



# Diversity and characteristics of the habitat of groupers (genus *Epinephelus*) in Moramo Bay, Southeast Sulawesi, Indonesia

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**Abstract.** Moramo Bay is a prominent grouper fish supplier in the South Konawe Regency area. Nevertheless, the current farming practices still need to consider sustainability aspects such as the spawning period, life cycle, and the natural fish habitat, which are concerned with harming its habitat and population. Therefore, this research is crucial to emphasize efforts to support the sustainability of groupers' natural resources by determining the habitat characteristics and diversity of groupers' species in Moramo Bay. The method used in this research is exploratory and descriptive. Data collection on coral cover was conducted using the Line Intercept Transect method by placing transect lines with a depth range of  $\pm 3$ -5 m and  $\pm 10$ -11 m. Grouper data were analyzed using a diversity index. The result showed that the coral reefs are more established at a depth of  $\pm 3$ -5 m, with hard coral percentage ranging from 43.03 to 64.32%, compared to the depth range of  $\pm 10$ -11 m, which has hard coral cover percentage in the range of 39.24-60.22%. An increased coral cover affects the grouper diversity, as shown by the correlation of the percentage of hard coral cover on Lara Island, ranging from 51.33 to 54.21% with the following indices: diversity ( $H'$ )=1.683, evenness ( $E$ )=0.939 and dominance ( $D$ )=0.042. The percentage of hard coral on Moramo Island ranges from 39.24 to 43.03% with  $H'$ =1.542,  $E$ =0.954, and  $D$ =0.03. The percentage of hard coral on Wawosunggu Island ranges from 60.22 to 64.32% for  $H'$ =1.714,  $E$ =0.881, and  $D$ =0.054. Generally, the diversity of groupers found in their habitat in Moramo Bay is in the medium category.

**Key Words:** coral cover, depth, correlation, diversity index, groupers.

**Introduction.** Grouper fish belongs to the Serranidae family. Currently, 159 species and 15 genera of groupers have been identified, dominated by the *Epinephelus* genus with 98 species (Allen et al 2003; Craig & Hastings 2007; Nadia 2022). Groupers have been identified as many as 39 species in Indonesia and 46 species in Southeast Asia. Groupers live solitary (Kuitert & Tonozuka 2001). Young groupers live in coral waters of 0.5-3 m depth. Once mature, the fish move to a 7-40 m depth. Groupers are pelagic in their egg and larval stages and demersal in the young and adult phases. Groupers are protogynous hermaphrodites that begin their reproductive cycle as functional female fish and become functional males after one spawning cycle (Wehitt et al 2015). The most suitable oceanographic parameters for the grouper's life are: a temperature of 24-31°C, a salinity 30-33 ppt, a dissolved oxygen >3.5 ppm and a pH 7.8-8. These preferred conditions are likely found in waters with coral reefs (Nadia et al 2021).

Grouper is one of the most intensively exploited fish for trade. The catches are marketed on local, domestic and export markets, both fresh catch and live fish (Kusumastanto 2008; Adam 2012). Recently, exported groupers have been obtained from mariculture, although the wild catch is still dominant (Campbell et al 2013). The demand for exports has triggered the increase of grouper exploitation. However, a high usage of non-friendly fishing methods results in a decline in the quality of groupers' habitat and resources. Due to unsustainable fishing, water conditions can change,

affecting grouper's life cycle and growth (Baskoro et al 2010). Thus, the conservation of the natural habitat of groupers is the primary key to preserving grouper fish resources in coastal waters. The unsustainable grouper fishing practice includes catching groupers in the spawning stage, which is found in many local fishermen's customs. Neglecting the spawning period and other biological aspects such as fish type, weight, and length, which are parameters for estimating fish maturity (Bhandari et al 2003), causes the decrease of both grouper population number and size of the fish caught. Although grouper spawns throughout the year, the peak spawning only occurs from June to October (Mariskha & Abdulgani 2012).

Based on their habitat, groupers are often found in coastal waters, lagoons, and estuaries. Meanwhile, the egg and larval stages settle in clear offshore waters (Sluka et al 2001). Most grouper larvae are planktonic for 30-50 days. When grouper fish become juveniles, they populate shallow waters and seek shelter in seagrass beds, mangrove roots, coral fragments, corals, or macroalgae. This vertical distribution follows the nature of grouper fish, which often hide in bottom habitats and coral crevices during the day. At night, groupers actively search for food. This pattern occurs in all grouper habitats, including Moramo Bay, Southeast Sulawesi Province, Indonesia.

The Moramo Bay ecosystem is a prominent supplier of groupers in the South Konawe Regency area. However, the current farming practices still need to consider to sustainability aspects such as the spawning period, life cycle, and habitat, which tend to damage the potential value of grouper production in the area (Nadia et al 2018). This unsustainable mass-fishing practice is likely due to domestic products' current high selling value. Groupers are sold around the harbor or on the Kendari City Fish Market (TPI). Even during spawning, continuous fishing practice without proper regulation and control is alarming. Therefore, research on the characteristics of grouper habitat in Moramo Bay is crucial. This research aimed to determine the characteristics of grouper habitat in Moramo Bay, in support to the sustainability of grouper fish resources in nature.

## Material and Method

**Data collection.** The study was carried out during 6 months, from April to October 2023, in the Moramo Bay, Southeast Sulawesi, Indonesia (Figure 1).

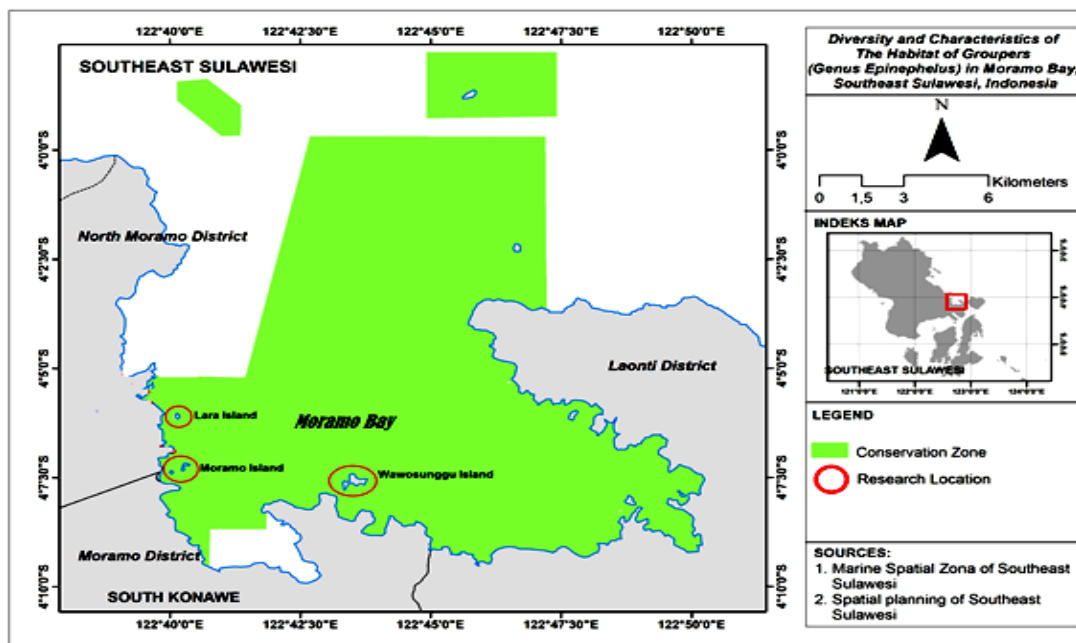


Figure 1. Map of study location.

An exploratory, descriptive method is used in this research (Arikunto 1993). The collection of coral cover data using the Line Intercept Transect method was modified from English et al (1997). The data was collected by placing transect lines with classification range depths of  $\pm 3-5$  and  $\pm 10-11$  m. Differences in depth while laying transect lines are closely related to fish life patterns in each basic habitat, while different depths can reveal the stratification of the fish communities (Mujiyanto & Syam 2014). The identification of coral biota types uses a guide sourced from Kuitert & Tonzuka (2001), while the identification of grouper fish uses the reference books of Heemstra & Randall (1993), Carpenter & Niem (1999).

**Data analysis.** The percentage of coral cover was analyzed using a formula referring to English et al (1997).

$$L(\%) = (L_i / N) \times 100$$

Where:

L – coral reef cover (%);

$L_i$  – length of  $i^{\text{th}}$  coral colony intercept (cm);

N – horizontal transect length (75 cm).

The groupers population's parameters observed were species composition, grouper fish abundance, diversity index (H), uniformity index (E) and dominance index (D). Species composition refers to Greenberg (1992):

$$SC = n_i / N \times 100$$

Where:

SC - species composition;

$n_i$  - number of individuals per species;

N - total number of individuals.

The abundance of an organism can be expressed as the number of individuals per area (Odum 1993). Groupers abundance was calculated by the formula:

$$A = \frac{X_i}{n_i}$$

Where:

A – individual abundance ( $\text{ind m}^{-2}$ );

$X_i$  – number of individuals of the  $i^{\text{th}}$  species;

$n_i$  – number of quadrants of  $i^{\text{th}}$  species.

The diversity index ( $H'$ ) was calculated by using the Shannon-Wiener equation (Odum 1993):

$$H' = - \sum_{i=1}^s P_i \ln P_i$$

Where:

$H'$  - Shannon-Wiener diversity index;

$P_i$  - ratio of the number of individuals of the species  $i$  against the number of individuals ( $n_i/N$ ).

The range of groupers diversity indexes are:  $H' < 1$  (low species diversity category),  $1.0 < H' < 3.0$  (medium species diversity category), and  $H' > 3.0$  (high species diversity category). The uniformity index (E) value indicates the shape of the relative distribution. The uniformity index formula (E) was calculated using the evenness index (Odum 1993):

$$E = \frac{H'}{\ln S}$$

Where:

E - uniformity index;

H' - diversity index;

S - number of species;

ln - natural logarithm.

The dominance index (D) is used to determine the relative abundance of one species of grouper in the area. If the dominance index is 0, it means that there are almost no species which dominate the population. If the dominance index value approaches 1, it means that there was one type of reef fish dominates the population. D is calculated by the formula (Odum 1993):

$$D = \sum (n_i/N)^2$$

Where:

D - index of dominance;

n<sub>i</sub> - number of individuals of each species;

N - number of individuals of all species.

## Results

**Coral cover.** The analysis of coral cover at a depth of ±3-5 m resulted in a percentage of the cover as follows: 43.03-64.32% hard coral, 6.20-15.90% soft coral, 11.20-19.45% non-coral or algae and 16.10-28.27% for the others. On the other hand, the cover results obtained at a depth of ±10-11 m were: 39.24-60.22% hard coral, 5.20-14.20% soft coral, 12.51-22.2% non-coral (algae) and 18.29-24.36% dead substrate. The results of the coral cover analysis in the groupers' habitat in Moramo Bay are presented in Figure 2.

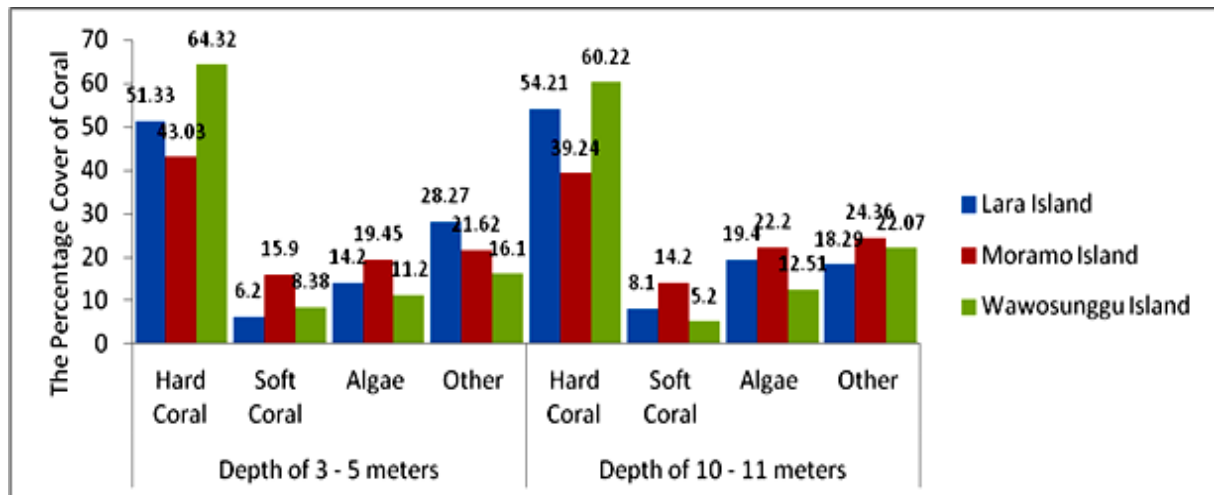


Figure 2. Coral cover found in grouper habitat in Moramo Bay, Indonesia.

**Species composition and abundance.** During the research, seven species of grouper of the Genus *Epinephelus* were found. The variety of species is spread across 3 locations: 6 types on Lara Island, 5 on Moramo Island, and 7 on Wawosunggu Island. The seven types of fish are *Epinephelus areolatus*, *Epinephelus coralticola*, *Epinephelus fuscoguttatus*, *Epinephelus merra*, *Epinephelus ongus*, *Epinephelus quoyanus*, and *Epinephelus sexfasciatus*. The species composition and abundance are presented in Table 1.

Table 1

The species composition and abundance of genus *Epinephelus* in the habitat of groupers in Moramo Bay, Indonesia

Species	Abundance (individual)			Individuals Total	Species Composition (%)
	Lara Island	Moramo Island	Wawosunggu Island		
<i>Epinephelus areolatus</i>	77	122	56	255	10.74
<i>Epinephelus coralticola</i>	119	96	122	337	14.20
<i>Epinephelus fuscoguttatus</i>	57	0	23	80	3.37
<i>Epinephelus merra</i>	215	250	307	772	32.52
<i>Epinephelus ongus</i>	0	0	216	216	9.10
<i>Epinephelus quoyanus</i>	75	105	75	255	10.74
<i>Epinephelus sexfasciatus</i>	165	151	143	459	19.33
Total	708	724	942	2,374	100

**Spatial diversity of groupers.** The total number of groupers was found to be 2,374 individuals. These fish were distributed at 3 locations, namely 708 on Lara Island, 724 on Moramo Island and 942 on Wawosunggu Island. Furthermore, the diversity of groupers was closely correlated to their habitat. The spatial diversity index values for groupers in Moramo Bay, Indonesia, are presented in Table 2.

Table 2

Spatial diversity of grouper fish value in Moramo Bay, Indonesia

Location	Total (N)	Total Species (S)	Diversity (H')	Uniformity (E)	Dominance (D)
Lara Island	708	6	1.683	0.939	0.042
Moramo Island	724	5	1.542	0.954	0.03
Wawosunggu Island	942	7	1.714	0.881	0.054

**Discussion.** The characteristics of grouper habitat in Moramo Bay, Southeast Sulawesi Province, are classified into 4 groups: 1) hard coral, 2) soft coral, 3) algae and sand, 4) other unidentified dead corals. The health condition of coral reefs in Moramo Bay, Southeast Sulawesi Province, is generally in the good category, as shown by the percentage value of live coral cover of around 39.24–64.32%. On the other hand, the percentage of algae cover tends to be high, ranging from 11.2 to 22.2%. The abundant presence of algae indicates degrading of coral reefs. According to Szmant (2002), coral damage and nutrient enrichment factors may cause increased algal cover. Another main factor is the decline in the population abundance of herbivorous fish is the irresponsible fishing.

Based on the water depth, coral reef conditions were found to be better at a depth of  $\pm 3$ -5 m, due to the increasing intensity of fishing and other marine biota at a depth of  $\pm 10$ -11 m, where many grouper fish were found in appropriate sizes for sale and consumption. Fishing activities cause an increase in the concentration of algae on the surface of the coral, thereby disrupting the coral's photosynthesis process. Furthermore, coral damage at this depth was also caused by ship anchors placed in the coral reef area and by the increased development of tourist activities (Santoso & Kardono 2008).

In general, differences in coral cover percentage are caused by pressure from human activities such as stone mining activities on the coast, large ship anchorages, and ship anchors around Moramo Bay, which directly influence or continuously threaten the aquatic environment in every season. Such conditions must be mitigated through measures able to prevent environmental damage. According to Dahlgren & Eggleston (2001) and Casey et al (2007), the threatening factors of the aquatic environment or the land activities might hinder the reduction of the ecological pressure on coral ecosystems. Effort can be made to reduce this ecological pressure by limiting fishing and tourism activities and regularly monitoring several core and protection zone locations. Increasing coral cover affects the diversity of groupers, genus *Epinephelus*. The number of grouper species caught at the research location varied from 5 to 7, with seven types found on Wawosunggu Island, 6 on Lara Island, and 5 on Moramo Island. The percentage of hard coral cover on Lara Island ranged from 51.33 to 54.21% with  $H'=1.683$ ,  $E=0.939$ , and  $D=0.042$ . The percentage of hard coral on Moramo Island ranges from 39.24 to 43.03% with  $H'=1.542$ ,  $E=0.954$ , and  $D=0.03$ . The percentage of hard coral on Wawosunggu Island ranges from 60.22 to 64.32%, with  $H'=1.714$ ,  $E=0.881$ , and  $D=0.054$ . The diversity of grouper fish of the *Epinephelus* genus found in their habitat is in the medium category. Some earlier studies have used the belt transect method and visual census to observe grouper fish with different analysis results: 14 types were found in the waters of the east coast of Weh Island, Sabang (Hastuty et al 2014), 7 types in Karimunjawa (Mujiyanto et al 2021), and 4 types on Eggano Island, Bengkulu Province (Adrim 2007). The number of types identified differed in this research, as the focus was only on studying the *Epinephelus* genus at the study location, whereas other studies focused on all types of groupers from the Serranidae family. Furthermore, differences in ecosystems and habitats also influence the diversity of groupers observed. The use of fishing gear also greatly influences the grouper sampling.

High diversity and distribution of the individuals of each species cause a high community stability and low ecological pressure. According to Gaspare et al (2015), the emergence of species in a body of water is influenced by dispersal due to migration for spawning and foraging, as organisms can survive, grow, and reproduce due to the energy available in their diet. Changes in grouper habitat conditions influence their diversity. Grouper fish prefer hard coral bottoms, dominated by massive corals with gaps or holes formed at the bottom of coral colonies. The behavior of grouper fish favors darker areas, with their movements tending to deeper waters, which influences the diversity, uniformity, and dominance indices in the waters of Moramo Bay, Southeast Sulawesi Province. Groupers quickly adapt to aquatic environments, from lagoons to coral reef areas. Groupers are different from other pelagic fish types that are schooled during migration which are found only in from the surface layer of the waters and in the water column. Groupers are demersal fish that live in deeper layers at the bottom of the water; thus, they are likely to be found in large numbers in a particular area. Most groupers are associated with coral reefs in shallow areas, with some living in rocky, sandy and muddy estuaries (Tupper 2007). According to Sluka et al (2001), grouper stays in shallow waters while moving to deeper waters in the adult stage as small species usually settle in waters near the coast and large coral fish species settle in offshore, deeper waters. Still, most groupers will remain in coral reef areas near caves to shelter.

**Conclusions.** The characteristics of the grouper habitat in Moramo Bay, Southeast Sulawesi Province, are divided into 4 groups: hard coral, soft coral, algae and others (sand, broken coral, and other unidentified dead coral). Coral reef conditions are better at a depth of  $\pm 3-5$  m, with a hard coral percentage ranging from 43.03 to 64.32%, compared to a depth of  $\pm 10-11$  m, which has a hard coral percentage in the range of 39.24-60.22%. An increased coral cover determines a higher grouper diversity index. Generally, the diversity of groupers found in their habitat is medium. Grouper fish prefer hard coral bottoms, dominated by massive corals that form gaps or holes at the bottom of coral colonies. The grouper fish prefer areas with low brightness and moves to deeper, darker waters.

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**Conflict of interest.** The authors declare no conflict of interest.

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