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COMMUNITY STRUCTURE AND TROPHIC STATUS OF REEF FISH IN NATUNA WATERS

Isa Nagib Edrus*[1] and Pratiwi Lestari[1]
[1]Researcher in Research Institute for Marine Fisheries, Jl. Raya Bogor No.507, Nanggewer Mekar, Cibinong, Bogor, West Java
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ABSTRACT

A field research on reef fish-community structures in Natuna waters was carried out in November 2015. This research aimed to obtain the trophic composition of reef fishes and its correlation to diversity, density, and biomass. Underwater visual census on several transect areas was used to collect data. Results show that the identified reef fishes were about 100 species of target-reef fish belonging to 18 families and 23 species of indicator-reef fish of the Chaetodontidae family. The mean species number of target reef fish and indicator reef fish were 42 and 7 species, respectively. The mean density of the target reef fish and indicator reef fish were 0.4 and 0.05 individual per $m^{2,}$ respectively. The mean of the reef fish relative stock was 0.6 ton/ha. The composition of the herbivores mostly found in the resilient coral reefs r was 46.45 % and the omnivores and planktivores as marketable targeted fishes were 18.64 % and 14.28 %, respectively. The most predominant or major families were from herbivorous, carnivorous, planktivorous, and corallivorous fishes, including Scaridae (i.e. *Scarus* spp), Lutjanidae (i.e. *Lutjanus* spp.), Caesionidae (i,e. *Caesio cuning* and *Pterocaesio caerulaurea*), and Chaetodontidae (i.e. *Chaetodon baronessa* and *Chaetodon octofasciatus*). The results suggested that the community structures were quite prospectively implemented for fisheries; however, it may not be promising for coral resilience. Furthermore, the coral health status was at moderate level in regard to the high numbers of corallivorous butterflyfishes.

Keywords: Reef fishes; structure community; biomass

INTRODUCTION

The Natuna Islands are administratively included in the Natuna Regency and part of the Riau Islands Province that is surrounded by wonderful coral reef waters. Physically, Natuna waters are under control of the Republic of Indonesia's Authority and also as a part of the Economic Exclusive Zone. From the national fishery policy view, Natuna waters is described as Fishery Management Area 711, bordering the South China Sea. The Natuna coral reef areas are potential spawning and nursery grounds for the high economical-valuable fisheries of both ornamental and edible reef fishes (COREMAP, 2007). However, the areas are vulnerably exposed to illegal fishing for a long time due to coral reef associated fisheries.

Escalating fisheries with poor environmental protected management for many years (Pet-Soede & Erdmann, 1998; Pauly *et al*., 1989) as well as cyanide and blast fishing have been making serious damages to coral reefs in Indonesia throughout the time (Edinger *et al*., 1998; Pet-Saode *et al*., 2000). The strongest reef fish affinity to coral reef is critical for habitat needs and the destructive fishing may be a threat to fish for living (Jones *et al*., 2004; Gratwicke & Speight. (2005). The undeniable fact that surrounds damages due to overfishing results in negative impact on fish resources in some regions of the provinces (Anonymous, 2011), particularly huge dwindling fish production came about within the regions was typically addressed to the habitat damaging and overfishing (Fauzi, 2005). Further impacts, each positive and negative manners, conjointly might happen in fish communities to preserve the functional purposes, particularly for herbivore fishes as a grazer group. The grazers have a considerable-essential role in coral reef resilience. Fishery activities may be an indirect controlling factor in composition shifting of the functional groups of fishes, mainly the structure balances among herbivores and carnivores (Berkepile & Hay, 2008 ; Green & Bellwood, 2009).

One of the most important challenges for policy decision making about the Natuna coral reef management is to describe and explain the health of

correspondence author:
e-mail: inedrus@yahoo.co.id
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coral reefs in terms of geographical patterns in diversity of reef fishes. Fish community structures, as well as percent coral covers, are suitable quality indicators for coral reef health assessment. They are used as substantial parameters to precisely assess the damage of coral reefs (Wilson & Green, 2009). Therefore, certain reef fish have the best habitual response to environmental changes in their favorable and suitable habitat and preferred feed. For this reason, some researcher often use the corallivorous fish group to generally define the damage of coral reefs (Crosby & Reese, 1996). Some "grazers" of herbivorous fishes are also habitually used in analyzing the roles of grazers in terms of resilience processes in a coral reef ecosystem. Carnivore fish groups, as well as some species of potential targeted fishes in fisheries, like groupers, snappers, and sweaplips, are a typical functional group of fishes used to assess population size growth of other functional groups in coral reef areas. Growing population of the carnivorous fish group may reduce the herbivorous fish group; however, fishery activities can reduce the population of all fish fungsional groups (Halford *et al*., 2004 ; Obura & Grimsditch, 2009).

Some indicators are actually warnings for policy decision making; however, those have not likely been considered yet by local government unit operators. As presumed that if tremendous damage of resources were taking place in the region, evaluation and monitoring activities may be late to carry for. Fish functional groups (economical value species) are a serious implication for the reef fish community structures, whereas environmental governance needs them. It's important to know the composition of functional fishes in the Natuna coral reefs. Coral reef management is likely insufficient information that is substantial to know how the critical support of reef fishes to coral reefs and the crucial threat of fisheries to coral reef resources (Salm & Kenchington, 1988).

Reef fish community structure patterns might be an interesting analysis that provides insight into monitoring coral reef degradation and supports sustainable uses of the coral reef resources (Salm & Kenchington, 1988). The analysis is likely close to a prerequisite for fishing management prioritization. Reef fish potency can be measured using the stock method, for which annual fishing data are prepared. Such data are rarely derived from nearby areas of coral reefs; however, those are mostly generated from offshore fishing areas. Actually, recorded demersal fish data didn't return from fishing mistreatment habitual fishing gears applying in reefs, however using special gears applying for demersal purposes. Hence, the data analysis does not focus on the intrinsic data to coral reef characteristics. On the other hand, reef fish data and information may be directly gathered from the genuine coral reef ecosystem by divers to find shortly time out primarily data, from which diversity, density, biomass, relative stock, and species composition can be analyzed. Guidelines on the study of reef fish health assessment have been prepared by Giyanto *et al*. (2014) to provide the COREMAP-CTI-monitoring needs for national coral reef health studies. However, it appears very little research has been focused on the structures of coral reef communities in the coral reefs of Natuna, while fishing stresses known to occur there seems to be highlighting the problems of fishery management.

This study aimed to obtain the variable data of diversity, density, biomass, and fish composition of fish functional groups in terms of herbivorous, carnivorous, omnivorous, and corallivorous fishes. It's essential to look forward to the management of potential marketable fishes in fisheries, supportable fishes in coral resilience, and suitable indicator fishes in coral reef health monitoring.

MATERIALS AND METHODS

Field observation was carried out in November 2015 at the waters of the Natuna Islands, Riau Islands Province. The study sites consisted of 14 geographical positions in the areas illustrated in Figure 1 and listed in Table 1.

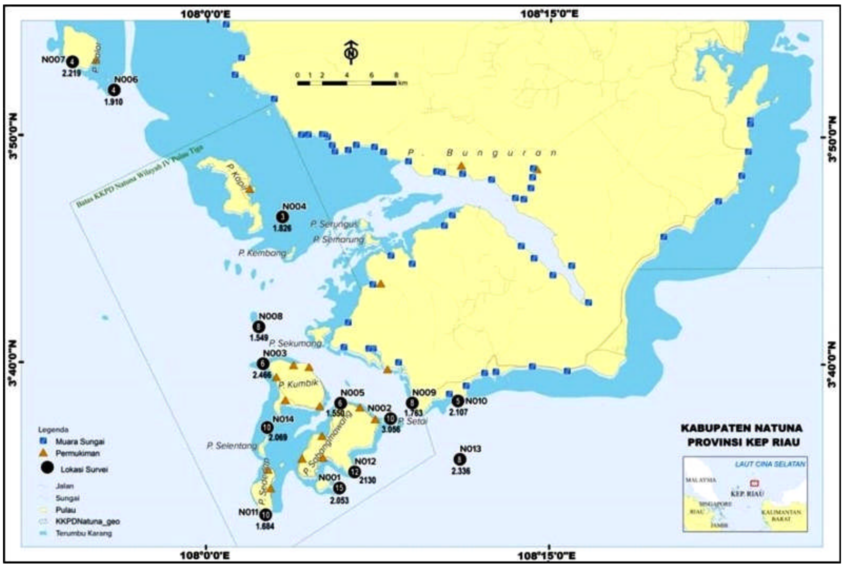

Figure 1. A map showing the study sites in reef waters of Natuna Island.

Table 1. Station codes, names, geographical positions and other remarks of the study sites

Transect Codes	***Location Names***	***Geographical Positions***		***Census Areas* (m²)**		
				Free Trans.	***Belt Trans.***	***Total Areas***
N001	Serantas Island	3°34.5038'	108°05.8247'	803	1,250	2,053
N002	Setai Island	3°37.5662'	108°08.0482'	1,806	1,250	3,056
N003	Kumbik Island	3°39.9653'	108°02.4717'	1,216	1,250	2,466
N004	Kembang Island	3°46.4282'	108°03.2980'	576	1,250	1,826
N005	Sabangmawang Island	3°38.2370'	108°05.8655'	300	1,250	1,550
N006	Kukop	3°51.9918'	107°55.9258'	660	1,250	1,910
N007	Solor Island	3°53.2237'	107°54.0990'	969	1,250	2,219
N008	Burung Island	3°41.5895'	108°02.2822'	299	1,250	1,549
N009	Tanjung Tekul	3°38.2540'	108°08.9935'	513	1,250	1,763
N010	Setukul	3°38.3542'	108°10.9892'	857	1,250	2,107
N011	Sededap Island	3°33.3135'	108°02.6047'	434	1,250	1,684
N012	Semasin Island	3°35.2137'	108°06.4835'	880	1,250	2,130
N013	Tekul Path Reef	3°35.7812'	108°11.0825'	1,086	1,250	2,336
N014	Buluh Island	3°37.1563'	108°02.6632'	819	1,250	2,069

The method used for data gathering was standard underwater visual census (UVC) of fish, focusing on functional fish groups, such as herbivores, carnivores, omnivores and corallivores, especially for the fish species of marketable fish groups, grazer fish groups, and indicator fish groups (English *et al*., 1994; Giyanto *et al*., 2014). Before the study sites were decided, a Manta Tow survey was conducted to find approximately more than 50 % coral coverage sites that were appropriate for underwater visual census (English *et al*., 1994).

Data collection at each study site was conducted using SCUBA by a scientific diver with a buddy (a diving partner as international diving rules) at five points that have 50 m long transect lines lay at the coral reef area. The distance between transect line points was approximately 50 m, parallel to the shore line of the island. While observing at each transect, the divers waited about 15 minutes after laying the transect before counting, to allow fishes to resume normal behaviour to settle before starting recording. The observers or divers swam slowly along the transect and recorded the fish encountered within approximately 2,5 meters on both sides (left and right side from the transect line). For each species at each transect, the total number of individuals and their body lengths were recorded. The species identification used a pictorial book guidance (Kuiter & Tonozuka, 2001; Allen & Erdmann, 2012). The assumption of body length used the stick method to obtain the relative size of fish total length, particularly for the five centimeter interval length of 6 to 10 11 to 15, 16 to 20, 21 to 25, 26 to 30, 31 to 35, etc.

The data analyses customarily emphasized on (1) reef fish species listed in taxonomic group and their species number in respective transects (Giyanto *et al*., 2014); (2) density calculation of individual number per transect area given in respective transects (Giyanto *et al*., 2014); (3) biomass calculation of the length-weight correlation formula for respective transects (Wilson & Green, 2009); (4) reef fish relative stock calculation of value conversion of the biomass per hectare in respective transect sites (Giyanto *et al*., 2014). The formulas used to approach those aims above were as follows.

$$\text{Mean of Density (individual/m}^2\text{)} = \frac{IN(T)}{TA(T)} \quad ....(1)$$

where :
IN = Individual Number
T = Transect Site
TA = Total Area in m^2

$$W = a \times L^b \quad .... (2)$$

where :
W = Body Weight (gr)
L = Total Length (cm)
a and *b* = constant variables, given in Fishbase Web (Froese & Pauly (2014).

$$\text{Mean of Biomass (g/m}^2\text{)} = \frac{\text{Gram Biomass of all Fishes in the Respective Site Transects}}{\text{Total Square Meter Areas in Respective Site Transects}} \quad ....(3)$$

$$\text{Relative Fish Stock (ton/ha)} = \frac{\text{Mean Biomass (gram/m}^2\text{)}}{\text{1,000,000 (gram)}} \times 10{,}000 \quad ....(4)$$

RESULTS AND DISCUSSION
Results

Diversity and Density

All data analyses were shown in Table 2. From 18 families that were found in all study sites, 100 species of them were the target fishes and 23 species were indicator species especially from family Chaetodontidae. They were varied in species number as well as in individual densities and biomass relative stocks among the study sites. The lowest species number were 25 species recorded in Kembang Island (N004) and its contrary were 55 species recorded in Sededap Island (N011). The calculation of the data variation presented 836 ± 235 (Mean±SD) for individual numbers and 0.4 individual per m^2 for density. The density was equivalent to 4,153 individuals per hectare.

Table 2. Individual numbers, species numbers, density, and its relative stock of reef fishes

Transect Codes	***Location Names***	***Ind. No.***	***Species No.***	***Density/m²* (ẍ)**	***Ind. Stock/ha.***
N001	Serantas Island	599	41	0.3	2,981
N002	Setai Is.	843	42	0.3	2,759
N003	Kumbik Is.	704	39	0.3	2,855
N004	Kembang Is.	652	25	0.4	3,571
N005	Sabangmawang Is.	611	33	0.4	3,942
N006	Kukop	741	48	0.4	3,880
N007	Solor Isl.	530	31	0.2	2,388
N008	Burung Is.	495	35	0.3	3,196
N009	Tanjung Tekul	1171	49	0.7	6,642
N010	Setukul	746	44	0.4	3,541
N011	Sededap Is.	1042	55	0.6	6,188
N012	Semasin Isl.	1304	52	0.6	6,122
N013	Tekul Path Reef	1466	47	0.6	6,26
N014	Buluh Island	800	42	0.4	3,867

Species Composition

Species with the highest individual number in Natuna coral reefs was *Scarus ghobban* (18.64 %) of family Scaridae, followed by *Caesio cuning* (14,28 %) of family Caesionidae (Appendix 1). Furthermore, the top biomass rank of reef fish species were *Caesio cuning* (15.2 %), followed by *Caesio caerulaurea* (12 %) and *Scarus ghobban* (10.5 %) (Appendix 2). The schooling of *Scarus ghobban* was mostly recognized in the juvenile phases; for this reason, the highest individual number of *Scarus ghobban* (in Table 2) did not affect on valuing their biomass; instead, *Caesio cuning* had the highest total biomass.

The fifteen major fish populations, with regard to total individuals , consisted of parrotfishes, fusiliers, and snappers, were *Scarus ghobban*, *Caesio cuning*, *Caesio caerulaurea, Scarus hypselopterus, Chlorurus sordidus, Pterocaesio tessellata, Scarus niger,* *Scolopsis ciliatus, Ctenochaetus striatus, Lutjanus ehrenbergii, Lutjanus biguttatus, Pterocaesio digramma, Lutjanus decussatus, Siganus virgatus,* dan *Lutjanus vitta* (Appendix 1).

Furthermore, the top fifteen of largest biomass were *Caesio cuning, Caesio caerulaurea, Scarus ghobban, Chlorurus sordidus, Naso lituratus, Scarus niger, Pterocaesio tessellata, Ctenochaetus striatus, Lutjanus decussatus, Scarus hypselopterus, Pterocaesio digramma, Scarus flavipectoralis, Lutjanus biguttatus, Lutjanus vitta,* and *Caesio lunaris* (Appendix 2). These species were classified as the families of parrotfishes (Scaridae), fusiliers (Caesionidae), snappers (Lutjanidae), and surgeonfishes (Acanthuridae).

The composition of fish functional groups based on their feeding behaviour were herbivores (46.45 %), carnivores (22.97 %), and planktivores (30.71 %) (Appendix 1). Mostly, herbivorous fishes were parrotfishes (Scaridae), whereas carnivorous fishes were mostly snappers (Lutjanidae) and the most planktivorous fishes were fusiliers (Caesionidae). Mainly, the functional groups of fish communities occupied the study sites -predominantly referred to the herbivore group, including grazers, that has been habitually well known as supporting resilience processes in coral reef ecosystems.

Biomass and Relative Stocks

Biomass calculation by separately interposing the body total length of fishes to the second formula created some individuals biomass information of all fish species with success known once the survey was conducted. The total biomass, referred to the sum of individual biomass of all fishes in each site of the study areas, was shown in Table 3.-The site with the highest biomass (332 kg) was Tekul Path Reef (N013), followed by Semasin Island (N012) with227 kg. The biomass between 100 kg and 200 kg were represented in some sites, i.e. Sededap Island (N011), Tanjung Tekul (N009), Kukop (N006), and Serantas Island (N001), while the rest had biomass less than 100 kg.

Biomass data, resulted by this method, often represents the only information available for the small scale measures of some local transects, but not for the general areas given in regional study areas. For this reason, relative stock is an important variable in fishery management as it provides a basis for predicting the adequately size recruitment in terms of harvesting management purposes. Biomass conversion into relative stock of reef fishes in the respective study areas (Table 3) showed the differences in availability of fish stocks resources, from high to low stocks, such as in Tekul Path Reef (1.4 ton/ha), Semasin Island (1.1 ton/ha), Sededap Island (1 ton/ha), and Tanjung Tekul (0.9 ton/ha). Furthermore, the average of reef fish relative stock, estimated from samples of 14 study sites, was 0.6 ± 0.29 (Mean±SD) ton/ha.

Table 3. Biomass and stock of reef fishes in Natuna coral reefs

Transect Code	***Location***	***Total Biomass (kg)***	Survey ***Area (m^2)***	***Biomass Mean (gram/m^2)***	***Relative Stock (ton/ha.)***
N001	Serantas Is.	102	2,053	50	0,5
N002	Setai Is.	98	3.056	32	0.3
N003	Kumbik Is.	79	2,466	32	0.3
N004	Kembang Is.	46	1,826	25	0.3
N005	Sabangmawang Is.	70	1,550	46	0.5
N006	Kukop	208	1,910	57	0.6
N007	Solor Is.	58	2.219	26	0.3
N008	Burung Is.	58	1,549	37	0.4
N009	Tanjung Tekul	162	1,763	92	0.9
N010	Setukul	86	2.107	41	0.4
N011	Sededap Is.	170	1,684	101	1.0
N012	Semasin Is.	227	2,130	107	1.1
N013	Tekul Path Reef	332	2,336	142	1.4
N014	Buluh Is.	94	2,069	43	0.5

Diversity of Indicator Fishes

Several species of indicator fishes were well known as the indicator of coral reef health conditions,includeing corallivorous fishes of the functional fish groups. Most of them were taxonomically classified in the familyChaetodontidae (butterflyfishes), some of Scaridae (parrotfishes), and some of Acanthuridae (surgeonfishes). There were 23 species of butterflyfishes (Chaetodontidae) successfully recorded in all sites of the study areas. The sites with a quite high species number of butterflyfishes included Buluh Island (N014), Tekul Path Reef (N013), and Burung Island (N008). Furthermore, the sites with higher individual numbers were Tekul Path Reef (N013), Kumbik Island (N003), Kukop (N006), Sededap Island (N011), and Buluh Island (N014), shown in Table 4.

Butterflyfish composition of the total individuals is presented in Figure 2. The five major corallivorous species based on total individuals recorded are *Chaetodon baronessa, Chaetodon octofasciatus, Heniochus varius, Chaetodon trifasciatus,* and *Chaetodon adiergastos.*

Table 4. Variation of individual and species numbers of Butterflyfishes

Description	STUDY SITES													
	N001	N002	N003	N004	N005	N006	N007	N008	N009	N010	N011	N012	N013	N014
Individual Number	16	34	74	12	11	66	21	53	35	51	57	13	94	57
Species Number	6	7	7	5	5	7	3	10	9	7	9	6	10	11

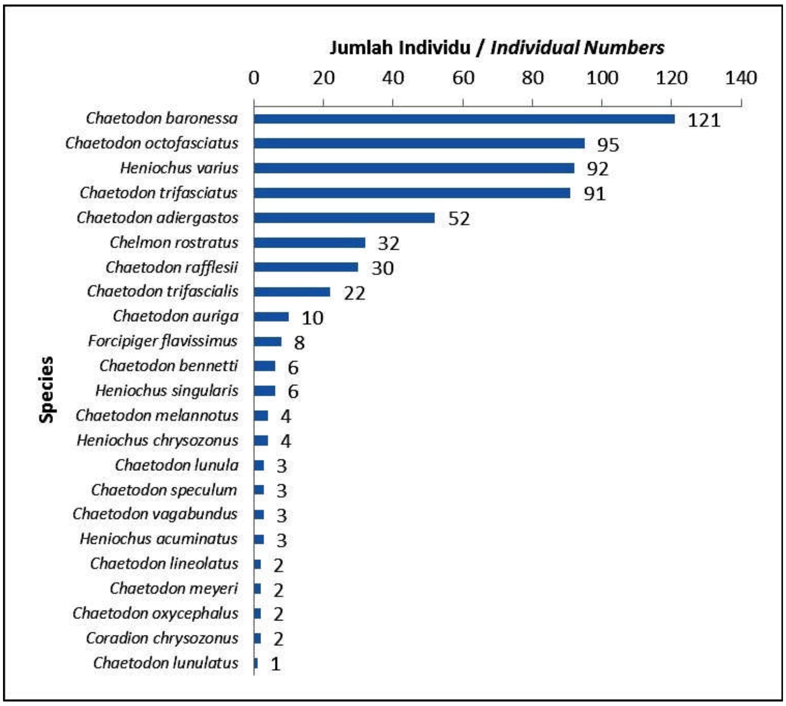

Figure 2. *Chaetodontid fishes (family Chaetodontidae) composition based on individual numbers.*

Discussion

The fish species richness presented in all study sites was higher than those in the each respective local sites, where it's especially true for coral reef fishes. The large scale of coral reef areas might have increased the target species that has been found by visual census activities. While habitat complexity may serve more reef fish diversity in spread out geographical gradients (Roberts & Ormond 1987; Feary *et al*., 2007.), the diversity and biomass of target species and indicator species identified in all study sites at unusually low levels, compared to other coral reefs (Hadi *et al*. 2017; Tuti *et al*., 2015; 2016 & 2017). For example, the study of COREMAP-CTI Program in the coral reefs area of Wakatobi waters in 2016 found around 40 to 60 species of 20 families in 15 study sites (Tuti et al., 2016), while Natuna coral reefs had only 41,64 species, in average. The number of species that had been identified in Wakatobi coral reefs in 2015 and 2016 ranged from 118 to 129 of total target species and 28 to 30 of indicator species (Tuti et al., 2015 & 2016); these numbers were higher than those in Natuna coral reefs. The relative stock average of target fishes settled in Wakatobi coral reefs (1.6 ton/ha) was higher than that in Natuna coral reefs (0.6 ton/ha). One of the similarities between both study areas was only the number of fusilier species (Caesionidae). This study indicated the needs of careful management because the phenomenon trends showed the critical condition of the sustainability of target fish species. Therefore, the entire coral reef ecosystem has to be maintained and managed more seriously in an appropriate way. Otherwise, the coral reef environment sustainability might be out of control and impacted closer to the financial local community capability in that area.

Despite the particular species number, a few greater big fusilier species in Natuna reef waters, especially Caesio spp. and Pterocaesio spp. in addition to *Lutjanus bigutattus*, *L. ehrenbergii*, and *L. vittae*, might be taken into consideration as specially interest withinside the context of fishery management. These species have been recorded as the important major capturing fish by Research Institute for Marine Fisheries (Suman *et al*., 2014) in the Republic of Indonesia - Fishery Management Area code 711 in the South China Sea region.

Thel reef fishes in Natuna waters were probably similar to other fish assemblages in the other damaged coral reef areas (Utama *et al*., 2019) that was mostly presented by small individual herbivores (46.45%) and a low number of the carnivorous fishes group. Such conditions may be reasonably favorable for implementing sustaining coral reef resilience. It's important that biodiversity of functional groups such as herbivorous fishes are critical substantial needs to provide guarantees for expanded coral reef growings, especially by stabilizing the certain functional fish groups for which they may have to manipulate shifting for biota regimes in terms of coral reef resilience purposes (Thibout *et al*., 2012).

Herbivorous fishes, such as parrotfishes (Scaridae), surgeonfishes (Acanthuridae), and rabbit fishes (Siganidae), are the most important grazers for coral reef resilience remedies. Therefore, they may considerably play a role of controlling and reducing algae expansion from which they may replace substrates for preparing coral larvae to grow so that new coral recruitment was established on substrates given (Berkepile & Hay, 2008; Green & Bellwood, 2009). However, the algae clearing and bio-erosion intensities , to provide more surfaces for reef planula attachment, depend on herbivorous fish composition and their body sizes. Functional fish groups in the inherent characteristics of excavators, scrapers, grazers, and browsers, in which fish species already listed by Obura & Grimsditch (2009), have differentiation of degrees in effectiveness for the algae clearing. It depends on the body size of the grazers. Usually small grazers are mostly less effective to the resilience process.

The present study found that most small herbivores, such as Scarus spp., Siganus spp., and Acanthurus spp., live in high individual numbers. Within this group, *Scarus ghobban* was the most active grazer species or scraper. Mostly, scrapers produce less effects on bio-erosion of the surfaces than that by excavators (Obura & Grimsditch, 2009). *Scarus ghobban* was abundantly found in the whole phases of ages; however, the juvenile sizes were mostly found in the habitat where the condition was in minor effects of resilience remedies. Meanwhile, the majority of parrotfishes and rabbitfishes considerable as grazers or browsers were rarely found high in both species and individual numbers at the study sites. The dominant rabbitfish was *Siganus virgatus.* In addition to excavators, Bolbometopon muricatum was the only large body size grazer, ,well known as the most important bioerosion fish (Obura & Grimsditch, 2009); however, its population size was at a low level in the study area. The other smaller excavators identified in the study sites primarily included *Chlorurus bowersi*, *Chlorurus sordidus,* and some *Naso* spp.

On the other hand, a large number of carnivorous fish species, such as soldierfishes, emperors, sweetlips, snappers, goatfishes, spinecheeks, rudderfishes, trevallies, and barracudas, as well as fusiliersof omnivorous fishes, considerably play important roles in controlling herbivorous fish groups and then indirectly affect the on-going coral reef resilience progresses (Obura & Grimsditch, 2009; Green & Bellwood, 2009). However, because the carnivore and omnivore groups are increasingly targeted by fishermen, including for live reef food fish trade, along with herbivore groups they are reasonably favorable for commercial fisheries. Hence, the fisheries sector actually leads to a negative ecological consequence for resilience progression, but not for economical fishery interests (Edrus & Abrar, 2016). Even with great schooling fenomena of fusiliers seen at the Natuna coral reefs that might seriously be a warning for the coral reef management authority, because the fusiller schooling will be attractive for blasting and muroami fishing (Edrus, 2014).

When the fusilier colonies in reef waters may be suitable for a fishing activity indicator in regard to alerting the coral reef threats, the butterflyfishes may be decided to be a confirmed indicator of coral health (Pratchett *et al*., 2013). This study found and indicated that the abundances of butterflyfishes were essential to carry out their community structure status, because it will indicate the coral reef's healthy environments. It was found that some coral reefs in the study sites, such as Buluh Island, Burung Island, Tekul Path Reef, Kumbik Island, Solor Island, and Sededap Island, performed good conditions. Some important butterflyfishes (fam. Chaetodontidae) based on their individual numbers and wide distribution were *Chaetodon adiergastos, Chaetodon baronessa, Chaetodon octofasciatus, Chaetodon trifasciatus, Chelmon rostratus,* and *Heniochus varius.* These species were quite widespread in the study sites. Furthermore, butterfly fish species with high individual numbers found in Natuna coral reefs were *Chaetodon baronessa* and *Chaetodon octofasciatus*. The species of *C. baronessa* was commonly found on the branching corals and tabulate corals in clear waters, whereas *C. octofasciatus* species was mostly found in shady reef waters (Allen & Erdmann, 2012; Reese, 1981; Edrus & Syam, 1998), with most study sites had shown low level horizontal visibility of water body (Table 1). According to Suharti (2012) and Suryanti *et al*. (2011), the butterflyfishes abundance and diversity have positive correlation to coral percent coverage and water depth. It was suggested that butterflyfishes found in varied abundances among respective study sites were due to differential conditions of coral reefs (Pratchett *et al*., 2006). According to Crosby and Reese (1996). The best reef health is addressed to high level species diversity of butterflyfishes, as they have been found in 44 species in the Papuan coral reefs, whereas in the Natuna coral reefs there were 23 species only. It indicated that the reef health in Natuna reef waters may be classified as moderate to poor levels.

CONCLUSIONS

The species number of reef fishes in Natuna reef waters is quite high with 123 species, where their mean relative stock was 0.6 ton/ha. The contribution of the herbivore group as functional supports on coral reef resilience was about 46.45%, the carnivore and planktivore groups as top predators and high commercial fishes were about 18.64% and 14.28%, respectively, and the corallivorous species as coral obligations and reef health indicators was the rest with about 23 species. The major herbivorous species were *Scarus* spp. The major carnivorous species were *Lutjanus* spp. The major omnivorous species were *Caesio cuning* and *Pterocaesio caerulaurea*. Meanwhile, the corallivorous species were dominated by *Chaetodon baronessa* and *C. octofasciatus*. The results suggested that the species composition were quite prospectively implemented for fisheries, especially for fusiliers and snappers; however, it may not be promised for coral reef resilience. Furthermore, the coral health status was at a moderate level regarding high species numbers of corallivorous butterflyfishes.

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Appendix 1. Individual composition of reef fishes in Natuna reef waters.

No.	SPECIES	FAMILY	Ind. No.	COMPOSITION (%)			
				Ind.	Herbivores	Carnivores	Planktivores
1	*Scarus ghobban*	Scaridae	2,182	18.64	18.64		
2	*Caesio cuning*	Caesionidae	1,671	14.28			14.28
3	*Caesio caerulaurea*	Caesionidae	1,006	8.60			8.60
4	*Scarus hypselopterus*	Scaridae	749	6.40	6.40		
5	*Chlorurus sordidus*	Scaridae	701	5.99	5.99		
6	*Pterocaesio tessellata*	Caesionidae	444	3.79			3.79
7	*Scarus niger*	Scaridae	343	2.93	2.93		
8	*Scolopsis ciliatus*	Scolopsidae	336	2.87		2.87	
9	*Ctenochaetus striatus*	Acanthuridae	262	2.24	2.24		
10	*Lutjanus ehrenbergii*	Lutjanidae	223	1.91		1.91	
11	*Lutjanus biguttatus*	Lutjanidae	217	1.85		1.85	
12	*Pterocaesio digramma*	Caesionidae	210	1.79			1.79
13	*Lutjanus decussatus*	Lutjanidae	183	1.56		1.56	
14	*Siganus virgatus*	Siganidae	166	1.42	1.42		
15	*Lutjanus vitta*	Lutjanidae	153	1.31		1.31	
16	*Scarus flavipectoralis*	Scaridae	143	1.22	1.22		
17	*Caesio lunaris*	Caesionidae	138	1,18			1.18
18	*Parupeneus barberinus*	Mullidae	136	1.16		1.16	
19	*Epibulus insidiator*	Labridae	115	0.98		0.98	
20	*Cheilinus fasciatus*	Labridae	114	0.97		0.97	
21	*Acanthurus nigricans*	Acanthuridae	103	0.88	0.88		
22	*Parupeneus multifasciatus*	Mullidae	103	0.88		0.88	
23	*Scolopsis margaritifer*	Scolopsidae	103	0.88		0.88	
24	*Chlorurus bowersi*	Scaridae	100	0.85	0.85		
25	*Naso lituratus*	Acanthuridae	98	0.84	0.84		
26	*Hemigymnus melapterus*	Labridae	92	0.79		0.79	
27	*Scarus forsteni*	Scaridae	90	0.77	0.77		
28	*Scarus schlegeli*	Scaridae	88	0.75	0.75		
29	*Pentapodus trivittatus*	Nemipteridae	87	0.74		0.74	
30	*Caesio teres*	Caesionidae	86	0.73			0.73
31	*Scolopsis bilineatus*	Scolopsidae	83	0.71		0.71	
32	*Upeneus tragula*	Mullidae	69	0.59		0.59	
33	*Scarus dimidiatus*	Scaridae	63	0.54	0.54		
34	*Hemigymnus fasciatus*	Labridae	62	0.53		0.53	
35	*Sargocentron caudimaculatum*	Holocentridae	56	0.48		0.48	
36	*Siganus vulpinus*	Siganidae	48	0.41	0.41		
37	*Siganus corallinus*	Siganidae	46	0.39	0.39		
38	*Kyphosus vaigiensis*	Kyphosidae	42	0.36		0.36	
39	*Scarus scaber*	Scaridae	41	0.35	0.35		
40	*Naso hexacanthus*	Acanthuridae	34	0.29	0.29		
41	*Cephalopholis argus*	Serranidae	31	0.26		0.26	
42	*Zebrasoma scopas*	Acanthuridae	31	0.26	0.26		
43	*Sphyraena flavicauda*	Sphyraenidae	30	0.26		0.26	
44	*Choerodon anchorago*	Labridae	28	0.24		0.24	
45	*Kyphosus cinerascens*	Kyphosidae	28	0.24		0.24	
46	*Myripristis murdjan*	Holocentridae	28	0.24		0.24	
47	*Caranx melampygus*	Carangidae	26	0.22		0.22	
48	*Parupeneus barberinoides*	Mullidae	26	0.22		0.22	
49	*Platax orbicularis*	Ephippidae	24	0.21			0.21
50	*Monotaxis grandoculis*	Lethrinidae	23	0.20		0.20	
51	*Parupeneus bifasciatus*	Mullidae	22	0.19		0.19	
52	*Parupeneus cyclostomus*	Mullidae	22	0.19		0.19	
53	*Plectorhinchus lessonii*	Haemulidae	21	0.18		0.18	

54	*Acanthurus mata*	Acanthuridae	20	0.17	0.17		
55	*Cephalopholis boenak*	Serranidae	19	0.16		0.16	
56	*Scarus spinus*	Scaridae	19	0.16	0.16		
57	*Scarus microrhinos*	Scaridae	17	0.15	0.15		
58	*Plectorhinchus chaetodontoides*	Haemulidae	16	0.14		0.14	
59	*Acanthurus leucocheilus*	Acanthuridae	15	0.13	0.13	0.13	
60	*Cephalopholis cyanostigma*	Serranidae	15	0.13		0.13	
61	*Lutjanus monostigma*	Lutjanidae	14	0.12		0.12	
62	*Pterocaesio trilineata*	Caesionidae	14	0.12			0.12
63	*Acanthurus olivaceus*	Acanthuridae	13	0.11	0.11		
64	*Cheilinus trilobatus*	Labridae	13	0.11		0.11	
65	*Macolor macularis*	Lutjanidae	13	0.11		0.11	
66	*Oxycheilinus digramma*	Labridae	12	0.09		0.10	
67	*Siganus guttatus*	Siganidae	12	0.09		0.09	
68	*Acanthurus lineatus*	Acanthuridae	10	0.09	0.09		
69	*Lethrinus erythropterus*	Lethrinidae	10	0.09		0.09	
70	*Lutjanus carponotatus*	Lutjanidae	10	0.09		0.09	
71	*Caranx bajad*	Carangidae	9	0.05		0.08	
72	*Cetoscarus bicolor*	Scaridae	9	0.05	0.08		
73	*Epinephelus fasciatus*	Serranidae	9	0.05		0.08	
74	*Lutjanus quinqueleneatus*	Lutjanidae	9	0.05		0.08	
75	*Siganus puellus*	Siganidae	9	0.05	0.08		
76	*Pomacanthus sexstriatus*	Pomacanthidae	8	0.07		0.07	
77	*Ctenochaetus binotatus*	Acanthuridae	7	0.05	0.06		
78	*Lutjanus bohar*	Lutjanidae	7	0.05		0.06	
79	*Zebrasoma veliferum*	Acanthuridae	7	0.05	0.06		
80	*Oxycheilinus celebicus*	Labridae	6	0.05		0.05	
81	*Siganus argenteus*	Siganidae	6	0.05	0.05		
82	*Cephalopholis urodeta*	Serranidae	5	0.04		0.04	
83	*Aethaloperca rogaa*	Serranidae	4	0.03		0.03	
84	*Bolbometopon muricatum*	Scaridae	4	0.03	0.03		
85	*Plectropomus leopardus*	Serranidae	4	0.03		0.03	
86	*Scarus tricolor*	Scaridae	4	0.03	0.03		
87	*Plectropomus aerolatus*	Serranidae	3	0.03		0,03	
88	*Scolopsis affinis*	Scolopsidae	3	0.03		0.03	
89	*Siganus canaliculatus*	Siganidae	3	0.03	0.03		
90	*Acanthurus triostegus*	Acanthuridae	2	0.02	0.02		
91	*Cheilinus undulatus*	Labridae	2	0.02		0.02	
92	*Diagramma pictum*	Haemulidae	2	0.02		0.02	
93	*Lethrinus harak*	Lethrinidae	2	0.02		0.02	
94	*Lethrinus obsoletus*	Lethrinidae	2	0.02		0.02	
95	*Mulloidichthys vanicolensis*	Mullidae	2	0.02		0.02	
96	*Naso caeruleacaudus*	Acanthuridae	2	0.02	0.02		
97	*Pentapodus caninus*	Nemipteridae	2	0.02		0.02	
98	*Siganus spinus*	Siganidae	2	0.02	0.02		
99	*Platax teira*	Ephippidae	1	0.01			0.01
100	*Pomacanthus imperator*	Pomacanthidae	1	0.01		0.01	
	Total				46.45	22.97	30.71

Appendix 2. Composition of reef fishes based on biomass ranks

No	SPECIES	FAMILIES	BIOMASS (Gram)	PERCENT (%)
1	*Caesio cuning*	Caesionidae	257,334.8	15.229
2	*Caesio caerulaurea*	Caesionidae	204,119.2	12.080
3	*Scarus ghobban*	Scaridae	177,214.8	10.488
4	*Chlorurus sordidus*	Scaridae	95,012.5	5.623
5	*Naso lituratus*	Acanthuridae	57,093.6	3.379
6	*Scarus niger*	Scaridae	50,778.9	3.005
7	*Pterocaesio tessellata*	Caesionidae	38,000.6	2.249
8	*Ctenochaetus striatus*	Acanthuridae	35,886.0	2.124
9	*Lutjanus decussatus*	Lutjanidae	33,509.0	1.983
10	*Scarus hypselopterus*	Scaridae	29,069.7	1.720
11	*Pterocaesio digramma*	Caesionidae	26,774.8	1.585
12	*Scarus flavipectoralis*	Scaridae	26,247.7	1.553
13	*Lutjanus biguttatus*	Lutjanidae	24,000.6	1,420
14	*Lutjanus vitta*	Lutjanidae	23,173.7	1,371
15	*Caesio lunaris*	Caesionidae	23,153.6	1.370
16	*Lutjanus ehrenbergii*	Lutjanidae	22,805.8	1.350
17	*Scarus forsteni*	Scaridae	22,047.5	1.305
18	*Siganus virgatus*	Siganidae	21,659.5	1.282
19	*Bolbometopon muricatum*	Scaridae	21,008.7	1.243
20	*Platax orbicularis*	Ephippidae	20,601.3	1.219
21	*Plectorhinchus chaetodontoides*	Haemulidae	19,343.9	1.145
22	*Scolopsis margaritifer*	Scolopsidae	18,717.3	1.108
23	*Scarus schlegeli*	Scaridae	17,903.7	1.060
24	*Kyphosus vaigiensis*	Kyphosidae	16,378.5	0.969
25	*Plectorhinchus lessonii*	Haemulidae	16,168.0	0.957
26	*Parupeneus barberinus*	Mullidae	15985.0	0.946
27	*Monotaxis grandoculis*	Lethrinidae	15,961.5	0.945
28	*Hemigymnus melapterus*	Labridae	15,920.8	0.942
29	*Scolopsis ciliatus*	Scolopsidae	15,541.2	0.920
30	*Acanthurus mata*	Acanthuridae	14,782.6	0.875
31	*Naso hexacanthus*	Acanthuridae	13,001.2	0.769
32	*Siganus corallinus*	Siganidae	12,786.2	0.757
33	*Cheilinus fasciatus*	Labridae	12,680.5	0.750
34	*Caranx melampygus*	Carangidae	12,220.4	0.723
35	*Epibulus insidiator*	Labridae	12,186.0	0.721
36	*Parupeneus multifasciatus*	Mullidae	12,083.3	0.715
37	*Scarus microrhinos*	Scaridae	10,709.6	0.634
38	*Sargocentron caudimaculatum*	Holocentridae	10703.5	0.633
39	*Kyphosus cinerascens*	Kyphosidae	10652.0	0.630
40	*Scolopsis bilineatus*	Scolopsidae	10,627.7	0.629
41	*Cephalopholis argus*	Serranidae	9,648.2	0.571
42	*Hemigymnus fasciatus*	Labridae	9,567.9	0.566
43	*Scarus spinus*	Scaridae	9,414.8	0.557
44	*Acanthurus leucocheilus*	Acanthuridae	8,996.2	0.532
45	*Caesio teres*	Caesionidae	8,238.8	0.488
46	*Chlorurus bowersi*	Scaridae	7,845.9	0.464
47	*Siganus vulpinus*	Siganidae	7,793.7	0.461
48	*Lethrinus erythropterus*	Lethrinidae	7,792.0	0.461
49	*Pentapodus trivittatus*	Nemipteridae	7,453.9	0.441
50	*Myripristis murdjan*	Holocentridae	7,312.0	0.433
51	*Acanthurus nigricans*	Acanthuridae	6,379.7	0.378
52	*Parupeneus bifasciatus*	Mullidae	6,227.8	0.369
53	*Scarus scaber*	Scaridae	5,694.4	0.337
54	*Choerodon anchorago*	Labridae	5,269.5	0.312

55	*Lutjanus monostigma*	Lutjanidae	5,058.0	0.299
56	*Zebrasoma scopas*	Acanthuridae	4,966.5	0.294
57	*Pomacanthus sexstriatus*	Pomacanthidae	4,848.9	0.287
58	*Parupeneus cyclostomus*	Mullidae	4,744.7	0.281
59	*Acanthurus olivaceus*	Acanthuridae	4,479.3	0.265
60	*Cetoscarus bicolor*	Scaridae	4,410.8	0.261
61	*Siganus guttatus*	Siganidae	4,022.6	0.238
62	*Cephalopholis cyanostigma*	Serranidae	3,883.9	0.230
63	*Lutjanus carponotatus*	Lutjanidae	3,859.5	0.228
64	*Upeneus tragula*	Mullidae	3,519.2	0.208
65	*Sphyraena flavicauda*	Sphyraenidae	3,353.0	0.198
66	*Scarus dimidiatus*	Scaridae	3,274.2	0.194
67	*Macolor macularis*	Lutjanidae	3,233.2	0.191
68	*Caranx bajad*	Carangidae	2,589.2	0.153
69	*Parupeneus barberinoides*	Mullidae	2,524.1	0.149
70	*Plectropomus leopardus*	Serranidae	2,286.4	0.135
71	*Siganus puellus*	Siganidae	2,241.1	0.133
72	*Scarus tricolor*	Scaridae	2,227.6	0.132
73	*Acanthurus lineatus*	Acanthuridae	1,886.8	0.112
74	*Aethaloperca rogaa*	Serranidae	1,747.7	0.103
75	*Lutjanus quinqueleneatus*	Lutjanidae	1,656.6	0.098
76	*Naso caeruleacaudus*	Acanthuridae	1397.9	0.083
77	*Lethrinus obsoletus*	Lethrinidae	1,364.1	0.081
78	*Lutjanus bohar*	Lutjanidae	1,292.1	0.076
79	*Oxycheilinus digramma*	Labridae	1289.5	0.076
80	*Pomacanthus imperator*	Pomacanthidae	1,192.1	0.071
81	*Cheilinus trilobatus*	Labridae	1,188.3	0.070
82	*Epinephelus fasciatus*	Serranidae	1,168.9	0.069
83	*Diagramma pictum*	Haemulidae	875.0	0.052
84	*Siganus argenteus*	Siganidae	814.2	0.048
85	*Zebrasoma veliferum*	Acanthuridae	758.4	0.045
86	*Ctenochaetus binotatus*	Acanthuridae	710.9	0.042
87	*Cephalopholis boenak*	Serranidae	707.0	0.042
88	*Plectropomus aerolatus*	Serranidae	633.4	0.037
89	*Oxycheilinus celebicus*	Labridae	624.1	0.037
90	*Pterocaesio trilineata*	Caesionidae	517.1	0.031
91	*Mulloidichthys vanicolensis*	Mullidae	456.9	0.027
92	*Siganus canaliculatus*	Siganidae	453.4	0.027
93	*Cephalopholis urodeta*	Serranidae	427.9	0.025
94	*Lethrinus harak*	Lethrinidae	316.1	0.019
95	*Siganus spinus*	Siganidae	286.5	0.017
96	*Acanthurus triostegus*	Acanthuridae	279.4	0.017
97	*Platax teira*	Ephippidae	234.8	0.014
98	*Scolopsis affinis*	Scolopsidae	204.3	0.012
99	*Cheilinus undulatus*	Labridae	195.4	0.012
100	*Pentapodus caninus*	Nemipteridae	46.4	0.003