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Mangrove vegetation and fish diversity in Kaledupa Island, Wakatobi National Park, Southeast Sulawesi, Indonesia

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Abstract. *Hewindati YT, Yuliana E, Winata A, Adimu HE, Djatmiko WA. 2023. Mangrove vegetation and fish diversity in Kaledupa Island, Wakatobi National Park, Southeast Sulawesi, Indonesia. Biodiversitas 24: 1766-1772.* The purpose of the study is to analyze the association of mangrove ecosystems with fish diversity at Kaledupa Island, Wakatobi National Park (WNP), Southeast Sulawesi, Indonesia. The study was conducted around the mangrove areas of Balasuna and Tampara villages. Observations and measurements of mangrove vegetation were collected using quadrats of 10×10 m^2. In addition, fish data were collected on the fish catches of fishermen who used a *sero* (a set net). The mangrove data was analyzed using the Importance Value Index (IVI), whereas the fish diversity was analyzed descriptively and length-weight correlation. The results indicated that the Tampara mangrove was dominated by *Bruguiera gymnorrhiza* with an IV of 172.31, followed by *akkapanda* (*Rhizophora apiculata*) and *ongke* (*R. mucronata*) with an IVI of 68.15 and 59.54, respectively. The Balasuna mangrove was dominated by *R. apiculata*, followed by *B. gymnorrhiza* and *R. mucronata*, with IVI of 143.67, 93.25, and 45.84, respectively. A total of 74 fish species were found at the two sites, including 63 species of reef fish and 11 species of non-reef fish. Based on the analysis of the length-weight correlation, it was found that the fish captured around the mangrove were not well-fed. From this result, it is presumed that food availability in the study location is reducing due to anthropogenic activities like tourism and transportation. Hence, it is proposed that periodic monitoring should be carried out to enhance the ecological health of the mangroves to ensure the fishery production services of mangroves.

Keywords: Diversity, fish, Kaledupa, mangrove, Wakatobi

INTRODUCTION

The mangrove ecosystem plays a major role in supporting the life of fish and other organisms (Wahyudewantoro 2018; Yuliana et al. 2019) and also provides ecosystem services to humans, especially those living around mangrove ecosystems. Therefore, the mangrove ecosystem must be preserved so that it may continue to provide ecosystem services for the benefit of humankind (Yuliana et al. 2019). In the mangrove ecosystem, there is a complex interaction between the physical and biological properties of the sea, characterized by the numerous types of animals and micro-organisms associated with the mangrove ecosystem (Sari et al. 2022). The basic mangrove substrate stores nutrients (inorganic materials) from the sea and land through various processes. Mangroves also have other crucial functions and roles, such as physical functions in maintaining stable coastal conditions, protecting the shorelines, preventing abrasion and seawater intrusion, and trapping pollutants (Das and Crépin 2013; Sari et al. 2022). The main biological function of mangroves is for life (Descasari et al. 2016), as a provider of food, a feeding ground, a nursery ground, and a spawning ground for both organisms that live in the mangrove ecosystem and those in the surrounding waters. The mangrove vegetation is also interesting for juveniles and small fish (Sari et al. 2022; Yuliana et al. 2022).

Wakatobi is one of the Marine Protected Areas (MPA), a national park in Indonesia that protects the marine ecosystem (Azhar 2018) and has mangrove vegetation coverage in its coastal area. The main purpose of declaring an MPA is to protect, preserve, and utilize natural resources sustainably (Azhar 2018), strengthen fish production, strengthen food and nutrition provision, and increase the fishers' income (Bennett and Dearden 2014). It is classified as a Large-Scale Conservation Area with an area exceeding 10,000 km^2 (Ban et al. 2017) and the second largest marine national park in Indonesia with an area of 1.39 million ha (Madduppa et al. 2020). Wakatobi has four large island clusters, Wangi-Wangi, Kaledupa, Tomia, and Binongko (Azhar 2018; Wakatobi National Park 2021). This area was appointed as a National Park through the Minister of Forestry's Decree Number 393/Kpts-VI/1996 on 30 July 1996 with an area of 1,390,000 ha, consisting of 97% sea and 3% land (Wakatobi National Park 2021).

The Wakatobi National Park (WNP) mangrove ecosystem is distributed on its large islands. Kaledupa Island is one of the WNP territory's islands, characterized by mangrove ecosystems and mudflats (Yuliana et al. 2022). A total of 20 species of true mangroves have been found in Wakatobi, belonging to 11 families; member family Rhizophoraceae are dominant in Wakatobi (Unsworth 2013). The most extensive mangrove coverage is found on Kaledupa Island, ±887 ha or approximately 78% of the total mangrove area in WNP, which is ±1131 ha (Wakatobi National Park 2021).

Several research results have explained a close relationship between the condition of the mangrove ecosystem and the richness of fish species and abundance (Yuliana et al. 2019; Sari et al. 2022). Therefore, the diversity and abundance of fish in the mangrove area could be a bioindicator of the mangrove ecosystem's health (Azhar et al. 2018; Yuliana et al. 2022). A high fish abundance and diversity mark a healthy mangrove ecosystem, and in contrast, a damaged mangrove ecosystem is signified by a low fish abundance and diversity. This is related to the mangrove ecosystem's ability to supply the food needs of the biota associated with it. Therefore, the condition of a healthy mangrove ecosystem characterized by an abundance of economically valuable aquatic biota such as fish, shrimp, and crabs could support the food needs and improve the economy of the community around it.

Mostly the people who live around the mangrove ecosystem on Kaledupa Island work as fishers who catch fish around the mangrove ecosystem. These fishers use traditional fishing gear such as the *sero* (a passive fish-catching tool) set in the waters around the mangrove. *Sero* is a passive fishing gear that has been used for generations by fishermen in the waters of Southeast Sulawesi and is environmentally friendly. However, fishing activities by traditional fishermen with traditional fishing gear must be a consideration because it is feared that overfishing will occur in certain types of fish. In addition, the fishing technology used by fishers strongly influences fish resource diversity (Yuliana et al. 2019). Unregulated fishing activities will degrade the fish resources in the waters surrounding the mangrove. Therefore, routinely measuring and monitoring the fish diversity in the waters surrounding the mangrove is important.

Considering the above, this study has been carried out to analyze the mangrove vegetation, the diversity of fish caught around the mangroves on Kaledupa Island, and WNP, and the relationship between them, descriptively. The diversity of fish resources in this study was observed from the status of fish species according to the International Union for Conservation of Nature (IUCN) and the length-weight relationship of fish. The study's results can be used as information about the importance of the mangrove ecosystem for the sustainability of fish resources. This information can be useful for WNP authorities, fishermen, and stakeholders in making management plans, implementation, monitoring, and evaluation.

MATERIALS AND METHODS

Study area

The study was conducted in the mangrove area of Balasuna Village (A) and Tampara Village (B), Kaledupa Island, WNP, Southeast Sulawesi (Figure 1). These villages were selected based on the representativeness of the region in the East, which faces the waters of the Banda Sea (Balasuna Village) and Flores Sea waters (Tampara Village). In addition, the selected locations were expected to represent the comparison between the mangrove presence and representation of fish distribution, especially that of the fish associated with the mangrove.

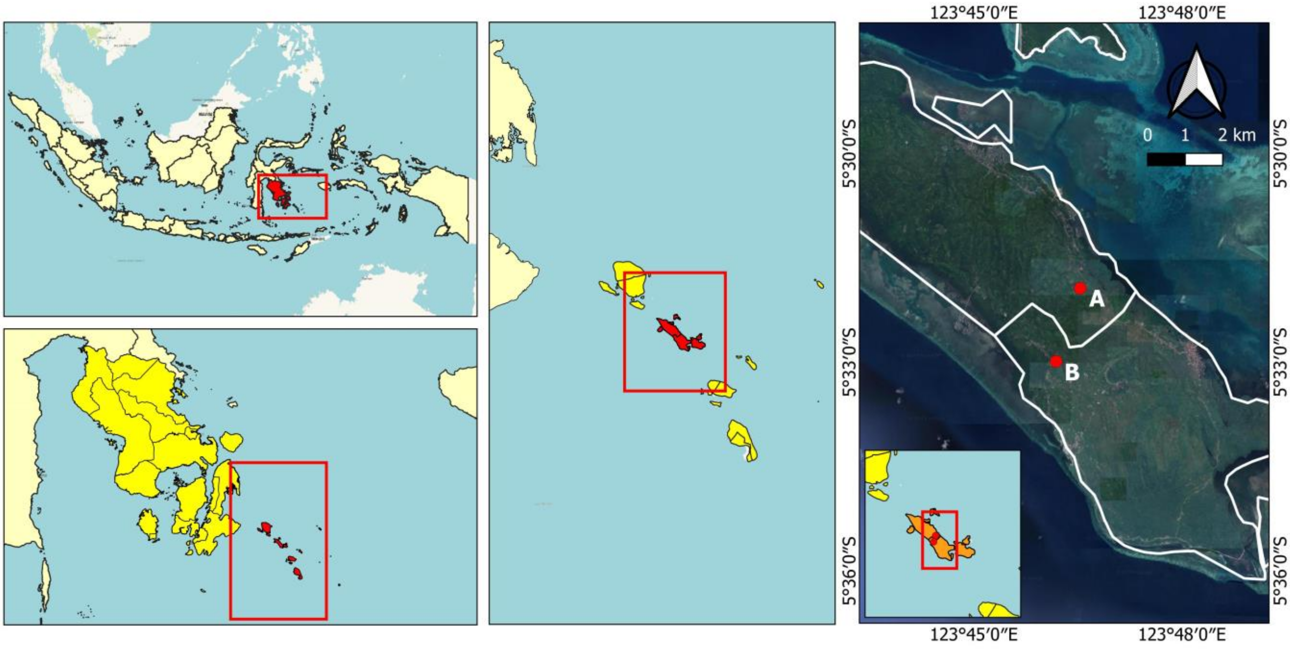

Figure 1. The research sites in Kaledupa Island: Balasuna Village (A) and Tampara Village (B) within the Wakatobi National Park territory, Southeast Sulawesi, Indonesia (Yuliana et al. 2022)

Data collection

Data about the mangrove vegetation and fish species around the ecosystem were collected. Therefore, to ascertain the character and variation of mangrove vegetation in the study location, data about the diversity, distribution, and vegetation structure in the tree strata, which is the mangrove plants with a height exceeding 1.5 m and a trunk diameter exceeding 10 cm. Observations and measurements of the mangrove vegetation were made in sampling plot sized 10×10 m^2, which were systematically placed in two observation transects from land to the sea. The data collected were the names (species) of the mangrove trees, number of stands, and Diameter at Breast Height (DBH) of each stand in the sampling plot. In addition, the types of other mangrove trees found in the location but were unrecorded within the sampling plot were also noted to supplement the overall mangrove vegetation information.

Fish data was collected daily on the fish caught using passive fishing gear, namely *sero*. Then, the fish caught were identified using an identification book (Allen 2020). Finally, the fish samples found were recorded based on the species, number of individuals, and the fish's length and weight.

Data analysis

The mangrove vegetation data were analyzed descriptively by presenting the numbers and types of flora and conducting a vegetation analysis. The Importance Value Index (IVI) is followed by calculating species density, relative density, species frequency, relative frequency, species dominance, and relative dominance. Fish diversity data analysis included the fish's status according to the IUCN, the composition of the catch, and the correlation between the fish's length and weight.

Mangrove vegetation data were analyzed using the following formulas:

Density of a species (De) (plants/ha):

$$\frac{\text{number of individuals of species}}{\text{size of sampling plot (ha)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Relative density (RDe):

$$\frac{\text{the density of a species}}{\text{the total density of all species}} \times 100\% \quad \ldots\ldots\ldots \quad (2)$$

Frequency of a species (F):

$$\frac{\text{number of plots where species are found}}{\text{number of all sampling plots}} \quad \ldots\ldots\ldots \quad (3)$$

Relative frequency (RF):

$$\frac{\text{frequency of a species}}{\text{frequency of all species}} \times 100\% \quad \ldots\ldots\ldots\ldots \quad (4)$$

Dominance of a species (Do):

$$\frac{\text{Total basal area of a species}}{\text{Total area of sampling plots}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Relative dominance (RDo):

$$\frac{\text{The dominance of a species}}{\text{The total dominance of all species}} \times 100\% \quad \ldots \quad (6)$$

Importance Value Index (IV):

$$IVI = RDe + RF + Rdo \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

The composition of the fish caught was calculated based on their weight. Furthermore, records were made per fish species. The composition based on the weight percentage of the fish caught compared to the total weight was then calculated.

The correlation between the length and weight can be calculated using the following formulas (Jisr et al. 2018).

$$W = a.L^b \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

W : fish's weight (gram)
L : fish's total length (mm)
'a' : constant
'b' : fish's growth pattern estimator.

The values of 'a' and 'b' are obtained from a simple linear equation.

$$Y = b_0 + b_1 X \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

Y : Log W
X : Log L.

Therefore, the constants b_1 and b_0 can be calculated using the following equation.

$$b_1 = \frac{\sum_{i=1}^{n} x_i y_i - \frac{1}{n}\sum_{i=1}^{n} x_i \ \sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2} \quad \ldots\ldots\ldots \quad (10)$$

and

$$b_0 = \bar{y} - b_1 \bar{x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

RESULTS AND DISCUSSION

Mangrove diversity

There were 18 species of true mangroves found on Kaledupa Island, namely *Avicennia alba, A. eucalyptifolia, A. lanata, A. marina, Barringtonia asiatica, Bruguiera cylindrica, B. gymnorrhiza, B. sexangular, Camptostemon philippinense, Ceriops decandra, C. tagal, Rhizophora apiculata, R. mucronata, R. stylosa, Sonneratia alba, S. caseolaris, Xylocarpus granatum, X. moluccensis,* and six associated mangrove species, i.e., *Calophyllum inophyllum, Derris trifoliata, Hibiscus tiliaceus, Morinda citrifolia, Pandanus odoratissimus,* and *Pongamia pinnata* (Wakatobi National Park 2021). The mangrove plants (Table 1) studied in the two sites (Tampara and Balasuna) grew in the mud accumulated on the dead reef top. Moreover, the mud substrate was not very thick; along the vegetation transects, the mud depth ranged between 20 and 50 cm. Having small but dense trunks with canopy heights ranging from 7 to 9 m, the mangrove vegetation in these two locations is classified as poor in species. Only three species of trees were recorded within the plots in Tampara, the *akkapanda* (*R. apiculata*), *ongke* (*R. mucronata*), and *selo* (*Bruguiera gymnorrhiza*). Similar conditions were found in Balasuna, with one additional species recorded within the plots: the *peapi* (*Avicennia* sp.).

Identification of mangrove species is important to determine the richness of mangrove species in an area. This important value supports the preservation of biodiversity, such as animals and plants that include mangrove areas (Ramadhani et al. 2022). The richness of mangrove species shows the richness of nutrients in the waters or mud of mangrove habitats and the level of public awareness of mangrove sustainability. Development in coastal areas sometimes does not pay attention to the area's sustainability and types of mangroves. Therefore, these development activities can result in damage to mangroves.

Mangrove ecosystems are fisheries' more fertile areas than mudflats, especially those found along the coast around reefs and lagoons. Mangrove plants can process food which is a food supply from the mud flats, into a form that is available and can be used by various types of marine animals, such as fish, crabs, and shellfish, that humans can eat. There is a positive relationship between the condition of the mangrove ecosystem (density) and the number of fish caught, the number of fish species, and the diversity of fish species (Descasari et al. 2016). Mangroves and ichthyofauna have a close relationship. A high abundance of ichthyofauna is found in mangrove conditions with a high density of mangrove species. Moreover, to that, a more varied number of mangrove vegetation types. Therefore, this shows that the mangrove ecosystem is used as a nursery ground, feeding ground, and shelter from predatory fish.

The results of the vegetation analysis conducted in the two sites show that even though the physical structure of both forests was similar (the tree density in Tampara was 58 trees/0.1 ha and in Balasuna 55 trees/0.1 ha), the species domination in the two locations was different. The mangrove forest in Tampara was dominated by *selo* (*B. gymnorrhiza*) with an IVI of 172.31, followed by *akkapanda* (*R. apiculata*) and *ongke* (*R. mucronata*) with an IVI of 68.15 and 59.54, respectively (Table 2). Meanwhile, the mangrove in Balasuna was dominated by *akkapanda* with an IVI of 143.67, followed by *selo*, *ongke*, and *peapi* (*Avicennia* sp.) with n IVI of 93.25, 45.84, and 17.24, respectively (Table 3). Based on this, there has been a shift in the dominant mangrove species on Kaledupa Island. The shift is likely due to several reasons, natural factors, and human activity factors.

Fish species diversity and distribution

A total of 74 species of fish have been found across the two study sites, viz., Balasuna Village and Tampara Village (Table 4). Of these, 63 species were reef fishes, and 11 were non-reef fishes. Table 4 shows that the types of fish found in Balasuna and Tampara Villages mostly have similarities. Several types of fish are found in one village but not in others. However, these types are only a small part. In general, the two villages have the same types of fish.

Based on the IUCN Red List of Threatened Species 2019, it has been observed that the species of reef fish in Wakatobi are mostly classified as Least Concern (LC) species, which means they are not likely to become extinct any time soon (Figure 2). It means these species are not the focus of species conservation because many are still in the wild. Furthermore, the fish diversity in WNP is high, with safe conservation status. Relatively high fish diversity was still recorded at the two study sites on Kaledupa Island. As reported in a previous publication (study), the Shannon-Wiener diversity index (H') values were close to 3, which is considered to be moderate to high (Yuliana et al. 2022). Government Regulation Number 60 of 2007 concerning the Conservation of Fish Resources has outlined that biodiversity conservation at the species level can be carried out with three main conservation efforts: Protection, preservation, and sustainable use. Protection and preservation of fish species in Wakatobi can be done by monitoring the fish caught by fishermen. The monitoring results show that most of the fish are in a safe condition (Figure 2). However, there are 15 fish species with not evaluated (NE) status. This evaluation must be accelerated, so these fish have a conservation status immediately. WNP authorities can drive several experts on these fish species to evaluate their conservation status. Meanwhile, one species with Data Deficient (DD) status is *Epinephelus bleekeri*.

Of the 74 species of reef fish found, five species had the most abundant number of individuals, viz., the *Siganus canaliculatus* (802 individuals), *Lethrinus harak* (505 individuals), *Lethrinus variegatus* (210 individuals), *Lethrinus ornatus* (172 individuals), and *Siganus spinus* (161 individuals). In Balasuna Village, 58 species were found; in Tampara, 59 species were found, with 44 species found in both villages (Yuliana et al. 2022). Therefore, the two villages do not differ significantly regarding the number of individuals found. However, in terms of biomass, the composition of the five species, compared with the total biomass of the fish found, was the greatest *L. harak* (21.40%) (Figure 3). This shows that *L. harak* had a relatively larger body size than *S. canaliculatus*, because the number of *L. harak* individuals found was lower than that of *S. canaliculatus; however*, it had a greater biomass.

Table 1. Plants species of the mangrove forest found in the two study sites

Scientific name	Local name	Location	
		Balasuna	Tampara
Avicennia marina	*Api-api*	-	√
Avicennia sp.	*Peapi*	√	-
Bruguiera gymnorrhiza	*Selo*	√	√
Derris trifoliata	*Tuba laut*	√	√
Lumnitzera sp.	*Duduk*	-	√
Morinda citrifolia	*Mengkudu*	√	-
Mucuna pruriens	*Kara gatal*	√	-
Pluchea indica	*Beluntas*	√	√
Rhizophora apiculata	*Akkapanda*	√	√
Rhizophora mucronata	*Ongke*	√	√
Rhizophora stylosa	*Bakau kecil*	√	√
Sonneratia alba	*Pidada*	-	√
Sonneratia ovata	*Peropa*	√	-
Sterculia foetida	*Kepuh*	-	√
Tamarindus indica	*Asam*	√	√
Terminalia catappa	*Ketapang*	√	-
Xylocarpus granatum	*Nirih*	-	√

Table 4. The species of reef fish found in two villages

Species	Balasuna	Tampara	Conservation Status (IUCN)
Acanthurus lineatus	+	-	LC
Acanthurus nigricauda	+	-	LC
Atherinomorus duodecimalis	-	+	LC
Atherinomorus lacunasus	-	+	NE
Balistapus undulatus	+	-	NE
Carangoides chrysophrys	+	-	LC
Carangoides ferdau	+	+	LC
Caranx hippos	-	+	LC
Caranx tille	+	+	LC
Cheilio inermis	-	+	LC
Chaetodon vagabundus	+	+	LC
Choerodon anchorago	+	+	LC
Choerodon cephalotes	+	-	LC
Cyambecephalus beauforti	+	+	LC
Cypselurus naresii	+	+	NE
Diagramma melanacrum	+	-	NE
Diodon holocanthus	+	+	LC
Elechelon vaigiensis	+	+	LC
Epinephelus bleekeri	+	+	DD
Gazza dentex	+	+	NE
Gerres punctatus	+	+	LC
Gerres oyena	+	-	LC
Hemiramphus far	+	-	NE
Hyporhamphus quoyi	+	+	NE
Hyporhamphus affinis	+	-	NE
Inegocia japonica	-	+	LC
Leptocerus vaigiensis	+	+	LC
Lethrinus erythropterus	+	+	LC
Lethrinus genivittatus	+	+	LC
Lethrinus harak	+	+	LC
Lethrinus lentjan	-	+	LC
Lethrinus ornatus	+	+	LC
Lethrinus variegatus	+	+	LC
Lutjanus fulviflamma	+	+	LC
Lutjanus monostigma	-	+	LC
Lutjanus quinquelineatus	+	-	LC
Mulloidichthys martinicus	+	+	LC
Mulloidichthys flavolineatus	+	+	LC
Myripristis berndti	-	+	LC
Myripristis amaena	-	+	LC
Naso lituratus	-	+	LC
Oxyeleotris lineolata	-	+	NE
Parupeneus barberinus	+	+	LC
Parupeneus crassilabris	+	+	LC
Parupeneus cyclostomus	+	+	LC
Platax orbicularis	+	+	LC
Platax pinnatus	+	+	NE
Plectorhinchus lineatus	+	+	NE
Plotosus canius	+	+	NE
Pomadasys furcatus	+	+	LC
Pseudorhombus dupliocellatus	-	+	NE
Rhinecanthus verrucosus	+	-	NE
Sargocentron cornutum	-	+	LC
Scarus croicensis	-	+	LC
Scarus dimidiatus	+	+	LC
Scarus ghobban	+	-	LC
Scarus psittacus	+	+	LC
Scarus quoyi	+	+	LC
Scarus schlegeli	+	+	LC
Scolopsis aurata	+	-	LC
Scolopsis ciliata	+	+	LC
Scolopsis lineata	+	+	LC
Scolopsis xenochroa	+	+	LC
Siganus canaliculatus	+	+	LC
Siganus guttatus	+	+	LC
Siganus spinus	+	+	LC
Siganus virgatus	+	+	LC
Sphyraena barracuda	+	+	LC
Sphyraena obtusata	+	-	NE
Thalassoma hardwicke	+	-	LC
Toxotes jaculatrix	+	+	LC
Tylosurus crocodilus	+	+	LC
Upeneus tragula	+	+	LC
Zanclus cornutus	-	+	LC

Notes: International Union for Conservation of Nature Red List (IUCN Red List of Threatened Species 2019), Least Concern (LC); Data Deficient (DD); Not Evaluated (NE)

Of the five dominant fish species found, the rabbitfish (*S. canaliculatus*) has the largest number of individuals but has the second-largest biomass (Figure 3). This shows that *S. canaliculatus* has a smaller body size than *L. harak*. The large number of individuals found indicates that the bearish is the main catch of fishermen. Therefore, monitoring and supervising the fishing activity is necessary to avoid the degradation of heronang fish resources. Fishing monitoring activities can be carried out simultaneously with counseling to fishermen so that they can only catch fish at their adult size.

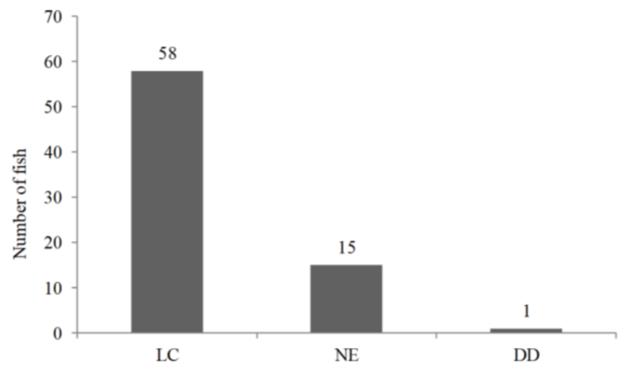

Figure 2. The fish species status distribution based on the IUCN (IUCN Red List of Threatened Species 2019) (Where is LC: Least Concern; NE: Not Evaluated; DD: Data Deficient)

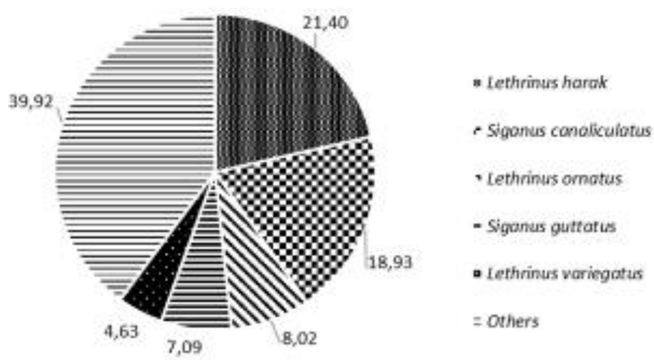

Figure 3. The reef fish biomass composition

Table 2. Importance value of mangrove species at Tampara village

Scientific name	Local name	De	Do	F	RDe	RDo	RF	IVI
B. gymnorrhiza	Selo	30	28,107.87	10	51.72	75.13	45.45	172.31
R. apiculata	Akkapanda	18	3683.40	6	31.03	9.85	27.27	68.15
R. mucronata	Ongke	10	5620.40	6	17.24	15.02	27.27	59.54
		58	37,411.67	22	100.00	100.00	100.00	300.00

Note: De: Density; Do: Dominance; F: Frequency; RDe: Relative Density; RDo: Relative Dominance; RF: Relative Frequency; IV: Importance Value

Table 3. Importance value of mangrove species at Balasuna village

Scientific name	Local name	De	Do	F	RDe	RDo	RF	IVI
R.apiculata	Akkapanda	35	4890.35	8	63.64	41.94	38.10	143.67
B. gymnorrhiza	Selo	11	3543.90	9	20.00	30.39	42.86	93.25
R. mucronata	Ongke	8	1983.55	3	14.55	17.01	14.29	45.84
Avicennia sp.	Peapi	1	1243.40	1	1.82	10.66	4.76	17.24
		55	11,661.20	21	100	100	100	300

Note: De: Density; Do: Dominance; F: Frequency; RDe: Relative Density; RDo: Relative Dominance; RF: Relative Frequency; IV: Importance Value

The fish length and weight relationship

Therefore, to estimate the biomass of different fish populations, it is necessary to know the studied species' length-weight relationships (LWRs) (Mehanna and Farouk 2021). Therefore, the fish species' LWR was analyzed on the three species with the greatest biomass, the *L. harak*, *S. canaliculatus*, and *L. ornatus*. The result of the analysis of the LWR of *L. harak* was b: 2.64 (Figure 4), which shows that the *L. harak* had negative allometric growth, meaning the increase in length was more dominant than the increase in weight. However, the coefficient of determination (R^2) has a value of 84.63%, indicating the ability of the independent variable (fish length) to explain the dependent variable (fish weight) is very large. Furthermore, the R^2 value is categorized as strong if it is more than 0.67, moderate between 0.33-0.67, and weak if it is between 0.19-0.33 (Jisr et al. 2018). Thus, the LWR of *L. harak* is strong based on the coefficient of determination obtained, which can result in a mangrove communities damage. This finding is very important for the Wakatobi authority to know trends in fish growth to determine the direction of management strategies. Therefore, fisheries management addresses, among others, the economic, social, and biological factors affecting fish stock (Jisr et al. 2018).

As with *L. harak*, the result of the analysis of the correlation between the length and weight of *S. canaliculatus* showed a negative allometric growth pattern with b: 1.90 (Figure 5). The coefficient of determination (R^2) has a value of 56.67%, indicating that it means that the ability of the independent variable (fish length) to explain the dependent variable (fish weight) is quite limited. The R^2 value is categorized as strong if it is more than 0.67, moderate between 0.33-0.67, and weak if it is between 0.19-0.33 (Jisr et al. 2018). Obtaining these results can lead to mangrove communities damage.

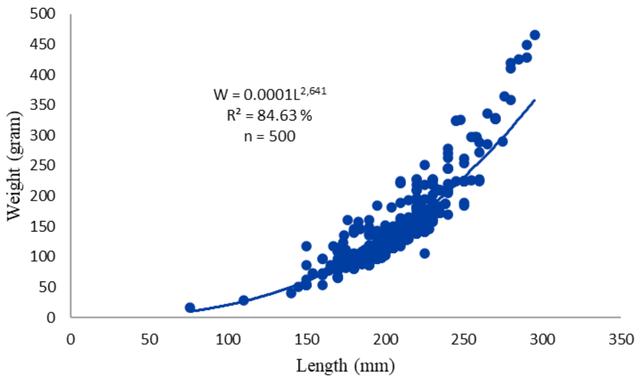

Figure 4. The correlation between the length and weight of *Lethrinus harak*

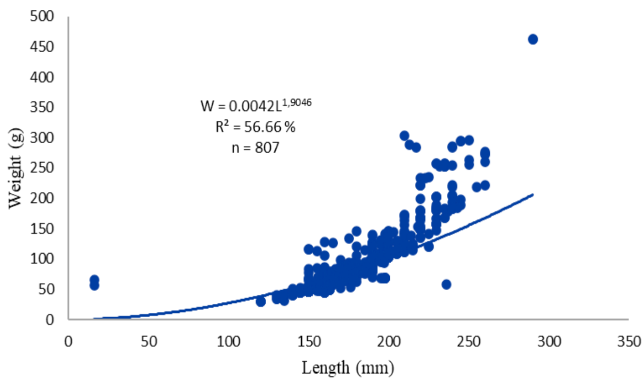

Figure 5. The correlation between the length and weight of *Siganus canaliculatus*

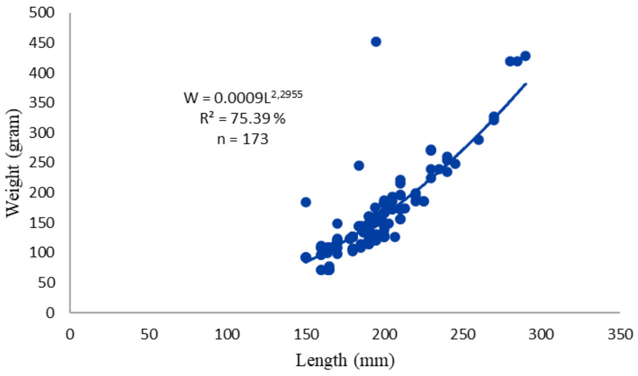

Figure 6. The correlation between the length and weight of *Lethrinus ornatus*

The analysis result of the correlation between the length and weight of *Lethrinus ornatus* also showed a negative allometric growth pattern with b: 2.30 (Figure 6). The coefficient of determination (R^2) has a value of 75.39%, indicating the ability of the independent variable (fish length) to explain the dependent variable (fish weight) is large. The R^2 value is categorized as strong if it is more than 0.67, moderate between 0.33-0.67, and weak between 0.19-0.33 (Jisr et al. 2018).

The analysis of the correlation between the length and weight of several species of dominant fish found in the mangrove ecosystem showed that reef fish (*L. harak*, *S. canaliculatus*, *L. ornatus*) had similar growth patterns. This negative allometric pattern means that the increase in length is more dominant than the increase in weight (fish have a thin body size). Many factors influence the fish's growth pattern, such as differences in age, sex, gonad development, and the availability of food in that environment. LWRs are not constant over the year, and LWR parameters may vary significantly due to food availability and biological, temporal, and sampling factors (Mehanna and Farouk 2021). The condition of the three fish with a negative allometric growth pattern relates to food availability and biological, temporal, and sampling factors.

The LWR of fish differs among fish species according to the body shape and within the same species according to the condition of individual fish (Mehanna and Farouk 2021). Another influential factor is the habitat behavior of the fish. For example, active swimming fish tend to have a lower b coefficient than passive swimming fish (Afdhila et. 2019). This is related to the level of energy used for swimming (Jisr et al. 2018). Thus, in the case of this study, the value of coefficient b is smaller than the value of coefficient a, one of which is because the fish sampled are active swimmers.

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