

# Responses of Herbivorous Fishes on Coral Reef Cover in Outer Island Indonesia (Study Case: Natuna Island)

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**Abstract.** Coral reefs are one of the most highly productive marine ecosystems, with the largest transfer of energy attributed to the trophic interaction between herbivores and algae. Rapid demographic growth, leading to transmigration to small islands such as Natuna Island where located on outer Island Indonesia. The aim of the present study is to test for significant associations between herbivore fish species traits and Habitat complexity was derived from coral reef cover. Method to record each observed herbivore fish species with UVC (Underwater Visual Census) using SCUBA diving equipment along modification line transects. A total of 39 different fish species belonging to 3 families' herbivore fish were identified. Total biomass of herbivorous fish correlated with Dead Coral Algae (DCA). Biplot of the first two axes for the nonmetric multidimensional a scaling (NMDS) analysis for family and grazer showed the dominance of herbivore fish grazer.

## 1 Introduction

Coral reefs are one of the richest and diverse and ecologically important marine ecosystems [1,2,3,4] and their feature has extraordinary biodiversity and a complex structure of interconnections between organisms and their environment [5,6] Among reef habitats, the richest and diverse coral reef ecosystem is found in the tropics in Indo-West Pacific region with the highest level of biodiversity particular around the islands of the Indonesia, Philippines, and Papua New Guinea [7,8,9] Unfortunately, the richest and

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diverse this marine ecosystem, coral reef are also among the most threatened ecosystem [10] with uncertain future [6]. The degradation of coral reef habitats of marine ecosystem has become a worldwide trend [1,11,12,13], many coral reefs have lost their typical community [14] and increasingly degraded due to anthropogenic threats and stressors on global scale [15,16,17].

A root cause of coral reef degradation due to anthropogenic threat is demographic growth worldwide [10]. Demographic growth cause increasing rapid growth in coastal areas. coastal areas become the main consideration in the placement of residence status from demographic worldwide due to the natural highly diverse coral reef ecosystem service such as coastal protection, food for coastal communities and income from tourism [18], and this consideration becomes worse without any strict regulation of the sustainability of coral reef ecosystems that through disturbance to coastal zones associated with coral environments [10].

The degradation coral reef ecosystem due to rapid demographic growth also occurs in Indonesia and the worse effect occurs in Small Island. Rapid demographic growth, leading to transmigration to small islands such as Natuna Island where located on outer Island Indonesia. Monitoring and controlling outer island area is limited, this condition can cause increasing threatening and degrade on the coral reef ecosystem. Threats to Indonesia's coral reef resources can be divided into two main types: acute threats; and chronic stresses [19] and most numerous incident threatening in coral reef ecosystem in outer island was acute threats by destructive fishing including the use of bombs, cyanide poison [20], coral mining and sand mining [21]. Acute threats from destructive fishing practice and sand mining cause dramatic damage and declining water clarity and quality have been associated with increased presence of macro alga growth [2,8] and in the long term, this effect will also cause phase shift on coral reef ecosystem. Shifts are characterized by the passage from a stage of coral dominance to alternative stages of coral depletion and increased cover of algae [16]. Increasing in algae cover is harmful coral growth because the relationship between non-endosymbiotic algae and corals is reciprocally negative [16] There are several varieties of increasing the shift from live coral to algal dominance as a major concern in assessments of outer island coral reef health; overfishing, pollution and coastal community that give impact pollution and nutrient enrichment [10] and all these varieties are suspected In small Islands Indonesia such as Natuna Island.

Evidence over the last 40 years has revealed a widespread loss of coral cover in tropical coastal waters of the Indo-West Pacific. In some areas, entire coral reefs have resulted in significant modification of the structure and functioning of an exploited ecosystem [22,23]. Coral reef has been overgrown and killed by fast-growing species of macro algae [24] and algal cover jumped from being slightly higher than corals [14], this condition linear correlation with destructive fishing practice and overfishing can cause degrade herbivore fish abundance very fast [25] and resulting in decrease in total biomass [26,17]. Abundance and biomass each functional species of the herbivorous reef fish group was also used as an indicator of the potential for coral reef recovery [20]. Herbivorous fish play a critical role and critical functional groups (CFGs) for maintaining coral reefs in the recovery of coral assemblages by limiting and control growth of algae communities [15] that are competing with reef-building corals such as for space and light [16,27,28,29]. Generally, coral reefs are a good example of understanding how herbivores control algae biomass and growth [15] which prevents algae from taking over [5].

Many studies in tropical areas such as in Indonesia water show how grazers from herbivore fish play the main role limiting and controlling the abundance of epilithic algal (EA) [4,30] and how overfishing can lead to trophic cascade effects driving ecosystem shifts [31]. The EA is one of the most nutritious food resources on coral reefs with high productivity rates that support a diverse and abundant assemblage of herbivore fish grazers

[32]. All goods and services that coral reef ecosystems provide rely on the status of their herbivore fish habitats [15] and spatial feeding patterns, herbivore fish can move between reefs and are less likely to feed at the same place [14].

Based on their foraging behavior, herbivorous reef fish can be differentiated into four main groups; which are scrapers/small excavators, large excavators/borders, grazers/detritivores, and browsers. Each category plays different and complementary roles in coral resilience in terms of how they feed benthic algae, what algae they consume, and their impact on the underlying substratum (i.e. hard corals). Moreover, the availability of stable substrates such as rock, dead coral, and coralline algae also plays an important role in providing a surface for coral planula to settle and grow [27,33]. Algae are involved in the bio-construction of coral reefs and can, therefore, be considered as bio-indicator of health for coral reefs as with hard corals [10]. In this research, we use dead coral with algae (DCA) cover as an indicator of coral reef health depending herbivore fish biomass as an indicator as well as biodiversity in outer island regional scale. The aim of the present study is to test for significant associations between herbivore fish species traits and Habitat complexity was derived from coral reef cover.

## 2 Methodology

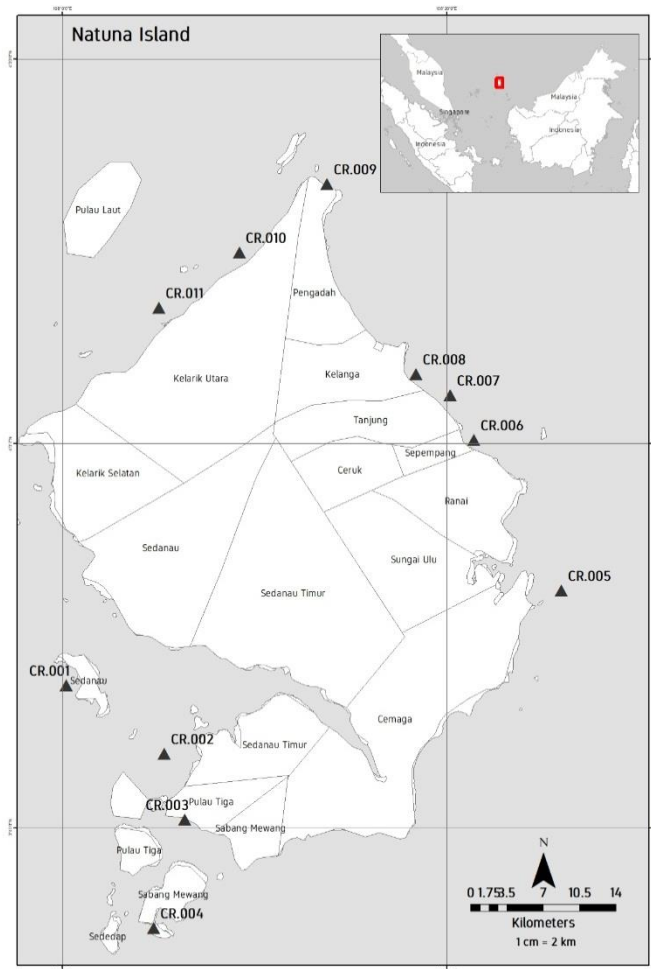
### 2.1. Study area

Sampling for the present study occurred from Augustus - September 2016 distributed on reef location of the north (N) to the southwest (SW) located in one of outer island Indonesia, Natuna Island (3°56'31.74" N, 108°12'27.18" E). A total of eleven survey sites reef were studied in 2016. In general, there are five sites in South Natuna (SW: 4 sites, SE: 1 site) and six sites in North Natuna (NE: 3 sites, N: 1 site, NW: 2 sites).

**Tabel 1.** Location and direction of the study sites.

Site ID	Longitude	Latitude	Location	Direction from central Natuna Island
CR.001	108°0'11.52" E	3°47'23.28" N	Sedanau Island	Southwest (SW)
CR.002	108°5'18.24" E	3°43'49.08" N	Sedanau.Timur	Southwest (SW)
CR.003	108°6'22.68" E	3°40'22.48" N	Pulau Tiga	Southwest (SW)
CR.004	108°4'45.84" E	3°34'43.68" N	Sabang Mawang	Southwest (SW)
CR.005	108°25'59.52" E	3°52'18.48" N	Cemaga	Southeast (SE)
CR.006	108°21'25.85" E	4°0'10.08" N	Sepempang	Northeast (NE)
CR.007	108°20'12.12" E	4°2'28.68" N	Tanjung	Northeast (NE)
CR.008	108°18'25.38" E	4°3'35.54" N	Kelanga	Northeast (NE)
CR.009	108°13'47.28" E	4°13'28.92" N	Pengadah	North (N)
CR.010	108°9'13.68" E	4°9'55.44" N	Kelarik Utara	Northwest (NW)

		N		
CR.011	108°5'02.04" E	4°7'03.00" N	Kelarik	Northwest (NW)



**Fig. 1.** Map of the study area and sampling sites.

## 2.2. Characterization of habitat complexity

Habitat complexity was derived from benthic cover based on the following substrate: hard coral (HC), dead coral (DC) and dead coral with algae (DCA). A principal focus of percent cover from 3 standard benthic categories HC, DC and DCA of its functional roles as a key builder of reef structure and a key provider of complex, rigid habitat for much another reef biodiversity especially for herbivore fish diversity [25,34]. Cover by substrate type was evaluated from 11 sites underwater photographic transects (UPT) [35,36,37] of 50 m length. The digital photograph was taken parallel on quadrat transect modification by [38] with dimension 58 x 44 cm at a height of 1.20 m, with approximately 1 m of distance between each photo. The UPT using Nikon D90 underwater digital camera mounted, for a total of 50 photos per site and 550 total photos for this study. The analysis of each photo

was carried out using the software CPCe 4.1 (Coral Point Count with excel extension) [39] to estimate the percent cover of dominant benthic categories at each reef sites (live coral, dead coral with algae, and recently dead coral) [37].

### 2.3. Reef fish community structure

To record fish species diversity, abundance, and their size length to estimate biomass, performed diurnal. Diurnal increase in temperature, as a result of heating, and dissolved oxygen, as a result of photosynthesis on the reef, seem most likely amongst environmental variables in diurnal condition correlate with the feeding activity patterns and herbivore fish abundance [39]. Method to record each observed herbivore fish species with UVC (Underwater Visual Census) using SCUBA diving equipment along modification line transects based on [41,42,43] with 70 m long at 5 – 10 m depth. The observer within 5 m on either side of transect was identified herbivore fishes. The UVC method is a nondestructive, capture-independent method, superior to collection techniques diversity and abundance of reef fishes although underwater visual censuses require little post-processing, whereas collections take many hours to complete [44]. This study was used three families herbivore fish that are most easily and rapidly identifiable by underwater visual census methods (Siganidae, Scaridae, and Acanthuridae) [10,45,41]. Herbivore fish species were characterized based on their diet information and feeding behavior, obtain from extensive published data [27] This study focuses on four functional groups of herbivorous reef fishes that each play different and complementary roles in coral reef resilience: scrapers/small excavators, large excavators/bio-erodes, grazers/detritivores, and browsers. For the herbivore fish community: diversity (number of species), abundance (number of individuals) and biomass per transect, was calculated using the length-weight relationship by [10,20].

$$W = a LT^b \tag{1}$$

Where  $W$  is the weight (g),  $LT$  the fork length of herbivore fish (cm) and  $a$  and  $b$  are coefficients specific to each species from FishBase data [27]. The total biomass for each station corresponds to the total weight of all fish per unit area ( $g/m^2$ )

### 2.4. Statistical Analysis

#### 2.4.1. Herbivore fish Indices

In the present study, the data herbivore fish were analyzed followed by [46] using Shannon-Wiener Index ( $H'$ ), Margalef richness index ( $d$ ), Pielou's evenness ( $J'$ ) index and Simpson's dominance index ( $D$ ).

#### 2.4.2. Cluster analysis

Cluster analysis was used to discriminate between herbivore fish species and the similarity between sites. The zero adjusted Bray-Curtis Dissimilarity index was chosen for the analysis, as it the most appropriate distance matrix for non-binary ecology abundance data [47]. The transformed abundance matrix was then converted to a Bray-Curtis coefficient similarity matrix and a resultant dendrogram was generated with of similar quadrat groupings was based on sites dominant location (North Natuna and South Natuna) location and used to characterize zones that were predicted (a priori) to correlate with herbivores fish abundance. Bray-Curtis coefficient of similarity analysis which is more

robust than techniques using maximum or minimum distances between sites. Cluster dendrogram provides two types of  $p$ -value: AU (Approximately Unbiased) and BP (Bootstrap Probability) for assessing the uncertainty in hierarchical cluster analysis for location habitat.

### **2.4.3. Meta Data Analysis.**

Meta-analysis show effect sizes and confidence intervals from herbivore fish species community, as well as grazer type overall, mean effects and confidence intervals from its abundant. Forest plots from this studies used the meta-analytic equivalent of error bar or confidence interval plots, and are useful for showing mean effect size and variation among herbivore fish from grazer type [48]. Meta-analysis forest plots are drawn with the dependent qualitative from abundant herbivore fish species (Y) axis horizontal, while the vertical axis is no quantitative from herbivore fish grazer (Excavator, Grazer, and Scraper) [49].

### **2.4.4 Nonmetric multidimensional scaling (nMDS) Analysis**

Visuals spatial and temporal patterns in the herbivore fish family community (Acanthuriade, Siganidae, and Scaridae) and grazer type (Excavator, Grazer, and Scraper) datasheet were used Non-metric multidimensional scaling (nMDS) solutions [50]. nMDS was performed for each site separately, as well as on spatially and temporally averaged datasets in herbivore fish communities and grazer types. Both herbivore fish and grazer type datasets were converted to relative diversity (i.e. row standardized) prior to analyses. Two dimensions were chosen in the nMDS and in all ordinations, stress values were less than 0.5. To identify herbivore family that was principally responsible for determining the grazer type dissimilarities. Herbivore fish family scores were calculated as weighted averages of the grazer scores. The weighted averages were 'expanded' so that their biased weighted variance was equal to the biased weighted variance of the corresponding grazer type [50].

### **2.4.4 Corresponding Analysis (CA)**

Corresponding analysis has been applied to indicate the main herbivore fish family variable (total biomass and density) factor in coral reef habitat benthic (Hard Coral, Dead Coral, Dead Coral Algae) of the study area considering the variable load size and the relationship between variable and the sampling point partition based on modification from [51]. Corresponding analysis is a robust multivariate statistical method of study of relationships between variables and relationship between. This analysis is a method to analyze many complicated variables, on this studies herbivore fish abundance in every family based on grazer type and coral reef habitat benthic. This variable can be compressed into two principal component variables. Subsequently, the relationships between herbivore fish abundance and coral reef habitat benthic can be easily analyzed and explained [51,52].

### **2.4.6 Regression Analysis (RA)**

Linear regression was used to investigate the effect on the relation between herbivore fish total biomass on sampling sites and coral reef benthic habitat after analyzed from the corresponding analysis (CA). Regression analysis has a function to determine the effect of

herbivore fish on total biomass recorded at each site and the main component type of coral reef habitat benthic [53].

### 3 Result and Discussion

We found 21 species from Scaridae family, 6 species from Acanthuridae, and 9 species from Siganidae family on 11 sites in Natuna Island. Daisy parrotfish (*Chlorurus sordidus*) from Scaridae had the highest mean density in the Natuna Island coral reef ecosystem ( $17.45 \pm 8.93$ ). Other species with significantly higher density including Java Parrotfish (*Scarus hypselopterus*) and Barrhead Spinefoot (*Siganus virgatus*) have significant mean density difference ( $12.27 \pm 7.20$ ) and ( $11.78 \pm 7.12$ ) respectively. The highest biomass herbivore fish in Natuna Island are Daisy parrotfish (*Chlorurus sordidus*) (with highest mean density) ( $2.159 \pm 1.535$ ). Orange-blotch Parrotfish (*Chlorurus bowersi*) have different IUCN status in coral reef ecosystem habitat with category NT (Near Threatened), another herbivore fish species categorized as LC (Least-Concerned). The lowest biomass herbivore fish in Natuna Island are Steephead Parrotfish (*Chlorurus microrhinos*) and Scribbled Rabbitfish (*Siganus spinus*) with biomass ( $0.002 \pm 0.007$ ) and ( $0.003 \pm 0.008$ ) respectively.

**Table 2.** List of herbivore fish recorded associated coral reef with density and biomass from Natuna Island

Family	Species	Grazer type	Common Name	IUCN Status	Mean Density (Ind/area*)	Biomass (kg/area*)
Scaridae	<i>Cetoscarus bicolor</i> (Ruppel, 1829)	Excavator	Bicolour parrotfish	LC	2.67 ± 0.58	0.065 ± 0.116
	<i>Chlorurus capistratoides</i> (Bleeker, 1847)	Scaper/small excavator	Pink-margined parrotfish	LC	2.67 ± 2.08	0.089 ± 0.154
	<i>Chlorurus spilurus</i> (Valenciennes, 1840)	Scaper/small excavator	Bullethead Parrotfish	LC	2.20 ± 1.30	0.189 ± 0.309
	<i>Chlororus bleekeri</i> (de Beaufort, 1940)	Scaper/small excavator	Bleeker's Parrotfish	LC	7.20 ± 5.12	1.003 ± 0.889
	<i>Chlororus bowersi</i> (Snyder, 1909)	Scaper/small excavator	Orange-blotch Parrotfish	NT	3.00 ± 2.88	0.130 ± 0.159
	<i>Chlororus sordidus</i> (Forsskål, 1775)	Scaper/small excavator	Daisy Parrotfish	LC	17.45 ± 8.93	2.159 ± 1.535
	<i>Chlororus michrohinos</i> (Bleeker, 1854)	Excavator	Steephead Parrotfish	LC	2.67 ± 0.58	0.002 ± 0.007
	<i>Scarus schlegeli</i> (Bleeker, 1861)	Scaper/small excavator	Yellowband parrotfish	LC	1.75 ± 0.96	0.107 ± 0.208
	<i>Scarus dimidiatus</i> (Bleeker, 1859)	Scaper/small excavator	Yellowbarred Parrotfish	LC	2.55 ± 3.08	0.118 ± 0.148
	<i>Scarus forsteni</i> (Bleeker, 1861)	Scaper/small excavator	Big belly Parrotfish	LC	2.00 ± 0.00	0.055 ± 0.127
	<i>Scarus frenatus</i> (Lacepède, 1802)	Scaper/small excavator	Bridled Parrotfish	LC	1.75 ± 0.96	0.230 ± 0.416
	<i>Scarus ghobban</i> (Forsskål, 1775)	Scaper/small excavator	Blue-barred parrotfish	LC	3.17 ± 1.17	0.501 ± 0.722
	<i>Scarus globiceps</i> (Valenciennes, 1840)	Scaper/small excavator	Globehead parrotfish	LC	9.50 ± 10.61	0.088 ± 0.261
	<i>Scarus hypselopterus</i> (Bleeker, 1853)	Scaper/small excavator	Java Parrotfish	LC	12.27 ± 7.20	0.370 ± 0.248
	<i>Scarus niger</i> (Forsskål, 1775)	Scaper/small excavator	Dusky Parrotfish	LC	8.71 ± 4.50	0.650 ± 0.905
	<i>Scarus oviceps</i> (Valenciennes, 1840)	Scaper/small excavator	Dark Capped Parrotfish	LC	4.80 ± 3.63	0.225 ± 0.381
	<i>Scarus xanthopleura</i> (Bleeker, 1853)	Scaper/small excavator	Red Parrotfish	LC	0.09 ± 0.30	0.012 ± 0.038
	<i>Scarus prasiognatus</i> (Valenciennes, 1840)	Scaper/small excavator	Blue-faced Parrotfish	LC	2.50 ± 2.12	0.041 ± 0.092
	<i>Scarus quoyi</i> (Valenciennes, 1840)	Scaper/small excavator	Green-blotched Parrotfish	LC	6.88 ± 3.72	0.459 ± 0.497



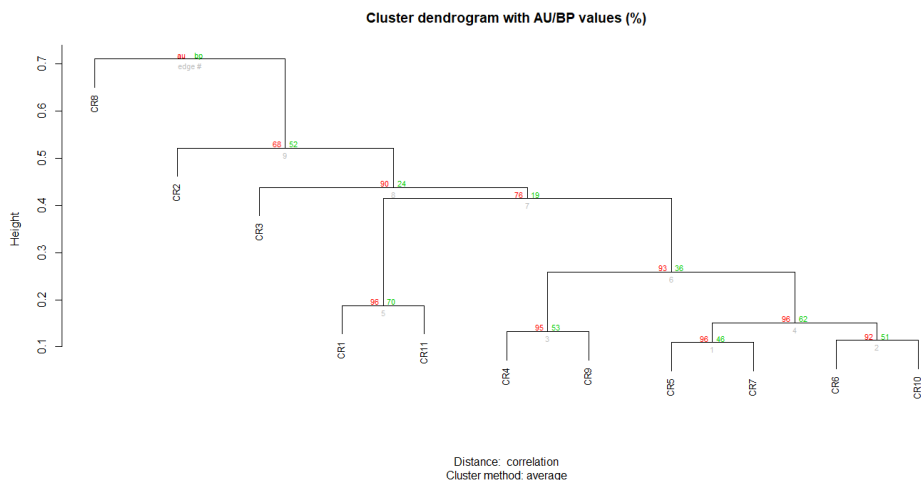
	<i>Scarus rivulatus</i> (Valenciennes, 1840)	Scaper/small excavator	Surf Parrotfish	LC	9.38 ± 5.26	0.515 ± 0.509
	<i>Scarus spinus</i> (Kner, 1868)	Scaper/small excavator	Greensnout Parrotfish	LC	2.80 ± 2.05	0.025 ± 0.046
Acanthuridae	<i>Acanthurus lineatus</i> (Linnaeus, 1758)	Grazer/Detritivore	Lined Surgeonfish	LC	3.67 ± 1.53	0.027 ± 0.055
	<i>Achanturus triostegus</i> (Linnaeus, 1758)	Grazer/Detritivore	Convict Surgeonfish	LC	2.00 ± 1.41	0.029 ± 0.095
	<i>Achanturus nigrofuscus</i> (Forsskål, 1775)	Grazer/Detritivore	Blackspot Surgeonfish	LC	7.00 ± 1.73	0.152 ± 0.360
	<i>Ctenochaetus striatus</i> (Quoy & Gaimard, 1825)	Grazer/Detritivore	Striped Bristletooth	LC	2.50 ± 0.71	0.116 ± 0.386
	<i>Naso lituratus</i> (Forster, 1801)	Browsers	Orange Spine Surgeonfish	LC	4.00 ± 2.00	0.190 ± 0.379
	<i>Zebbrasoma scopus</i> (Cuvier, 1829)	Grazer/Detritivore	Brushtail Tang	LC	1.00 ± 0.00	0.046 ± 0.154
Siganidae	<i>Siganus corallinus</i> (Valenciennes, 1835)	Grazer/Detritivore	Blue-spotted Spinefoot	LC	3.67 ± 3.27	0.326 ± 0.513
	<i>Siganus argenteus</i> (Quoy & Gaimard, 1825)	Grazer/Detritivore	Forktail Rabbitfish	LC	1.50 ± 0.71	0.105 ± 0.249
	<i>Siganus doliatus</i> (Guérin-Méneville, 1829)	Grazer/Detritivore	Barred Spinefoot	LC	1.00 ± 0.00	0.027 ± 0.089
	<i>Siganus guttatus</i> (Bloch, 1787)	Grazer/Detritivore	Golden Rabbitfish	LC	3.50 ± 0.71	0.083 ± 0.185
	<i>Siganus punctassiumus</i> (Fowler & Bean, 1929)	Grazer/Detritivore	Fine-spotted Rabbitfish	LC	1.50 ± 0.71	0.045 ± 0.149
	<i>Siganus puellus</i> (Schlegel, 1852)	Grazer/Detritivore	Masked Rabbitfish	LC	1.50 ± 0.58	0.154 ± 0.418
	<i>Siganus spinus</i> (Linnaeus, 1758)	Grazer/Detritivore	Scribbled Rabbitfish	LC	1.50 ± 0.71	0.003 ± 0.008
	<i>Siganus virgatus</i> (Valenciennes, 1835)	Grazer/Detritivore	Barhead spinefoot	LC	11.78 ± 7.12	0.812 ± 0.735
	<i>Siganus vulpinus</i> (Schlegel & Müller, 1845)	Grazer/Detritivore	Foxface Rabbitfish	LC	4.71 ± 2.87	0.278 ± 0.292

Note: \*Area of study is 350m<sup>2</sup> from UVC method with 70 m long line transect within 5 m on either side of the transect. Mean density and Biomass from 11 (eleven) survey sites reef. IUCN status from <http://www.iucnredlist.org> based on Red List Category & Criteria: (LC-Least Concern, NT-Near Threatened). Grazer type of herbivore fish (Scaridae, Siganidae, and Acanthuridae) from data (Green and Bellwood 2009; Froese and Pauly, 2012). Format the table modification based on (Jayaprabha, Purusothaman, and Srinivasan 2018)

**Table 3.** Sites variation of diversity indices calculated for herbivore fish in Natuna Island (2016)

Sites	Herbivore fish indices				Diversity (n/350m <sup>2</sup> )	Abundance (Ind/350m <sup>2</sup> )	m ± Sd
	<i>H'</i>	<i>J'</i>	<i>D</i>	<i>d'</i>			
CR1	2.499	0.882	0.093	7.916	17	105	2.838 ± 4.776
CR2	2.380	0.840	0.112	7.557	17	131	3.541 ± 6.619
CR3	2.486	0.877	0.106	7.793	17	113	3.054 ± 5.553
CR4	1.971	0.856	0.148	4.392	10	112	3.027 ± 6.685
CR5	1.916	0.872	0.162	4.413	9	65	1.757 ± 4.159
CR6	2.118	0.920	0.117	5.444	10	45	1.216 ± 2.485
CR7	2.525	0.891	0.092	7.682	17	121	3.270 ± 5.440
CR8	2.711	0.938	0.062	9.343	18	66	1.784 ± 2.440
CR9	2.432	0.858	0.113	7.966	17	102	2.757 ± 5.236
CR10	1.987	0.828	0.164	5.092	11	92	2.486 ± 5.867
CR11	2.523	0.910	0.080	8.305	16	64	1.730 ± 2.765

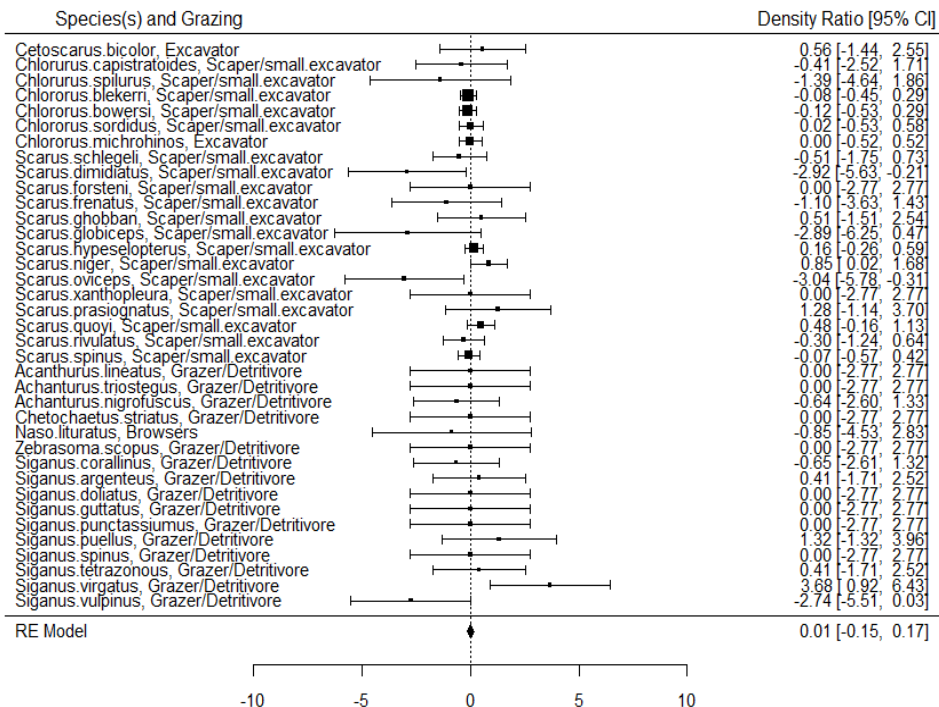
Note: *H'* – Shannon Wiener index; *J'* – Evenness; *D* – Simpson’s dominance index; *d'* – Margalef index



**Fig 2.** Dendrogram showing similarity in herbivore fish composition of coral reef sites recorded in AU/BP

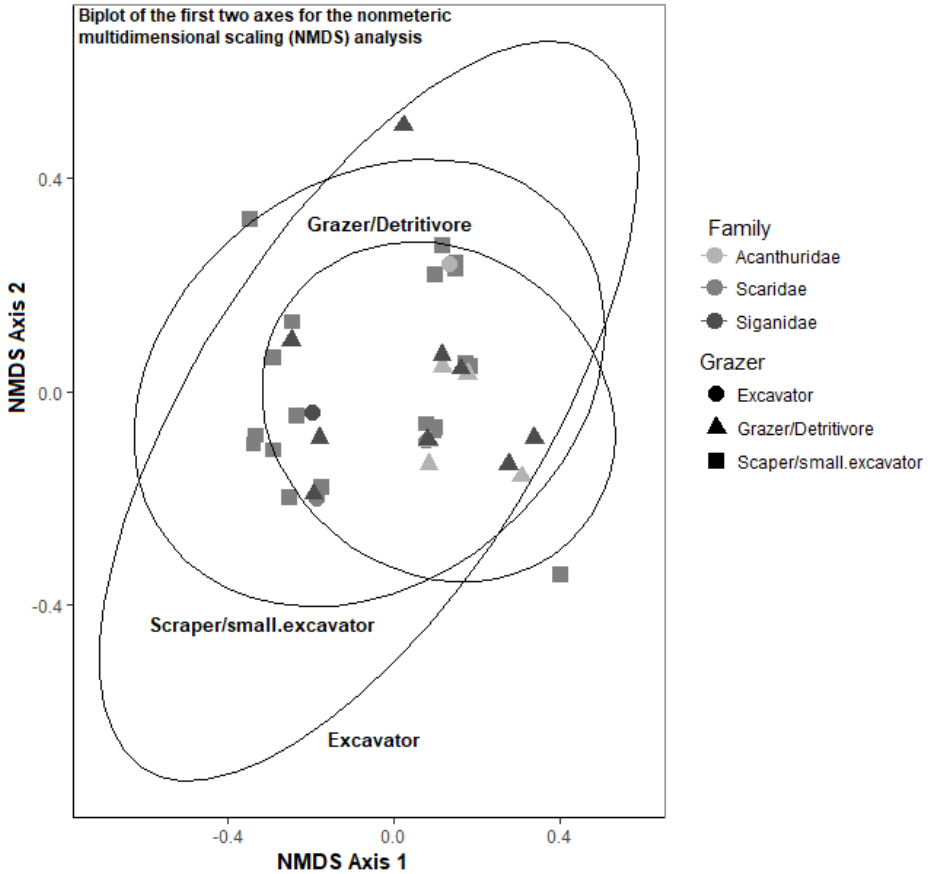
Dendrogram analysis indicated that the herbivore fish species mainly responsible for the dissimilarity in abundance between the sampling sites (Fig. 2). Fishing has major effects both directly and indirectly on the environment, diversity, and productivity of communities. The average similarity of dendrogram in clustering sites sample showed three group clustering similarity (group 1, CR6-CR10; CR5-CR7, group 2, CR4-CR9, group 3 CR1-CR11). Similarity on herbivore fish abundance and diversity each site with Approximately Unbiased and Bootstrap Probability (AU/BP) to group 1 showed CR6-CR10 and CR5-CR7 have AU/BP (92/51) % and (96/46) % respectively. Group 2 similarity on clustering

sampling CR5-CR7 showed AU/BP value (95/53) % and group 3 to CR1-CR11 with AU/BP value (96/70) %



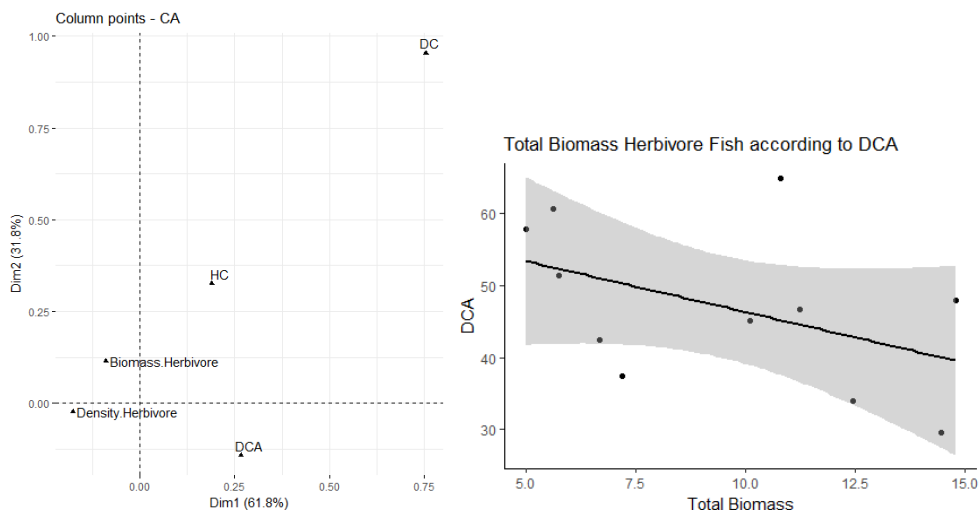
**Fig. 3.** Forest plots used the meta-analytic equivalent of density herbivore fishes based on the type of grazing on a coral reef in 11 sites

Thirty-nine herbivore evaluations were included (11 coral reef sites and 3 grazer types). Overall from meta-data analysis there was no statistically significant grazer type's bias for included herbivore evaluations (Fig.3). Only two species from Siganidae Family - *Siganus virgatus* (mean = 3.68, 95% CI [0.92, 6.43]) and Scaridae family – *Scarus niger* (mean = 0.85, 95% CI [0.02, 1.68]) reported differences in two species fish population for herbivore fish grazer type that were *Siganus vulpinus* (mean = -2.74, 95% CI [-5.51, 0.03]) and *Scarus oviceps* (mean = -3.04, 95% CI [-5.78, -0.31]). The grand mean (Fig 1.), mean = 0.01, 95% CI [-0.15,0.17] and mean effect size for herbivore fish grazer. *Chlorurus blekeri*, *Chlorurus bowersi*, *Scarus hypselopterus* have higher abundant from herbivore fish population in 11 sites with meta-analysis evaluation (mean = -0.08, 95% CI [-0.45, -0.29]), (mean = -0.12, 95% CI [-0.53, -0.29]), and (mean = -0.16, 95% CI [-0.26, -0.59]) respectively



**Fig. 4.** Biplot of the first two axes for the nonmetric multidimensional a scaling (NMDS) analysis for Herbivore fish grazer

nMDS ordination of herbivore fish community showed there is no clear separation of grazer types. Ellipse representing the standard deviation of grazer types from herbivore fish family. There was significant overlap in every grazer type. This overlap deviation showed similarity component of variance due to sites location and habitat between herbivore fish communities could be attributed to the similarity of paired grazer types. nMDS ordination of herbivore fish community and grazer types revealed a gradient in the structure of these herbivore fish on coral ecosystem across his habitat consume alga on a coral reef (Fig. 4). Generally, Grazer/Detrivore was more similar to Scaper/small excavator types of herbivore fish abundance on coral reef habitat. However, some herbivore fish family within a particular grazer type were just as dissimilar to each other as they were to reefs site in another coral reef ecosystem habitat type such *Excavator*. These herbivore family similar related to grazer type so that herbivore fish diversity within each coral reef site sampling were generally more similar to each other grazer type although one species form Scaridae Family *Chlorurus micrhohinos* has different grazer type. This pattern was consistent for ordinations of herbivore fish its grazer type.



<b>Residuals:</b>				
Min	1Q	Median	3Q	Max
-12.8421	-8.7734	-0.8998	6.3413	19.7209
<b>Coefficients:</b>				
	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	60.4902	9.2323	6.552	0.000105 ***
Total.biomass	-1.413	0.9168	-1.541	0.157637

Residual standard error: 10.43 on 9 degrees of freedom  
 Multiple R-squared: 0.2088, Adjusted R-squared: 0.1209  
 F-statistic: 2.376 on 1 and 9 DF, p-value: 0.1576

**Fig. 5.** Corresponding Analysis Herbivore Fish variable data (Biomass and Density) according to Coral Benthic Substrate type (Hard Coral, Dead Coral and Dead Coral with Algae), Regression analysis (RA) Total biomass herbivore fish according to Dead Coral Algae (DCA)

Corresponding Analysis herbivore fish variable data (Total biomass and density) according to the coral benthic substrate (DCA, DC, and HC) showed establishes repeatable relationships between Dead Coral Algae (DCA) and Biomass herbivore (Fig 5.a) as well as between density herbivore fish and DC. This both relationships showed opposite correlation. Dead Coral Algae on coral reef benthic decrease with increasing total biomass on herbivore fish family (Fig 5b). From regression analysis showed multiple R-squared from this analysis 0.2088 with Adjusted R-squared 0.1209.

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