Abundance and spatial distribution of reef fish based on coral lifeforms at Tidung Island, Seribu Islands, Jakarta Bay

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Abstract. Reef fish are coral reef ecosystem inhabitants, ecologically and economically important. The type of coral lifeform cover can affect the abundance of reef fish species. This study aims to examine the abundance and spatial distribution of reef fish based on coral lifeforms in Tidung Island, Indonesia. Data were collected in July 2018 in Tidung Island using visual census methods and photo transects. Coral fish were grouped into three categories, namely indicator fish, major fish, and target fish. The spatial distribution of reef fish based on coral lifeforms was analyzed using correspondence analysis. The results showed that the Pomacentridae family had the highest number of species (23) and an abundance of individuals of 0.52 individuals m^{-2} in the major fish group. The Scaridae family had the most species in the target fish group (6), but the highest abundance was in the Caesionidae family, with 0.08 individuals m^{-2}. The indicator fish group was dominated by the Chaetodontidae family, consisting of 6 species with an abundance of 0.01 individuals m^{-2}. The spatial distribution of reef fish based on coral lifeforms was divided in two groups. Group I consisted of the families Balistidae, Caesionidae, Haemulidae, Lutjanidae, Scarinidae, Holocentridae, and Nemipteridae, and were spread in the coral encrusting, coral massive, coral foliose, and coral submassive lifeforms. Group II consists of the fish families Serranidae, Labridae, Ostraciidae, and Phempherididae, and were spread in the lifeforms of Acropora encrusting and coral branching. The results of the study concluded that the Caesionidae family of the target fish group had the highest abundance and spread in the coral submassive lifeform, whereas the Serranidae family was mostly found in the coral branching lifeform.
Key Words: coral-fish association, fish distribution, Tidung Island.

Introduction. Coral reef ecosystems have many services, especially for supporting life, like providing habitats, spawning grounds, nurseries and feeding grounds for various marine biota (Dorenbosch et al 2005; Adrim et al 2006). Coral reef ecosystem inhabited by various marine biota indicate a good status of the ecosystem (McField & Kramer 2007).

One of the inhabiting biotas in the coral reef ecosystem are coral fish. Coral fish have a close relationship with coral reefs, in which the coral fish increase the economic value of coral reef ecosystems (Bengen 2013). Reef fish can be grouped into three categories, namely major fish group, target fish group, and indicator fish group, where the roles and the functions are related to coral reef ecosystems.

Indicator fish groups generally come from the Chaetodontidae family, and are usually bio-indicators of coral reef health (Suryanti et al 2011; Bawole et al 2014; Shidqi et al 2018). The target fish group is generally the main catch of the fishermen, because these fish can be consumed, having high economic value (Edrus & Abrar 2017). Major fish groups are groups of reef fish that generally play a role in the food chain of the coral reef ecosystems (Dewi et al 2018; Edrus & Abrar 2017). Moreover, the fish from this group are often found in coral reef ecosystems due to their diverse species and large

number of individuals (several species live in groups). The existence of reef fish becomes an indicator of life in coral reef ecosystems.

Tidung Island is one of the small islands in the Seribu Islands, Jakarta. Its economy is partially based on coral reef tourism. The condition of the coral reefs largely determines the distribution of reef fish. The decline in the diversity of coral reefs both because of natural and anthropogenic factors can indirectly affect the diversity of reef fish. This study aims to examine the abundance and spatial distribution of reef fish based on coral lifeforms in Tidung Island, Seribu Islands, Jakarta Bay.

Material and Method

Description of the study sites. This study was conducted at Tidung Island (including Tidung Besar and Tidung Kecil), Seribu Islands, Jakarta Bay (Figure 1). The research was conducted in July 2018.
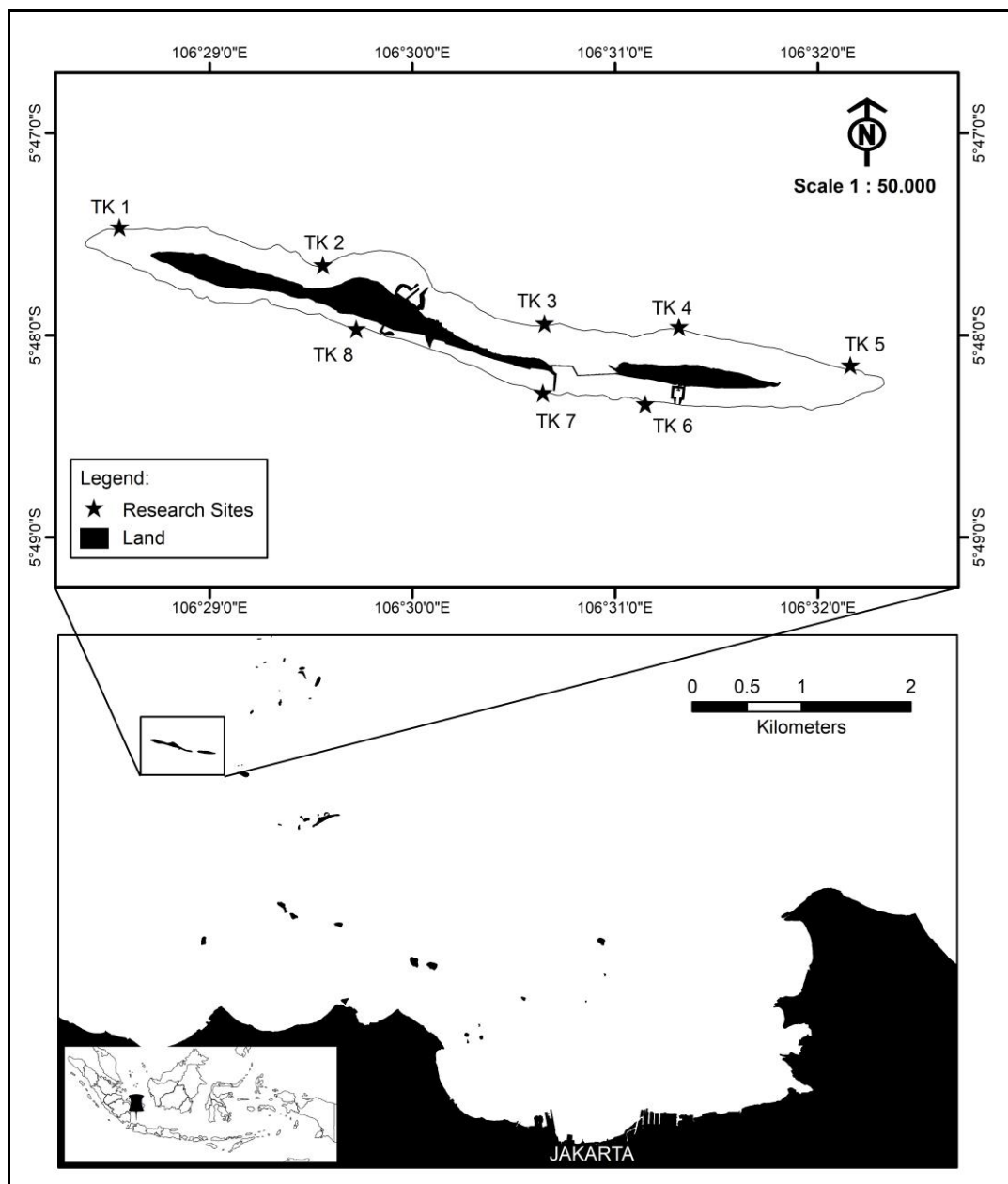

Figure 1. The coral reef fish site survey at Tidung Islands, Jakarta Bay.

Data collection. The data were collected from eight stations that had been determined based on their water characteristics. Reef fish data were collected using the Underwater Visual Census (UVC) and belt transect methods (Samoilys & Carlos 2000; RCI 2015; Wilson et al 2018). The area of reef fish observation is 250 m^2 (5x50 m) in each station. The fish were identified, and the abundance was calculated based on fish groups and fish species. At the same location, coral lifeform data was collected using the Underwater Transect Photo (UPT) method. A 50-meter line transect was placed in each station, and then images were taken on each meter on the left and right sides of the transect (Giyanto et al 2010; Giyanto 2013).

Statistical analysis. The reef fish were identified using materials by Allen et al (2003) and Fish-base (2018). The percentage of lifeform cover was calculated based on English et al (1997). The spatial distribution of reef fish based on coral lifeforms was analyzed using the correspondence analysis (CA).

Results and Discussion

Coral fish abundance. 20 families of reef fish were found in the coastal waters of Tidung Island. The fish were divided into three groups of reef fish, namely, indicator fish (1 family), target fish (7 families), and major fish (12 families). The total number of fish from all the families is 1875. Fish from the major fish group were found in every research station. The percentage of the appearance of fish species in all stations based on group categories is 73% for major fish, 20% for target fish, and 7% for indicator fish. Species from the major fish group were found in all stations, ranging from 15 to 27 species. On the other hand, indicator fish groups are sporadic in the observation stations. At least one species from the indicator fish group was found in every station.

Based on the abundance of individuals per station (250 m^2), reef fish are found in stations far from human activities. The highest abundance of reef fish species is in the major fish group. The major fish group contains fish that are have the highest number of species (Allen et al 2003; Taira et al 2017). The abundance of species and the most significant individual abundance in the major fish group is represented by the family Pomacentridae, with a total of 23 species and an abundance of individuals per family of 0.52 individuals m^{-2}. The major fish species found in all research locations include *Amblyglyphidodon curacao, Pomacentrus alexanderae, Pomacentrus amboinensis, Pomacentrus moluccensis, Cheilinus fasciatus,* and *Thalassoma lunare*. In the target fish group, the highest species abundance is in the Scaridae family (6 species), but the highest individual abundance per family is in the Caesinoidae (0.08 individuals m^{-2}). This shows that the target fish from the Caesinoidae family were found in each sampling location, with a large number of individuals. The species of the Caesionidae family found in all sampling locations is *Caesio cuning* (138 fish). The indicator fish group was dominated only by the Chaetodontidae family, with 6 species and an abundance of individuals per family of 0.01 individuals m^{-2} (Table 1).

Coral lifeform cover. Nine lifeforms of coral were identified in Tidung Island. Based on English et al (1997) coral lifeforms commonly found in Tidung Island are: coral encrusting (CE), coral foliose (CF), and coral massive (CM). Coral foliose has the highest percentage, with a cumulative cover percentage of 27.53%. A form that is rarely found in Tidung Island is the Acropora encrusting (ACE), with a cumulative cover percentage of 0.32% (Table 2).

Table 1

Number of species and abundance of reef fish in the Tidung Islands

Category	Family	Number of species	Abundance (individuals m^{-2})	Species	Number of fish/species	Abundance (individuals m^{-2})
Indicator	Chaetodontidae	6	0.018	*Chaetodon octofasciatus*	20	0.01
				Chaetodon vagabundus	2	0.001
				Chelmon rostratus	2	0.001
				Coradion altivelis	4	0.002
				Heniochus pleurotaenia	6	0.003
				Heniochus singularis	2	0.001
Target	Balistidae	1	0.0015	*Balistapus undulatus*	3	0.0015
	Caesionidae	3	0.086	*Caesio cuning*	138	0.069
				Caesio teres	13	0.0065
				Pterocaesio chrysozona	21	0.0105
	Haemulidae	2	0.0015	*Plectorhinchus chaetodonoides*	1	0.0005
				Plectorhinchus vittatus	2	0.001
	Lutjanidae	3	0.0065	*Lutjanus decussatus*	9	0.0045
				Lutjanus fulviflamma	2	0.001
				Lutjanus monostigma	2	0.001
	Scaridae	6	0.0345	*Chlorurus bleekeri*	18	0.009
				Chlorurus sordidus	8	0.004
				Scarus ghobban	5	0.0025
				Scarus niger	16	0.008
				Scarus quoyi	17	0.0085
				Scarus rivulatus	5	0.0025
	Serranidae	3	0.0065	*Cephalopholis boenak*	7	0.0035
				Cephalopholis microprion	4	0.002
				Plectropomus maculatus	2	0.001
	Siganidae	3	0.0095	*Siganus canaliculatus*	8	0.004
				Siganus tetrazona	4	0.002
				Siganus virgatus	7	0.0035
Major	Acanthuridae	2	0.004	*Acanthurus auranticavus*	3	0.0015
				Naso brevirostris	5	0.0025
	Apogonidae	2	0.007	*Apogon compressus*	14	0.007
	Holocentridae	1	0.0055	*Sargocentron rubrum*	11	0.0055
	Labridae	15	0.151	*Cheilinus chlorurus*	3	0.0015
				Cheilinus fasciatus	34	0.017
				Cheilinus oxyrhynchus	4	0.002
				Choerodon anchorago	13	0.0065
				Cirrhilabrus cyanopleura	110	0.055
				Epibulus insidiator	3	0.0015
				Halichoeres chloropterus	3	0.0015
				Halichoeres hortulanus	24	0.012
				Halichoeres leucurus	12	0.006

Table 1 (continuation)
Number of species and abundance of reef fish in the Tidung Islands

Category	Family	Number of species	Abundance (individuals m^{-2})	Species	Number of fish/species	Abundance (individuals m^{-2})
Major				*Halichoeres ornatissimus*	4	0.002
				Hemigymnus fasciatus	3	0.0015
				Hemigymnus melapterus	16	0.008
				Labroides dimidiatus	18	0.009
				Pteragogus guttatus	3	0.0015
				Thalassoma lunare	52	0.026
	Mullidae	1	0.0075	*Parupeneus barberinus*	15	0.0075
	Nemipteridae	7	0.0545	*Pentapodus trivittatus*	9	0.0045
				Scolopsis bilineatus	15	0.0075
				Scolopsis ciliate	15	0.0075
				Scolopsis lineata	10	0.005
				Scolopsis linieata	4	0.002
				Scolopsis margaritifer	56	0.028
	Ostraciidae	1	0.0005	*Ostracion cubicus*	1	0.0005
	Phempherididae	1	0.004	*Phempheris vanicolensis*	8	0.004
	Pomacanthidae	2	0.01	*Chaetodontoplus mesoleucus*	14	0.007
				Pomacanthus semicirculatus	6	0.003
	Pomacentridae	23	0.5235	*Abudefduf sexfasciatus*	99	0.0495
				Abudefduf vaigiensis	125	0.0625
				Amblyglyphidodon aureus	13	0.0065
				Amblyglyphidodon curacao	201	0.1005
				Amblyglyphidodon leucogaster	9	0.0045
				Amphiprion clarckii	2	0.001
				Dascyllus reticulatus	14	0.007
				Dascyllus trimaculatus	12	0.006
				Dischistodus perspicillatus	16	0.008
				Dischistodus prosopotaenia	47	0.0235
				Neoglyphidodon nigroris	32	0.016
				Neopomacentrus anabatoides	36	0.018
				Pomacentrus alexanderae	143	0.0715
				Pomacentrus amboinensis	86	0.043
				Pomacentrus bankanensis	8	0.004
				Pomacentrus burroughi	13	0.0065
				Pomacentrus lepidogenys	17	0.0085
				Pomacentrus littoralis	25	0.0125
				Pomacentrus moluccensis	111	0.0555
				Pomacentrus philippinus	15	0.0075
				Pomacentrus simsiang	8	0.004
				Pomacentrus smithi	9	0.0045
				Premnas biaculeatus	6	0.003

Table 1 (continuation)
Number of species and abundance of reef fish in the Tidung Islands

Category	Family	Number of species	Abundance (individuals m^{-2})	Species	Number of fish/species	Abundance (individuals m^{-2})
Major	Ptereleotrididae	1	0.002	*Ptereleotris evides*	4	0.002
	Zanclidae	1	0.004	*Zanclus cornotus*	8	0.004

Table 2

Percentage of coral lifeform cover in each study site

Life Form	Station (% cover)								Total (%)	Cumulated total (%)
	TK1	TK2	TK3	TK4	TK5	TK6	TK7	TK8		
ACB	0.47	0.60	0.0	2.73	2.00	0.80	0.33	0.00	6.93	3.67
ACT	0.13	0.13	0.0	1.27	0.13	0.00	1.00	0.47	3.13	1.66
ACE	0.60	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.60	0.32
CB	5.93	28.07	1.7	0.07	0.87	0.00	0.00	0.00	36.60	19.40
CE	7.07	7.47	2.2	2.47	0.60	1.67	3.20	0.80	25.47	13.50
CF	3.73	34.07	0.4	8.07	0.87	3.73	0.07	1.00	51.93	27.53
CM	19.93	0.07	11.9	1.33	2.40	0.67	7.20	2.80	46.33	24.56
CMR	1.87	0.20	0.4	1.33	0.00	3.33	1.00	0.53	8.67	4.59
CS	2.13	4.20	0.0	0.00	0.00	0.07	1.07	1.53	9.00	4.77
Hard Coral	41.87	74.80	16.60	17.27	6.87	10.27	13.87	7.13	188.67	100

Note: ABC - Acropora branching; ACT - Acropora Tabulate; ACE - Acropora Encrusting; CB - Coral Branching; CE - Coral Encrusting; CF - Coral Foliose; CM - Coral Massive; CMR - Coral Mushroom; CS - Coral Subassive.

Spatial distribution of coral fish based on coral lifeforms. The results of the correspondence analysis showed that there were two main groups of associations between the coral lifeform and the reef fish family, centered on Axis 1 (F1) and Axis 2 (F2), with a total diversity of 77.17% (Figure 2). Group I consists of the families Balistidae, Caesionidae, Haemulidae, Lutjanidae, Scaridae, Holocentridae, and Nemipteridae, closely associated with CE, CM, CF, and coral submassive (CS) lifeforms. Group II was closely associated with the families Serranidae, Labridae, Ostraciidae, and Phempheriididae in the ACE and coral branching (CB) lifeforms. The families Acanthuridae and Ptereleotrididae are also associated with ACE and CB growth. The families Mullidae, Pomacanthidae, and Zanclidae are associated with CE, CF, CM, and coral mushroom (CMR) lifeforms.
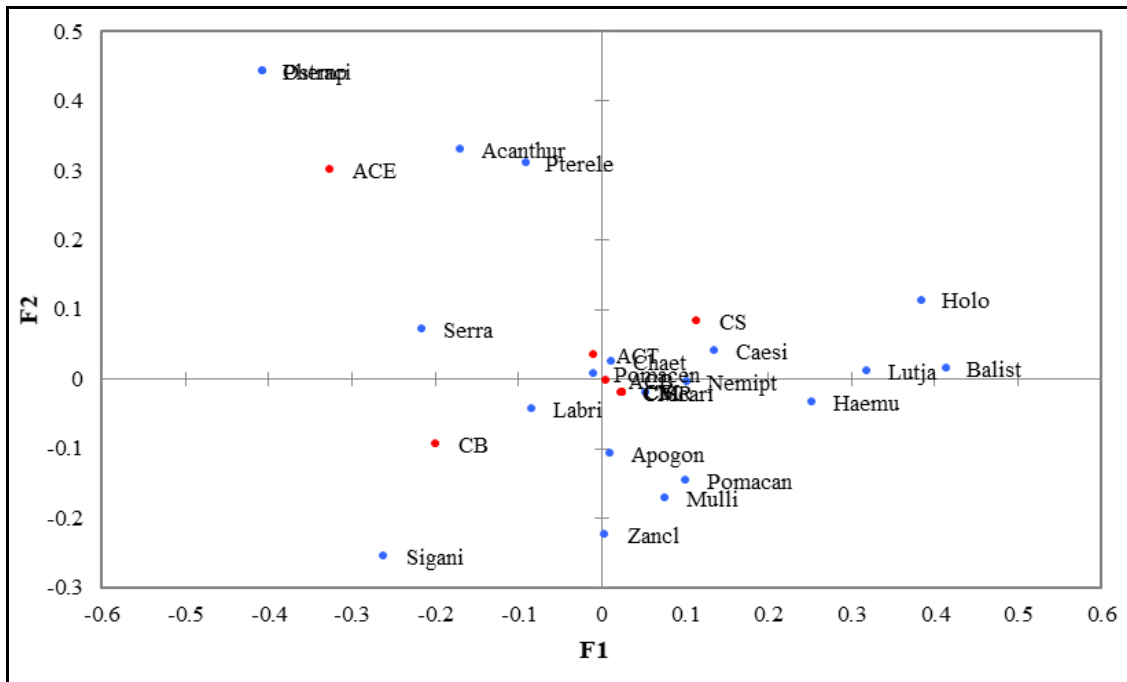
Figure 2. Association of reef fish families on coral lifeforms. ABC - Acropora branching; ACT - Acropora Tabulate; ACE - Acropora Encrusting; CB - Coral Branching; CE - Coral Encrusting; CF - Coral Foliose; CM - Coral Massive; CMR - Coral Mushroom; CS - Coral Submassive; Chaet - Chaetodontidae; Balist - Balistidae; Caesi - Caesionidae; Haemu - Haemulidae; Lutja - Lutjanidae; Scari - Scaridae; Serra - Serranidae; Sigani - Siganidae; Acanthur - Acanthuridae; Apogon - Apogonidae; Holo - Holocentridae; Labri - Labridae; Mulli - Mullidae; Nemipt - Nemipteridae; Ostraci - Ostraciidae; Phemp - Phempheriididae; Pomacan - Pomacanthidae; Pomacen - Pomacentridae; Pterele - Ptereleotrididae; Zancl - Zanclidae.

The existence of reef fish follows the diversity of coral reefs as an area for shelter, foraging, and breeding (Dorenbosch et al 2005; Adrim et al 2006). Reef fish have a preference for living or even foraging on certain coral lifeforms. There are two significant groups of reef fish associations with coral lifeforms on Tidung Island. The abundance and diversity of reef fish groups will be different in each location due to different environmental conditions. Generally, shallow waters will be dominated by major fish groups, these fish groups being generally inhabitants of the coral reef ecosystem (Dewi et al 2018).

The major fish group, as inhabitants of coral reef ecosystems, are generally diurnal fish. Major fish groups active during the day include the Achanturidae, Labridae, Pomacanthidae, Pomacentridae, Blennidae, and Tetraonidae families. Besides indicator fish groups such as the Chaetodontidae family and target fish groups with the Balistidae

and Lutjanidae families, some species of the Scaridae and Serranidae families are also diurnal fish (Dhahiyat et al 2003).

The existence of several species of fish or specific groups of fish on a particular form of coral reef is a result of the inseparable relationships between fish and coral reefs. The correspondence analysis results are presented in Figure 2. Based on the squared cosines value, Caesinoiddae family has the highest value in the target fish group, in CS lifeform in Group I. The Serranidae family has a high value in the CB lifeform from Group II. Thus, the results show that the Caesionidae family spreads in the CS lifeform, and the Serranidae family spreads in the CB lifeform.

One species of reef fish can be associated with several lifeforms, or it can also be a lifeform associated with several species or groups of reef fish. The Labridae family dominates the CM lifeform according to Madduppa et al (2012), by 27%. However, the correspondence analysis on the Labridae family shows that it is associated with the ACE and CB lifeforms. Labridae family is a group of major fish that is often found in coral reef ecosystems in addition to the Pomacentridae family. 15 species from the Labridae family were obserced, with an abundance per family of 0.15 individuals m^{-2}. *Cirrhilabrus cyanopleura* and *Thallassoma lunare* are species of the Labridae family that are often found in Tidung Island. These species are ornamental fish and are permanent residents of the coral reef ecosystem.

ACE is the coral lifeform in Tidung Island with the smallest cover percentage of 0.6%. According to the results of the correspondence analysis, the ACE lifeform is grouped with the Serranidae family of the target fish group, and the Labridae family of the major fish group (5 individuals from the Serranidae family and 53 individuals from the Labridae family. Serranidae and Labridae are associated in a small proportion with the ACE lifeform, so it can be hypothesized that if the percentage of ACE is greater, then the abundance of fish of the Serranidae and Labridae families is likely to increase.

The CE, CF, and CM are lifeforms commonly found in Tidung Island. The target fish group of the Lutjanidae family, according to Syaputra et al (2009), prefers to live in a coral environment with branching growth due higher food availability. However, other results from the research show that Lutjanidae also like coral reefs with massive form, where the percentage of hard corals is 34.86%. Massive forms are found in almost all stations on Tidung Island.

Conclusions. This study identified 20 families of reef fish. The fish are divided in the major fish group (55 species), target fish group (21 species), and indicator fish group (6 species). The major fish group has the highest species richness and abundance of individuals within the family Pomacentridae, with a total of 23 species and an abundance of individuals of 0.52 individuals m^{-2}. The abundance of species from the target fish group is highest in the Scaridae family, with 6 species, but the abundance of individuals per family is in the Caesinoidae family, with 0.08 individuals m^{-2}. The indicator fish group is dominated by the Chaetodontidae family, with a total of 6 species and an individual abundance of 0.01 individuals m^{-2}.

Spatial distribution of reef fish based on the coral lifeform is divided into two large groups. Group I consists of the families of Balistidae, Caesionidae, Haemulidae, Lutjanidae, Scarinidae, Holocentridae, Nemipteridae and is closely associated with the coral encrusting, coral massive, coral folios, and coral submassive lifeforms, which are spread in almost all research stations. Group II closely associated with the Acropora encrusting and coral branching lifeforms consists of the Serranidae, Labridae, Ostraciidae, and Phempherididae families. The Caesionidae family of the target fish group has the highest abundance and spreads on the coral submassive lifeform, while the Serranidae family was found on the coral branching lifeform.

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