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by Unstain N.w.j. Rembet 4

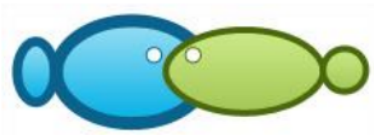
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1 Reef fishes community performances in Olele marine tourism area, Bone Bolango Regency, Indonesia

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Abstract. Olele waters, as one of the leading diving location for tourism in the Gorontalo Province, lack information about its resources. The reef fish diversity, which is a major tourist attraction, has never been evaluated. This search was conducted to determine the structure of reef fish communities in Olele waters. The survey was carried out using a visual census method in two zones: away from the settlement and close to the settlement. A total of 26,466 individual reef fishes were found during the study, with a density of 8.82 ind m⁻². The Pomacentridae family has the highest number of species among all stations. Shannon diversity (H'), Shannon similarity (E), and Simpson dominance (C) index indicate that the Olele waters belong to a biodiversity category characterized by a high diversity, stable community conditions, and a low dominance.

Key Words: composition, density, ecology index, community structure, Gorontalo.

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Introduction. Fishes are one of the most notorious faunal groups on coral reefs. They include a variety of functional groups that play fundamental, diverse, and complex ecological roles (Sale 2002). The coral fish community is one of the biological resources that compose the complexity of the coral reef ecosystem. The existence of fish in these areas makes them one of the most productive ecosystems on the planet (Maduppa 2013). Over 4,000 species of fish inhabit coral reefs, representing over 25% of all marine fish species (Spalding et al 2001). These fish play critical ecological roles in the reef ecosystem, serve as vital food resources for coastal populations, and provide one of the chief attractions offered by reefs to tourism (Sale 2015).

The Indo-Pacific region has the highest coral reef richness and fish diversity. It is estimated that there are around 3,000 species of reef fish in this region (Nybakkken 1993). In the Indo-Pacific region there are 2,057 species of reef fishes included in 113 families and spread from Western to Eastern Indonesian waters (Allen & Adrim 2003). Indonesia is one of the most eminent countries for endemic reef fishes, in terms of absolute numbers, boasting with the highest overall species diversity (Allen 2000). The reefs and its fishes are also essential components of the eco-tourism, reefs with high fish diversity can attract local and foreign tourists (Balisco & Dolorosa 2019). Several areas in Indonesia that have the potential of the richness and magnificence of the sea developed marine tourism activities (Supriharyono 2000).

Olele waters, one of the primary locations for marine tourism in Gorontalo Province, are located 20 km from the center of Gorontalo City, being the gateway to the waters of Tomini Bay. The Wallacea II expedition found 140 species of coral reefs in the waters of Olele, which enabled this zone to become one of the famous diving sites in Gorontalo, also labeled "the hidden paradise" by tourists visiting this area. This undeniable marine tourism potential is equally due to the presence of both coral reefs

and reef fishes making the stunning coral reef ecosystem. However, information about the ecological conditions, especially the description of the reef fish community, has never been gathered and synthesized, though the existence of reef fish is crucial for the coral reef ecosystem and for the sustainability of marine tourism in the Olele Waters. The study of coral fish ecology is an indicator of the level of coral reefs health and illustrates that the coral reefs ecosystem is functioning optimally (Fatimah et al 2018; Hourigan et al 1988). This research was conducted to provide an overview of the coral fish community in the Olele waters, as reference information for a sustainable coastal and marine conservation and tourism management.

Material and Method

Study site. This research was conducted in the Olele waters, Bone Bolango Regency, Gorontalo Province. The location for the research is divided into two zones, representing areas with and without community settlements, respectively. In each zone, there are three observation stations. In general, the entire station chosen is snorkeling and diving tourist spots. The research location is provided in Figure 1.

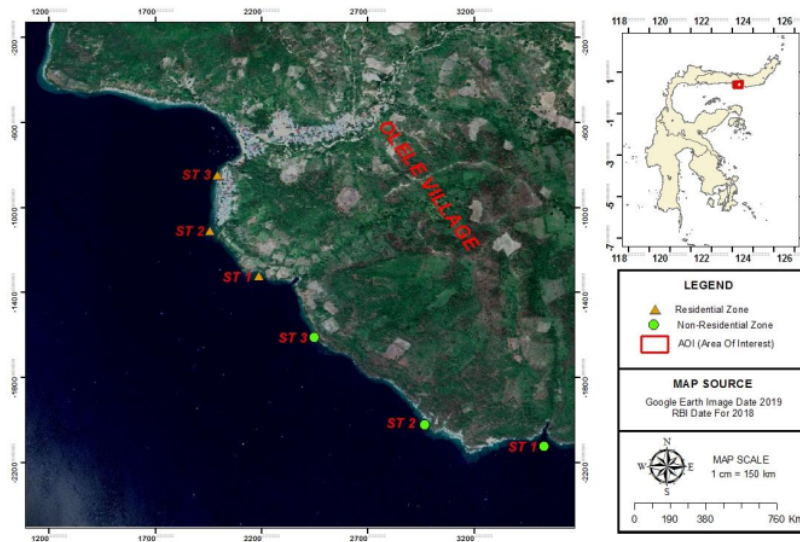


Figure 1. Research location.

Reef fish survey. Observation of reef fish was carried out using an underwater visual census (UVC) on the line intercept transect (LIT), which was placed along 50 m at a depth of 3 and 10 m at each research station. The observation method consists in swimming at a constant speed along the 50 m line transect in 3 and 10 m depth and counting fish encountered within 2.5 meters on each side and 5 meters above the transect, according to English et al (1997) and Hill & Wilkinson (2004). The total area of the survey is 250 m² for each station. Identification was based on Allen & Steene (2007), Kuitert & Toru (2001), and fish base (www.fishbase.org). Illustration of reef fish observations can be seen in Figure 2.

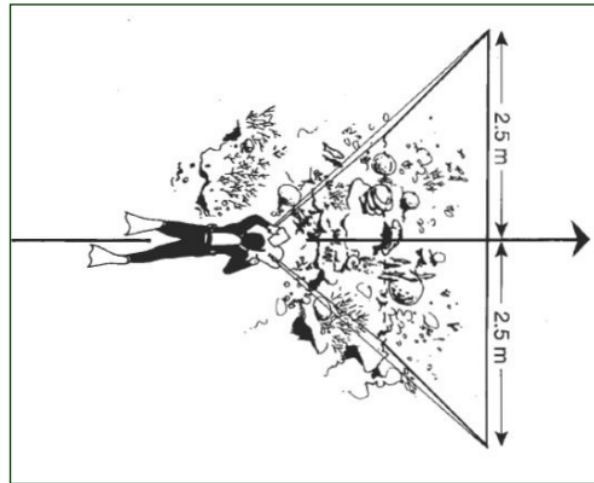


Figure 2. Illustration of visual census survey using transects (English et al 1997).

The status of the reef fish communities was obtained through the species composition analysis, the Shannon diversity index (H'), the evenness index (E), and the Simpson dominance index (C), based on Odum (1993).

Results and Discussion. The number of reef fish recorded from the results of the visual census in Olele waters is 174 species, belonging to 78 genera and 32 families with a total of 26,466 individuals. A total of 14,239 reef fish individuals are included in 114 species, 63 genera, and 29 families found in distant zones from the settlement. A total of 12,227 individual reef fishes belonging to 131 species, 65 genera, and 26 families were found in the settlement area (Table 1). The number of species found varies for each station, ranging from 57 species (Station 1 non-residential zone) to 85 species (Station 1 residential zone).

Table 1
Summary of reef fish composition found during the study

Zone/Station	Number of transect	Family	Genera	Species	Individual	D (ind m^{-2})
Non-residential zone						
Station 1	2	15	39	57	3,699	7.40
Station 2	2	20	45	67	4,443	8.89
Station 3	2	22	43	62	6,097	12.19
Sub-total	6	29	63	114	14,239	9.49
Residential zone						
Station 1	2	22	52	85	4,128	8.26
Station 2	2	21	47	74	5,467	10.93
Station 3	2	15	39	64	2,632	5.26
Sub-total	6	26	65	131	12,227	8.15
Total	12	32	78	174	26,466	8.82

Table 1 informs that the population of individual reef fish is larger in non-residential zone. However, in terms of species and genera diversity, the residential zone is richer. A large number of species found in the residential zone, which is a snorkeling tour spot, where visitors mostly interact directly with biota, for instance by feeding reef fish, one of the most popular tourist attractions in the world. However, this phenomenon is a significant

cause of altering patterns of distribution, abundance, behavior, and structure of fish communities in coral reef areas (Giglio et al 2015; Paula et al 2018).

The number of fish species found in these study sites was higher than at similar research locations in other regions in Indonesia. For example, Adrim et al (2012) recorded 111 reef fish species in Kendari waters. Utomo et al (2013) recorded 20 reef fish species in Legon Boyo Karimunjawa National Park, and Runtuboi et al (2018) found 116 reef fish species on the Numfor Island, Biak Numfor. The 174 species recorded in this study were also higher than in some similar studies conducted in other countries. For comparison, Mendonça-Neto et al (2008) found 42 species of reef fish on three islands of Itaipu, Southeast Brazil. Palacios & Zapata (2014) reported 70 species of reef fish in Tropical Eastern Pacific, and Cuadrado et al (2016) successfully recorded 102 reef fish species in Tubay, Agusan del Norte, Philippines.

The study results found that Pomacentridae (damselfishes) were families with the highest number of representative species, followed by Labridae (wrasses), Chaetodontidae (butterflyfishes), Acanthuridae (surgeonfishes) and Serranidae (groupers) (Figure 3). Pomacentridae are resident species that have territorial behavior and rarely roam far from food sources and shelter (Runtuboi et al 2018).

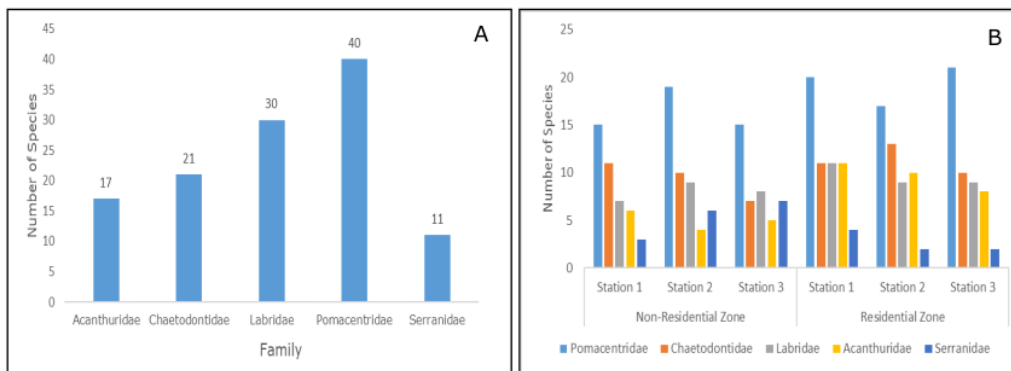


Figure 3. Five reef fish families having the highest number of species in all research stations (A) and in each zone/research station (B).

Species from the Pomacentridae family are most commonly found in the residential zone (17-21 species), which is not explained by a sedentary behavior. During the visual data collection in the area, tourists feeding fish were observed and alleged to be a contributor to the abundant presence of Pomacentridae fish family and more specifically of the *Abudefduf vaigiensis* species. A research done by Sa-nguansil et al (2017) showed that the Pomacentridae family is a dominant "bread feeder fishes" (a term for fish involved in feeding attractions) with 70-96% aggregation. The results also indicate that *Abudefduf vaigiensis*, *A. bengalensis*, and *A. sexfasciatus* are an omnivore group with a relatively high abundance.

The density of coral fish. Reef fish's entire life cycle occurs in the area of a coral reef, has a strong relationship with living coral, and its density reflects the number of microhabitats in the coral reef environment (Sale 1991; Allen 1997; Sufsono 1996). The density of reef fish in Olele waters ranged between 5.26 and 12.19 ind m⁻² with a total density of 8.82 ind m⁻² (Table 1). The highest density of reef fish was found in Station 3 zone which was far from the settlement and station 2 zone located near the settlement (Figure 4).

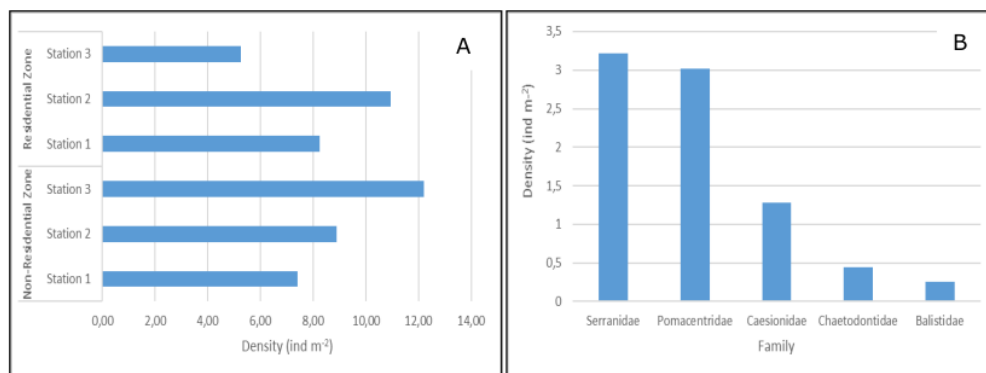


Figure 4. The density of reef fish at each station (A) and five families of reef fish with the highest density (B).

The results showed that the reef fish families that had the highest density in a row were the Serranidae, Pomacentridae, Caesionidae, Chaetodontidae, and Balistidae (Figure 4). *Pseudanthias tuka* (Station 3 at non-residential zone) and *Abudefduf vaigiensis* (Station 2 at the residential zone) species contributed to the high density of reef fish populations in both research stations. The types of fish in the Serranidae and Pomacentridae families, which have the highest density in Olele waters, are included in the significant fish group. Major fish groups, throughout their lives on coral reefs, are territorial and found to be abundant in terms of the number of individuals and species (English et al 1997).

Reef fishes community performances. Ecological indices (diversity, similarity, and dominance) indicate that waters are in balance in the distribution of the number of individuals of each species and indicate species richness (Mum 1993). The results of the analysis of the reef fish ecology index can be seen in Table 2. The Shannon diversity index is in the range $H' = 2.09$ to $H' = 2.74$, with a total $H' = 3.29$. The Index can be used to assess community diversity in an area. According to Mason (1981) in Limmon et al (2018), diversity index categories are as follows: low diversity ($H' < 1$), moderate diversity ($1 \leq H' \leq 3$), and high diversity ($H' > 3$). Based on these categories, the diversity of reef fish at six research stations is in the moderate category. The lowest diversity index is at station 1 Non-residential Zone. This is caused by the unequal distribution of individuals, especially from three species of the family Pomacentridae and Balistidae, namely *Pseudanthias evansi*, *Pseudanthias squamipinnis*, and *Odonus niger* which were found in large numbers (76.6%) at this station. Variations influence high or low diversity values in the presence of several species in a community (Lukom et al 2012). However, overall, the Shannon diversity index in the Olele Waters is in the high diversity category with a value of $H' = 3.29$.

Table 2
Ecological indexes of coral fish in Olele waters

Location/Zone	Station	H'	E	C
Non-residential zone	Station 1	2.09	0.52	0.21
	Station 2	2.74	0.65	0.11
	Station 3	2.45	0.59	0.15
Residential Zone	Station 1	2.55	0.57	0.18
	Station 2	2.74	0.64	0.11
	Station 3	2.59	0.62	0.19
Total		3.29	0.63	0.08

H'- Shannon diversity index, E-the evenness index, C-the Simpson dominance index.

The range of similarity index obtained is $E=0.52$ to $E=0.64$, where the index for the sampling area is $E=0.63$. According to Odum (1975), a community is called in a stable condition if the value of $E \geq 0.6$. Based on this statement, the reef fish community in Olele waters has a stable condition ($E=0.63$). However, there are three stations with an E value < 0.6 , thus in an unstable condition, namely stations 1 and 3 in the Non-residential Zone and station 1 in the Residential Zone. This unstable community condition is caused by the dominance of several reef fish species in each location, namely *Pseudanthias evansi* (Station 1, Non-residential zone), *Pseudanthias tuka* (Station 3, non-residential zone) and *Pterocaesio tile* (Station 1, residential zone).

The results also showed that the Simpson dominance index at the study location ranged from $C=0.11$ to $C=0.21$, and overall Simpson dominance index $C=0.08$. Based on Odum's dominance criteria (1993), the Simpson dominance index can be classified into 3 categories, namely low ($C < 0.5$), moderate ($0.5 < C < 0.75$) and high ($C > 0.75$). Based on these criteria, the reef fish community in Olele waters is included in the category of low dominance or no fish dominating each observation.

Conclusions. This study succeeded in identifying 174 reef fish species in Olele waters, belonging to 78 genera and 32 families with a total of 26,466 individuals and a density of 8.82 ind m^{-2} . Pomacentridae, Labridae, Chaetodontidae, Serranidae, and Acanthidae are the five families with the highest number of species at each research station. Based on the ecological index, the reef fish community structure in the Olele waters was categorized as being characteristic for a stable community, with a high diversity and a low dominance. Moreover, the unstable stations were caused by species abundance attracting visitors to feed fish. Thus, the controlling of such activities is needed. Additionally monitoring the coral reef coverage as the fish habitat for sustainable tourism purpose also needs to be carried out continually.

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