BIODIVERSITAS
Volume 23, Number 10, October 2022
Pages: 5184-5193

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d231026

Diversity of reef fish species in presence of mangrove habitat in Ternate, North Maluku, Indonesia

RIZKIE SATRIYA UTAMA[1,♥], JEVERSON RENYAAN[1], DONI NURDIANSAH[1], PETRUS CHRISTIANUS MAKATIPU[1], SUYADI[2], BETALINI WIDHI HAPSARI[3], EKA MARTHA DELLA RAHAYU[4], ARWAN SUGIHARTO[5], NEBUCHADNEZZAR AKBAR[6]

[1]Research Center for Oceanography, National Research and Innovation Agency. Jl. Pasir Putih I, East Ancol, North Jakarta 14430, Jakarta, Indonesia. Tel.: +62-21-64713850, Fax.: +62-21-64711948, ♥email: rizkie.s.u.biogama@gmail.com

[2]Research Center for Ecology and Etnobotany, National Research and Innovation Agency. Jl. Raya Jakarta-Bogor Km 46, Cibinong, Bogor 16911, West Java, Indonesia

[3]Research Center for Genetically Modified, National Research and Innovation Agency. Jl. Raya Jakarta-Bogor Km 46, Cibinong, Bogor 16911, West Java, Indonesia

[4]Research Center for Plant Conservation, Botanical Gardens and Forestry, National Research and Innovation Agency. Jl. Ir. H. Juanda No. 13, Bogor 16911, West Java, Indonesia

[5]Research Center for Applied Microbiology, National Research and Innovation Agency. Jl. Raya Jakarta-Bogor Km 46, Cibinong, Bogor 16911, West Java, Indonesia

[6]Faculty Fisheries and Marine Sciences, Universitas Khairun. JI. Abdurrahman Yusuf, Ternate 97719, North Maluku, Indonesia

Manuscript received: 29 June 2022. Revision accepted: 7 October 2022.

Abstract. *Utama RS, Renyaan J, Nurdiansah D, Makatipu PC, Suyadi, Hapsari BW, Martha E, Rahayu EMD, Sugiharto A. Akbar N. 2022. Diversity of reef fish species in presence of mangrove habitat in Ternate, North Maluku, Indonesia. Biodiversitas 23: 5184-5193.* Research on reef fish has been widely reported, where information about reef fish communities is an important factor for evaluating fisheries management and coral reef management. Mangroves as the nursery, foraging, and growing areas were also important to assure sustainable reef fish fisheries. This paper studies reef fish abundance and diversity in Ternate Waters in the presence of mangrove in coral reef habitats. To determines coral reef condition underwater photo transect was performed while an underwater visual census (UVC) was used to determine the abundance and diversity of reef fishes in Ternate waters between 2017 and 2018. A total of 14 stations were used, with eight stations near the mangroves and six stations that did not contain mangroves. Based on the observation, fish species richness in mangrove absence was higher than in the presence of mangroves, with 68 and 65 species in 2017 and 66 and 62 species in 2018. However, the abundance of reef fish was recorded high in the presence of mangroves than in the absence of mangroves, with 390 and 289 individual differences in 2017 and 2018. Mangroves' complexity affected part of reef fish communities in Ternate water, particularly Lutjanidae, Serranidae, and Scaridae, which might influence the abundance of reef fishes rather than the species richness. In addition, carnivore shows a negative effect in the presence of mangroves, in contrast with herbivores. It is related to mangrove functioning as a temporary shelter when high-pressure presence in their natural habitat (reef) and a place for foraging. Therefore, mangrove management must be a consideration in the coral reef or fisheries management program.

Keywords: Abundance, diversity, management, mangroves, reef fish

INTRODUCTION

Coastal ecosystems such as coral reefs, mangroves, and the sea were necessary to support the coastal fisheries. However, in the past decade, conditions of coastal habitats have shown a declining pattern due to sedimentation, anthropogenic activities, and climate change (Adam et al. 2015). The decline in environmental conditions and fishing pressure impacts the availability of reef fish in nature (de la Guardia et al. 2018). Linkages between reef fishes and the ecological situation are a response to the coastal ecosystem function as an aggregation area, nursery, shelter, and foraging area for reef fishes (Mumby et al. 2004).

Connectivity between coastal ecosystems provides sufficient space and time for the movement of biota, nutrients, and energy (Olds et al. 2012; Hyndes et al. 2014; Carr et al. 2017; Whitfield 2017; Du et al. 2020 Ward et al. 2020). As an illustration, mangroves provide food and protection for various biota, including reef fish. However, there are mangrove areas that are far from coral habitats. At the same time, the presence of reef fish was closely related to the mangrove ecosystem, so it is vital to know the relationship between mangrove characteristics, distance, and the influence of waters on the presence of reef fish (Olds et al. 2012; Ulumuddin et al. 2021). Many economically important reef fish are reported to spend part of their life cycles in estuaries as juveniles before migrating to offshore populations as adults (Olds et al. 2012; Berkström et al. 2013; Olds et al. 2013; Igulu et al. 2014; Martin et al 2015; Whitfield 2017; Bradley et al. 2019). Several families of reef fish, such as Haemulidae, Lutjanidae, and Scaridae, were continuously associated with mangroves (Serafy et al. 2015). They use mangroves as the nursery, foraging, and growing areas (Jaxion-Harm et al. 2012; Nagelkerken et al. 2012; El-Regal et al. 2014; Riswandha et al. 2015; Hamilton et al. 2017).

As an area with promising fishery eventuality in the northern Maluku region, Ternate is a destination for prisoner fisheries products, especially for types of demersal fish and pelagic fish. The most significant production from capture fisheries activities is tuna, skipjack tuna, and little eastern tuna, with a total production of 319,925 tons (BPS 2022; KKP 2022a). With the increasing number of capture fisheries production, most of the population in coastal areas make a living as fishermen, with a total number of 93,017 people in 2020 (KKP 2022b). The high fishery exertion has an impact on the condition of the submarine terrain and its constituent ecosystem, similar to corals, seagrasses, and mangroves (Hyndes et al. 2014). According to Prayudha (2012), the mangrove area in Ternate was 5097.71 ha, with a density of 1037 ind/ha (Dharmawan and Purnomo 2012). Dominant species are *Sonneratia* and *Rhizophora* because they're tolerant species to high saltness and substrate in the form of coral fracture (Nurdiansah and Dharmawan 2018; Basyuni et al. 2019). Mangrove communities spread from the island of Hiri, Ternate, Maitara, Tidore, Failonga, Sibu to Halmahera (Dharmawan and Purnomo 2012; Nurdiansah and Dharmawan 2018). Based on Data BPDAS Ake Malamo (2017), the mangrove forest area in North Maluku province reaches 41,228 ha with distribution in almost every city and district in North Maluku, with the highest area in South Halmahera District at 16,331 ha and the smallest area in Ternate City at 25.73 ha. Research about reef fish has been reported greatly, considering reef fish community information is important in evaluating fisheries management and coral reef management (Edrus and Suharti 2017). However, mangrove influence on the reef fish abundance and diversity is not often reported, although mangroves have an important function as a nursery ground. This paper studies reef fish abundance and diversity in Ternate Waters in the presence of mangroves in coral reef habitats.

MATERIALS AND METHODS

Study area

The reef fish survey was part of the Reef Health Monitoring (RHM) carried out by the Coral Reef Rehabilitation and Management Program Coral Triangle Initiative (COREMAP-CTI). The study was carried out in Ternate waters, North Maluku (Moluccas) Province, Indonesia. Ternate reefs were in the heart of the coral triangle and near the populated area. The research station was divided into two groups of sites, where the first groups were sites that were near the mangrove habitat and the second group was reefs with absent or far from the mangroves. The first groups were indicated by the reefs that had mangroves within a 1000-3000m radius from the center of the station. The distance between sites and the presence of mangroves were taken into account in the reef fish home range (Swadling et al. 2019). According to this criteria, there are eight stations located near mangrove habitats and six stations with an absence of mangroves (Figure 1). The study sites are located on six islands (Hiri, Ternate, Maitara, Tidore, Filonga, and a small part of Halmahera). Of those six islands, Ternate and Tidore were the most populated islands, with 205,870 and 116,149 residents. Mangrove areas were located in the East part of Halmahera, Maitara, and Tidore. Maitara was the most well-known tourist area in Ternate District.

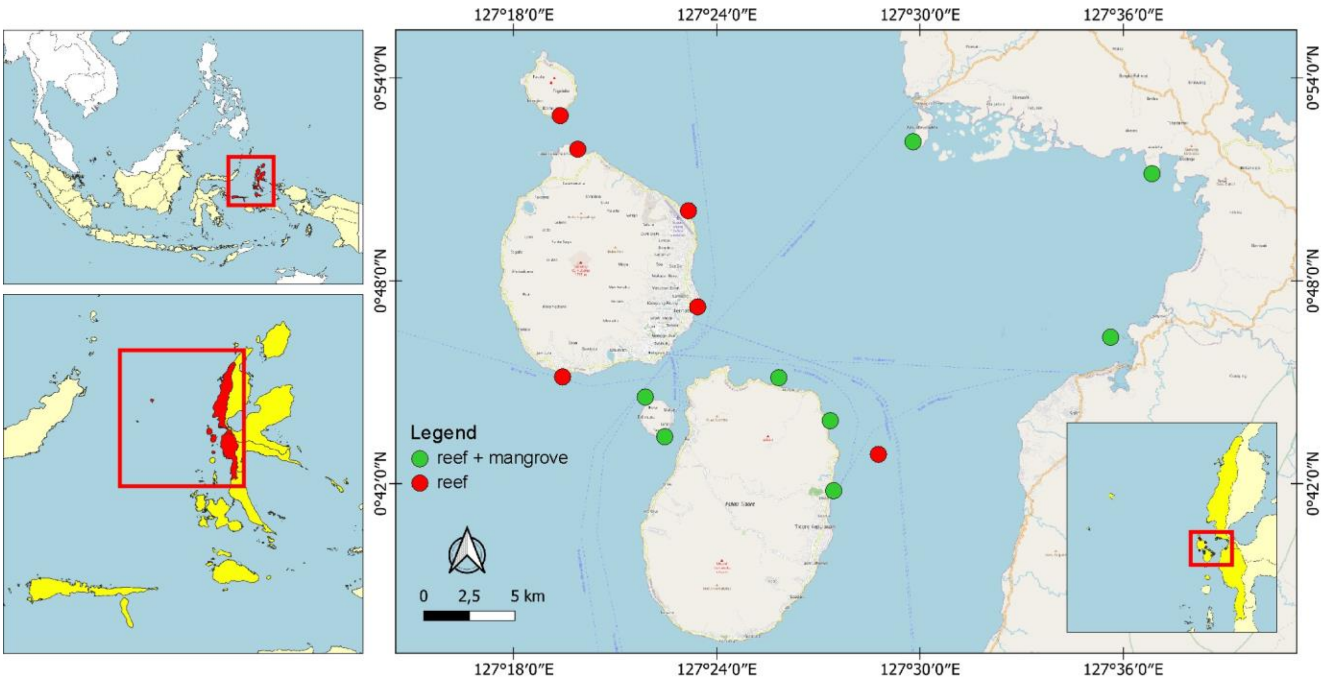


Figure 1. The survey areas at Ternate waters, red indicate sites with the absence of mangrove, while green reef with the presence of mangrove habitat

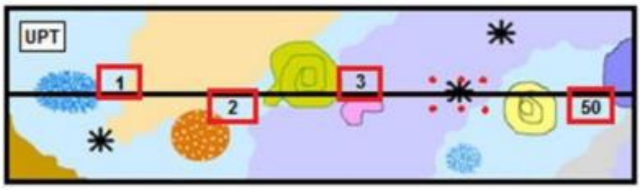


Figure 2. Underwater photo transect (UPT) sampling protocol

Sampling

The research was conducted in 2017 and 2018 between September and October. A 70-meter transect line was placed parallel to the coastline on coral reefs in all sites at a relatively similar depth of 5m-7m (measured using the transect tape before photo data collection). Afterward, an Underwater photo transect (UPT) was used to estimate the benthic coverage (live coral, dead coral with algae, fleshy seaweed, and rubble). Photos of a 44 x 58 cm frame were taken from meters 1 to 50 with an interval of 1 meter (50 frame photos in total for one transect), a photo with the odd number was above the transect line, and the even number in the bottom of the transect line. Underwater Visual Census (UVC) was used for estimating the reef fish length and abundance (Figure 2). A 70 m long and 5 m width (2.5 m width on left and right of the transect line) transect was laid along with the benthic survey with a fish transect 20 m longer and 4 m wider than the benthic survey to cover the fish mobility. The reef fish that count in the study was only the reef fish species from the following families: Haemulidae, Lutjanidae, Lethrinidae, Scaridae, Serranidae, and Siganidae. The fish were identified following Allen (2009) and categorized by feeding behaviors (herbivore and carnivore) based on published data in Fish Base (Froese and Pauly 2017).

Data analysis

For the assessment of benthic composition, photos were analyzed using CPCe 4.1 software, with 30 random points used to estimate the benthic cover. The diversity indices, such as species diversity index (Shannon-Wiener, H') and equitability index (Pielou, J'), were calculated using the Vegan package on R software. The fish composition among sites between the presence and absence of mangroves was further examined using the ordination method on dissimilarity matrices in R software with R package Vegan. Non-metric scaling analysis on the Bray Curtis dissimilarity matrix was performed to evaluate fish composition. The percent cover of live coral (HC), macroalgae (FS), dead coral with algae (DCA), and rubble (R), the abundance and species richness of reef fishes in the absence and presence of mangroves were illustrated in the bar chart showing the means ± SE (standard error).

RESULTS AND DISCUSSION

Coral reef habitat condition

Overall, coral reef habitat conditions in Ternate District were declining. The decline of reefs was shown by the reduction of coral cover in 2018 by 2.9%. The decline of coral cover was higher in the reef with the presence of mangroves than reef with mangrove absence, with a loss of almost 3.78% and 1.78% (Figure 3), respectively. Loss of coral cover was followed by the increase of dead coral with algae, fleshy seaweed, and rubble. Dead coral with algae declined by 0.59% but shows different patterns between the absence and presence of mangrove habitat, with an increase in presence of mangroves by 4.3% and a decline in absence of mangroves by 4.25%. Fleshy seaweed was the increase in both the presence and absence of mangroves by 1.73% and 1.81%. Meanwhile, rubble cover increases in mangroves' presence by 2.6% and a decline in absence of mangroves absence by 0.45%.

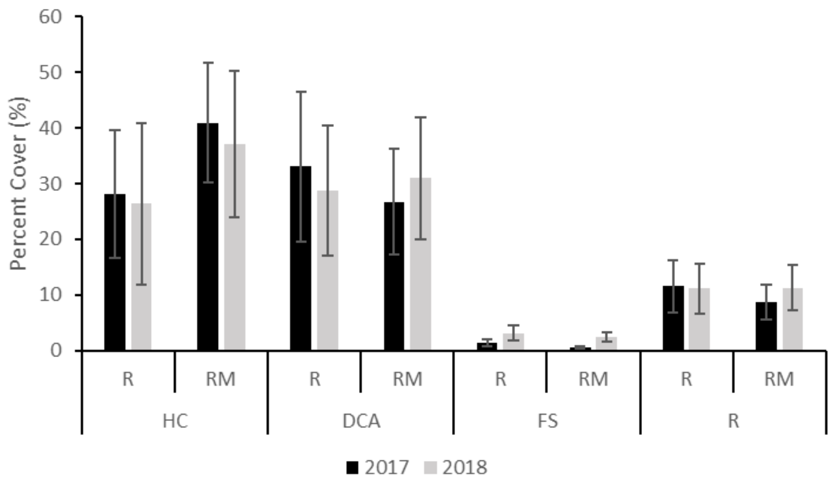


Figure 3. Percent cover of benthic categories in reef absence (R) and presence of mangrove (RM) between 2017 (black) and 2018 (gray). Live coral cover (HC), dead coral with algae (DCA), macroalgae (FS), and rubble (R). Note: the error bars show standard error

Reef fish species richness and abundance

Based on the observation, a total of 5621 reef fish belongings to 89 species and seven families were found in two types of seascapes (reef with/without mangrove habitat) (Table 1) during the research period. The number of reef fish species increased in 2018 by two species but with different species between 2017 (77) and 2018 (79). Even though overall reef fish increased but the decline in species richness was recorded in mangroves presence and absence from 65 to 62 and 68 to 66 between 2017 and 2018 (Supp. 1). Differences in species richness might be related to the reef fish species dependency on the mangrove habitat such as *Epinephelus ongus* and *Epinephelus merra* which can live in estuarine and mangrove habitats (Hamilton et al. 2005). Herbivorous reef fish increased from 45 to 48 species, while carnivores fish declined from 32 to 31 species. Similarly, an increase of herbivore species was recorded in presence of mangroves from 37 to 39, while carnivores declined from 28 to 23.

Species diversity describes the number of species and abundance of each species that live in a particular location. The diversity index had been used to measure differences in the community through differences in species composition and distribution of individuals within the species (species abundance) (You et al. 2009). Therefore, the diversity index is a useful tool for describing biodiversity profile. Based on the data analysis in reefs without mangroves in 2017, the Shannon-Weiner diversity index value was 2.907, which indicated the medium criteria. Meanwhile, the evenness index value was 0.847, indicating that the abundance of reef fish was almost evenly. In 2018, the Shannon diversity index was recorded at 2.684 and the evenness at 0.801. Thus, it can be seen that there was a decline in the diversity value of the two indices (Figure 4).

Based on the results of data analysis in the Ternate water in the absence or presence of mangrove habitat showed no difference in both areas between 2017 and 2018, which was recorded at 2.907 and 2.684 in absence of mangroves and 2.699 and 2.778 in presence of mangroves (Figure 4), respectively. This index value informed the biodiversity of reef fish at the medium criteria. The diversity index on herbivore fish was higher than on carnivore fish, which is in line with the species richness of those functional groups. The evenness index value in the study area were 0.847 and 0.842 in the absence and presence of mangroves, which is indicating that the abundance of each reef fish species was almost evenly distributed. The diversity index in reefs with mangrove presence was lower than in absence of mangrove. The Shannon-Weiner diversity index was 2.699 and 2.778 in 2017 and 2018, respectively, which indicated medium diversity. The evenness index value was 0.840 and 0.855 in 2017 and 2018, respectively. Therefore, it could be concluded that there was an increase in the two indices (Figure 4). The diversity index for reef fish in Ternate was higher than reported by Ilyas et al. (2017), which indicates low pressure on the environment. The diversity index is an indication of habitat heterogeneity and the number of species and abundance in areas implies the importance of the areas (Mengesha and Bekele 2008). Nanjo (2022) mentioned that the reef fish diversity was affected mangrove habitats due to habitat complexity structured by mangrove vegetation, which in line with the present study that the diversity index was increased in reefs with mangroves although the reef covers were declined.

The abundance of reef fish was shown an increased pattern with reefs with the absence of mangroves increasing while the decline in presence of mangroves in the coral reef ecosystem. Reef with the presence of mangroves was higher in fish abundance than in absence of mangroves with the difference between the absence/presence of mangroves in 2017 and 2018 being 390 and 289 individuals (Figure 5). The high number of reef fishes found in reef habitats where the mangrove presence was related to the mangrove habitat used as a feeding ground and shelter from predators (Sambrook et al. 2019). Herbivore and carnivore reef fish have shown contrast patterns where herbivores show an increase while carnivores decline. Herbivore abundance was higher in mangrove presence than in mangrove absence. In contrast, carnivore abundance was higher in absence of mangroves with differences in abundance in 2017 being 20 individuals and 207 individuals in 2018.

Although reef fish abundance showed higher in the presence of mangrove habitat, mangrove presence was not the only factor that influenced the abundance. Other factors, such as tidal, which is essential to the fish movement over coastal habitat, and human activities also play an important role that enhancing fish abundance. Therefore, further investigation needs to be done before we examine the effect on mangrove habitat.

Reef fish community dissimilarity

The clustering analysis based on the Bray Curtis dissimilarity index was used to determine the similarity of reef fish communities between reefs with the absence and presence of mangroves in 2017 and 2018 (Figure 6). The result of the Bray Curtis dissimilarity showed that the presence of mangroves in reefs not influenced the community structure of reef fish in the coral reef ecosystem. The community dissimilarity index at 0.6 produced only two groups with st13 and st04 the distinct group in 2017 and 2018, while the rest of the observation stations were grouped as one cluster. There were only 12 and 10 species not found in 2017 and 2018, and less than 40% of species were found only in the absence/presence of mangrove habitat. Among those species, *Acanthurus mata*, *A. nigricans*, *Plectorhinchus chaetodonoides*, and *Lutjanus fulvus* were found in the reef with an absence of mangroves while *E. merra* and *E. ongus* were found in the reef with the presence of mangroves. In total, more than 40 species were found in both reefs in absence and presence of mangrove forests (Table 1). *Ctenochaetus binotatus*, *Ctenochaetus striatus*, *Zebrasoma scopas*, and *Lutjanus biguttatus* were the most abundant species that found in both reef conditions.

Table 1. Comparison of reef fish abundance in presence of mangrove habitat in Ternate Water

Species	Family	Functional group	Mangrove absence		Mangrove presence	
			Ab	RA	Ab	RA
Acanthurus auranticavus	Acanthuridae	Herbivore	24	8%	12	6%
Acanthurus blochii	Acanthuridae	Herbivore	6	3%	0	2%
Acanthurus fowleri	Acanthuridae	Herbivore	0	0%	3	1%
Acanthurus lineatus	Acanthuridae	Herbivore	4	2%	6	1%
Acanthurus mata	Acanthuridae	Herbivore	24	8%	0	8%
Acanthurus nigricans	Acanthuridae	Herbivore	22	9%	0	7%
Acanthurus nigroris	Acanthuridae	Herbivore	6	2%	19	0%
Acanthurus olivaceus	Acanthuridae	Herbivore	2	1%	0	1%
Acanthurus pyroferus	Acanthuridae	Herbivore	69	29%	113	34%
Acanthurus thompsoni	Acanthuridae	Herbivore	34	12%	18	15%
Ctenochaetus binotatus	Acanthuridae	Herbivore	153	64%	166	70%
Ctenochaetus striatus	Acanthuridae	Herbivore	92	37%	119	40%
Ctenochaetus tominiensis	Acanthuridae	Herbivore	11	4%	9	4%
Naso brachycentron	Acanthuridae	Herbivore	6	2%	6	2%
Naso brevirostris	Acanthuridae	Herbivore	3	1%	5	1%
Naso hexacanthus	Acanthuridae	Herbivore	3	1%	8	1%
Naso lituratus	Acanthuridae	Herbivore	33	13%	17	12%
Naso vlamingi	Acanthuridae	Herbivore	20	6%	6	6%
Paracanthurus hepatus	Acanthuridae	Herbivore	0	0%	2	1%
Zebrasoma scopas	Acanthuridae	Herbivore	132	55%	157	57%
Zebrasoma veliferum	Acanthuridae	Herbivore	20	8%	12	8%
Cetoscarus bicolor	Scaridae	Herbivore	0	0%	5	0%
Chlorurus bleekeri	Scaridae	Herbivore	40	17%	43	19%
Chlorurus sordidus	Scaridae	Herbivore	69	30%	131	32%
Hyposcarus longiceps	Scaridae	Herbivore	2	1%	2	1%
Scarus chameleon	Scaridae	Herbivore	2	1%	1	0%
Scarus dimidiatus	Scaridae	Herbivore	75	32%	86	34%
Scarus flavipectoralis	Scaridae	Herbivore	14	7%	16	7%
Scarus forsteni	Scaridae	Herbivore	1	1%	3	1%
Scarus ghobban	Scaridae	Herbivore	8	3%	7	3%
Scarus japanensis	Scaridae	Herbivore	2	1%	0	1%
Scarus niger	Scaridae	Herbivore	93	40%	88	42%
Scarus prasiognathus	Scaridae	Herbivore	2	1%	0	1%
Scarus psittacus	Scaridae	Herbivore	2	1%	0	0%
Scarus quoyi	Scaridae	Herbivore	2	1%	4	1%
Scarus rubroviolaceus	Scaridae	Herbivore	7	3%	3	2%
Scarus schlegeli	Scaridae	Herbivore	0	0%	4	0%
Scarus spinus	Scaridae	Herbivore	3	1%	1	1%
Siganus canaliculatus	Siganidae	Herbivore	41	14%	38	24%
Siganus corallinus	Siganidae	Herbivore	6	2%	4	1%
Siganus doliatus	Siganidae	Herbivore	26	11%	18	10%
Siganus guttatus	Siganidae	Herbivore	2	1%	0	1%
Siganus lineatus	Siganidae	Herbivore	2	1%	0	1%
Siganus puellus	Siganidae	Herbivore	12	4%	22	5%
Siganus punctatissimus	Siganidae	Herbivore	12	5%	16	5%
Siganus spinus	Siganidae	Herbivore	2	1%	2	1%
Siganus virgatus	Siganidae	Herbivore	6	3%	8	4%
Siganus vulpinus	Siganidae	Herbivore	29	12%	37	12%
Plectorhinchus chaetodonoides	Haemulidae	Carnivore	3	1%	0	1%
Plectorhinchus lessonii	Haemulidae	Carnivore	3	1%	4	1%
Plectorhinchus lineatus	Haemulidae	Carnivore	9	2%	0	2%
Plectorhinchus vittatus	Haemulidae	Carnivore	4	2%	1	2%
Plectorhinchus polytaenia	Haemulidae	Carnivore	0	0%	1	0%
Lethrinus erythropterus	Lethrinidae	Carnivore	5	2%	2	2%
Lethrinus ornatus	Lethrinidae	Carnivore	4	1%	1	1%
Lethrinus harak	Lethrinidae	Carnivore	2	1%	0	1%
Monotaxis grandoculis	Lethrinidae	Carnivore	32	12%	15	13%
Lutjanus biguttatus	Lutjanidae	Carnivore	250	67%	70	67%
Lutjanus bohar	Lutjanidae	Carnivore	1	0%	3	0%
Lutjanus decussatus	Lutjanidae	Carnivore	12	4%	11	4%
Lutjanus fulviflamma	Lutjanidae	Carnivore	3	1%	0	1%
Lutjanus fulvus	Lutjanidae	Carnivore	2	1%	0	0%

Lutjanus gibbus	Lutjanidae	Carnivore	26	8%	0	3%
Macolor macularis	Lutjanidae	Carnivore	6	2%	0	1%
Macolor niger	Lutjanidae	Carnivore	3	1%	0	1%
Anyperodon leucogrammicus	Serranidae	Carnivore	2	1%	1	1%
Aethaloperca rogaa	Serranidae	Carnivore	3	1%	1	1%
Cephalopholis argus	Serranidae	Carnivore	7	3%	2	2%
Cephalopholis cyanostigma	Serranidae	Carnivore	7	2%	3	3%
Cephalopholis leopardus	Serranidae	Carnivore	8	2%	6	2%
Cephalopholis miniata	Serranidae	Carnivore	1	0%	1	0%
Cephalopholis micropion	Serranidae	Carnivore	8	4%	22	4%
Cephalopholis urodeta	Serranidae	Carnivore	3	1%	12	1%
Diploprion bifasciatum	Serranidae	Carnivore	0	0%	2	0%
Epinephelus fasciatus	Serranidae	Carnivore	6	2%	6	2%
Epinephelus merra	Serranidae	Carnivore	0	0%	10	0%
Epinephelus ongus	Serranidae	Carnivore	0	0%	3	0%
Plectropomus maculatus	Serranidae	Carnivore	2	1%	0	1%
Variola louti	Serranidae	Carnivore	3	1%	3	0%
Total abundance			1348		1588	
Total Species Richness			66		62	

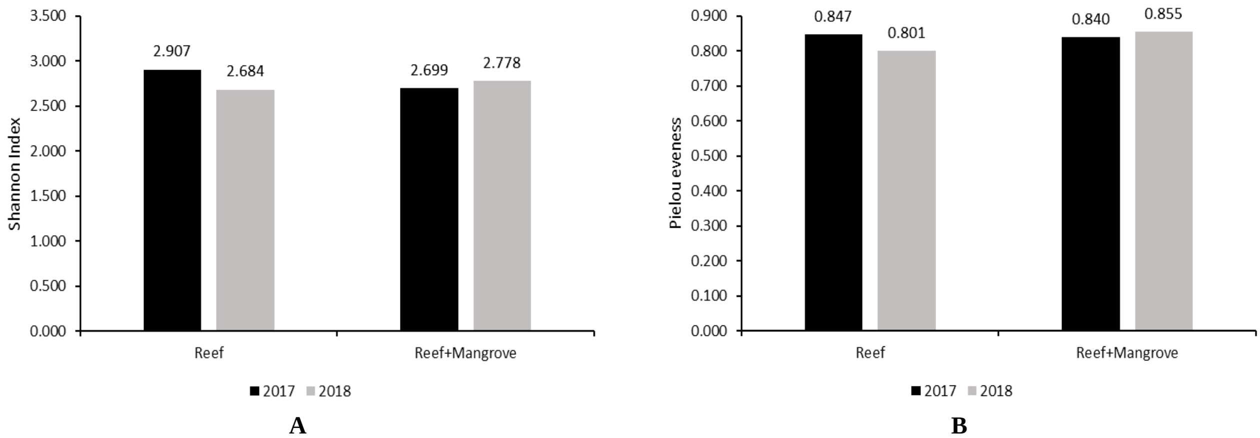


Figure 4. Comparison of Shannon diversity index (A) and Pielou-evenness (B) of herbivore and carnivore fish between mangrove forest absence/presence in near reef areas

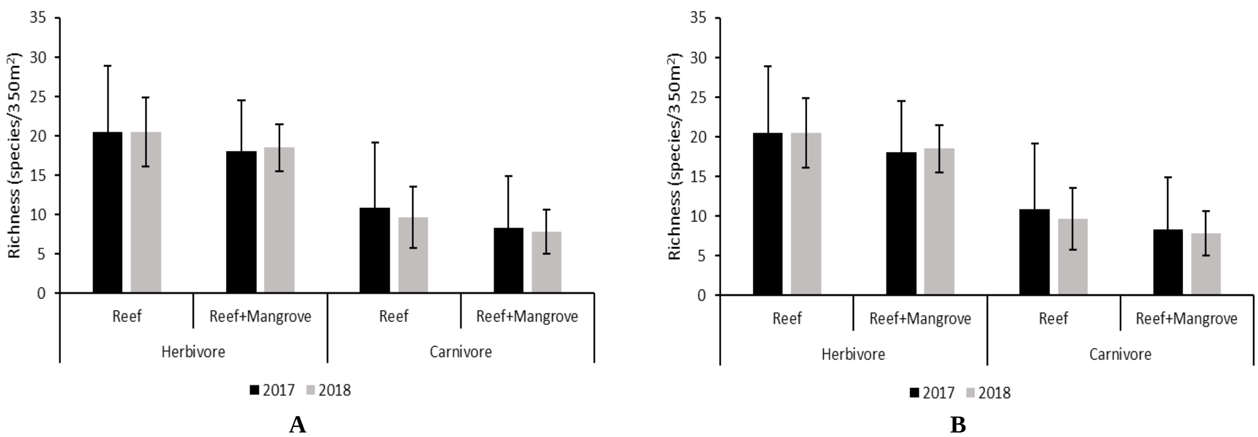
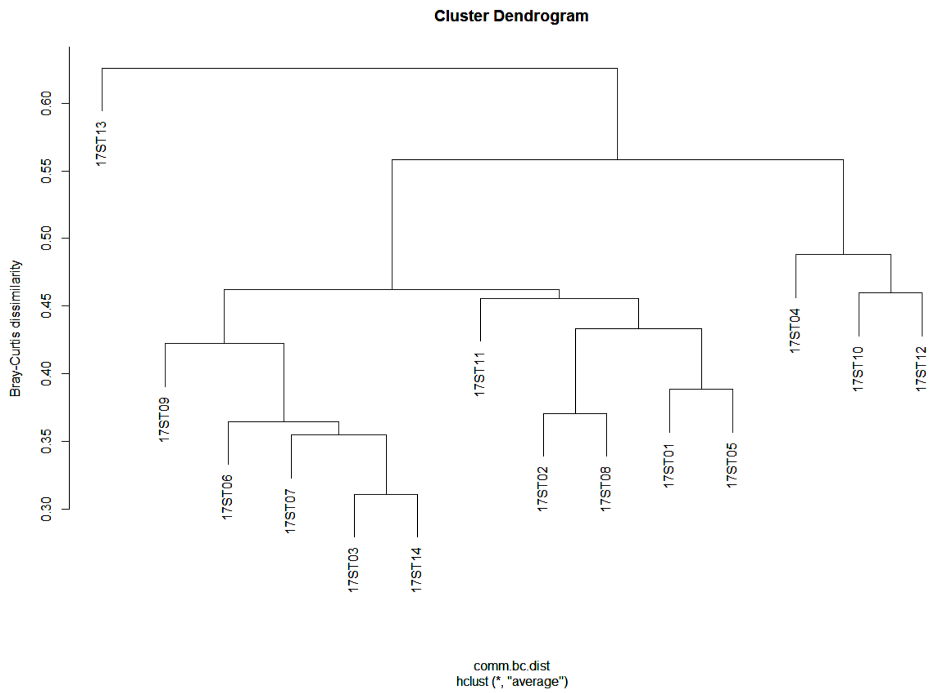
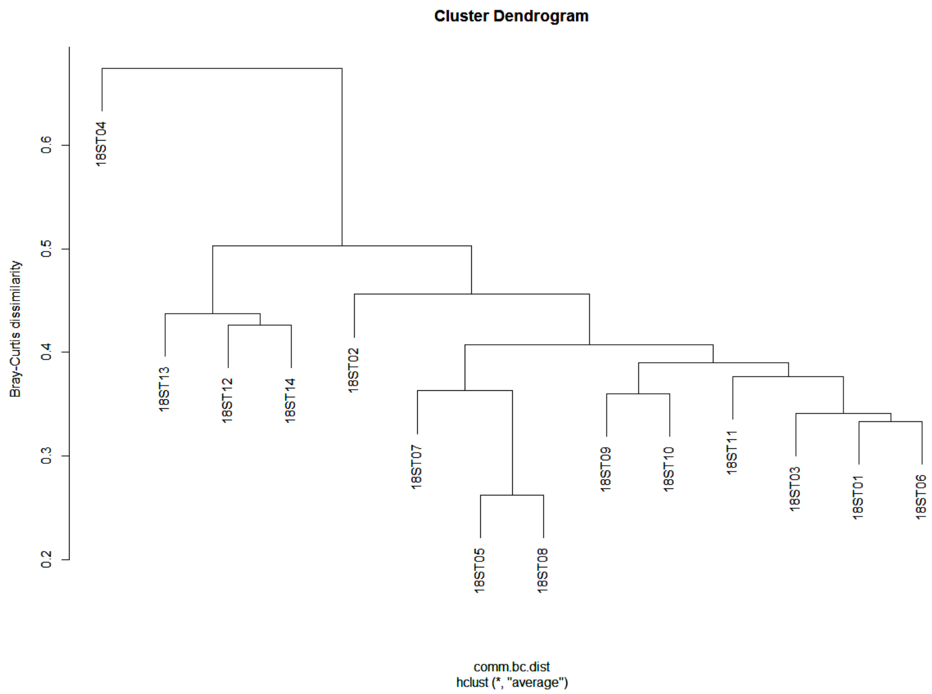


Figure 5. Comparison of abundance (A) and species richness (B) of herbivore and carnivore fish between mangrove forest presence in near reef areas. Note: the error bars show standard error



A



B

Figure 6. Dendrogram of reef fish community obtained from hierarchical cluster analysis of Ternate reefs in 2017 (A) and in 2018 (B)

Discussion

Reef biodiversity and abundance were influenced by habitat conditions. Changes in reef fish due to a decline of coral reef habitat have been reported regularly in Indonesian waters (Hadi et al. 2018). However, the decline of coral cover was not often followed by declining in reef fish abundance, especially between carnivorous and herbivorous fish. The decline of coral cover was often followed by the decline of reef rugosity and an increase of macroalgae or dead coral that was covered by algae, which enhanced herbivorous and carnivorous abundance as the reduction of coral cover functions as shelter and increased food sources both for herbivorous and carnivorous fish. Similarly, this study's results show an increasing pattern of reef fish abundance. However, contrast patterns are shown in the abundance of herbivorous and carnivorous reef fish in the absence or presence of mangroves in coral reef habitat, although all reefs experience decline in coral covers.

Mangrove habitat presence showed different effects between reef functional groups. The species richness showed a similar pattern between herbivore and carnivore fish, where the number of species found in the presence of mangrove habitat was lower than in the absence of mangrove. The contrast pattern illustrated the abundance of herbivores and carnivores in presence of mangroves (Figure 3). The positive effect of the mangrove habitat showed in herbivore fish, while the contrast result showed in the carnivore abundance. A similar result showed by Ulumuddin et al. (2021), who showed a decreased pattern of carnivore abundance as it was farther away from the mangrove habitat. Reef fishes tend to use mangrove habitats for temporary shelter when high-pressure presence in their natural habitat (reef) and a place for foraging (Mumby et al. 2004). Moreover, the mangrove root structure provides better protection for the fish, which can be a reasonable explanation for the low abundance of carnivorous fish and the high abundance of herbivorous fish.

The results of the diversity index in the absence/ presence of mangrove habitat in reef areas were not different, which indicates that both types of reef were likely similar in composition of reef fish. Different reef species composition has been reported between estuarine and reef habitats throughout the Indo-Pacific region, such as New Caledonia, Papua New Guinea, Solomon Island, Tanzania, and Australia (Blaber et al. 1985; Blaber and Milton 1990; Dorenbosch et al. 2005; Gilby et al. 2016; Kimirei et al. 2016). Variability in environmental characteristics has been a major role in structuring the species composition. Environmental properties such as salinity, temperature, and turbidity have been identified as limiting factors of fish assemblage interaction between different habitats (Eick and Thiel 2014; McClanahan and Jadot 2017). This study was conducted in non-estuarine mangrove and adjacent reef habitats, where there was no apparent variability of environmental characteristics, which resulted in similar species composition in both conditions.

In the tropical Atlantic Ocean, such as in the Caribbean, where mangroves commonly occur in the same areas as coral reefs, mangroves are used as nursery areas of *Lutjanidae* (snappers), *Serranidae* (grouper), and *Scaridae* (parrotfish) (McMahon et al. 2012; Sambrook et al. 2019). As a result, several fish abundance was higher in the coral reef areas that were near to mangrove habitat (Mumby et al. 2004). In contrast, this study showed that carnivorous abundance in presence of mangroves was lower than in absence of mangroves. Moreover, a lower abundance of lutjanid in this area supports a previous study by (Ulumuddin et al. 2021), that shows decreasing biomass of lutjanid fish as it was farther from the mangrove's habitat. The presence of mangroves habitat in the coral reef areas affected the abundance of reef fish due to the fact that the mangroves give shelter, particularly to herbivorous fish. Therefore, the existence of healthy mangroves gives benefits to maintaining the abundance of reef fish, especially when the coral complexity declines, which is important to maintaining fish productivity in that area.

In conclusion, the number of reef fish species that occurred on the Ternate reef without mangrove presence was higher than reef with the presence of mangrove habitat. However, the community structure between the two habitats was similar. In contrast, the abundance of reef fish was different between the two habitats, and carnivore abundance showed a distinct pattern to herbivores. This was due to the mangrove being used by the reef fish as shelter from predators and feeding ground, which is shown in the high abundance of herbivores and low abundance of carnivorous fish in the mangrove habitat. This shows that mangrove habitat can gives a positive impact on the reef fish abundance. Therefore, mangrove management has to be a consideration in the coral reef management program.

ACKNOWLEDGEMENTS

This study was supported by the Coral Reef Monitoring and Management Program, Coral Triangle Initiative (COREMAP-CTI) Capacity Development Research Project conducted during coastal ecosystem monitoring programs and Capacity Building Program in 2021-2022 based on the decision letter Head of Earth Science Research Organization No. 3/III/HK/2022. The authors declare no conflicts of interest affecting the publication of this paper.

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