Herbivore fish diversity patterns in an Indonesian outer island

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Abstract. Coral reefs are highly productive communities and the most complex ecosystems in the seas, being also ecosystems with fish communities with the highest degree of diversity. The present study aimed to measure the species richness and total herbivore biomass using Underwater Visual Census with number of individuals encountered within 2.5 m on either side of a 75-m transect laid down. Within each habitat species were counted, length of each herbivore fish species that counted on seventeen reefs sites was considered. Free-ranging herbivores of interest in study were fishes in the family Acanthuridae (Surgeonfish), Scaridae (parrotfishes), and Siganidae (Rabbitfishes). Fourthy one herbivore fish species were found; Scaridae (25 species), Siganidae (10 species) and Acanthuridae (6 species). The location of RS15 in Penagi, East Natuna showed the highest abundance and biomass of herbivorous fish. The environmental condition in Natuna Island has good condition with the less of ecological stresses although in several site (at the western Natuna) destructive fishing have been reported.
Key Words: Acanthuridae, coral reef, Natuna, Scaridae, Siganidae.

Introduction. Coral reefs are highly productive communities and the most complex ecosystems in the seas as fish communities reach their highest degree of diversity in these ecosystems, and differ enormously within and between reefs in the same area and between geographic regions (Harmelin-Vivien 2002). Coral reefs are one of the most highly productive marine ecosystem, with a strong connection between herbivores and the algal production (Marshell & Mumby 2015) and play a critical role in preventing phase shifts to algae but their ability to remove the algae may be limited (Bellwood et al 2006). Pérez-Matus & Shima (2010) revealed strong behaviorally mediated linkages between the abundance of reef fishes and the composition of vegetative structure in ecosystem dominated by algae. The high abundance of algae is caused by reduced number of herbivorous fish.

Degradation and mortality of corals was increasing worldwide and expected to have significant effects on coral reef fish (Yahya et al 2011). The great diversity of coral reef fish communities is being disturbed by the continuing destruction of coral reefs. The high pressure on coral reefs was not only occurring on mainland but also affects the outer small islands of Indonesia in South China Sea region. Almost 12% of over 3,365 fish species are recorded in the South China Sea (Adrim et al 2004; Randall & Lim 2000) and one of them on Outer Island - Natuna Island. As an important component of the shallow coastal environment, marine fish can support global fisheries and also maintain ecosystem functions (Pratchett et al 2011). Two of the most fundamental properties to maintaining ecosystem function part of an ecological community are the species richness it contains and the total biomass of those species (Fox 2004).

Herbivorous fishes play a significant role in the prevention of coral smothering and aiding in their resilience (Gowri et al 2016). Corals also rely on intense feeding by herbivorous fishes to remove seaweeds that can overgrow and kill corals (Burkepile et al 2013). Grazing by topical herbivores contribute to maintaining resilient coral reefs; marine reserves are critical in conserving herbivores and the functional role they provide (Ferguson et al 2016) which proves that herbivore fish have important role to maintain the ecosystem good balancing in order to prevent coral death. Herbivore fish abundance was the main factor influencing fish community structure, because there is a negative relationship between algae and herbivore fish biomass and species richness (Campbell & Pardede 2006).

Multiple researchers have conducted research on the abundance, total biomass and diversity of herbivorous fish. Herbivorous fishes have certain characteristics that caused abundance, biomass and diversity is different on each location and there are several variations in abundance within the herbivore fishes. Also Chabanet et al (2012) found that the abundance of herbivorous fish depends on the time and type of fish considered. A previous study of Mallet et al (2016) showed that Acanthuridae were more numerous during the morning, whereas Scaridae were more abundant at sunrise and sunset. A significant habitat variation relative abundance has found for two major groups of herbivorous fishes, with Acanthuridae fishes predominant in shallow habitats and Scaridae fishes more dense in deeper habitat and high relief reefs than in low relief or patch reefs (Paddack & Cowen 2006).

Differences in physical and biological aspect can affect abundance, species richness and biomass of marine fishes in reef. There was another factor that could affect the abundance, biomass and diversity of marine fish that was fishing. Changes in abundance, species composition and behavior of target species can be caused by fishing activities which in turn can change the aquatic ecosystem (Januchowski-Hartley et al 2015). These conditions imply that increased fishing pressure in an area would increase fish vigilance and could reduce the value of some ecosystem functions in small marine reserves.

Coral reefs has the highest biodiversity, are among, yet most threatened ecosystems on the planet (Burkepile & Hay 2010) and have an impact on coral-reef fish. Worldwide, about 31% of coral-reef fishes are now considered critically endangered and 24% threatened (Hixon 2001). Biodiversity of marine fishes is high and about 32,000 species, with the highest rate living in marine environments (Safina & Duckworth 2013) and about 4500 fish species inhabit coral reefs globally. Populations of reef fish are threatened due to habitat degradation and overfishing and there are indications that species are endangered (Hixon 2015). Within the Outer Island, there are strong gradations in species richness that permit comparisons of faunas of differing diversity within a biogeographic region (Bellwood & Wainwright 2002) and the most important factor can degrade reefs because process such as overfishing of herbivores fishes (Burkepile et al 2013) and lack of controlling from government and Corporate Social Responsibility (CSR). From above factors the circumstances, coral reef ecosystems can be determined by observe the structure of herbivorous fish population in an outer region.

The main objective of the present study is to determine herbivore fish abundance, biomass and diversity patterns at an Outer Island.

Material and Method

Study sites and specimen collection. The study area was located at Natuna Island. Data Sampling was conducted on seventeen reefs sites (RS01 – RS17) on Tiga Island, Sedanau, Selat Lampa, Penagi, Sepempang, Kelanga, Tanjung Buton and Kelarik (Table 1). The present study used Underwater Visual Census Method with an observation area of 350 m^2 developed by English et al (1997) with number of individuals encountered within 2.5 m on either side of a 75-m transect laid down. Within each habitat were counted species and length of each herbivore fish species considered. The large, free-ranging herbivores of interest in study were fishes in the family Acanthuridae (Surgeonfish), Scaridae (parrotfishes), and Siganidae (Rabbit fishes) based on Guide to Monitoring Coral Reef Health by Giyanto et al (2014).

Table 1

The coordinates for the study area on Natuna Island, Indonesia

Site	*Region*	*Cardinal location*	*Latitude*	*Longitude*	*Sample area*
HB.1	Sedanau	West (W)	108.00321	3.78984	350 m^2
HB.2	Pulau Tiga	South (S)	108.07323	3.68760	350 m^2
HB.3	Pulau Tiga	South (S)	108.07261	3.63147	350 m^2
HB.4	Pulau Tiga	South (S)	108.07939	3.57879	350 m^2
HB.5	Selat Lampa	South (S)	108.10630	3.67291	350 m^2
HB.6	Penagi	East (E)	108.43320	3.87179	350 m^2
HB.7	Sepempang	East (E)	108.37560	3.99171	350 m^2
HB.8	Sepempang	East (E)	108.35718	4.00281	350 m^2
HB.9	Kelanga	East (E)	108.30705	4.05990	350 m^2
HB.10	Tanjung Buton	North (N)	108.22983	4.22471	350 m^2
HB.11	Kelarik	West (W)	108.15382	4.16541	350 m^2
HB.12	Kelarik	West (W)	108.08387	4.11754	350 m^2
HB.13	Kelarik	West (W)	108.0258	4.06018	350 m^2
HB.14	Kelanga	East (E)	108.3367	4.04131	350 m^2
HB.15	Penagi	East (E)	108.4243	3.90435	350 m^2
HB.16	Sedanau	West (W)	108.0441	3.79323	350 m^2
HB.17	Selat Lampa	South (S)	108.0884	3.73033	350 m^2

Identification. The recorded herbivore fish were identified according to Allen & Erdmann (2012), Allen et al (2009), and Kuiter & Tonozuka (2001). Beside abundance, the length of each herbivore fish was determined. Total length of each herbivore fish were measured in centimeters and their corresponding weight were recorded in grams (Akel & Philpis 2014).

$$W=a \times L^b$$

Where W = weight of fish in grams, and a and b are constants estimated by the least square method, L = Total Length of each herbivore fish recorded. The coefficients for the a and b values were obtained from the fishbase.org website. The value of weight of herbivore fish W is required to conduct biomass based analysis (Froese & Paully 2014).

$$B = \frac{\text{W total weight of each species (gram)}}{\text{Area transect } (350 \text{ m}^2)}$$

Biodiversity is currently a key indicator of an ecosystem's health. The species diversity was evaluated using the Shannon diversity index (H') (Shannon & Weaver 1963).

$$H' = -\sum_{1}^{S}\left(\frac{n_1}{N}\right)\ln\left(\frac{n_1}{N}\right)$$

Where n is the total number of certain species, N is the total number of all species and S is the number of different species. Shannon diversity index (H') commonly was used to characterize species' diversity in a community, which accounts for the abundance of the species present. H' value increase with increasing number of species (Akel & Philpis 2014).

Results. The total composition of herbivore fish species recorded during research is presented in Table 2. In total 41 species have been recorded. Scaridae family with 25 species which derives from three genera: Cetoscarus, Chlorurus and Scarus, Acanthuridae family with 6 species with 4 genera: Acanthurus, Chetenochaetus, Naso and Zebrasoma whereas Siganidae family with 10 species which derived from a single genera, namely Siganus. The total number of herbivorous fish that recorded was 2008 ind. 350 m^{-2} with the highest abundance in RS 15 at Penagi (East Natuna) with 390 ind. 350 m^{-2}. Whereas the lowest density of herbivorous fish was found in RS 13 at Kelarik (West Natuna) with only 2 ind. 350 m^{-2}.

Table 2

Herbivore species abundance and distribution

Species	*Code*	*Density (Transect)*	*Density (ind ha^{-1})*	*%*
Cetoscarus bicolor	SC01	16	457	0.8
Chlorurus capistratoides	SC02	8	229	0.4
Chlorurus spilurus	SC03	20	571	1
Chlorurus blekerri	SC04	78	2229	3.88
Chlorurus bowersi	SC05	43	1229	2.14
Chlorurus sordidus	SC06	322	9200	16.04
Chlorurus michrohinos	SC07	17	486	0.85
Scarus schlegeli	SC08	11	314	0.55
Scarus dimidiatus	SC09	30	857	1.49
Scarus forsteni	SC10	11	314	0.55
Scarus frenatus	SC11	17	486	0.85
Scarus fuscocaudalis	SC12	1	29	0.05
Scarus ghobban	SC13	25	714	1.25
Scarus globiceps	SC14	45	1286	2.24
Scarus hypselopterus	SC15	180	5143	8.96
Scarus niger	SC16	178	5086	8.86
Scarus oviceps	SC17	43	1229	2.14
Scarus psittacus	SC18	4	114	0.2
Scarus prasiognathos	SC19	6	171	0.3
Scarus quoyi	SC20	190	5429	9.46
Scarus rivulatus	SC21	214	6114	10.66
Scarus rubroviolaceus	SC22	3	86	0.15
Scarus spinus	SC23	57	1629	2.84
Scarus scaber	SC24	1	29	0.05
Scarus xanthopleura	SC25	13	371	0.65
Acanthurus lineatus	AC01	20	571	1
Acanthurus triostegus	AC02	12	343	0.6
Acanthurus nigrofuscus	AC03	36	1029	1.79
Ctenochaetus striatus	AC04	5	143	0.25
Naso lituratus	AC05	25	714	1.25
Zebrasoma scopas	AC06	7	200	0.35
Siganus corallinus	SG01	23	657	1.15
Siganus argenteus	SG02	6	171	0.3
Siganus doliatus	SG03	1	29	0.05
Siganus guttatus	SG04	14	400	0.7
Siganus punctatissiumus	SG05	3	86	0.15
Siganus puellus	SG06	6	171	0.3
Siganus spinus	SG07	3	86	0.15
Siganus canaliculatus	SG08	1	29	0.05
Siganus virgatus	SG09	276	7886	13.75
Siganus vulpinus	SG10	37	1057	1.84
Total		2008	57371	100

Distribution pattern and abundance of herbivore fish in Natuna Island. Considering seventeen sites, the results showed that the highest abundance of herbivore fish in Natuna Island was dominated by Scaridae family regardless of site (North, South, East and West Natuna Island) (Figure 1). The result concerning the distribution pattern of herbivorous fish (Scaridae, Siganidae and Acanthuridae) shows the highest abundance was found site in eastern Natuna waters. Distribution pattern of abundance for Scaridae family showed dominancy in the east Natuna on site RS15 (9571 ind ha^{-1}) at Penag, whereas the lowest abundance was recorded on site RS13 (57 ind ha^{-1}) at Kelarik, West Natuna. The highest abundance for Siganidae family (Rabbitfishes) was found on Site RS7 (3314 ind ha^{-1}) at Sepempang, located in east Natuna, whereas there were three sites were Siganidae was not found, RS3, RS13, and RS16 respectively. The highest distribution abundance of Acanthuridae was recorded on site RS15 (886 ind ha^{-1}) whereas there were seven sites with no Siganidae occurrence, RS1, RS8, RS9, RS12, RS13, RS16 and RS17 respectively.

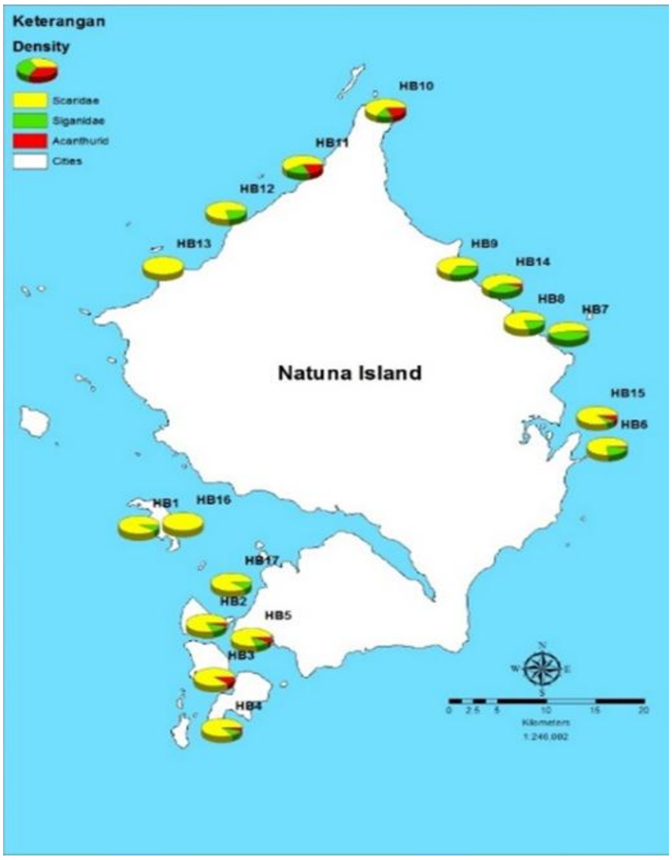

Figure 1. Map of abundance distribution of herbivorous fish in Natuna Island. Comparative abundance of herbivorous fish family (Scaridae, Siganidae and Acanthuridae).

Cluster analysis of herbivore fish In Natuna Island. There were five groups based on cluster dendogram of herbivore fish abundance (Figure 2). Three sites have become separated clusters: RS15, RS2, and RS7, which has the highest total abundance, respectively. Two other clusters were combination of several sites, which have the total abundance as similar as the other site in the same cluster: moderate abundance (RS4, RS6, RS12, RS14, RS8, and RS10) and low abundance (RS13, RS16, RS11, RS3, RS9, RS5, RS1, and RS17). Based on location, low abundance was located in the western part of the Natuna Island, whereas moderate and high abundance in the eastern region.

There were several groups of herbivore fish abundance and biomass based on species (Figure 3). Each family (Scaridae, Acanthuridae, and Siganidae) of herbivore fish were not grouping in special cluster. Generally, every cluster consisted of species combination. *C. sordidus* (SC06) and *S. virgatus* (SG06) were the highest Approximately Unbiased *p-value* and Bootstrap Probability value (AU/BP), respectively. This corresponded to the total amount of both of species, but this pattern was not applied for all fishes. It was indicated that the schooling of *C. sordidus* (SC06) and *S. virgatus* (SG06) has a higher biomass and uniform body size.

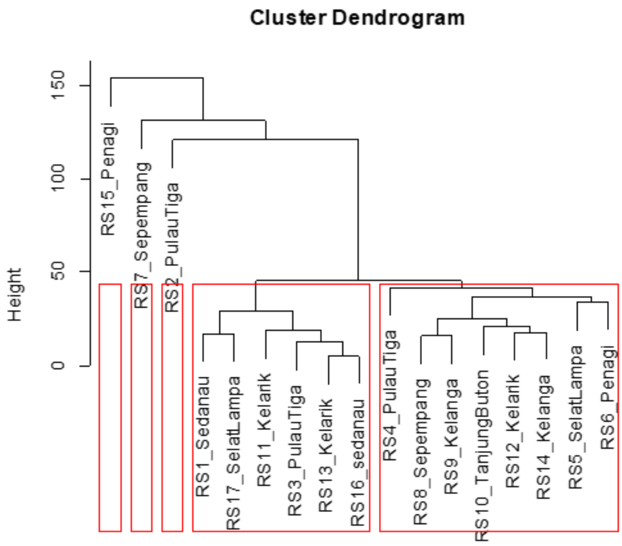

Figure 2. Cluster dendrogram of site research sampling of herbivore fish on Natuna Island.

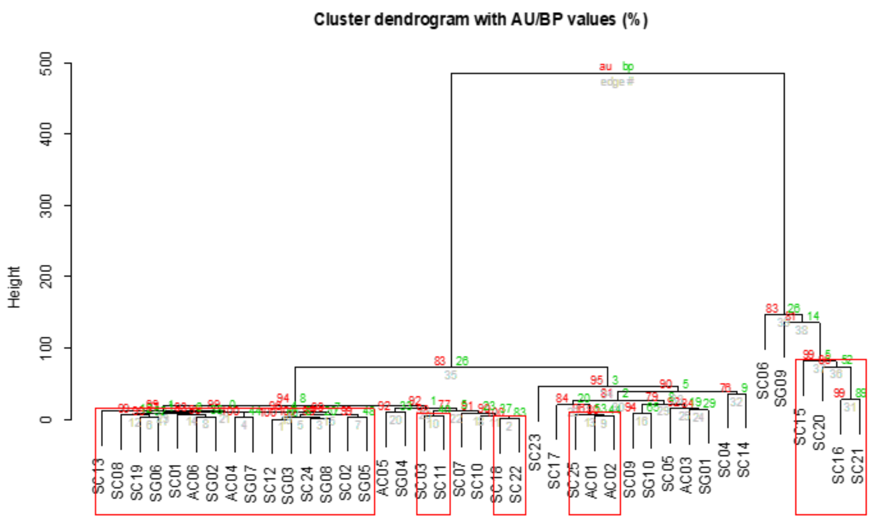

Figure 3. Cluster dendrogram with Approximately Unbiased *p-value* and Bootstrap Probability value (AU/BP) of herbivore fish on Natuna Island.

Species rank of herbivore fish In Natuna Island. Species ranking of the highest total abundance of herbivore fish recorded were represented by the species *C. sordidus* (SC06) (16.04%) Scaridae family, followed by species *S. virgatus* (SG06) (13.75%) Siganidae family, *S. rivulatus* (SC21) (10.66%), *S. quoyi* (SC20) (9.46%), *S. hypselopters* (SC15) (8.96%), *S. niger* (SC16) (8.86%), *C. bleekeri* (SC04) (3.88%), *S. spinus* (SC23) (2.84%), *C. bowersi* (SC05) (2.14%), *S. oviceps* (SC17) (2.14%), *S. vulpinus* (SG10) (1.84%), *A. nigofuscus* (AC03) (1.79%), *S. dimidiatus* (SC09) (1.49%), *S. ghobban* (SC13) (1.25%), *N. lituratus* (AC05) (1.25 %) and *S. corralinus* (SG01) (1.15%). Twenty-two species were represented by less than 1%. Herbivorous fish species abundance and rank found at Natuna Island is presented in Figure 4.

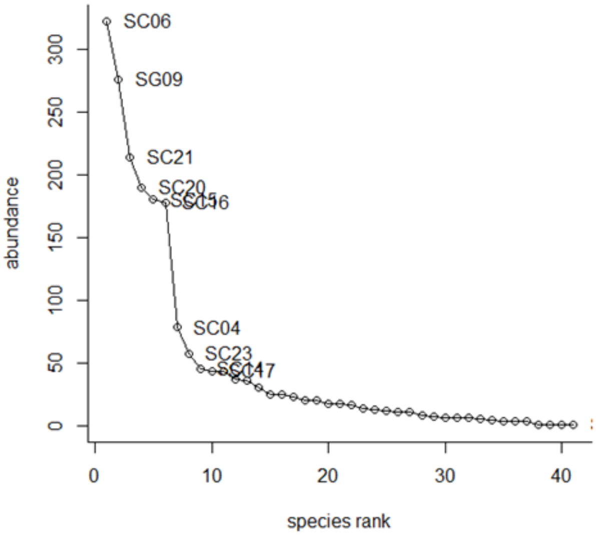

Figure 4. Species rank diagram of herbivore fish on Natuna Island.

Component analysis of herbivore fish in Natuna Island. The species which had low abundance (<70 ind) were grouped in the center of PCA graphic (Figure 5), whereas the highest abundance was scattered, namely *C. sordidus* (SC06), *S. virgatus* (SG06), *S. rivulatus* (SC21), *S. quoyi* (SC20), *S. hypselopters* (SC15), *S. niger* (SC16), and *C. bleekeri* (SC04) (3.88%). According to sites, the CA (Corresponding Analysis) showed the *S. virgatus* (SG09) was more dominant in Sepempang location (RS7), while *S. quoyi* (SC20) was dominant in Pulau Tiga. The results of CA analysis also showed that several fish species from the Siganidae family were mostly found in Klarik (RS13), including *S. guttatus* (SC04), *S. canaliculatus* (SC08) and *S. corallinus* (01).

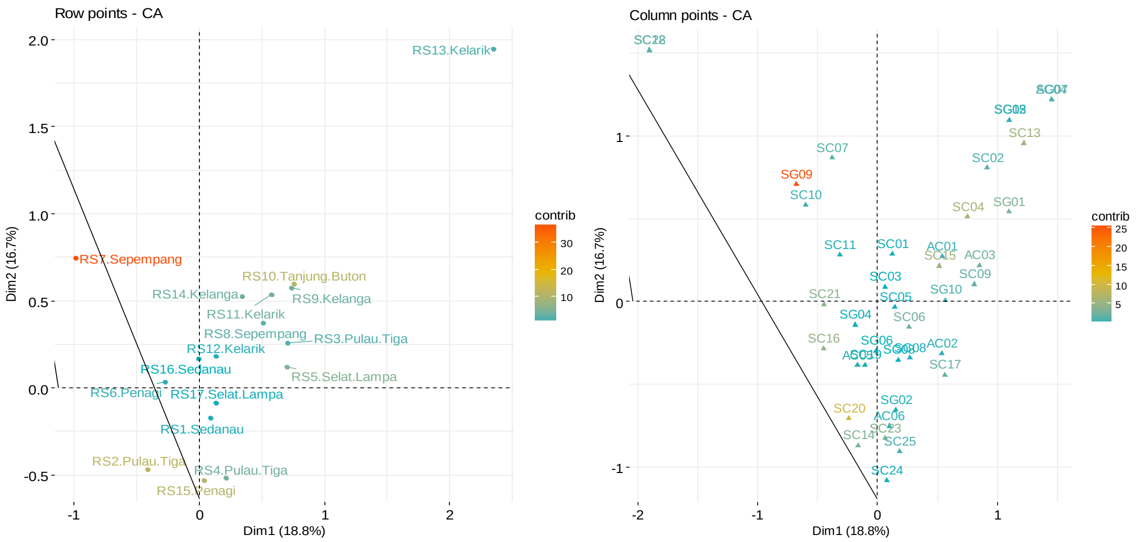

Figure 5. Species rank diagram of herbivore fish on Natuna Island.

Discussion. During the present study, differences in abundance and richness of herbivore fish family (Scaridae, Acanthuridae and Siganidae) were significant (Figure 6) and these differences are reflected in relative importance of certain distribution pattern from significant habitat variation and abundance on each site. One Way Anova analysis of density from herbivore fish (Scaridae, Acanthuridae and Siganidae) shown high mean of herbivore fish 1,124.94 ind ha^{-1} where herbivore fish abundance were higher on Scaridae family, with a mean density of 2,577 ind ha^{-1} followed by Siganidae family with a mean density of 621.8 ind ha^{-1}. The difference in contrast coefficients used in plotting the family from herbivore fish for Scaridae 1,451.54, Siganidae -503.08 whereas Acanthuridae -948.46 (d.f. between = 2; d.f. within = 48) were significant (P<0.005).

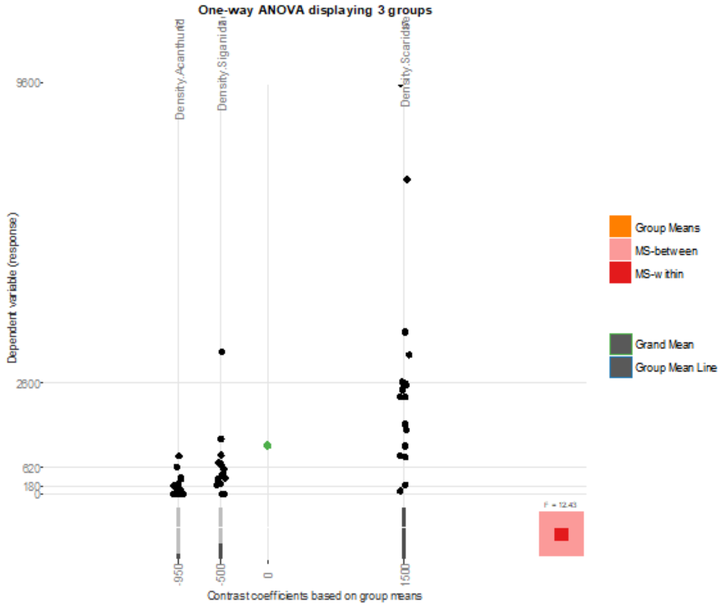

Figure 6. One Way Anova displaying 3 group of herbivore fish density (Scaridae, Acanthuridae and Siganidae).

Globally the coral reefs are in decline, due to the fact that some reefs undergoing phase shifts from coral-dominance to degraded states dominated by large fleshy algal (Hoey & Bellwood 2011). Reefs with intact herbivore communities appear to be able to compensate for this increased algal abundance, maintaining the algal communities in a cropped state (Arthur et al 2006). The major threats concerning the sustainability of coral reef are sedimentation, chemical pollution, sewage, temperature stress, coral bleaching, coral disease, toxic waste, destructive fishing practices, crown-of-thorn starfish (Richmond 1993). These factors have a significant effect upon herbivorous fish abundance, biomass and diversity.

In the present study, the most common herbivorous fish were found in Natuna Island (Scaridae family (Parrotfish)) (Figure 1). Parrotfishes are reef-dwellers and are widely distributed in all tropical oceans (Liao et al 2004) including Natuna Island. Fish found at Natuna Island, around reefs in shallow water areas, mostly, were Parrotfish species *C. bicolor* (SC01), *C. capistratoides* (SC02), *C. spilurus* (SC03), *C. bleekeri* (SC04), *C. bowersi* (SC05), *C. sordidus* (SC06), *S. dimidiatus* (SC09), *S. frenatus* (SC11), *S. ghobban* (SC13), *S. globiceps* (SC14), *S. hypselopterus* (SC15), *S. oviceps* (SC17), *S. quoyi* (SC20), *S. rivulatus* (SC21) and *S. spinus* (SC2); in wtare with depth less than 18 meters.

C. sordidus (Forsskål) (SC06) was the most dominant herbivore fish species in Natuna Island (Figure 4) and the most abundant species on both the flat and slope reefs (Alwanya et al 2009); the characteristics of the species is that form conspecific or multispecies schools and occasionally solitary or in large (higher than 25 individuals) schools (Bellwood & Choat 1989). *C. sordidus* (SC06) was a herbivorous fish that have a wide range of mobility. Juveniles are particularly abundant in lagoon, found in pomacentridae territories particularly those with rich algal abundance and recorded over all substratum types in all reef habitats from 1-14 m whereas abundant on mid and outer shelf reefs. (Bellwood 1986) suggested that *C. sordidus* (SC06) migrate from lagoon during late juvenile phase. Apart from Scaridae, *S. virgatus* SG06 from Siganidae also was found in Natuna with multiple schooling (Gundermann et al 1983). During observations *S. virgatus* (SG06) frequently was found schooling together with parrotfishes. The tendency to constantly stay in groups facilitated this fish to be easily recognized and always was found in the flat reef. Most of *S. virgatus* SG06 was constantly found in groups with uniform body size. Often found in Natuna Island, *S. virgatus* (SG06) is an endemic species of the western Indian Ocean (Woodland 1979).

Acanthurus was the lowest abundant fish in Natuna (Figure 5). Low abundance of this fish was due to the fact that the observations, mostly, were conducted on the reef slope and in late morning. Acanthuridae were more abundant during the morning and predominant in shallow habitats (Mallet et al 2016). The higher abundance of herbivorous fish in the East Natuna (Figure 4) was represented by *C. sordidus* (SC06), *S. virgatus* (SG09), *S. rivulatus* (SC21) and *S. quoyi* (SC20) frequently appearing in multispecies schools. Although some species of Scaridae were found in juvenile fish schooling (Lopez et al 2013) e.g. *C. sordidus* (SC06), *S. rivulatus* (SC21) and *S. hypselopterus* (SC15) but *S. quoyi* (SC20) species was found highly abundant adult schooling. The phenomenon is very interesting that species of this family was not schooling at juvenile stage. Some herbivorous fish schooling to spawning and some of herbivore fish join schools and move off open areas to feed (Bellwood & Choat 1989). *S. quoyi* SC20 as individuals are highly mobile, having either large home ranges or seminomadic behavior on inshore reefs although juveniles are most abundant on flat reefs. In the present study was found that schooling of herbivorous fish in East Natuna indicates a positive effect on coral reefs in Natuna Island. The result of our research is in accordance with previous research of (Barclay 2009) who stated that the presence of fish schooling in seawater shows good conditions for the health of coral reefs. Grazing by large number of herbivorous fish indicates that herbivorous fish can respond to raised algal production and cover by raising their feeding rates and thus keeping algae in a pruned state (Williams et al 2001) may be critical for reef system resilience by maintaining low algal cover required for coral re-colonization and growth (Birkeland 1977).

In addition, there were several species of herbivorous fish which was found in the deeper reefs as *S. niger* SC16, *S. frenatus* SC11, *S. forsteni* SC10, *S. schelegeli* SC08, *C. michrohinos* SC07, *S. rubroviolaceus* SC22, *C. sordidus* SC06 and *S. guttatus* SG04. The existence of herbivorous fish in depth waters is very influential on the population of herbivorous fish existing; deeper the waters decreases biodiversity. Most of herbivores fish consuming algae on coral because algae can grow if it gets adequate sunlight for photosynthesis activity that going to occur very quickly and provide food for metabolism and growth. Therefore, common herbivorous fish has a distribution pattern around the reefs, which prefer shallow waters. The presence of several species of herbivorous fish found in the deeper reef indicated the waters on Natuna Island were still excellent with a level of visibility which could help reef growth becomes more intense and the growth of algae as the main food of herbivorous fish could reach the deeper reef, thus herbivore fish would be more diverse.

Corresponding Analysis on RS13 (Figure 5) site on Kelarik area in the west Natuna showed significant differences in herbivore fish abundance comparing to other observation sites and only found 2 ind 350 m^{-2} of *S. ghobban* SC13. The abundance of herbivorous fish on this site was very low, due to the fact that there was rubble almost all over the reef, because in these areas the practice of catching fish by blast fishing was operated. Destructive fishing with explosives is an illegal practice to stun or kill groups of fish that are easily collected and is a threat that can directly destroy coral reefs (Fox & Caldwell 2006).

The direct destructive effect on fish, especially on herbivore fishes that inhabit a reef is because this impact not only affect (kill) the preferred size and species, but commercially unattractive organism, species and size classes (juvenile) fall victim to the explosion as well (Soede et al 2000). In addition, there are several areas in the western Natuna at site RS1 and RS16 at West Natuna where was found that local communities apply toxic potassium cyanide and sodium cyanide. These toxins can reduce the productivity of herbivore fish and threatens the availability of herbivorous fish species in the future. Many adverse effects on herbivore fish eggs, fry and adult fish was reported such as reduced growth, impaired swimming performance, increased metabolism, inhibition of reproduction due to alteration of lipid metabolism (Rubec 1986), damage of reproductive organs (Ruby et al 1979), reduction of hatching success and survival of fish (Cheng & Ruby 1981). Multiple observation sites located in West Natuna showed that these waters have visible turbidity caused by the influence of a high suspended sedimentation in the reef and its impact on coral reefs ecosystem is evident. The suspended sedimentation load has effect on light blockage. When the light intensity falls below some limiting value, many reef building organism die after a period of time (Roy & Smith 1971).

The highest biomass of herbivorous fish (Scaridae, Siganidae and Acanthuridae) on Natuna Island generally was dominated by Scaridae, site RS15 (997,817.83 g ha^{-1}) in Penagi. The highest biomass of Siganidae was in site RS2 (171,834.89 g ha^{-1}) in Tiga Island whereas the highest Acanthuridae biomass was found on site RS2 (119,144.42 g ha^{-1}) in Tiga Island (Figure 7).

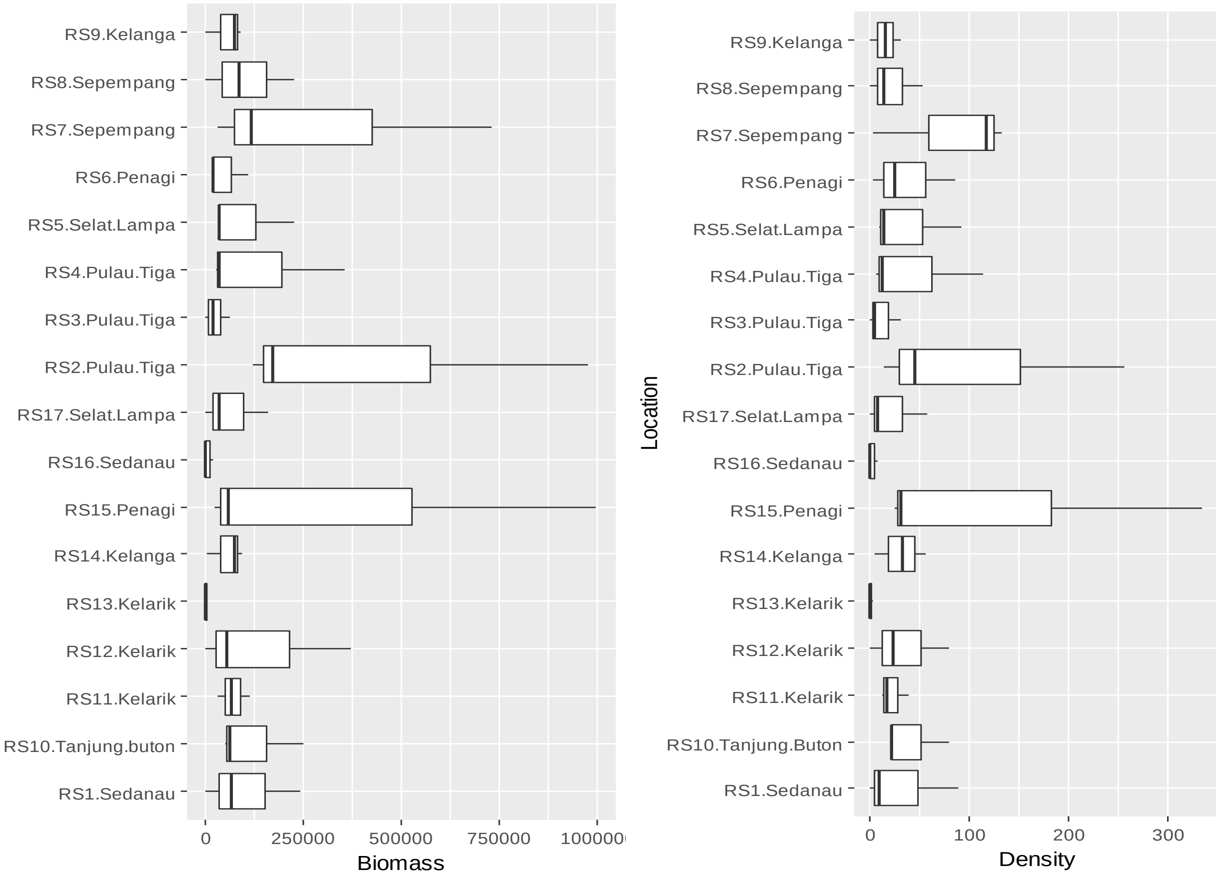

Figure 7. Boxplot density and biomass of herbivore fish (Scaridae, Siganidae and Acanthuridae) for each site monitored.

The most interesting incidence of the parrotfish fish on Natuna Island was of the type of grazers divided into two groups: excavators and scrapers. The excavator group has a strong jaw that can dig the substrate and leave a bite mark on the substrate, while the scraper does not have strong jaws and do not leave bite marks on the substrate. The group consisted of excavators were from Chlorurus, Bolbometopon, Cetoscarus, and *Sparisoma viride*, while the scraper consisted of Scarus and Hipposcarus (Bellwood 1994). The most parrotfish found on Natuna Island as scraper belonged to the Scarus genera. Scrapers of Scarus have important effect in marine bio erosion and has ecological value as grazers on dead corals alga, because arecapable of controlling the growth of algal which competing the living coral.

The values of ecological indices (Figure 8) shown that Shannon diversity indices of Scaridae, Siganidae, and Acanthuridae were 2.92, 2.58, and 2.27, respectively. Evenness indices of Scaridae, Siganidae, and Acanthuridae were 0.8732, 0.8707, and 0.8589, respectively.

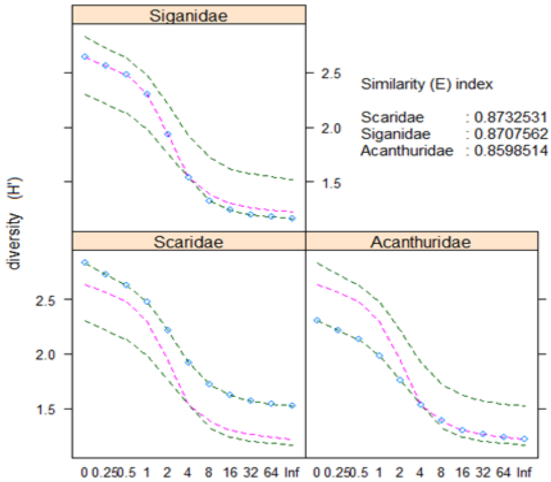

Figure 8. Boxplot density and biomass of herbivore fish (Scaridae, Siganidae and Acanthuridae) for each site observed.

Conclusions. Free-ranging herbivores fish of interest in the present study were individuals from the Acanthuridae (Surgeonfish), Scaridae (parrotfishes), and Siganidae (Rabbitfishes) family with 41 species, Scaridae (25 Species), Siganidae (10 Species) and Acanthuridae (6 species). Penagi (RS15) in eastern Natuna was the location with the highest herbivorous fish abundance and biomass. The environmental conditions in Natuna Island have revealed good conditions with the lowest ecological stresses, although in several sites (at the western Natuna) destructive fishing practices were observed.

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