COMMUNITY STRUCTURE AND TROPHIC STATUS OF REEF FISH IN NATUNA WATERS

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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 m², 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
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 sweeplips, 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 functional 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 (ecomonical 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.
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.

### 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 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.

Mean of Density (individual/m²) = \( \frac{IN(T)}{TA(T)} \) ............(1)

where :
IN = Individual Number
T = Transect Site
TA = Total Area in m²

\[ W = a \times L^b \] ............................................................ (2)

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

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 m² for density. The density was equivalent to 4,153 individuals per hectare.

| Transect Codes | Location Names | Ind. No. | Species No. | Density/m² (x) | 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 cunning (14.28 %) of family Caesionidae (Appendix 1). Furthermore, the top biomass rank of reef fish species were Caesio cunning (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 cunning 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 cunning, Caesio caerulaurea, Scarus hypselopterus, Chlorurus sordidus, Pterocaesio tessellata, Scarus niger,
Scolopsis ciliatus, Ctenochaetus striatus, Lutjanus ehrenbergii, Lutjanus decussatus, Pterocaesio digramma, Lutjanus 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) with 227 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.

| Transect Code | Location            | Total Biomass (kg) | Survey Area (m²) | Biomass Mean (gram/m²) | 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          | Sabangmwang 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, including corallivorous fishes of the functional fish groups. Most of them were taxonomically classified in the family Chaetodontidae (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 |
|-------------|-------------|
| Individual Number | N001 | N002 | N003 | N004 | N005 | N006 | N007 | N008 | N009 | N010 | N011 | N012 | N013 | N014 |
| 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 reef 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 biguttatus, L. ehrenbergii, and L. vitia, might be taken into consideration as specially interest within 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.

The 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 phenomena 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 adiargastos, 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 caerulaeura. 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      |            |              |
| 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       |            |              |
| 7   | Scarus niger       | Scaridae  | 343      |      | 2.93       |            |              |
| 8   | Scoplosisciliatus  | Scloposidae | 336    |      | 2.87       |            | 2.87         |
| 9   | Ctenochaetus striatus | Acanthuridae | 262   |      | 2.24       |            | 2.24         |
| 10  | Lutjanus ehrenbergi | Lutjanidae | 223    |      | 1.91       |            | 1.91         |
| 11  | Lutjanus biguttatus | Lutjanidae | 217    |      | 1.85       |            | 1.85         |
| 12  | Pterocaesio digramma | Caesionidae | 210   |      | 1.79       |            |              |
| 13  | Lutjanus decussatus | Lutjanidae | 183    |      | 1.56       |            |              |
| 14  | Siganus virgatus   | Siganidae | 166     |      | 1.42       |            | 1.42         |
| 15  | Lutjanus vitta     | Lutjanidae | 153    |      | 1.31       |            |              |
| 16  | Scarus flavipectoralis | Scaridae | 143    |      | 1.22       |            | 1.22         |
| 17  | Caesio lunaris     | Caesionidae | 138  |      | 1.18       |            |              |
| 18  | Parupeneus barberinus | Mullidae | 136    |      |           |            |              |
| 19  | Epibulus insidiator | Labridae  | 115     |      | 0.98       |            |              |
| 20  | Chelinus fasciatus | Labridae  | 114     |      | 0.97       |            |              |
| 21  | Acanthurus nigricans | Acanthuridae | 103   |      | 0.88       | 0.88       |              |
| 22  | Parupeneus multifasciatus | Mullidae | 103    |      | 0.88       |            |              |
| 23  | Scoplosis margaritfer | Scloposidae | 103    |      | 0.88       |            |              |
| 24  | Chlorurus bawersi  | Scaridae  | 100     |      | 0.85       | 0.85       |              |
| 25  | Naso luturatus     | 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  | Scoplosis bilineatus | Scloposidae | 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       |            |              |
| 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 lessoni | Haemulidae | 21     |      | 0.18       |            | 0.18         |
|   | Species                  | Family      | Length | Mass (kg) | Width (cm) |
|---|--------------------------|-------------|--------|-----------|------------|
| 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 | Plectorrhinchus chaetodontoides | Haemulidae | 16 | 0.14      | 0.14       |
| 59 | Acanthurus leucocheilus  | Acanthuridae| 15     | 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 trifilobatus   | 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 | Carax 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 quinquelineatus | Lutjanidae  | 9      | 0.05      | 0.08       |
| 75 | Siganus puellus          | Siganidae   | 9      | 0.05      | 0.08       |
| 76 | Pomacanthus sexstriatus  | Pomacanthida| 8     | 0.07      | 0.07       |
| 77 | Ctenochaetus binitatus   | 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 | Scloposis affinis        | Scloposidae | 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 | Mullolidichthys vanicolensis| Mullidae | 2      | 0.02      | 0.02       |
| 96 | Naso caeruleaeaudus      | 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    | Pomacanthida| 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 lüturatus           | 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   | 23,153.6       | 1.370       |
| 10 | Scarus hypselopterus     | Scaridae     | 22,805.8       | 1.350       |
| 11 | Pterocaesio digramma     | Caesionidae  | 21,008.7       | 1.243       |
| 12 | Scarus flavipectoralis   | Scaridae     | 20,601.3       | 1.219       |
| 13 | Lutjanus biguttatus      | Lutjanidae   | 19,343.9       | 1.145       |
| 14 | Lutjanus vitta           | Lutjanidae   | 17,903.7       | 1.060       |
| 15 | Caesio lunaris           | Caesionidae  | 16,717.3       | 1.005       |
| 16 | Lutjanus ehrenbergii     | Lutjanidae   | 15,961.5       | 0.945       |
| 17 | Scarus forsteni          | Scaridae     | 15,541.2       | 0.920       |
| 18 | Siganus virgatus         | Siganidae    | 14,782.6       | 0.875       |
| 19 | Bolbometopus maculatus   | Scaridae     | 13,001.2       | 0.769       |
| 20 | Platax orbicularis       | Ephippidae   | 12,786.2       | 0.757       |
| 21 | Plectorhinchus chaetodontoides | Haemulidae | 12,680.5       | 0.750       |
| 22 | Scolopsis margaritifer    | Scolopsidae  | 12,220.4       | 0.723       |
| 23 | Scarus schlegeli         | Scaridae     | 11,903.7       | 0.715       |
| 24 | Kyphosus vaigiensis       | Kyphosidae   | 10,709.6       | 0.634       |
| 25 | Plectorhinchus lessonii   | Haemulidae   | 10,652.0       | 0.630       |
| 26 | Parupeneus barberinus    | Mullidae     | 10,627.7       | 0.629       |
| 27 | Monotaxis grandoculis    | Lethridae    | 9,845.9        | 0.566       |
| 28 | Sargocentron cadmiumalatum | Holocentridae | 9,648.2        | 0.571       |
| 29 | Kyphosus cinerascens     | Kyphosidae   | 9,567.9        | 0.566       |
| 30 | Acantthurus mata          | Acanthuridae | 8,996.2        | 0.532       |
| 31 | Naso hexacanthus         | Acanthuridae | 8,238.8        | 0.488       |
| 32 | Siganus corallinus       | Siganidae    | 7,933.7        | 0.461       |
| 33 | Chelinus fasciatus       | Labridae     | 7,792.0        | 0.461       |
| 34 | Caranx melampygus        | Carangidae   | 7,792.0        | 0.461       |
| 35 | Epibulus insidarius      | Labridae     | 7,792.0        | 0.461       |
| 36 | Parupeneus multifasciatus | Mullidae | 7,792.0        | 0.461       |
| 37 | Scarus microrhinos       | Scaridae     | 7,792.0        | 0.461       |
| 38 | Serranops cahma          | Serranidae   | 7,792.0        | 0.461       |
| 39 | Kyphosus cinerascens     | Kyphosidae   | 7,792.0        | 0.461       |
| 40 | Parupeneus multifasciatus | Mullidae | 7,792.0        | 0.461       |
| 41 | Cephalopholis argus      | Serranidae   | 7,792.0        | 0.461       |
| 42 | Hemigymnus fasciatus     | Labridae     | 7,792.0        | 0.461       |
| 43 | Scarus spinus            | Scaridae     | 7,792.0        | 0.461       |
| 44 | Parupeneus multifasciatus | Mullidae | 7,792.0        | 0.461       |
| 45 | Caesio teres             | Caesionidae  | 7,792.0        | 0.461       |
| 46 | Chlorurus bowersi        | Scaridae     | 7,792.0        | 0.461       |
| 47 | Siganus vulpinus         | Siganidae    | 7,792.0        | 0.461       |
| 48 | Lethrinus erythrophusius | Lethridae    | 7,792.0        | 0.461       |
| 49 | Pterocaesio tessellata    | Caesionidae  | 7,792.0        | 0.461       |
| 50 | Pterocaesio tessellata    | Caesionidae  | 7,792.0        | 0.461       |
| 51 | Lutjanus rhombus         | Lutjanidae   | 7,792.0        | 0.461       |
| 52 | Parupeneus multifasciatus | Mullidae | 7,792.0        | 0.461       |
| 53 | Scarus scaber            | Scaridae     | 7,792.0        | 0.461       |
| 54 | Choerodon anchorago      | Labridae     | 7,792.0        | 0.461       |
| No. | Species              | Family          | Total Weight | Total Weight % |
|-----|----------------------|-----------------|--------------|----------------|
| 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    | Scardae         | 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      | Scardae         | 2,227.6      | 0.132          |
| 73  | Acanthurus lineatus  | Acanthuridae    | 1,886.8      | 0.112          |
| 74  | Aethaloperca roga    | Serranidae      | 1,747.7      | 0.103          |
| 75  | Lutjanus quinqueleneatus | Lutjanidae     | 1,656.6      | 0.098          |
| 76  | Naso caeruleapectus | Acanthuridae    | 1,397.9      | 0.083          |
| 77  | Lethrinus obsoletus  | Lethrinidae     | 1,364.1      | 0.081          |
| 78  | Lutjanus bohar       | Lutjanidae      | 1,292.1      | 0.076          |
| 79  | Oxycheilinus digramma | Labridae       | 1,289.5      | 0.076          |
| 80  | Pomacanthus imperator | Pomacanthidae  | 1,192.1      | 0.071          |
| 81  | Cheilinus triobatus  | 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 velliferum | 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 urodelta | 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          |