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Reef Fish Biodiversity at Different Depths in Tunda Island, Banten Province, Indonesia

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ABSTRACT

Reef composition and diversity of coral reef fishes play an essential role in the ecosystem. The reef fish diversity is a crucial indicator of the health level of coral reef ecosystems. The benefit of fish diversity in coral reef ecosystems is to describe ecological services. This research intended to determine reef fish diversity among stations at different depths, consisting of shallow water and reef slope. Research sampling was done in July 2018 and July 2019 in Tunda Island waters at eight stations billowing the coral distribution pattern. Collected data of reef fishes were by using Underwater Visual Census (UVC) on Belt Transects Method at 250 m^2 transect area (50 meters of length and 2.5 m on either side). The result showed 69 reef fishes in shallow water and 67 species on the reef slope. The total of fish species ware from 13 families consisting of Acanthuridae, Apogonidae, Blenniidae, Chaetodontidae, Ephippidae, Haemulidae, Labridae, Lutjanidae, Nemipteridae, Pomacentridae, Pseudochromidae, Scaridae and Serranidae. The community services structure of coral reef fishes is included in the moderate community stability category with an H' value ranging from 1.19-1.60 in shallow water and 1.23-1.44 at reef slope, respectively. Diversity in coral reef fish communities might be associated with species' spatial distribution over the reef habitat's physical structure, but these patterns could be highly scale-dependent. In general, it could be said that the higher the coral reef diversity, the higher the reef fish diversity.

1. Introduction

The composition and diversity of coral reef fishes play an essential role in the ecosystem (Mumby *et al.* 2004). Runtuboi *et al.* (2018) explained that the condition of coral reefs determines reef fish composition and diversity. In the coral reef ecosystem, reef fishes are the most abundant organisms (Nybakken 1982). The high diversity of reef fishes impacts various and complex habitats in the coral reef ecosystem. Therefore, the reef fish diversity is an important indicator of the health level of coral reef ecosystems (Adrim *et al.* 2012; Hourigan *et al.* 1988). Bell and Galzin (1984) also explained that changes in the diversity of reef fish communities could indicate changes in the ecosystem.

Coral reef ecosystems positively correlate with reef fish diversity (Bengen 2013; Marshel and Mumby 2015). Besides playing an essential role as an environmental health indicator, the existence of reef fish is also a source of livelihood for the community living on the coast and small islands. Reef fish diversity will help accumulate more ecological service capital (eco-service capital) and is also used to evaluate the various impacts of human activities on ecosystem function (Eduardo *et al.* 2018; Palumbi *et al.* 2009; Paulangan *et al.* 2019).

Reef fish is one of the aquatic organisms that correlates significantly in the coral reef ecosystem. There is an excellent coral reef ecosystem that can increase reef fish production. The primary function of the coral reef ecosystem for the reef life is as a spawning ground, nursery ground, and feeding ground. Smith (1978) and Rondonuwu *et al.* (2019) revealed that one describing the complexity of coral reef habitat structure is the abundance of individual coral reef fish. The research results in North Minahasa illustrate that the complexity of the coral reef habitat in Likupang Village, and Ambong

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Village is low due to the typical composition of coral fish (Rondonuwu *et al.* 2019).

The provision of ecological services in coral reef ecosystems could be seen in the great diversity of coral fish species in coral reef ecosystems. It can be seen in small island communities. In the northern region of Banten Bay, 17 small islands are included in the administration of Serang Regency, Banten Province (Mujiyanto *et al.* 2020). Of the 17 small islands, there are two inhabited islands: Panjang Island and Tunda Island. The benefits of fish diversity in the coral reef ecosystem as providers of ecological services are evident on the two islands, especially Tunda Island, because it is far from the mainland of Serang Regency. More than 80% of Tunda Island's community depends on coral reef ecosystem resources. Without reasonable management effort on these conditions, it will affect habitat change, showing a picture of declining the state of coral reef conditions. Plass-Johnson *et al.* (2016) and Fahlevy *et al.* (2017) explained that changes in coral reef conditions would affect the resources and use of niches by reef fish communities. It is well known that coral reefs, as the primary habitat for reef fishes, are prone to degradation due to fisheries and tourism activities, which are often not environmentally friendly (Campbell *et al.* 2013).

This research aims to determine reef fish diversity among research stations at different depths, in shallow water, and on reef slopes. Choosing the reef fish diversity in shallow water and reef slope is critical. Suppose there is a change in coral reef conditions, a base of data and information for rehabilitating or restoring coral reefs as a habitat for restoring reef fish resources (Beldade *et al.* 2015). This condition is explained too by Carpenter *et al.* (1981); Suharti and Edrus (2018) that there is a significantly positive correlation between fish biomass and reef bottom complexity. Still, it does not correlate with fish species abundance.

2. Materials and Methods

2.1. Study Site

The study was carried out along the coast of Tunda Island waters, Serang Regency, Banten Province, at eight stations (Figure 1). The stations were: 1) West Side (5.810605 S and 106.253949 E); 2) Kampung Barat Port (5.812517 S and 106.259856 E); 3) Central South Side (5.815657 E and 106.275295 S); 4) South toward East Side (5.816812 E and 106.288616 S); 5) East Side (5.811365 E and 106.296650 S); 6) North toward East Side (5.808671 E and 106.290591 S); 7) Central North Side (5.807669 S and 106.278476 S); and 8) North toward West Side (5.807861 E and 106.264466 S). The selection of stations was followed by the pattern distribution of coral reefs at research locations.

The study was conducted in July 2018 and July 2019. The coast has a lot of fish diversity as one of the sources of community livelihood. The coast provides an excellent site for the ecological survey of reef

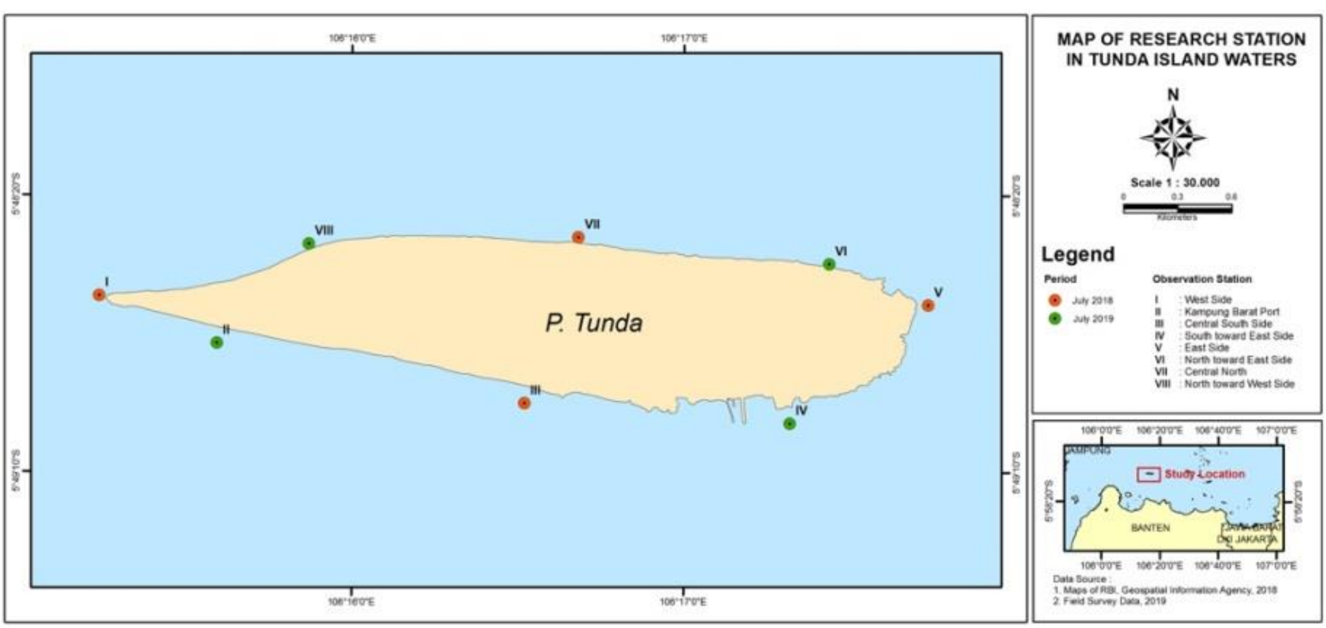

Figure 1. Study sites in the coastal area of Tunda Island waters, Banten Province

fishes. Moreover, Tunda Island's coast is also a place for marine tourism of some local tourists.

The data of live coral cover as base data make a correlation between reef fish biodiversity and its habitat, according to Mujiyanto *et al.* (2020). The data of live coral cover in Tunda Island have consisted of 17 categories, namely: Live Coral (LC); Acropora (AC); Non-Acropora (NA); Dead Coral (DC); Dead Coral with Algae (DCA); Soft Coral (SC); Gorgonians (G); Zoanthids (Z); Sponges (S); Fleshy Seaweed (FS); Other (OT); Other Live (OT); Coraline Algae (CA); Rubble (R); Sand (S); Silt (SI); and Rock (RK).

2.2. Data Collecting

Data collecting of reef fish used Underwater Visual Census (UVC) with the Belt Transects Method according to English *et al.* (1997) at 250 m^2 transect area (50 m length and 2.5 either side) (see Figure 2). Collected data of reef fish and live coral cover were done in 2 depths, including the depths of shallow water (±3-4 m) and reef slope (±10-11 m) (Figure 2). Reef fish found inside the belt transect area were identified to the species level based on Kuiter (1992), Allen (2000), Kuiter and Tonozuka (2001), and Allen *et al.* (2003). The identified species were then categorized into target species, major species, and indicator species, according to English *et al.* (1997).

2.3. Data Analyzed

Reef fish species diversity analyses the number of reef fish species identified during the dive (Suharti and Edrus 2018). The data collected was analyzed descriptively and presented in tables and graphs to determine fish species composition at the two different depths (Tuaputty *et al.* 2018). The analysis of reef fish species diversity used the Shannon-Wiener diversity index (H'). According to Wilhm and Dorris 1966; Toruan *et al.* 2018, the Shannon diversity index is used to identify community diversity as a reflection of changes in community structure that reflect the presence or absence of ecological pressures. The values of the Shannon diversity index were obtained using the following formula (Wilhm and Dorris 1968): H' = -S Pi*Log Pi; Pi= ni/N. The assessment category of the H' index, according to base on Odum (1971) as follows:

a. H'≤1 = Low diversity, low spread, low community stability
b. 1<H'<3 = Medium diversity, moderate distribution, moderate community stability
c. H'≥3 = High diversity, high spread, high community stability

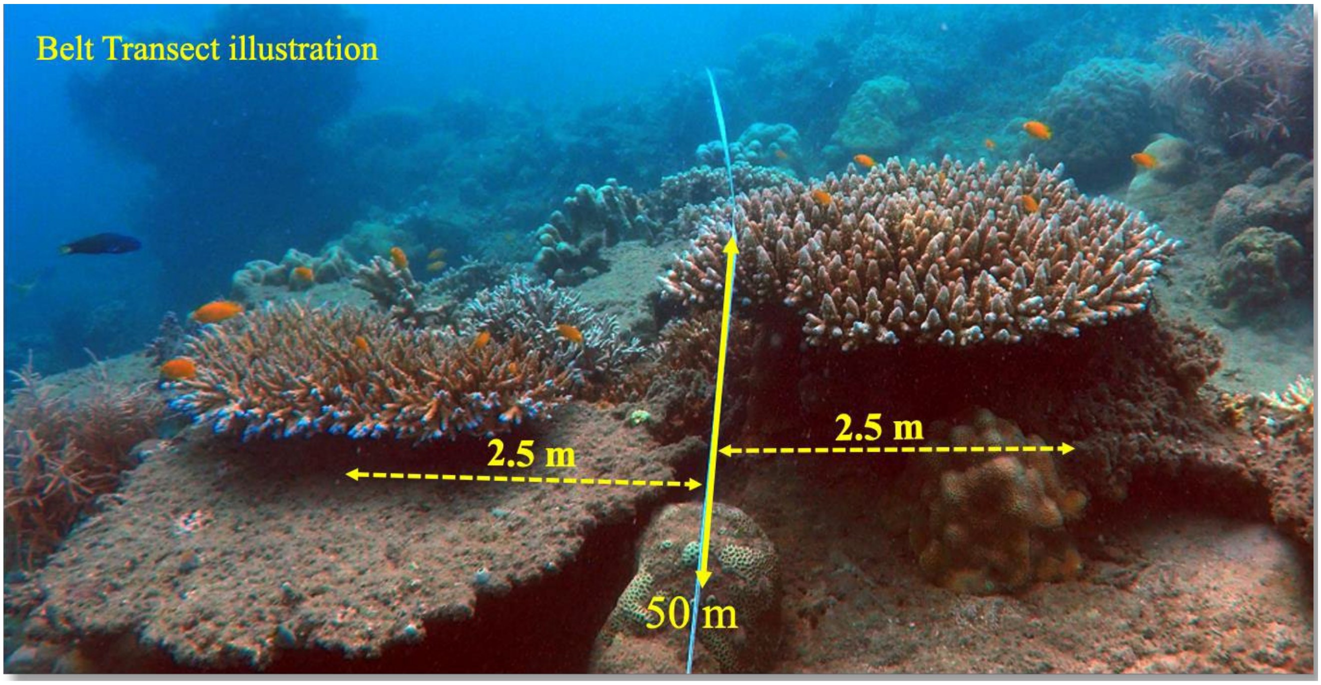

Figure 2. The illustration of the belt transect method

The data were analyzed using the similarity index to determine the reef fish species at the stations. Rahman *et al.* (2019) explained that a similarity index provides a quantitatively based measurement (Chuang 2012; Lynch 1990). The similarity index is also widely used in ecology (Chao *et al.* 2006; Hubalek 1982). The composition of fish species significantly influences the diversity of fish species in a community. A similarity index is used to measure changes in design between habitats. The likeness index used is the Jaccard likeness index (Magurran 1988).

$$JS = \frac{J}{a + b + j} \times 100$$

Where JS = Similarity Index; J = the number of species present in the two habitats in the two compared communities; a = number of species in the community A; b = Number of species in community B. Presentation in the picture facilitates discussion of fish species abundance using Minitab software in Multivariate Research Version 15, it used the software to make a dendrogram.

The correlation health of coral reef and reef fish abundance was analyzed using Simple linear regression analysis methods in Microsoft Excel, where the variable independent (X) was coral coverage, and variable dependent (Y) was the abundance of coral fishes. The following formula obtained the common form of Simple linear regression analysis (Nachtsheim *et al.* 2004; Nugraha *et al.* 2020): Y = a + bX. Whereas, Y = Dependent variable; a = Constant; b = Regression coefficient; X = Independent variable. Further analysis of the effect between variables (health of coral reef on coral fish abundance) was completed using the t-count and t-table approaches. Between t count > t table means that the coral reef's health had impacted the abundance of reef fish.

3. Results

3.1. Composition of Reef Fish Species

Tunda Island is located north of Banten Province. It is generally included in the Banten Bay area waters. The potential of fish resources in the coral reef ecosystem is still one of the primary livelihood sources for the Tunda Island community. Besides being a source of catch, the existence of coral reefs is also a tourist attraction that is used by the society around Serang, Tangerang, Jakarta, Bogor, and Lampung so that they can become a source of income for the community when they are not out to sea to catch fish. The observations at two depths, shallow water, and reef slope, with eight observation stations surrounding Tunda Island, showed 13 families and 69 reef fish species, as presented in Figure 3 and Table 1. The reef fish families found were Acanthuridae, Apogonidae, Blenniidae, Chaetodontidae, Ephippidae, Haemulidae, Labridae, Lutjanidae, Nemipteridae, Pomacentridae, Pseudochromidae, Scaridae, and Serranidae (see Figure 3).

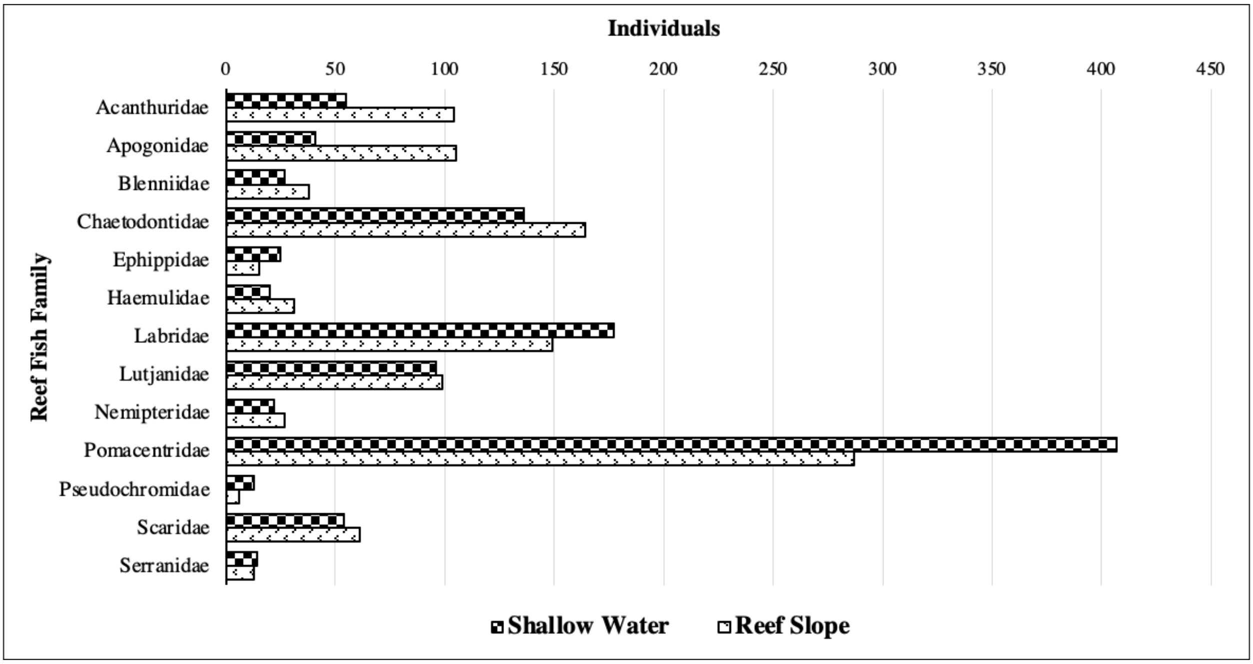

Figure 3. The presence number of reef fish species found around Tunda Islands waters

Table 1. Composition of reef fish at shallow water and reef slope

Family	Species	Observation stations	
		Shallow water	Reef slope
Acanthuridae	*Acanthurus leucosternon*	1; 2; 3; 4; 6; 8	2; 4; 5
	Amblyglyphidodon plagiometopon	3; 4; 8	1; 5
	Neoglyphidodon carlsoni	1; 2; 8	2; 4; 6
	Paracanthurus hepatus	5; 8	1; 3
	Stegastes fasciolatus	3; 5; 8	1; 3; 4; 5; 6
Apogonidae	*Apogon cyanosoma*	1; 3; 4; 5; 6; 8	3; 4; 5; 7; 8
	Apogon endekataenia	3; 4	1; 2; 6; 7
	Apogon fraenatus	3	2; 4; 5; 6
	Cheilodipterus intermedius	6; 7; 8	1; 3; 8
	Ostorhinchus angustatus	2; 4; 6	2
Blenniidae	*Aspedinantus taeniatus*	2; 4; 5; 8	4; 8
	Aspidontus fuscus	1; 3; 8	1; 2; 3; 4; 8
Chaetodontidae	*Heniochus chrysostomus*	1; 3; 7; 8	4; 5; 8
	Chaetodon trifasciatus	3; 8	2; 3; 5
	Chaetodon undulatus	1	1; 4; 5
	Chelmon rainfordi	2; 3; 6	1; 2; 3; 4; 6
	Chelmon rostratus	1	1; 4; 5; 7
	Coradion muelleri	1; 3	1; 3; 5; 7
	Heniochus varius	1; 2; 3; 4; 5; 6	2; 4; 7
Ephippidae	*Platax pinnatus*	1; 3; 4; 6; 8	2; 4; 6; 8
Haemulidae	*Pomadasys polytaenia*	1; 2; 6	4; 5; 6; 8
Labridae	*Choerodon graphicus*	1; 2; 3; 8	3; 6; 7
	Choerodon schoenleinii	1; 4; 5; 8	1; 3; 7
	Cheilinus chlorourus	1; 2; 4; 6; 8	7
	Cheilinus fasciatus	3; 6; 8	4; 5
	Chlorurus bleekeri	1; 2; 6	4; 5
	Chlorurus troschelii	1; 2; 4; 6; 8	1; 2; 3; 4; 6; 8
	Coris pictoides	1; 2; 3	3; 5; 8
	Halichoeres hortulanus	3; 4; 5; 8	3; 4; 7
	Thalassoma amblycephalum	2; 4	6; 7; 8
	Thalassoma lunare	1; 2; 6; 7	2; 3; 4; 6
Lutjanidae	*Caesio cuning*	1; 2; 3; 4; 6; 7	1; 2; 4; 5; 7
	Caesio xanthonota	1; 3; 4	2; 3; 5; 7
	Caesio sp.	1; 3; 4; 5; 6; 7	1; 3; 5
	Casio teres	1; 2; 3; 4; 6; 8	5; 7; 8
Nemipteridae	*Scolopsis bilineatus*	1; 8	3; 4; 6
	Scolopsis lineatus	1; 2; 4	7
Pomacentridae	*Abudefduf bengalensis*	1; 2; 3; 6	1; 2; 4; 7; 8
	Abudefduf sexfasciatus	1; 2; 3; 4; 6	3; 4; 7; 8
	Abudefduf sordidus	1; 3; 4; 5; 7; 8	-
	Acanthochromis polyacanthus	1; 2; 6; 8	1; 2; 4; 5; 6; 7
	Acanthochromis sp.	1; 2; 3; 4	1; 2; 3; 4
	Amblygphidodon curacao	2; 3; 5; 6	-
	Amphiprion ocellaris	3; 6; 7	1; 5; 6; 8
	Chromis atripes	3; 4; 6; 7; 8	3; 7; 8
	Chromis flavomaculata	1; 4; 6; 7; 8	5; 8
	Chromis fumea	1; 6	1; 2; 3; 6
	Chromis viridis	1; 2; 3; 4	5; 8
	Chromis weberi	1; 3; 4; 5; 6; 8	4; 6
	Dischistodus pseudochrysopoecilus	1; 4; 5; 6	1; 7; 8
	Neoglyphidodon crossi	1; 2	1; 4; 5; 8
	Neoglyphidodon melas	1; 2; 5; 7	1; 2; 5; 7; 8
	Neoglyphidodon nigroris	5; 7; 8	8
	Neoglyphidodon sp.	1; 4; 6; 8	6; 8

Table 1. Continued

Family	Species	Observation stations	
		Shallow water	Reef slope
Pomacentridae	*Neopomacentrus azysron*	3; 4; 5; 6; 7; 8	1; 2; 6
	Pomacentrus alexanderae	3; 4; 6; 7; 8	3; 7
	Pomacentrus chrysurus	1; 3; 6; 7	1; 4; 6; 8
	Pomacentrus littoralis	1; 3; 4; 8	1; 2; 8
	Pomacentrus moluccensis	2; 3; 4; 8	3; 8
	Pomacentus brachialis	1; 2; 4; 6; 8	2; 5; 8
	Pomachromis richardsonii	1; 3; 4; 6; 8	3; 5; 7; 8
	Stegastes aureus	1; 4; 6; 7; 8	1; 3; 7
Pseudochromidae	*Pseudochromis bitaeniatus*	3; 4; 5; 6; 8	7; 8
Scaridae	*Chlorurus frontalis*	1; 4; 5; 7; 8	3; 5
	Chlorurus sordidus	1; 2; 4; 5; 6	1; 2
	Scarus dimidiatus	3; 4; 6	1; 2; 3; 7
	Scarus frenatus	1; 3; 6	4; 5; 8
	Scarus sp.	3; 4; 8	1; 2; 7; 8
Serranidae	*Cephalopholis polleni*	1; 3; 5; 7; 8	2; 4; 5; 6

1: West side, 2: kampung barat port, 3: central south side, 4: south toward east side, 5: east side, 6: north toward east side, 7: central north side, 8: north toward west side

The analysis results at eight stations around Tunda Island showed that common reef fish species were from Family Pomacentridae, as many as 25 species. Some of the families with the highest species found were Pomacentridae, Labridae, Chaetodontidae, Apogonidae, and Scaridae. Found the number of individual reef fish from the Pomacentridae family sequentially, namely at Station I (18 ind./m^3), Station 4 (17 ind./m^3), and Station 6 (17 ind./m^3) on shallow water. Meanwhile, in the reef slop area of the Pomacentridae family, sequentially, found the highest presence at Station 1 (12 ind./m^3) and Station 7 (9 ind./m^3). In other stations, the presence of the family Pomacentridae < 9 ind./m^3. Reef fish families were classified as low from 8 stations and two different depths, namely Ephippidae, Haemulidae, Pseudochromidae, and Serranidae, with the number of species present from all research stations < 2 fish species.

The study results at a depth of 3-4 meters (shallow water) at eight observation stations recorded 69 species of reef fish classified into 13 families. The dominance of the species found was Family Pomacentridae, Chaetodontidae, Labridae, Ephippidae and Lutjanidae. In detail, the order of the fish dominance according to reef fish species can be seen in Figure 4 and Table 2. The ten fish species that occupy the highest distinction were *Heniochus varius, Choerodon graphicus, Caesio cuning, Chlorurus troschelii, Abudefduf sordidus, Heniochus chrysostomus, Abudefduf sexfasciatus, Platax pinnatus, Stegastes aureus*, and *Acanthurus leucosternon*, respectively. The visual census observation of fish at a depth of 10-11 meters (reef slope) at eight stations recorded many 67 species of reef fish classified into 13 families. The dominant species found were seven families, including Acanthuridae, Chaetodontidae, Lutjanidae, Haemulidae, Labridae, Blenniidae, and Apogonidae. The ten fish species that occupy the highest dominance were *Caesio cuning, Chelmon rainfordi, Stegastes fasciolatus, Coradion muelleri, Pomadasys polytaenia, Chlorurus troschelii, Amblyglyphidodon plagiometopon, Aspidontus fuscus, Apogon endekataenia*, and *Balistpus undulatus*, respectively. In detail, the order of the fish dominance according to reef fish species at a depth of the reef slope can be seen in Figure 4 and Table 3.

Species classification from each fish family found that the highest number of species was at a depth of 3-4 meters, including station 1 (West Side), with 18 species from the family Pomacentridae, followed by station 4 (South toward East Side), and station 6 (North toward East Side) with 17 species. It also found a relatively high number of reef fish species

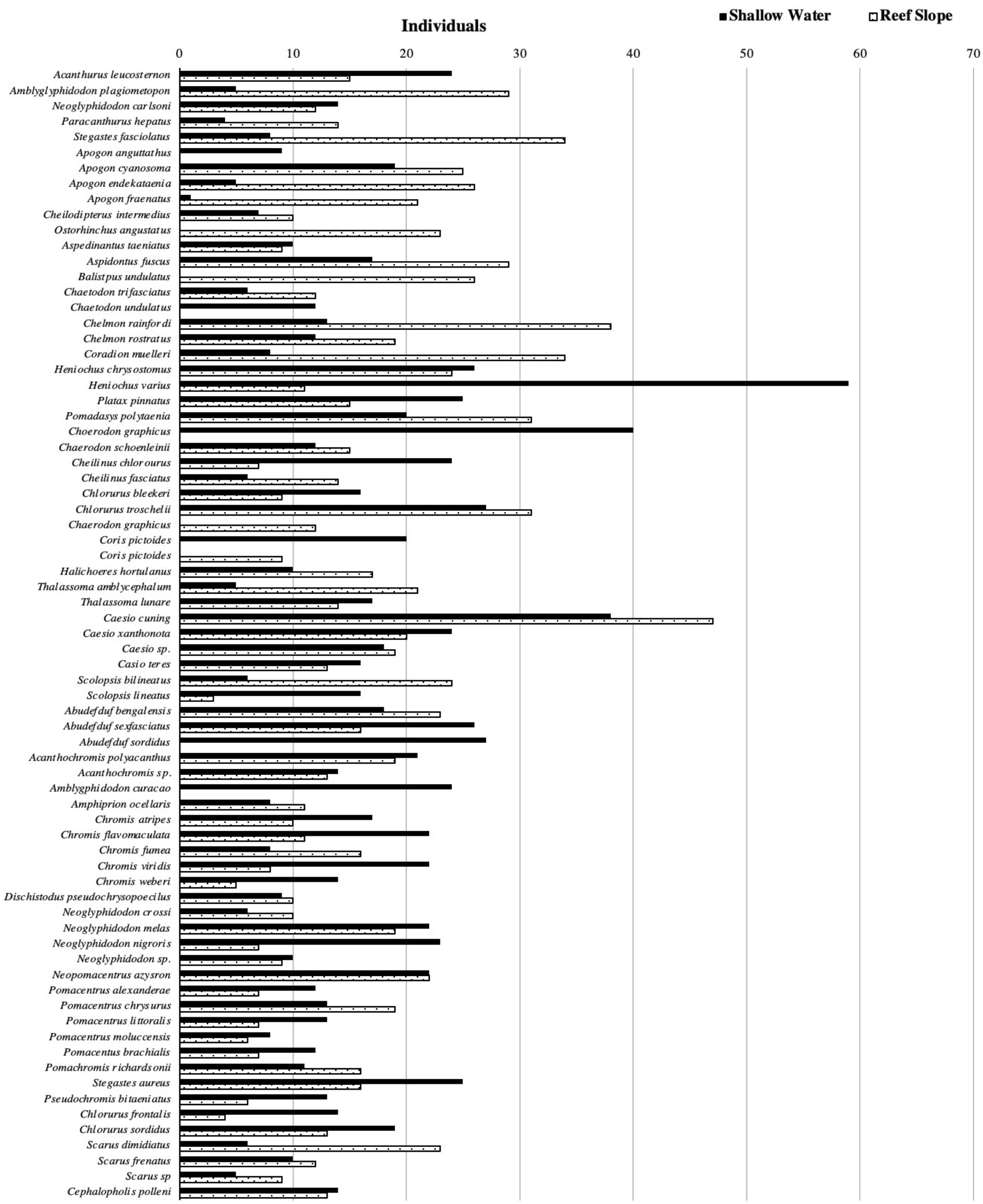

Figure 4. Reef fish species each depth waters (shallow water and reef slope)

at Station 3 (Central South Side) with 15 species. The results of the analysis of the number of each reef fish species at different depths are presented in Table 4.

The analysis of the presence of reef fish species for each family at eight research stations at a depth of 10-11 meters showed that the highest number found 16 species at station 8 (North toward West Side). Both shallow water depths and reef slopes were dominated by reef fish species from the family Pomacentridae.

Table 2. The dominance of coral reef fish species found in shallow water

Species	Family	Percentage (%)	Total individuals
Heniochus varius	Chaetodontidae	5.428	59
Choerodon graphicus	Labridae	3.680	40
Caesio cuning	Lutjanidae	3.496	38
Chlorurus troschelii	Labridae	2.484	27
Abudefduf sordidus	Pomacentridae	2.484	27
Heniochus chrysostomus	Chaetodontidae	2.392	26
Abudefduf sexfasciatus	Pomacentridae	2.392	26
Platax pinnatus	Ephippidae	2.300	25
Stegastes aureus	Pomacentridae	2.300	25
Acanthurus leucosternon	Acanthuridae	2.208	24
Cheilinus chlorourus	Labridae	2.208	24
Caesio xanthonota	Lutjanidae	2.208	24
Amblygphidodon curacao	Pomacentridae	2.208	24
Neoglyphidodon nigroris	Pomacentridae	2.116	23
Chromis flavomaculata	Pomacentridae	2.024	22
Chromis viridis	Pomacentridae	2.024	22
Neoglyphidodon melas	Pomacentridae	2.024	22
Neopomacentrus azysron	Pomacentridae	2.024	22
Acanthochromis polyacanthus	Pomacentridae	1.932	21
Pomadasys polytaenia	Haemulidae	1.840	20
Coris pictoides	Labridae	1.840	20
Apogon cyanosoma	Apogonidae	1.748	19
Chlorurus sordidus	Scaridae	1.748	19
Caesio sp.	Lutjanidae	1.656	18
Abudefduf bengalensis	Pomacentridae	1.656	18
Aspidontus fuscus	Blenniidae	1.564	17
Thalassoma lunare	Labridae	1.564	17
Chromis atripes	Pomacentridae	1.564	17
Chlorurus bleekeri	Labridae	1.472	16
Casio teres	Lutjanidae	1.472	16
Scolopsis lineatus	Nemipteridae	1.380	16
Neoglyphidodon carlsoni	Acanthuridae	1.288	14
Acanthochromis sp.	Pomacentridae	1.288	14
Chromis weberi	Pomacentridae	1.288	14
Chlorurus frontalis	Scaridae	1.288	14
Cephalopholis polleni	Serranidae	1.288	14
Chelmon rainfordi	Chaetodontidae	1.196	13
Pomacentrus chrysurus	Pomacentridae	1.196	13
Pomacentrus littoralis	Pomacentridae	1.196	13
Pseudochromis bitaeniatus	Pseudochromidae	1.196	13
Chaetodon undulatus	Chaetodontidae	1.104	12
Chelmon rostratus	Chaetodontidae	1.104	12
Chaerodon schoenleinii	Labridae	1.104	12
Pomacentrus alexanderae	Pomacentridae	1.104	12
Pomacentus brachialis	Pomacentridae	1.104	12
Pomachromis richardsonii	Pomacentridae	1.012	11
Aspedinantus taeniatus	Blenniidae	0.920	10
Halichoeres hortulanus	Labridae	0.920	10
Neoglyphidodon sp.	Pomacentridae	0.920	10
Scarus frenatus	Scaridae	0.920	10
Apogon anguttathus	Apogonidae	0.828	9
Dischistodus pseudochrysopoecilus	Pomacentridae	0.828	9
Stegastes fasciolatus	Acanthuridae	0.736	8
Coradion muelleri	Chaetodontidae	0.736	8
Amphiprion ocellaris	Pomacentridae	0.736	8
Chromis fumea	Pomacentridae	0.736	8
Pomacentrus moluccensis	Pomacentridae	0.736	8
Cheilodipterus intermedius	Apogonidae	0.644	7

Table 2. Continued

Species	Family	Percentage (%)	Total individuals
Scolopsis bilineatus	Nemipteridae	0.644	6
Chaetodon trifasciatus	Chaetodontidae	0.552	6
Cheilinus fasciatus	Labridae	0.552	6
Neoglyphidodon crossi	Pomacentridae	0.552	6
Scarus dimidiatus	Scaridae	0.552	6
Amblyglyphidodon plagiometopon	Acanthuridae	0.460	5
Apogon endekataenia	Apogonidae	0.460	5
Thalassoma amblycephalum	Labridae	0.460	5
Scarus sp.	Scaridae	0.460	5
Paracanthurus hepatus	Acanthuridae	0.368	4
Apogon fraenatus	Apogonidae	0.092	1

Table 3. The dominance of coral reef fish species found in reef slop

Species	Family	Percentage (%)	Total individuals
Caesio cuning	Lutjanidae	4.28	47
Chelmon rainfordi	Chaetodontidae	3.46	38
Stegastes fasciolatus	Acanthuridae	3.09	34
Coradion muelleri	Chaetodontidae	3.09	34
Pomadasys polytaenia	Haemulidae	2.82	31
Chlorurus troschelii	Labridae	2.82	31
Amblyglyphidodon plagiometopon	Acanthuridae	2.64	29
Aspidontus fuscus	Blenniidae	2.64	29
Apogon endekataenia	Apogonidae	2.37	26
Balistpus undulatus	Chaetodontidae	2.37	26
Apogon cyanosoma	Apogonidae	2.27	25
Heniochus chrysostomus	Chaetodontidae	2.18	24
Scolopsis bilineatus	Nemipteridae	2.18	24
Ostorhinchus angustatus	Apogonidae	2.09	23
Abudefduf bengalensis	Pomacentridae	2.09	23
Scarus dimidiatus	Scaridae	2.09	23
Neopomacentrus azysron	Pomacentridae	2.00	22
Apogon fraenatus	Apogonidae	1.91	21
Thalassoma amblycephalum	Labridae	1.91	21
Caesio xanthonata	Lutjanidae	1.82	20
Chelmon rostratus	Chaetodontidae	1.73	19
Caesio sp.	Lutjanidae	1.73	19
Acanthochromis polyacanthus	Pomacentridae	1.73	19
Neoglyphidodon melas	Pomacentridae	1.73	19
Pomacentrus chrysurus	Pomacentridae	1.73	19
Halichoeres hortulanus	Labridae	1.55	17
Abudefduf sexfasciatus	Pomacentridae	1.46	16
Chromis fumea	Pomacentridae	1.46	16
Pomachromis richardsonii	Pomacentridae	1.46	16
Stegastes aureus	Pomacentridae	1.46	16
Acanthurus leucostermon	Acanthuridae	1.36	15
Platax pinnatus	Ephippidae	1.36	15
Chaerodon schoenleinii	Labridae	1.36	15
Paracanthurus hepatus	Acanthuridae	1.27	14
Cheilinus fasciatus	Labridae	1.27	14
Thalassoma lunare	Labridae	1.27	14
Casio teres	Lutjanidae	1.18	13
Acanthochromis sp.	Pomacentridae	1.18	13
Chlorurus sordidus	Scaridae	1.18	13
Cephalopholis polleni	Serranidae	1.18	13
Neoglyphidodon carlsoni	Acanthuridae	1.09	12
Chaetodon trifasciatus	Chaetodontidae	1.09	12
Chaerodon graphicus	Labridae	1.09	12

Table 3. Continued

Species	Family	Percentage (%)	Total individuals
Scarus frenatus	Scaridae	1.09	12
Heniochus varius	Chaetodontidae	1.00	11
Amphiprion ocellaris	Pomacentridae	1.00	11
Chromis flavomaculata	Pomacentridae	1.00	11
Cheilodipterus intermedius	Apogonidae	0.91	10
Chromis artipes	Pomacentridae	0.91	10
Dischistodus pseudochrysopoecilus	Pomacentridae	0.91	10
Neoglyphidodon crossi	Pomacentridae	0.91	10
Scarus sp.	Scaridae	0.82	9
Aspedinantus taeniatus	Blenniidae	0.82	9
Chlorurus bleekeri	Labridae	0.82	9
Coris pictoides	Labridae	0.82	9
Neoglyphidodon nigroris	Pomacentridae	0.82	9
Chromis viridis	Pomacentridae	0.73	8
Cheilinus chlorourus	Labridae	0.64	7
Neoglyphidodon sp.	Pomacentridae	0.64	7
Pomacentrus alexanderae	Pomacentridae	0.64	7
Pomacentrus littoralis	Pomacentridae	0.64	7
Pomacentus brachialis	Pomacentridae	0.64	7
Pomacentrus moluccensis	Pomacentridae	0.55	6
Pseudochromis bitaeniatus	Pseudochromidae	0.55	6
Chromis weberi	Pomacentridae	0.45	5
Chlorurus frontalis	Scaridae	0.36	4
Scolopsis lineatus	Nemipteridae	0.27	3

Table 4. The number of each reef fish species per family at different depths

Family	St. 1		St. 2		St. 3		St. 4		St. 5		St. 6		St. 7		St. 8	
	SW	RS	SW	RS	SW	RS	SW	RS	SW	RS	SW	RS	SW	RS	SW	RS
Acanthuridae	2	3	2	2	3	2	2	3	2	3	1	2	-	-	5	-
Apogonidae	1	2	1	3	3	2	3	2	1	2	3	2	1	2	2	2
Blenniidae	1	1	1	1	1	1	1	2	1	-	-	-	-	-	2	2
Chaetodontidae	5	4	2	3	5	3	1	5	1	5	2	1	1	3	2	1
Ephippidae	1	-	-	1	1	-	1	1	-	-	1	1	-	-	1	1
Haemulidae	1	-	1	-	-	-	-	1	-	1	1	1	-	-	-	1
Labridae	7	2	7	2	4	5	5	6	2	3	5	4	1	5	6	3
Lutjanidae	4	2	2	2	4	2	4	1	1	4	3	-	2	3	1	1
Nemipteridae	2	-	1	-	-	1	1	1	-	-	-	1	-	1	1	-
Pomacentridae	18	12	9	8	15	8	17	7	7	8	17	7	10	9	14	16
Pseudochromidae	-	-	-	-	1	-	1	-	1	-	1	-	-	1	1	1
Scaridae	3	3	1	3	3	2	4	1	2	2	3	-	1	2	2	2
Serranidae	1	-	-	1	1	-	-	1	1	1	-	1	1	-	1	-

SW: shallow water, RS: reef slope

3.2. The Diversity Index of Reef Fish

The results of the diversity index analysis did not show a high level of diversity. The reef fish diversity in shallow water ranged from 1.19 to 1.60, while the reef slope ranged from 1.23 to 1.44 (see Table 5). At several study sites, the dominance of fish species decreased the diversity of reef fish at shallow water depths at Stations 2, 5 and 7. Meanwhile, other stations have low diversity on the reef slope at Stations 6 and 7.

Table 5. Value of diversity index (H') in research stations at two different depths

Stations	Locations	Shallow waters	Reef slope
St. 1	West side	1.60	1.38
St. 2	Kampung Barat port	1.35	1.34
St. 3	Central south side	1.53	1.34
St. 4	South toward east side	1.54	1.44
St. 5	East side	1.19	1.39
St. 6	North toward east side	1.51	1.23
St. 7	Central north side	1.15	1.37
St. 8	North toward west side	1.53	1.41

3.3. Similarity Index of Reef Fish Species in Two Different Stations

The results of the species similarity analysis at two different stations at a depth of 3-4 meters (see Figure 5) found three fish groups with relatively the same species similarity index, including a) groups at stations 1, 3, 4, 6, and 7; b) groups at stations 5 and 8, and groups at station 2. This grouping showed differences in the composition of reef fish species between groups at each station. It can be seen that the collection of group 1 covered stations 1, 3, 4, 6, and 7, where the four sides had steeper depth contours so that the possibility of fish species in this area was almost the same.

The results of the species similarity analysis at a depth of 10-11 meters at the similarity index value of >95% formed two groups of stations that had similarities in reef fish species (see Figure 6). The two groups were: a) the first group is station one and station 2, b) the second group is station three and station 7. The two groups showed a significant difference between the south side and the north side of Tunda Island, where station one and station two were in the same group because the location of station 2 was more likely to be close to the southern part of Tunda Island. Meanwhile, stations six and eight were areas on the north side of Tunda Island. They were four stations and considered the proximity of the composition of fish species at station one and station two because the area in both stations was a fishing area for the local community. The similarity of fish species composition at reef slope was more likely due to research stations.

3.4. Correlation of Reef Fish Abundance and Coral Health in Two Different Stations

The results of simple linear regression analyzed the abundance level of reef fish found on coral health at eight stations in the pale water, resulting in the equation: Y = 24.625 + 0.313. This equation illustrates that the value of 24.625 means that if the coral health is 0%, the abundance of reef fish in the waters of Pulau Tunda is 24.625 in./ha. The regression coefficient value for coral health was 0.313, indicating that if coral health increased by one unit, coral fish abundance would increase by 0.313 ind./ha. Meanwhile, the results of linear regression analysis on the depth of the reef slope resulted in the following equation: Y = 21.437 + 0.311. This similarity showed that if the coral health at a depth of the reef slope is 0%, the amount of coral fish found is 24.625 ind./ha. The regression coefficient's value in the reef slope depth was 0.311, and if the coral health is increased by 1%, this condition will increase the abundance of reef fish by 0.311 ind./ha.

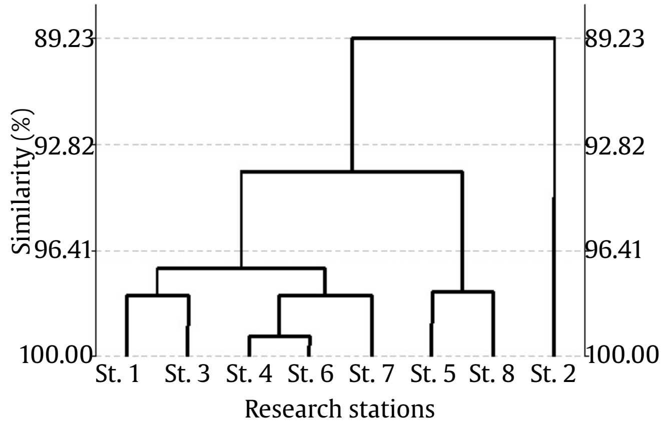

Figure 5. The similarity level of reef fish species in shallow water

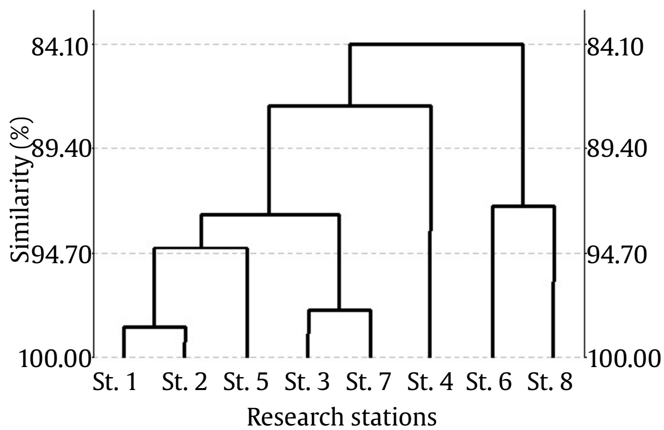

Figure 6. The similarity level of reef fish species on reef slope

4. Discussion

The composition of reef fish from 13 families of reef fish found in the Pomacentridae, Labridae, and Chaetodontidae families was quite dominant in their presence at a depth of 3-4 meters (shallow water) and a depth of 10-11 meters (reef slope) compared to fish species from other families. This condition follows the study by Edrus and Hadi (2020). From the day of their research, it established that the species composition of reef fish from the Pomacentridae (38 species), Labridae (37 species), and Chateodontidae (13 species) from families a total of 25 coral fish families had been found in the coastal waters of Kendari, Southeast Sulawesi. The primary living conditions strongly influence the difference in reef fish species composition in Tunda Island waters. Table 4 shows that the fish composition of the types of the three families that dominate can be found in stations. They can be found more at stations 5, 6, and 8. The study results by Mujiyanto *et al.* (2020) showed that the three pensions' health values fell into the moderate to good category. Differences in reef fish species composition from location to location are related to changes in habitat in general, and can be attributed to the type of niches being lost and the degradation of coral reef cover (Amesbury 1981; Edrus and Hadi 2020; Halford *et al.* 2004; Jones and Syms 1998).

Coker *et al.* (2013) explained that most fish (59%) recorded living in coral habitats were from five families: Pomacentridae, Gobiidae, Labridae, Apogonidae, and Chaetodontidae. Fishes within these families are generally small-bodied (150 mm) and live or shelter within the branches of live coral colonies throughout their lives. Some species also depend on coral for food (Cole *et al.* 2008). The study by Runtuboi *et al.* (2018) on Numfor Island, Biak Regency, also found observed from 4 sides of the island as stations that surround Numfor Island. The family Pomacentridae dominates up to 17%. Of the 36 families of reef fishes, the Pomacentridae species are the fish with the most abundance. They are the resident species with territorial behavior and rarely move far from food sources and shelter.

The composition of fish species from the family Pomacentridae is mainly found at 3-4 meters (shallow water). However, of the 25 species found at a depth of 3-4 meters, two species were not found at a depth of 10-11 meters (reef slope), which were *Abudefduf sordidus and Amblygphidodon curacao.* Carpenter and Niem (2001); Allen and Adrim (2003) explained that the genus of *Abudefduf* and *Amblyghipidodon* are groups of fish like crevices and branching corals Acropora, which provides shelter for Pomacentridae. In addition, these corals also offer food for Pomacentridae because they are a place for algae to attach and a place for invertebrates to live. Besides family Pomacentridae, the reef fish species commonly found on Tunda Island were from Labridae, with several ten species. This condition is in line with the study results by Hasbi *et al.* (2012) in Panjang Island, Jepara Regency, that the family Labridae (*Cina-cina fish*) is one of the reef fish groups which have the second-highest species diversity after the family Pomacentridae. The species of this fish family commonly found are *Chlorurus troschelii* and *Thalassoma lunare*.

The values generated from the two depths were in the range of values indicating that the reef fish community structure on Tunda Island was in the category of medium diversity, moderate distribution, and moderate community stability (Odum 1971). This pattern was in agreement with studies suggesting that diversity in many coral reef fish communities is similar to that expected by chance due to stochasticity in larval recruitment, assuming that habitat area and characteristics are relatively homogeneous (Caley and St. John 1996; Sale 1977; Sale and Williams 1982). When standardized by reef area, species density on small reefs was similar to or greater than species density on extensive reefs (Acosta and Robertson 2002). These patterns suggest that fish diversity on groups of smaller reefs was consistently high and similar to diversity on a single large reef of equivalent area.

The diversity of reef fish in terms of population statistics and the diversity of reef fish communities is related to the number of species present and the distribution pattern of each species population that compose the community (Sani *et al.* 2021). The index value of the diversity of coral fish on Tunda Island is classified as moderate diversity. It shows that only part of the coral reef ecosystem in the waters of Tunda Island is still in good condition. There is no evidence of extreme changes in the aquatic environment affecting reef fish communities (Jones *et al.* 2004 in Edrus and Hadi 2020).

They have found species similarity to the highest density of reef fish at shallow water depths at stations 4 and 6. This condition is believed to be due to the level of habitat percentage. Coral reef health at stations 4 and 6 is moderate to good. Based on the study results of Mujiyanto *et al.* (2020), coral health at station 4 was 42.12% (intermediate), and station 6 was 55.76% (good). Founded the following similarities with equal equivalence distances were stations 1 and 3 and 5 and 8. This condition was described with the similarity value in the reef slope, with the closest composition found at stations 3 and 7. The existence of habitats and environmental factors is believed to influence the differences and similarities in the interactions of reef fish in the foraging and shelter stages. Suppose it looks at the interaction pattern with the dominance of the composition of fish species on Tunda Island of Pomacentridae, Labridae, and Chaetodontidae. In that case, these conditions show an interaction pattern closely related to changes and requirements of coral reef habitat. However, other parameters such as water quality, temperature, and current also significantly influence the life pattern of reef fish. A large number of living corals will directly impact the food consumed by the fish of the Chaetodontidae family (Titaheluw *et al.* 2015). Fatimah *et al.* (2020) explain the relationship between Chaetodontidae and Pomacentridae fish with the coral genus in Bedukang waters, showing that Chaetodontidae and Pomacentridae fish such as the coral genus Acropora, Euphylia, Favites, Fungia, Galaxia, Goniopora, Lobophyllia, Pavona, Porites, Pstiammpora, Turbinpora, Platygyra and Symphyllia with a data accuracy of 70.80%.

The results of the analysis of the division table of the t-table were derived from the value α = 5% and the results of the 2-sided test (abundance of reef fish and coral reef health) with degrees of freedom (df) n-1 or 8 -1-1 = 6 resulted at t-table values on the shallow waters, and the reef slope is 2,477. Similarity index of the t value at shallow water depth is t count> t table (3,325>2,477) while at reef slope depth is t count> t table (3,200>2,477). The t value at both depths shows that the t value> t table means that coral health affects the abundance of reef fish, although the effect differs between the two depths. The difference in fish abundance in each depth waters area that the R-square at shallow waters is 0.47% (47.4%) and the abundance of reef fish at a depth of the reef slope, the abundance of coral fish are affected by the coral health of 0.631. (63.1%). The effect of a percentage value of more than 60% on coral reef health is in line with the study by Kusuma *et al.* (2020) that the effect of reef health on the abundance of coral fish on Enggano Island Bengkulu 0.615 (61.5%) was coral fish, affected by the health of corals. Similar results Rondonuwu *et al.* (2019) reports high fish stock found in a high coral cover in western Halmahera, west Maluku province, Indonesia, in contrast to a low fish stock found in a low coral cover.

In conclusion, the composition of reef fish species found in Tunda Island waters is 69 species in shallow water and 67 reef fish species at reef slope, consisting of 13 families. The reef fishes were dominated by Pomacentriade's family (37.76%), whereas Haemulidae (1.45%) was the lowest. The community structure is in a good category, both in the shallow water area at a depth of 3-4 meters and in the reef slope at 10-11 meters. The reef fish diversity in shallow water ranges from 1.19-1.60, while that at reef slope ranges from 1.23-1.44. The Fish Species Diversity Index values generated from the two depths in shallow water and reef slope show that the community structure conditions on Tunda Island are medium diversity or moderate distribution and reasonable community stability. The correlation analysis showed a positive correlation with "R-square" at 0.631 in shallow water and 0.615 at reef slope, and their determination coefficient was 63.1% and 61.5%. Simple regression linear analysis in shallow water was showed Y = 24.625 + 0.313, and reef slope was showed Y = 21.437 + 0.311. They indicated an increasing abundance of reef fish, each addition to the health of the coral reef ecosystem.

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References

Acosta, C.A., Robertsno, D.I.N., 2002. Diversity in coral reef fish communities: the effects of habitat patchiness revisited. *Mar. Ecol. Prog. Ser.* 227, 87-96. https://doi.org/10.3354/meps227087

Adrim, M., Harahap, S.A., Wibowo, K., 2012. Struktur komunitas ikan karang di perairan Kendari. *Ilmu Kelautan.* 17, 154-163. http://doi.org/10.14710/ik.ijms.17.3.154-163

Allen, G.R., 2000. *Marine fishes of South East Asia.* Kaleidoscope Print and Prepress Perth, Western Australia.

Allen, G.R., Steene, R., Human, P., Deloach, N., 2003. *Fish Reef Identification: Tropical Pasific.* New Word Publications, Singapore.

Allen, G.R., Adrim, M., 2003. Review article: coral reef fishes of Indonesia. *Zoological Studies.* 42, 1-72.

Amesbury, S.S., 1981. Effects of turbidity on shallow-water reef fish assemblages in Truk, Eastern Caroline Islands. *In: Proceedings of the Fourth International Coral Reef Symposium.* Manilla, Philippnes: Marine Sciences Center, Philippines University. pp. 155-159.

Beldade, R., Mills, S.C., Claudet, J., Côté, I.M., 2015. More coral, more fish? Contrasting snapshots from a remote Pacific atoll. *Peer. J.* 3, 745. https://doi.org/10.7717/peerj.745

Bell, J.D., Galzin, R., 1984. Influences of live coral cover on coral-reef fish communities. *Mar. Ecol. Prog. Ser.* 15, 265-274. https://doi.org/10.3354/meps015265

Bengen, D.G., 2013. Bioekologi terumbu karang status dan tantangan pengelolaan, in: Nikijuluw, V.P.H., Andrianto, L., Bengen, D.G., Sondita, M.F.A., Monintja, D., Siry, H.Y., Nainggolan, P., Susanto, H.A., Megawanto, R., Koropitan, A.F., Amin, I., Wiryawan, B., Kinseng, R.A., Zulbainarni, N., Suryawati, S.H., Purnomo, A.H., Djohani, Subijanto, J. (Eds.), *Coral Governance*. IPB Press, Bogor, pp. 62-74.

Caley, M.J., St John, J., 1996. Refuge availability structures assemblages of tropical reef fishes. *J. Anim. Ecology.* 65, 414-428. https://doi.org/10.2307/5777

Campbell, S.J., Kartawijaya, T., Yulianto, I., Prasetia, R., Clifton, J., 2013. Co-management approaches and incentives improve management effectiveness in the Karimunjawa National Park, Indonesia. *Marine Policy.* 41, 72-79. https://doi.org/10.1016/j.marpol.2012.12.022

Carpenter, K.E., Miclat, R.I., Albaladejo, W.D., Corpuz, V.T., 1981. The influence of substrate structure on the local abundance and diversity of Philippine reef fishes, in: Carpenter, K.E., Miclat, R.I., Albaladejo, V.D., Corpuz, V.T. (Eds.), *Prociding of the Fourth International Coral Reef Symposium*. Manila: Marine Science Center, University of The Philippines, pp. 497-502.

Carpenter, E.K., Niem, V.H., 2001. *FAO Species Identification Guide for Fishery Purposes. The Living Marine Resources of the Western Central Pacific*. Food and Agriculture Organization of The United Nations, Rome.

Chao, A., Chazdon, R.L., Colwell, R.K., Shen, T.J., 2006. Abundance-based similarity indices and their estimation when there are unseen species in samples. *Biometrics.* 62, 361-371. https://doi.org/10.1111/j.1541-0420.2005.00489.x

Chuang, C., 2012. Estimation of similarity indices via two-sample jackknife procedure. *J. Appl. Sci. Eng.* 15, 301-310.

Coker, D.J., Wilson, S.K., Pratchett, M.S., 2013. Importance of live coral habitat for reef fishes. *Rev. Fish Biol. Fisheries.* 24, 89-126. https://doi.org/10.1007/s11160-013-9319-5

Cole, A.J., Pratchett, M.S., Jones, G.P., 2008. Diversity and functional importance of coral-feeding fishes on tropical coral reefs. *Fish Fish.* 9, 286–307. https://doi.org/10.1111/j.1467-2979.2008.00290.x

Eduardo, L.N., Frédou, T., Lira, A.S., Ferreira, B.P., Bertrand, A., Ménard, F., Frédou, F.L., 2018. Identifying key habitat and spatial patterns of fish biodiversity in the tropical Brazilian continental shelf, *Continental Shelf Research.* 166, 108-118. https://doi.org/10.1016/j.csr.2018.07.002

Edrus, I.N., Hadi, T.A., 2020. Community structures of reef-fishes in the adjacent Kendari's reef waters, Southeast Sulawesi. *J. Lit. Perikan. Ind.* 26, 59-73. https://doi.org/10.15578/jppi.26.2.2020.59-73

English, S.A., Baker, V.J., Wilkinson, Clive, R., 1997. *Survey Manual for Tropical Marine Resources*, second ed. Australian Institute of Marine Science, Townsville.

Fahlevy, K., Prabowo, B., Santoso, P., Subhan, B., Madduppa, H., 2017. Penilaian struktur komunitas dan keterkaitan ikan terumbu pada terumbu karang di Pulau Tunda, Banten, in: Cahyo, F.d., Simbolon, S. (Eds.), *Prosiding Seminar Nasional Ekosistem Perairan Teluk Lada dan Pulau Tunda Tahun 2017.* Serang: Loka Pengelolaan Sumberdaya Pesisir dan Laut Serang. pp. 75-86.

Fatimah, F., Kurniawan, K., Syari, I. A. 2018. Abundance of chaetodontidae and pomacentridae fish in coral reefs ecosystem in Bedukang Waters in Bangka Regency. *Akuatik: Jurnal Sumberdaya Perairan.* 12, 76-83.

Halford, A., Cheal, A.J., Ryan, D.A.J., Williams, D.M., 2004. Resilience to large-scale disturbance in coral and fish assemblages on the great barrier reef. *Ecology*. 85, 1892-1905.

Hasbi, K.A.I., Rejeki, S., Munasik, M., 2012. Distribusi spasial ikan terumbu karang family labridae (wrasess) di perairan Pulau Panjang Jepara. *Jurnal Penelitian Kelautan*. 1, 1-15.

Hourigan, T.F., Tymothy, C., Tricas, Reese, E.S., 1988. Coral reef fishes as indicators of environmental stress in coral reefs. In: Dorothy FS, Kleppel GS (Eds.). *Marine Organisms as Indicators, Chapter: 6.* Springer-Verlag, New York, pp. 107-135. https://doi.org/10.1007/978-1-4612-3752-5_6

Hubalek, Z., 1982. Coefficients of association and similarity, based on binary (presence-absence) data: an evaluation. *Biological Reviews.* 57, 669-689. https://doi.org/10.1111/j.1469-185X.1982.tb00376.x

Jones, G.P., Syms, C., 1998. Disturbance, habitat structure and the ecology of fishes on coral reefs. *Aust. J. Ecol.* 23, 287-297. https://doi.org/10.1111/j.1442-9993.1998.tb00733.x

Jones, G.P., McCormick, M.I., Srinivasan, M., Eagle, J.V., 2004. Coral decline threatens fish biodiversity in marine reserves. *Proc. Natl. Acad. Sci. USA.* 101, 8251-8253. https://doi.org/10.1073/pnas.0401277101

Kuiter, R.H., 1992. *Tropical Reef Fishes of Western Pacific: Indonesia and Adjacent Waters.* PT. Gramedia Pustaka Utama, Jakarta.

Kuiter, R.H., Tonozuka, T., 2001. *Indonesian Reef Fishes Part 1.* Zoonetic, Australia.

Kusuma, A.B., Renta, P.P., Purnama, D., Negara, B.F.S.P., Claudea, C., Budiharto, T., Kholid, I., 2020. The correlation between coral cover and the associated reef fishes abundance in Enggano Island Bengkulu. *IOP Conf. Ser.: Earth Environ. Sci.* 593, 012034. https://doi.org/10.1088/1755-1315/593/1/012034

Lynch, M., 1990. The similarity index and DNA fingerprinting. *Mol. Biol. Evol.* 7, 478-484.

Magurran, A.E., 1988. *Ecological Diversity and Its Measurement.* Pricenton University Press, New Jersey. https://doi.org/10.1007/978-94-015-7358-0

Marshel, A., Mumby, P.J., 2015. The role of surgeonfish (Acanthuridae) in maintaining algal turf biomass on coral reef. *J. of Experimental Marine Biologi and Ecology.* 473, 152-160. http://doi.org/10.1016/j.jembe.2015.09.002

Mujiyanto, M., Garcia, M.G., Haryadi, J., Rahayu, R., Budikusuma, R.A., 2020. Health status of coral reef in Tunda Island, Banten Province, Indonesia. Indonesian. *Journal of Marine Sciences/Ilmu Kelautan.* 25, 66-74. https://doi.org/10.14710/ik.ijms.25.2.66-74

Mumby, P.J., Edwards, A.J., Arias, González, J.E., Lindeman, K.C., Blackwel, P.G., Gall, A., Gorczynska, M.I., Harborne, A.R., Pescod, C.L., Renken, H., Wabnitz, C.C.C., Llewellyn, G., 2004. Mangroves enhance the biomass of coral reef fish communities in the Caribbean. *Nature.* 427, 533-536. https://doi.org/10.1038/nature02286

Nachtsheim, C.J., Neter, J., Li, W., Kutner, M.H., 2004. Applied linear statistical models. *Journal of the Royal Statistical Society Series A General.* 5, 1396.

Nugraha, W.A., Mubarak, F., Husaini, E., Evendi, H., 2020. The correlation of coral reef cover and rugosity with coral reef fish density in East Java Waters. *JIPK.* 12, 131-139, https://doi.org/10.20473/jipk.v12i1.14356

Nybakken, J.W., 1982. Marine biology: an ecological approach, in: Eidman, H.M. (Eds.). Gramedia Pustaka Utama, Jakarta.

Odum, E.P., 1971. *Fundamentals of Ecology*, third ed. Sanders and Co, Philadelphia.

Palumbi, S.R., Sandifer, P.A., Allan, J.D., Beck, M.W., Fautin, D.G., Fogarty, M., Halpern, B.S., Incze, L.S., Leong, J., Norse, E., Stachowicz, Wall, D.H., 2009. Managing for ocean biodiversity to sustain marine ecosystem services. *Front. Ecol. Environ.* 7, 12-23. https://doi.org/10.1890/070135.

Paulangan, Y.P., Fahrudin, A., Sutrisno, D., Bengen, D.G., 2019. Diversity and similarity of reef profile form based on reef fishes and reef lifeform in Depapre Bay Jayapura, Papua Province, Indonesia. *Jurnal Ilmu dan Teknologi Kelautan Tropis.* 11, 249-262. http://doi.org/10.29244/jitkt.v11i1.24140

Plass-Johnson, J.G., Heiden, J.P., Abu, N., Lukman, M., Teichberg, M., 2016. Experimental analysis of the effects of consumer exclusion on recruitment and succession of a coral reef system along a water quality gradient in the Spermonde Archipelago, Indonesia. *Coral Reefs.* 35, 229-243.

Rahman, I.U., Hart, R., Afzal, A., Iqbal, Z., Ijaz, F., Abdallah, E.F., Ali, N., Khan, S.M., Alqarawi, A.A., Alsubeie, M.S., Bussmann, R.W., 2019. A new ethnobiological similarity index for the evaluation of novel use reports. *Applied Ecology and Environmental Research.* 17, 2765-2777. http://doi.org/10.15666/aeer/1702_27652777

Rondonuwu, A.B., Moningkey, R.D., Tombokan, L.J., 2019. The coral fish in the coastal areas, Likupang Kampung Ambong Village, East Likupang District, North Minahasa Regency. *Jurnal Ilmiah Platax.* 7, 90-97.

Runtuboi, F., Bawole, R., Goram, A., Wawiyai, Y., Wambrauw, M., Numberi, Y.Z., Gandegoai, A., Lamahoda, P.B.E., Rumakabes, S., Luturmase, M., Suparlan, Andoi, D.K., 2018. Inventory of coral fish and composition on important economic fish (case study in Kornasoren Village, Saribi and Syoribo) Numfor Island, Biak Numfor District. *Jurnal Pengelolaan Perikanan Tropis.* 2, 11-18.

Sale, P.F., 1977. Maintenance of high diversity in coral reef fish communities. *Am. Nat.* 111, 337-359.

Sale, P.F., Williams, D.Mc.B., 1982. Community structure of coral reef fishes: are patterns more than those expected by chance?. *Am. Nat.* 120, 121-127.

Sani, L.M.I., Benyamin, A., Husna A K, Arafat D, Subhan B, Sunuddin A, Cakasana N, Lestari D F, Madduppa H., 2021. A contrast pattern of reef fish species diversity and distribution using environmental DNA (eDNA) metabarcoding in longitudinal distance from Jakarta Bay. *J. Ilmu dan Teknologi Kelautan Tropis.* 13, 467-482. https://doi.org/10.29244/jitkt.v13i3.37971

Smith, C.L., 1978. Coral reef area and the contributionof reef to processes and resources of the world's oceans. *Nature.* 273, 225-226.

Suharti, R.S., Edrus, I.N., 2018. Kondisi ikan karang di perairan Tapanuli Tengah. *Oseanologi dan Limnologi di Indonesia.* 3, 105-121.

Titaheluw, S.S., Kamal, M.M., Yunizar, E. 2015. Hubungan antara ikan chaetodontidae dengan bentuk pertumbuhan karang. *Jurnal Ilmiah Agribisnis dan Perikanan.* 8, 77-86.

Toruan, L.N.L., Fonny, J.L., Risamasu, Paulus, C.A., 2018. Shannon-wiener diversity index on benthic foraminifers is less effective to approximating coral reef ecosystem quality in Kupang Bay. *In: Prosiding Seminar Nasional Kelautan dan Perikanan IV*. Kupang: Fakultas Kelautan dan Perikanan, Universitas Nusa Cendana. pp. 167-173.

Tuaputty, H., Leasa, M., Batlolona, J.R., 2018. Diversity and abundance of coral reef fish species in the coastal waters of salahutu sub-District, central Moluccas regency, Indonesia. *Eco. Env. and Cons.* 24, 1866-1874.

Wilhm, J.L., Dorris, T.C., 1966. Species diversity of benthic macroinvertebrates in a stream receiving domestic and oil refinery effluents. *American Midland Naturalist.* 76, 427-449. https://doi.org/10.2307/2423096

Wilhm, J.L., Dorris, T.C., 1968. Biological parameters for water quality criteria. *Bioscience.* 18, 477-481. https://doi.org/10.2307/1294272