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MORALITY BEFORE KNOWLEDGE

The Distribution of Coral Reef Fish Biodiversity on Bontosua Island, Spermonde Archipelago, South Sulawesi Province

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ABSTRACT

Background: Bontosua Island, located in the Spermonde Archipelago, is one of the strategic and historical islands in the region. The island plays a vital role in ecosystem conservation efforts by the local community, who are committed to preserving their natural environment. With dynamic ecosystem conditions, it is essential to understand the seabed cover and biodiversity on the island to support more effective conservation efforts. **Methods:** This study was conducted from March to September 2022 to mark the seabed cover of Bontosua Island and understand the relationships between coral reef fish species and the ecosystem. The method used was a stationary visual census, followed by descriptive analysis and one-way ANOVA to assess the biodiversity and diversity of coral reefs. **Findings:** The results showed a total of 1,306 coral reef fish from 9 families with 63 species identified, including the families Chaetodontidae, Serranidae, Lutjanidae, Haemulidae, Lethrinidae, Scaridae, Acanthuridae, and Siganidae. The families with the highest citations were Scaridae, Acanthuridae, and Siganidae. The highest coral reef fish were found in the north, west, and southwest of the island, where live coral areas are more dominant. **Conclusion:** This study shows that Bontosua Island has significant coral reef diversity, and certain areas, such as the north and southwest sides, have higher reported fish. These findings indicate the importance of these areas in conservation efforts. **Novelty/Originality of this article:** This study provides a comprehensive picture of the seabed cover and coral reef fish diversity in Bontosua Island, which has yet to be widely discussed in previous studies. These findings provide a scientific basis for more targeted conservation strategies and help improve understanding of the dynamics of coral reef ecosystems in the Spermonde Islands.

KEYWORDS: biodiversity; fish; reef; stationary visual census.

1. Introduction

Coral reef fish, especially those traded in the Live Reef Fish Trade (LRFT), are significant marine resources for fishermen. There are 12 target fish species in this trade, including 11 grouper species (Family Serranidae) and 1 Napoleon wrasse species (Family Labridae), which hold high economic value. According to LIPI (2017), these target fish originate from four main families: Serranidae, Lutjanidae, Lethrinidae, and Haemulidae, with each family comprising 35, 21, 12, and 8 species, respectively. Ecologically, these fish

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play crucial roles as carnivores or predators in maintaining ecosystem balance by regulating populations of lower trophic level fish. Economically, they are primary targets for fishermen. However, environmentally unfriendly fishing methods such as the use of bombs, cyanide, and overfishing have significant impacts on ecosystem sustainability. Hence, the presence or absence of these species can serve as important indicators of anthropogenic disturbances (LIPI, 2017).

Coral reef fish live in association with coral reefs, serving as sites for foraging, sheltering, spawning, and nurturing. Based on their biology and behavior, coral reef fish can be used to assess habitat suitability. Due to their mobility, fish can relocate to find more suitable habitats, making the presence or absence of certain species in a coral reef area an accurate indicator of ecosystem conditions (LIPI, 2018).

Coral reef fish are associated with coral reefs and are found in various microhabitats. Habitat variation, including sandy areas, bays, crevices, algae beds, and sponge areas, is a primary factor in the high diversity of coral reef fish species, explaining the abundance of coral reef fish in these ecosystems (Rani et al., 2019). Spatial complexity in coral reefs provides refuge for fauna. Several studies indicate that physical substrate complexity in coral reefs is closely related to fish diversity, though not necessarily to their abundance. Biological substrate characteristics, such as species richness and/or live coral cover, do not influence fish diversity and abundance. However, other research suggests that fish characteristics are closely linked to live coral cover (Rani et al., 2019).

For monitoring purposes, several indicators are established by identifying target coral reef fish groups and indicator fish (*Chaetodontidae*) to facilitate temporal and spatial comparisons. Target coral reef fish are economically important for regional management, but their exploitation can threaten coral reefs (English et al., 1997; Giyanto et al., 2014). Understanding the structure of these fish communities can be used as an indicator of coral reef recovery from damage, such as the discovery of abundant herbivorous fish groups. Conversely, the abundance of carnivorous and planktivorous fish groups indicates intensive use of coral reefs. Indicator fish abundance serves as a relative measure to assess overall coral reef health (Indrawati, 2020).

The number and size of coral reefs can indicate overall coral reef health. Coral reef communities can show signs of natural oceanographic processes such as upwelling and disturbances caused by overfishing, pollution, and climate change impacts (Indrawati, 2020). Therefore, monitoring and analyzing coral reef biodiversity and community structure is essential to understanding ecosystem conditions and environmental impacts. Bontosua Island in the Spermonde Archipelago can be a representative of the region. Therefore, this study aims to obtain in-depth information on the biodiversity and community structure of coral reef fish around Bontosua Island, Pangkajene Regency, and the surrounding islands. This study is expected to provide valuable insights into conservation strategies and management of marine resources in the area.

2. Methods

This research was conducted from February to March 2022 and involved a series of comprehensive stages. The process began with initial preparation, including methodological planning and team coordination to ensure that all aspects of the research were carried out correctly. After preparation, initial observations were carried out to evaluate field conditions, which included an initial survey to determine the most representative and strategic location for the research station on Bontosua Island.

In the next stage, field data was collected using the stationary visual census method, which included direct observation and detailed recording of seabed cover and coral reef fish communities. The data collected included various parameters such as the type and number of fish, size, and species distribution in various locations. This process aims to obtain an accurate picture of the condition of the coral reef ecosystem around Bontosua Island. After data collection, data processing was carried out involving descriptive analysis to identify species diversity and distribution of coral reef fish. The final stage of the research included

preparing results and reports, which presented key findings and interpretation of the analysis results. This study focuses on Bontosua Island, located in Liukang Tupabbiring Selatan District, Pangkajene and Kepulauan Regency. This location was chosen because of its ecological significance and as a representation of the coral reef ecosystem in the area, as well as its relevance in ecosystem conservation efforts carried out by the local community.

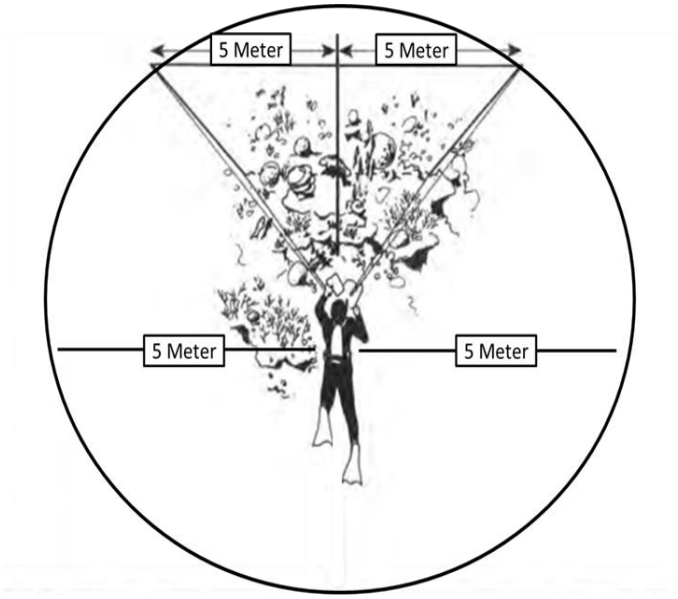

Fig. 1 Fish stationery sensus
(Bohnsack et al, 1986)

The fish data collection on Pulau Bontosua utilized the Stationary Visual Census method with snorkeling and scuba gear for observations within the coral reef ecosystem. Observations involved remaining stationary within a 10-meter radius along transect lines, conducting a 10-minute stationary observation per replicate to monitor fish species presence within the designated area and estimate fish sizes (English, 1997). The fish observation scheme is detailed in Figure 1.

Meanwhile, this study uses a descriptive analysis approach to display and present the diversity of coral fish species identified on Bontosua Island. The analysis begins with collecting data on various coralfish species and reporting them found in the research area. This data is then analyzed to determine the number of fish species and report each species at different locations around the island. To identify significant differences in species diversity and reporting of fish, a one-way ANOVA analysis was conducted, which allows comparisons between variations in the number of species and reporting at various research stations. The results of this analysis are presented in the form of graphs that visually illustrate the distribution and variation of coral fish species. Data processing and analysis were conducted using SPSS software, which provides the statistical tools for in-depth data analysis and interpretation.

3. Results and Discussion

Based on Table 1, it is evident that the most frequently encountered family is Siganidae, with a total of 722 individuals. Following this, the species Scaridae comprises 186 individuals, and Chaetodontidae comprises 158 individuals. The least represented species is Haemulidae, with only 1 fish observed. The distribution of fish numbers shows the highest abundance in live coral areas, with 611 individuals and 50 fish species. The lowest fish distribution is found in coral rubble cover, with 185 individuals, and the lowest species diversity is observed in mixed cover, with 25 fish species. Additionally, the most abundant species identified is Chlorurus bleekeri, with 168 individuals.

Table 1. Distribution of fish community species richness with benthic cover

Spesies	LC	DCA	Rb	Mix	Total
Haemulidae					
Plectorhinchus chrysotaenia			+		1
Lethrinidae					
Lethrinus harak	+			+	8
Lutjanidae					
Lutjanus carponotatus	+	+		+	28
Lutjanus decussatus	+	+	+	+	12
Lutjanus ehrengergii	+				23
Lutjanus fulvus	+				5
Lutjanus monostigma	+				15
Lutjanus ruselli	+		+		2
Serranidae					
Cephalopholis argus	+	+		+	6
Cephalopholis boenack		+		+	3
Cephalopholis microprion				+	2
Epinephelus merra	+				10
Plectropomus maculatus	+		+		4
Chaetodontidae					
Chaetodon adiergastos	+	+			3
Chaetodon auriga	+			+	9
Chaetodon baronessa	+	+			5
Chaetodon falcula	+				2
Chaetodon kleinii	+	+			10
Chaetodon lineolatus		+			2
Chaetodon lunulatus	+		+		8
Chaetodon melannotus	+		+	+	4
Chaetodon octofasciatus	+	+	+	+	98
Chaetodon rafflesii		+			2
Chaetodon speculum	+				3
Chaetodon trifascialis			+		2
Chaetodon vagabundus	+	+			9
Chaetodon rostratus	+				1
Acanthuridae					
Acanthurus auranticafus	+		+	+	24
Acanthurus auranticavus	+	+	+		14
Acanthurus lineatus	+		+	+	20
Acanthurus pyroferus		+			1
Acanthurus thompsoni			+		2
Acanthurus triostegus		+			12
Acanthurus xanthopterus			+		5
Ctenochaetus striatus	+	+	+	+	39
Zebrasoma veliferum		+	+		4
Scaridae					
Cetoscarus bicolor	+				2
Chlorurus spilurus	+				3
Chlorurus bleekeri	+	+	+	+	158
Chlorurus bowersi	+	+	+	+	15
Chlorurus microrhinos	+				2
Chlorurus spilurus	+	+	+	+	110
Scarus dimidiatus	+	+	+	+	61
Scarus flavipectoralis	+	+	+	+	95
Scarus ghobban	+	+	+	+	93
Scarus hypselopterus	+			+	6
Scarus niger	+	+	+	+	12
Scarus psittacus	+			+	4
Scarus quoyi	+	+	+		19
Scarus rivulatus	+	+	+	+	47
Scarus scaber	+	+			88

Scarus schlegeli		+			2
Scarus spinus	+		+		4
Scarus tricolor		+			1
Siganidae					
Siganus canaliculatus	+	+			19
Siganus corallinus	+	+			4
Siganus doliatus	+	+			3
Siganus guttatus	+	+			4
Siganus puellus	+		+		4
Siganus punctatissimus	+	+		+	5
Siganus punctatus	+				2
Siganus virgatus	+	+	+	+	116
Siganus vulpinus	+	+	+	+	29
Total	611	324	185	186	1306
Total Species	50	35	28	25	63

Note: LC=Live Coral; DCA=Dead Coral With Algae; Rb-Rubble; Mix=LC, DCA, RB and Sand

Based on Figure 2, major fish dominate the fish abundance on Pulau Bontosua, followed by target fish and indicator fish. In the mixed bottom substrate (live coral, coral rubble, dead coral with algae, and sand), herbivorous fish have the highest percentage at 88%, followed by target fish at 10%, and the least are indicator fish at 2%. Meanwhile, in live coral substrate areas, major fish dominate with 83%, followed by target fish at 15%, and indicator fish at 2%. In dead coral with algae substrate, herbivorous fish significantly dominate with 94%, followed by target fish at 4%, and indicator fish at 2%. On the coral rubble substrate, major fish remain dominant at 93%, followed by target fish at 4%, and indicator fish at 3%. According to Munandar et al. (2019) in their research on Rubiah Island and Iboih Waters, the relationship between bottom cover and fish composition is not significant in mixed bottom cover because fish will divide themselves according to their physiological habits and feeding grounds.

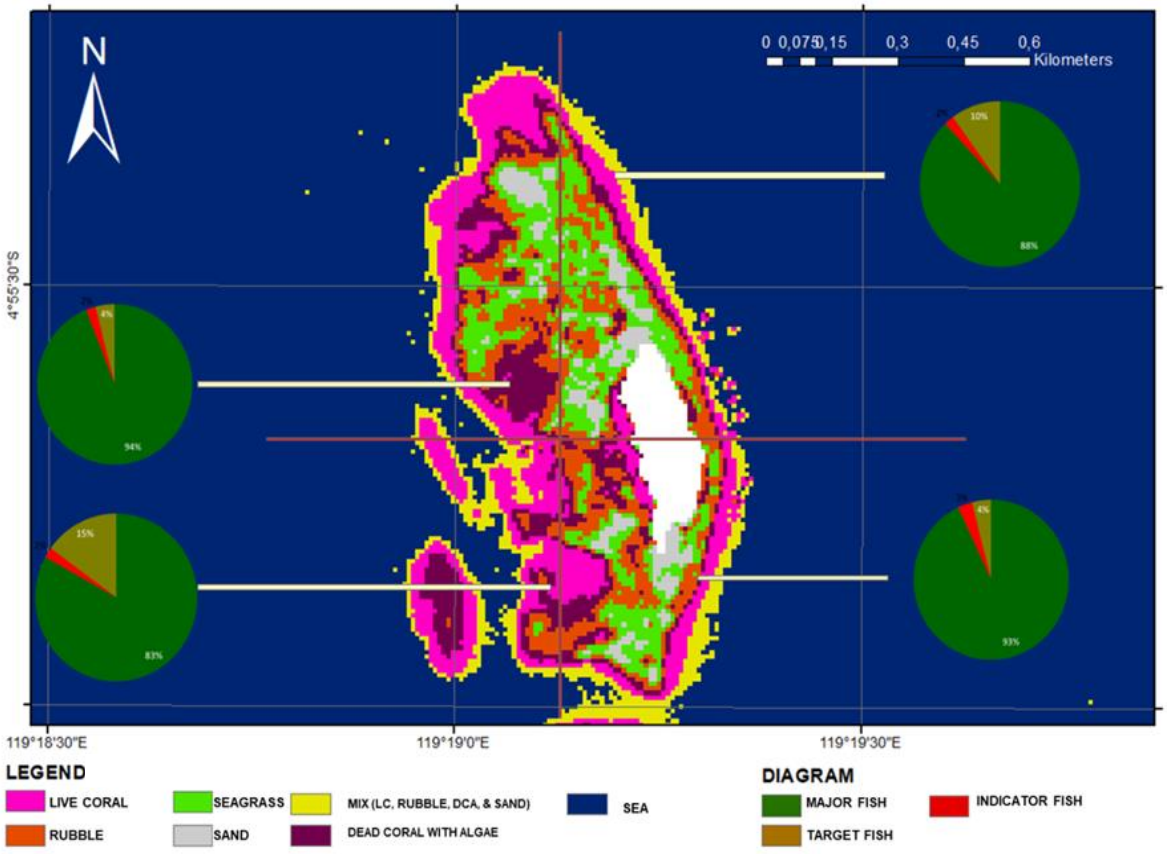

Fig. 2 Map of reef fish distribution

Table 2 shows that among the eight types of fish mentioned based on family, the most commonly found family is Scaridae, which is dominant in the North region with a percentage of 64.4%. Meanwhile, the Haemulidae family is most commonly found in the Southwest region, with a percentage of 0.4%, and the Chaetodontidae family is most commonly found in the West region, with 16.1%. In addition, the Lethrinidae family is dominant in the West region with a percentage of 1.4%; the Acanthuridae family is most often found in the West (hope) region with a percentage of 24.4%, and the Lutjanidae family is dominant in the North region with a percentage of 14.9%. The Serranidae family is often found in the East region, with a percentage of 8%, while the Siganidae family is dominant in the South region, with 35.5%.

Table 2. Distribution of fish based on cardinal directions

Family	Percentage based on wind direction (%)			
	North	East	South	West
Haemulidae	0.00	0.00	0.00	0.13
Lethrinidae	0.25	0.00	0.00	0.90
Lutjanidae	14.85	10.00	0.00	2.58
Serranidae	3.47	8.00	0.00	0.90
Chaetodontidae	6.44	4.00	11.84	15.59
Acanthuridae	4.95	24.00	2.63	11.21
Scaridae	64.36	46.00	50.00	51.68
Siganidae	5.69	8.00	35.53	17.01
Total	100	100	100	100

Based on Figure 3, the composition of coral fish by family on Bontosua Island shows that the Scaridae family is the most commonly found, accounting for 52.28% of the total coral fish population. In contrast, the family with the least representation is Haemulidae, making up only 0.08%. This significant difference in composition highlights the dominance of Scaridae in the coral reef ecosystem of the island. The low presence of Haemulidae may indicate specific habitat preferences or environmental factors limiting their population in this area.

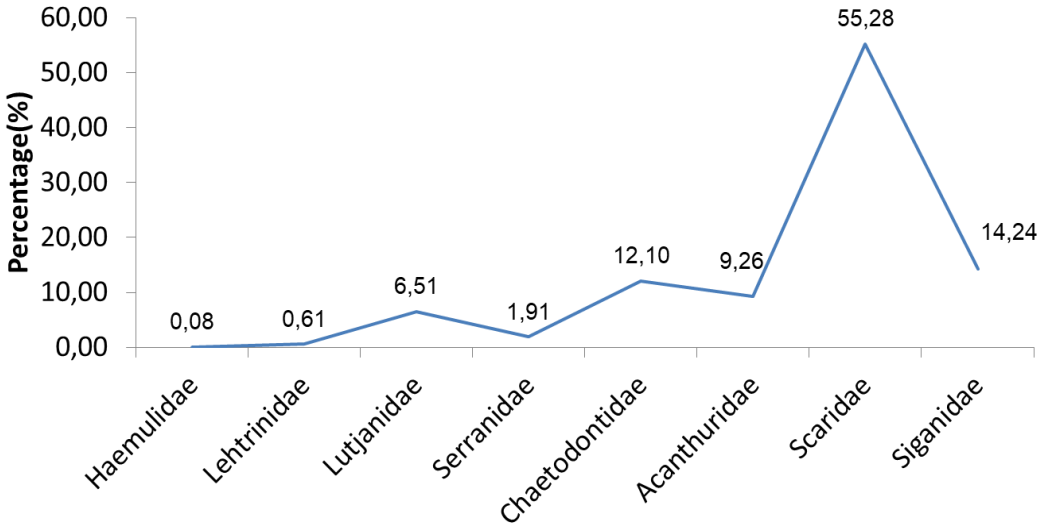

Fig. 3 Percentage composition of fish by family

Based on the graph in Figure 4, it is evident that carnivorous reef fish are most frequently found in the northern area, comprising 18% of the total population. Meanwhile, indicator reef fish are predominantly found in the western area, where they make up 16%. Major reef fish species are most commonly concentrated in the southern area, accounting for a significant 88% of the population. This distribution suggests distinct ecological

patterns, with different species favoring specific areas of the reef, possibly due to varying environmental conditions or food availability.

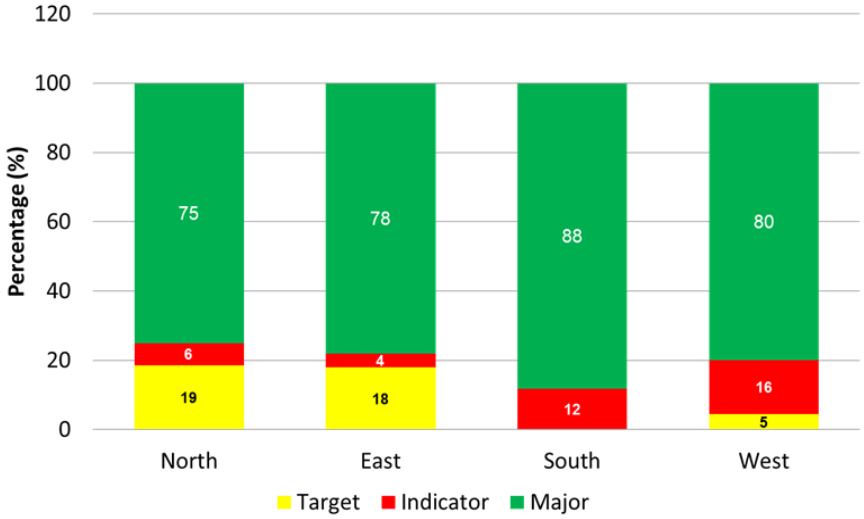

Fig. 4 Percentage of reef fish based on distribution by cardinal directions

Based on Figure 5, coral fish compositions on different substrates in the waters around Pulau Bontosua reveal that coral fish are only found on mixed substrate, live coral, rubble, and dead coral with algae (DCA) stations. There were no coral fish found on sandy and seagrass substrates. The compositions are predominantly major coral fish at 87-93%, followed by target coral fish ranging from 4-15% across each substrate composition. Indicator coral fish showed low dominance, ranging from 1-3% across the substrates.

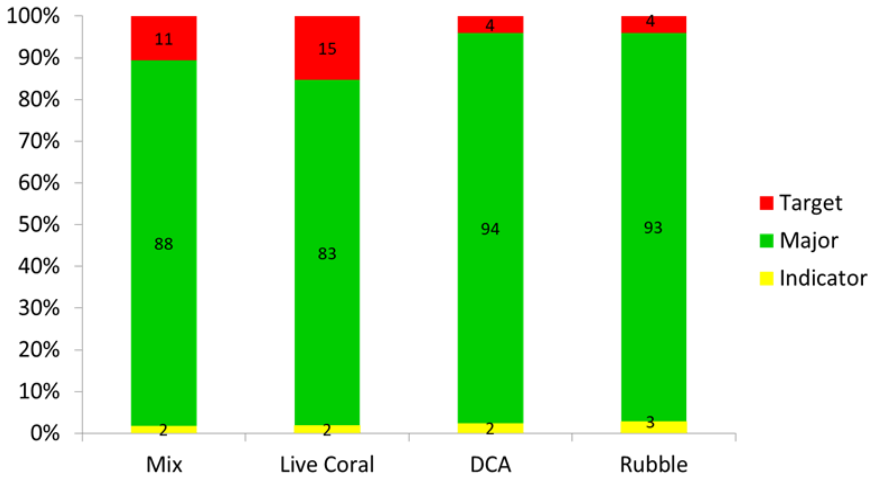

Fig. 5 Composition of reef fish based on benthic cover

Based on the fish density data on various substrate covers shown in Figure 6, it appears that the highest fish density is found in the live coral and dead coral areas with algae, reaching 0.23 ind/m^2 and 0.2 ind/m^2, respectively. This indicates that these two substrate covers provide relatively more favourable habitats for coral reef fish. The coral rubble area also showed significant fish density with a value of 0.18 ind/m^2. To ensure the validity of the data, a homogeneity test was carried out and produced a probability value of 0.23 or P> 0.05, indicating that the data were homogeneous; in other words, there was no significant difference between the data groups. Furthermore, an analysis of variance (ANOVA) was carried out to test the differences in fish density between the various coral reef substrate covers. The analysis of variance showed an F value of 2.69 with a probability value of 0.379, indicating no significant difference in fish density between the various substrate covers observed. This indicates that although there is variation in fish density

across different types of substrate cover, the differences are not large enough to be considered statistically significant.

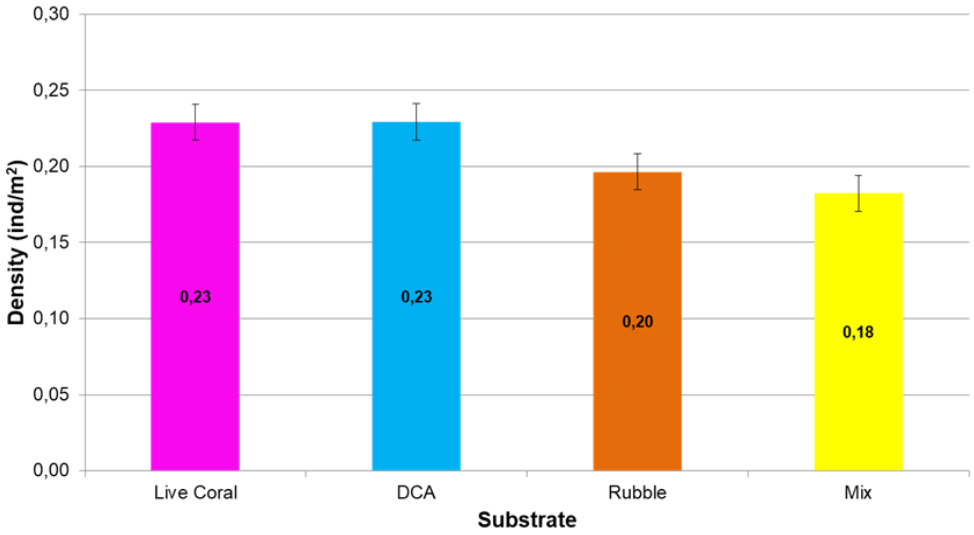

Fig. 6 Fish density in each water bottom cover

The number of observed fish on Bontosua Island (Figure 2) totaled 1306 individuals, distributed among 8 families, namely Chaetodontidae, Lutjanidae, Haemulidae, Lethrinidae, Serranidae, Scaridae, Acanthuridae, and Siganidae, across the north, east, south, and west. The distribution of fish community species numbers with substrate coverage (Table 1) shows that the Siganidae family comprises 722 individuals, predominantly found on live coral (302 individuals). In total, 63 species were recorded, amounting to 1306 fish individuals. Herbivorous fish compositions are highest, with Haemulidae and Lethrinidae families each contributing 1%. Research by Faricha (2020) in the Kei Small Islands suggests that the low presence of target fish (*Haemulidae and Lethrinidae*) indicates high fishing pressure in an area. The Major family accounts for 1187 individuals, while Indicator fish represent the lowest presence with 158 individuals. According to Zamdial et al. (2022), coral loss and coral reef habitat damage significantly affect coral fish populations. Species highly dependent on coral, such as indicator fish from the Chaetodontidae family, which feed on coral, are most vulnerable to these impacts. Based on the LIPI classification (2017), herbivorous fish groups like Scaridae, Acanthuridae, and Siganidae play crucial roles in ecosystems as plant eaters. These species aid coral regeneration by controlling macroalgae and turf algae growth and providing essential substrates for new coral growth. Besides their ecological roles, these species are also primary targets for fishing activities, similar to carnivorous fish groups.

The distribution and number of fish species (Table 1) indicate the highest dominance by Major fish (79%), both in terms of quantity and species richness. Riansyah et al. (2018) state that Chaetodontidae can be used as indicators of coral reef ecosystem health due to their preference for specific substrate types reflecting reef conditions. The indicator fish in this group belong to the Chaetodontidae family, where most species feed on coral polyps. Therefore, the distribution, abundance, and diversity of these fish species in coral reef ecosystems can be used as bio-indicators to monitor ecosystem health. According to LIPI (2017), the Chaetodontidae fish group plays a crucial role in indicating the condition of coral reef ecosystems in various regions of Indonesia. Menawhile, the composition of fish species on Bontosua Island based on cardinal directions (Table 2) shows that Scaridae dominates with percentages ranging from 50% to 70% on each underwater substrate, while Haemulidae has the lowest percentage at 1%. Meanwhile, target fish (Haemulidae) have high economic value and are the main target of fishing activities by fishermen, thus serving as an important parameter in evaluating fishing levels in a location.

The percentage composition of fish species by family (Figure 3) is dominated by Scaridae with a percentage of 55% of the total recorded fish. This is consistent with Sale (2002), who identified Scaridae as the dominant family with the highest diversity in the Indo-Pacific region. On the other hand, Haemulidae only contributes 0.08% of the total recorded fish, with distinct characteristics and behaviors as stated by Setiawan (2010) in Putra (2015), often found in coral caves and active at night.

The distribution of coral fish based on cardinal directions (Figure 4) shows the highest distribution in the west (37%), which is a marine protected area (MPA), and in the north (31%), which is a well-preserved fishing area. Meanwhile, the lowest distribution occurs in the east (4%), often affected by dock and ship activities. Research by Zamdial et al. (2022) shows that intensive fishing activities by fishermen can lead to a decrease in coral fish density in several locations.

The composition of fish structure based on substrate distribution (Figure 5) shows varying percentage compositions for each type of substrate. Major fish dominate with percentages of 75% to 88%, followed by Indicator fish at 4% to 16%, while carnivorous or target fish have the lowest percentages ranging from 4% to 15%. The fish community composition is dominated by Major fish (82-93%), most commonly found on dead coral with algae and coral rubble substrates. Target fish (4-15%) are predominantly found on live coral, while Indicator fish (1-3%) dominate on coral rubble. Paulungan (2019) suggests that the presence of Indicator fish serves as a key indicator of ecosystem fertility, while the presence of Major fish indicates abundant algae growth in the ecosystem. The presence of target or carnivorous fish also indicates fishing pressure by fishermen in the area.

Fish density in each type of underwater substrate (Figure 6) shows a density of 0.23 ind/m^2 for live coral and dead coral with algae, with the lowest density in mixed substrates at 0.18 ind/m^2. Rani (2020) suggests that the complexity or spatial structure provided by branching coral significantly influences the richness and abundance of coral fish. This complexity allows various species to use habitats simultaneously. Habitat destruction resulting in a significant reduction in branching coral cover can reduce species numbers and fish density.

The results of variation and homogeneity analysis are similar to Rani et al. (2019) in Liukang Loe Island. This study reveals that coral reef conditions, particularly live coral cover, significantly correlate with fish abundance but do not significantly correlate with fish species richness. This lack of significance is due to ecosystem diversity in several coastal locations that affect fish species richness. Variation analysis shows that groups with higher coral cover have more coral fish and significantly differ from groups with lower live coral cover. Healthy coral reefs provide excellent protection for various biota and are important sites for fish spawning and larval development. High-quality food in healthy coral reefs also positively affects fish diversity. Coral reefs create an ideal environment for fish spawning and larval development, ultimately influencing the structure of adult fish communities. This is in line with the theory of island biogeography which states that in coral reef habitats, fish richness tends to decrease with increasing distance from the main coral reef as a 'source', while coral fish richness increases with increasing area of local coral reefs. At a broader spatial scale, declines in coral reef species richness have also been shown to occur with increasing distance from sources of diversity (Mora et al., 2003).

4. Conclusions

This study successfully identified a total of 1,306 individuals of reef fish from nine different families, covering 63 species from the families Chaetodontidae, Serranidae, Lutjanidae, Haemulidae, Lethrinidae, Scaridae, Acanthuridae, and Siganidae. The results of the disclosure found that the highest fish reporting was in the families Scaridae, Acanthuridae, and Siganidae, collectively known as Major species. The highest fish descriptions were observed in the north, west, and southwest of the island, where live coral areas are more dominant. Although there were variations in fish densities across different

substrate covers, the analysis showed that fish densities did not show significant differences between the types of coral reef substrates observed. This implies that although different types of substrates may affect fish, the differences are not large enough to be considered statistically significant.

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Author Contribution
All authors contributed to the conception of the study, conducted the research activities, analyzed the data, drafted the manuscript, and took responsibility for the final content. The authors approved the final version and agreed to be accountable for all aspects of the work.

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Data Availability Statement
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Conflicts of Interest
The authors declare no conflict of interest.

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