	*M. danae*		+	+		+				+
14	*M. delicatula*									
15	*M. digitata*	+	+	+		+	+			+
16	*M. foliosa*		+	+		+	+			+
17	*M. grisea*	+	+					+	+	+
18	*M. incrassata*					+				
19	*M. informis*	+	+	+			+	+		+
20	*M. monasteriata*	+	+		+	+		+		
21	*M. peltiformis*	+								
22	*M. spumosa*		+							
23	*M. tuberculosa*		+							+
24	*M. undata*						+	+	+	+

25	*Montipora sp. 1*										
26	*Montipora sp. 2*										
27	*Anacropora forbesi*					+			+	+	+
28	*Acropora abrolhosensis*								+	+	+
29	*A. aspera*				+		+				+
30	*A. awi*					+			+	+	+
31	*A. brueggemanni*	+			+	+	+				+
32	*A. carduus*								+	+	+
33	*A. caroliniana*				+	+	+	+			+
34	*A. clathrata*	+	+								
35	*A. cuneata*	+	+	+					+	+	+
36	*A. cytherea*	+	+			+					+
37	*A. digitifera*				+						
38	*A. divaricata*	+	+								
39	*A. echinata*					+			+	+	+
40	*A. elegans*								+		+
41	*A. florida*	+	+		+	+	+				+
42	*A. formosa*	+	+			+	+	+	+	+	
43	*A. gemmifera*		+	+	+	+	+	+			+
44	*A. grandis*	+	+	+							
45	*A. granulosa*		+			+			+	+	+
46	*A. horrid*								+		
47	*A. humilis*								+	+	+
48	*A. hyacinthus*	+	+		+		+				
49	*A. jaquelineae*										+
50	*A. lokani*					+	+				
51	*A. longicyathus*								+	+	+
52	*A. loripes*					+	+	+			+
53	*A. microphthalma*								+	+	+
54	*A. millepora*	+	+	+	+	+			+	+	+
55	*A. nobilis*								+	+	+
56	*A. orbicularis*										
57	*A. palifera*	+	+	+	+		+	+	+	+	
58	*A. tenuis*					+					
59	*A. valenciennesi*		+			+			+	+	+
60	*A. yongei*									+	+
61	*Astreopora gracilis*										+
62	*A. myriophthalma*						+	+	+	+	
63	*Acropora sp. 1*										+
64	*Acropora sp. 2*										+
IV	PORITIDAE										
65	*Porites australiensis*										+
66	*P. cylindrica*	+	+	+	+	+	+	+	+	+	
67	*P. lichen*			+							
68	*P. lobata*	+	+	+	+	+	+	+	+		
69	*P. lutea*	+	+	+	+	+	+	+	+		

70	*P. negrosensis*	+								
71	*P. nigrescens*	+	+	+	+	+	+	+	+	+
72	*P. rus*							+	+	+
73	*P. solida*			+	+	+	+			
74	*Porites sp.*								+	+
75	*Goniopora columna*	+	+	+	+	+	+	+		+
76	*G. djiboutiensis*					+			+	+
77	*G. lobata*	+			+	+	+	+	+	+
78	*Goniopora sp.*									
79	*G. stokes*		+	+	+					
80	*Goniopora sp.*					+		+		
V	SIDERASTREIDAE									
81	*Pseudosidera streatayami*							+		+
82	*Psammocora contigua*					+		+	+	
VI	AGARICIIDAE									
83	*Pavona cactus*	+			+	+		+	+	+
84	*P. decussata*	+	+				+			
85	*P. explanulata*	+						+		+
86	*P. varians*	+	+		+	+	+	+	+	+
87	*Leptoseris papyracea*					+				
88	*Pachyseris foliosa*									+
89	*P. rugosa*							+		
90	*P. speciosa*	+	+		+	+	+	+	+	+
VII	FUNGIIDAE									
91	*Ctenactisal bitentaculata*							+	+	+
92	*C. crassa*								+	
93	*C. echinata*	+		+		+	+	+	+	+
94	*Heliofungia actiniformis*	+	+	+	+	+	+		+	+
95	*Fungia concinna*							+	+	+
96	*F. fungites*	+					+	+	+	+
97	*F. granulosa*									
98	*F. horrid*	+	+		+	+	+	+	+	+
99	*F. paumotensis*	+	+					+	+	+
100	*F. repanda*	+	+	+	+	+	+	+	+	+
101	*Fungia sp.*							+		+
102	*Herpolith alimax*					+	+	+	+	+
103	*Polyphyllia talpina*			+	+	+		+	+	
104	*H. pileus*	+						+	+	+
105	*Sandalolitha dentata*								+	
106	*S. robusta*					+	+	+	+	+
107	*Podabacia crustacea*					+				+
VIII	OCULINIDAE									
108	*Galaxea acrhelia*				+	+	+	+	+	+
109	*G. astreata*	+	+	+	+	+	+	+	+	+
110	*G. cryptoramosa*	+								
111	*G. fascicularis*	+	+	+	+	+	+	+	+	+

112	*G. horrescens*								+	+
113	*Acrhelia horrescens*					+		+	+	+
IX	PECTINIIDAE									
114	*Echinophyllia aspera*		+	+	+	+	+	+	+	+
115	*Oxypora lacera*	+				+	+	+	+	+
116	*Mycedium elephantotus*	+			+	+	+		+	+
117	*Pectinia lactuca*	+			+	+	+	+	+	+
118	*P. paeonia*	+			+			+	+	
X	MUSSIDAE									
119	*Acanthastrea echinata*	+			+					
120	*Lobophyllia corymbosa*					+	+	+	+	+
121	*L. flabelliformis*			+		+	+		+	+
122	*L. hataii*				+			+		+
123	*L. hemprichii*	+	+	+	+	+	+	+	+	+
124	*L. pachysepta*								+	
125	*L. robusta*		+							
126	*Symphyllia agaricia*						+			
127	*S. radians*	+		+		+	+	+	+	+
128	*S. recta*					+				+
129	*S. valenciennesii*				+		+	+	+	+
130	*Symphyllia sp.*									+
XI	MERULINIDAE									
131	*Hydnophora exesa*	+			+	+	+			
132	*H. pilosa*	+				+	+			
133	*H. rigida*	+	+	+	+	+	+	+	+	+
134	*Merulina ampliata*	+				+	+	+	+	+
135	*M. scabricula*	+						+		+
XII	FAVIIDAE									
136	*Caulastrea furcata*	+								+
137	*Favia danae*							+		
138	*F. favus*			+						+
139	*F. helianthoides*									+
140	*F. lizardensis*					+				
141	*F. maritima*							+		
142	*F. matthaii*				+	+	+	+	+	+
143	*F. pallid*				+	+	+	+		+
144	*F. rotundata*			+						
145	*F. speciosa*	+		+	+		+	+	+	+
146	*F. stelligera*			+						
147	*F. veroni*						+	+		
148	*Favites abdita*	+		+			+	+	+	+
149	*F. chinensis*				+					
150	*F. complanata*									+
151	*F. halicora*	+			+	+	+	+		+
152	*F. pentagona*			+			+	+		+
153	*Favia sp. 1*									+

154	*Favia sp. 2*									+
155	*Goniastrea aspera*							+		+
156	*G. edwardsi*	+					+	+		
157	*G. retiformis*	+			+	+	+			+
158	*Goniastrea sp.*							+		+
159	*Platygyra daedalea*				+		+	+	+	+
160	*P. lamellina*	+		+	+	+	+	+	+	+
161	*P. pini*							+		
162	*P. sinensis*	+	+							+
163	*Platygyra sp.*									
164	*Leptoria phrygia*				+		+			+
165	*Oulophyllia crispa*				+		+	+	+	+
166	*Montastrea curta*	+			+	+	+		+	+
167	*M. magnistellata*						+	+		+
168	*M. valenciennesi*			+				+		
169	*Plesiastrea versipora*									
170	*Diploastrea heliopora*			+		+	+	+	+	+
171	*Leptastrea purpurea*	+			+					+
172	*L. transversa*	+					+	+	+	+
173	*Cyphastre achalcidicum*	+		+						
174	*C. microphthalma*	+	+		+	+				
175	*C. serailia*						+			
176	*Echinopora gemmacea*	+				+	+	+	+	+
177	*E. horrid*									+
178	*E. lamellosa*	+			+	+	+	+	+	+
179	*E. mammiformis*									+
180	*Echinopora sp.*									
XIII	CARYOPHYLLIIDAE									
181	*Euphyllia ancora*	+		+	+	+	+	+	+	+
182	*E. divisa*	+								
183	*E. glabrescens*		+	+	+	+	+			+
184	*E. yaeyamaensis*								+	+
185	*P. simplex*	+			+	+	+	+	+	+
186	*P. sinuosa*	+			+	+	+	+	+	+
187	*Physogyra lichtensteini*	+			+	+	+			+
XIV	DENDROPHYLLIIDAE									
188	*Turbinaria frondens*	+				+	+			
189	*T. peltata*	+		+			+			
190	*T. reniformis*						+			
191	*Tubastrea faulkneri*			+						
192	*T. micrantha*		+	+			+			
XV	MILLEPORIDAE									
193	*Millepora. tenella*	+		+		+	+	+	+	+
XVI	STYLASTERIDAE									
194	*Stylaster sp.*		+							

Table 3. The number of species (S), the number of individuals (N), Pielou's evenness index (J') and Shannon's diversity index (H').

Study sites	S	N	J'	H'
Site 1	32	55	0.96	3.32
Site 2	31	41	0.98	3.36
Site 3	23	56	0.85	2.66
Site 4	26	52	0.93	3.03
Site 5	30	79	0.93	3.15
Site 6	24	37	0.93	2.97
Site 7	23	72	0.88	2.76
Site 8	28	59	0.91	3.03
Site 9	17	47	0.75	2.12

REFERENCES

Clarke, K. R. and R. M. Warwick. 2001. *Change in Marine Communities: An approach to Statistical Analysis and Interpretation. 2 ndedition*.Primer-E Ltd, UK.175 pp.

Colwell, R. K. 2005. *Biodiversity : concept, patterns and measurement.* http://press.princeton.edu/chapters/s3_8879.pdf

Eleftheriou, A. and A. Mclntyre. 2005. *Methods for the study of marine benthic 3rd Edition*. Blackwell Publishing Company, UK. 409 pp.

English, S.; C. Wilkinson and V. Baker 1997.*Survey Manual for Tropical Marine Resources. Secondedition*.Australian Institute of Marine Science.Townsville : 390 pp.

Fadlalah, Y. H. (1985). Reproduction in the coral *Pocillopora verrucosa* on the reefs adjacent to the industrial city ofYanbu. Red Sea, Saudi Arabia. *Proc. 5th Int. Coral Reef Symp*. Tahiti 4: 373–378.

Gomez, E.D. and Yap H.Y. 1988. Monitoring Reef Condition.*In* :Kenchington R.A, Hudson BET, editor. Coral Reef Management handbook. Jakarta: UNESCO Regional office science and technology for Southeast Asia. Pp187 – 195.

Grimsditch, G. D. and R. V. Salm. 2006. *Coral reef resilience and resistance to bleaching.*The World Conservation Union (IUCN), Switzerland.56 pp.

Hartini S, Guridno B.S, Doddy M.Y., Suroyo, Dede S. Isa N. E. 2006. *Sumber Daya Alam Pesisirdan-Laut, Kabupaten Banggai*, Pusat Survei Sumber Daya Alam Laut – BAKOSURTANAL 99 Hal.

Hoeksema, B. W. 2012. Distribution Patterns of Mushroom Corals (Scleractinia: Fungiidae) Across The Spermonde Shelf, South Sulawesi. *The Raffles Bulletin of Zoology,* 60 (1): 183–212.

Johnson, M. E. and P. A. Marshall. 2007. *Climate change and the Great Barrier Reef: a vulnerability assessment*. Great Barrier Reef Marine Park Authority, Australia. 10 pp.

Johnson, M. E., D. S. Gilliam, M. W. Miller, C. Lustic, L. Larson, K. Nedimyer, E. Bartels, D. Lirman, S. Schopmeyer and L. B. Baums. 2012. *Caribean Acropora : restoration guide*. The Nature Conservancy, The US. 66 pp.

MacClanahan, T., N. Polunin, T. Done. 2002. Ecological states and resilience of coral reefs. *Conservation Ecology*, 6: 1–18.

MacClanahan, T.R. 2004. The relationship between bleaching and mortality of common corals. *Marine Biology* 144: 1239–1245

Marshall, P. and Schuttenberg, H. 2006. *A reef manager's guide to coral bleaching*. Great Barrier Reef Marine Park Authority, Australia.178 pp.

Pielou, E.C. 1975. *Ecological diversity*. A willey – Inter science Publication : 165 pp.

Richmond, R. H. and C. L. Hunter. 1990. Reproduction and recruitment of corals: comparisons among the Caribbean, the Tropical Pacific, and the Red Sea. *Marine Ecology Progress Series*, 6: 185–203.

Shannon, C.E. 1948. A mathematical theory of communication. *Bell System Tech. J*., *27* : 379–423.

Suhendra D, S. Hartini and A. Jamil, 2007. *Sumber Daya Alam Pesisir dan Laut, Kabupaten Banggai*, Pusat Survei Sumber Daya Alam Laut − BAKOSURTANAL 107 pp.

Supriharyono, 2000.*Pengelolaan Ekosistem Terumbu Karang*. Djambatan, Jakarta. 108pp.

Veron, J.E.N. 2000a. *Corals of the world*. Australian Institute of Marine Science, PMB3, Townsville MC, Qld4810, Australia Vol.1 : 463 pp.

Veron, J.E.N. 2000b. *Corals of the world*. Australian Institute of Marine Science, PMB3, Townsville MC, Qld4810, Australia Vol.2 : 429 pp.

Veron, J.E.N. 2000c.*Corals of the world*. Australian Institute of Marine Science, PMB3, Townsville MC, Qld4810, Australia Vol.3 : 490 pp.