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Supporting Habitat Contribution to Reef Fish Diversity in Sekotong Bay, West Lombok, Indonesia

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Abstract: Habitat complexity plays a crucial role in shaping the diversity and structure of coral reef fish communities by offering a range of ecological niches for feeding, reproduction, and shelter. This study investigates how different levels of habitat complexity, particularly the presence of supporting habitats such as seagrass beds and mangroves, influence the richness and diversity of coral reef fish communities in Sekotong Bay, Lombok, Indonesia. Data were collected at four stations using the Underwater Visual Census (UVC) method, with observations focusing on habitat parameters, substrate complexity, and anthropogenic activity. Results showed that stations with buffer habitats — mangroves at Station III and seagrass beds at Station IV— exhibited significantly higher species richness and diversity indices compared to other stations. Seagrass beds, in particular, were associated with the highest diversity (H' = 2.95; 42 species), suggesting their key role in maintaining fish community structure. Although Station IV experienced human activity, it still supported a complete community structure, including target fish species, highlighting the ecological buffering capacity of adjacent seagrass habitats. These habitats not only function as nursery grounds and sediment filters but also sustain the ecological balance and resilience of coral reef ecosystems. The study also found that river mouths may negatively affect benthic substrate diversity due to sedimentation unless mitigated by buffer vegetation. Overall, findings underscore the importance of preserving habitat complexity and integrating seagrass and mangrove protection into coastal management strategies to enhance biodiversity, ecosystem stability, and local socio-economic resilience.

Keywords: Community structure, coral reef fish, Sekotong Bay, species diversity, species richness, supporting habitats.

Introduction

Habitat complexity refers to the diversity and variability of physical structures within an ecosystem, playing a critical role in shaping the composition and diversity of resident biological communities, including coral reef fishes. Complex habitats provide a range of ecological niches that different species can exploit for survival, reproduction, and foraging. The structural heterogeneity of these habitats helps reduce interspecific competition by offering a wider array of spatial and resource options, thereby enhancing the likelihood of coexistence among multiple species. Ultimately, this process contributes to increased coral reef fish community diversity (Smith et al., 2014).

Coral reef ecosystems, highly heterogeneous habitat structures—such as complex reef formations, seagrass beds, and mangrove forests—are vital for supporting species richness. Each of these habitats offers distinct environmental conditions and resources for the organisms that inhabit them (Carlson et al., 2021; Hasim, 2021). For instance, Carlson et al. (2021) noted that structurally complex reefs offer refuge for small fish against predators, while seagrass beds serve as important spawning and feeding

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grounds. Mangrove forests, on the other hand, provide shelter and food resources for a variety of organisms, both in shallow waters and along the coast. These components interact synergistically to form a dynamic and biodiverse ecosystem that is essential for the resilience and ecological balance of coral reefs.

Sekotong Bay, located on the western peninsula of Lombok Island, is a coastal region with high ecological potential, featuring coral reefs with varied habitat complexity. The area is also important for fisheries, tourism, and marine transportation. However, coral reef ecosystems in Sekotong Bay face significant pressures from both natural and anthropogenic sources. Previous studies have reported declines in species richness and coral reef composition, primarily linked to overfishing and coral bleaching events (Fitrianti & Ghafari, 2021; Karnan, 2022; Ghafari, 2024). These findings suggest that environmental factors may significantly alter the structure and composition of reef fish communities in the region.

A more recent study by Fitrianti & Ghafari (2023) revealed high levels of microplastic contamination in sediments, with average pollutant densities exceeding those of other coastal areas in western Lombok. This highlights the potential ecological impact of pollution on habitat quality and marine organism health, including that of coral reef fishes. The accumulation of microplastics may reduce fisheries productivity and further degrade environments that depend on diverse species assemblages.

Nonetheless, field observations indicate that the loss of buffer habitats may be a primary driver of reduced species richness and diversity indices in coral reef fish communities in Sekotong Bay. This factor has received comparatively little attention compared to others such as water temperature fluctuations, anthropogenic stressors, and pollution (Bachtiar & Hadi, 2019; Karnan, 2022; Fitrianti & Ghafari, 2023). Buffer habitats such as seagrass beds and mangrove forests naturally function to protect coral reefs by filtering pollutants and providing a physical barrier against human activities (Camp et al., 2016; Carlson et al., 2021). The degradation of these habitats could compromise the ecological integrity of coral reef ecosystems, making them more susceptible to external disturbances. Additionally, the absence of buffer zones may limit the recruitment and nursery grounds essential for many reef-associated fish species.

This study, I describe the species richness and diversity indices of coral reef fish communities across habitat types with varying levels of structural complexity in Sekotong Bay. The findings are intended to inform coral reef management and conservation in the region, and to underscore the importance of protecting buffer habitats for the long-term sustainability of marine ecosystems.

Materials and Method

Data collection

Sekotong Bay is located in the northern part of the western peninsula of Lombok Island, West Nusa Tenggara, Indonesia. The area is recognized as a coastal tourism destination with high habitat diversity, including seagrass beds, mangrove forests, and coral reefs. This habitat heterogeneity makes Sekotong Bay a highly suitable site for biodiversity and coastal ecosystem studies. The bay is also easily accessible via both land and sea routes, facilitating field research and environmental monitoring activities.

Data were collected from four different stations across Sekotong Bay, as shown in Fig. 1. The stations were selected based on the variation in buffer habitat complexity, ranging from terrestrial zones to nearshore reef flats. Coral reef fish community data at each station were gathered using the Underwater Visual Census (UVC) method following Giyanto et al. (2014). Observations included species identification and individual counts, classified by ecological roles (corallivores, herbivores, target/carnivores, major/omnivores, and cryptic species).

Habitat complexity at each station was assessed through field-based visual observations. Substrate complexity was categorized according to criteria adapted from Tarigan et al. (2020). Observed habitat complexity parameters included the presence of buffer habitats (seagrass beds, mangrove forests, and river mouths), substrate complexity, and human activity.

Data analyses

Data were analysed using the Shannon-Weaver diversity index (Shannon & Weaver, 1963) to assess species diversity at each station. Differences in diversity values among stations were compared descriptively. Community structure differences across stations were represented by the percentage composition of ecological roles of coral reef fishes, based on both species richness (role-richness%) and population density (role-density%).

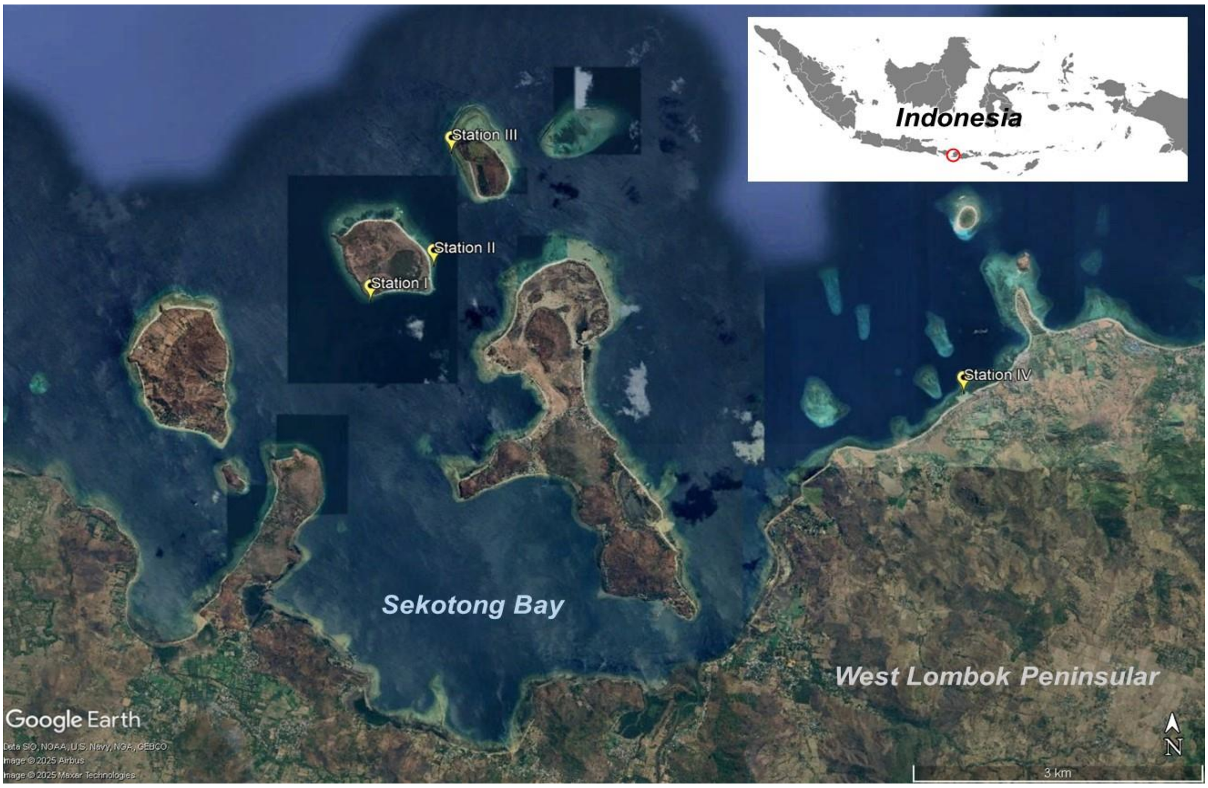

Fig. 1. Location of observation stations in Sekotong Bay, Indonesia.

Results and Discussion

Observations on habitat complexity and biodiversity indices in Sekotong Bay revealed key insights into how habitat features influence ecological diversity. Habitat complexity, which refers to both structural and functional variation within ecosystems, is widely acknowledged as a primary driver of biodiversity (Loke & Todd, 2015). Field data showed considerable variation in habitat complexity among the four sampling stations, particularly regarding the presence of seagrass beds, mangrove forests, and river mouths (Table 1). Seagrass was only found at Station IV, mangroves only at Station III, while river mouths were observed at Stations I and IV. This distribution reflects a dynamic habitat mosaic, where different habitat types may provide distinct ecological functions that support varying levels of species richness and community structure (Loke & Todd, 2015; Henseler et al., 2019; Ghafari & Fitrianti, 2021).

Seagrass and mangrove habitats likely exert contrasting ecological influences compared to river mouths. While all three can serve as nursery grounds, seagrass and mangroves act as sediment buffers, whereas river mouths introduce sediment runoff. Substrate complexity, a key component of habitat structure, strongly influences biodiversity by offering varied niches and resources (Ghafari & Fitrianti, 2021). Station I, which lacks both seagrass and mangroves, had the lowest substrate complexity score possibly due to unbuffered sediment runoff from the river mouth. Conversely, Station IV showed both high substrate complexity and the presence of seagrass, which may function as a sediment trap and contribute to stabilization of the adjacent reef habitat.

Substrate heterogeneity is linked to higher species richness, as it creates a range of microhabitats suitable for different taxa (Loke & Todd, 2015). Although substrate complexity scores were relatively uniform across most stations (moderate scores of 2–4), subtle differences in habitat configuration could influence species composition. For example, Station IV hosted the highest richness and density of corallivorous fishes (Fig. 2), potentially due to nutrient input from the river mouth mitigated by adjacent seagrass beds. These findings suggest complex interactions between habitat features and community structure, meriting further investigation.

Table 1. Habitat complexity and biodiversity metrics across stations

Parameter	Station			
	I	II	III	IV
Habitat complexity:				
a. Seagrass beds	-	-	-	+
b. Mangrove	-	-	+	-
c. River mouth	+	-	-	+
d. Substrate complexity*	2	4	4	4
e. Human activity	-	+	-	+
Diversity index (H')	2.33	2.27	2.42	2.95
Species richness	17	28	26	42

*Note: Substrate complexity scores follow Tarigan et al. (2020)

Human activity also emerged as a significant factor influencing habitat composition. Observable anthropogenic activity was recorded at Stations II and IV. Activities such as coastal development, pollution, and resource exploitation are known to degrade habitat complexity and disrupt ecological processes, often leading to biodiversity loss (Ghafari & Fitrianti, 2021; Bachtiar et al., 2024). Nevertheless, biodiversity patterns in this study did not align directly with human disturbance. Station IV, despite its human activity, recorded the highest species richness and diversity index (H' = 2.95). Moreover, this station also exhibited the most complete community structure, marked by the presence of target fish species (Table 1), despite recorded human activity in the area. This suggests that the presence of nearby buffer habitats—such as seagrass beds adjacent to coral reef zones—can offer significant ecological protection and enhance community resilience.

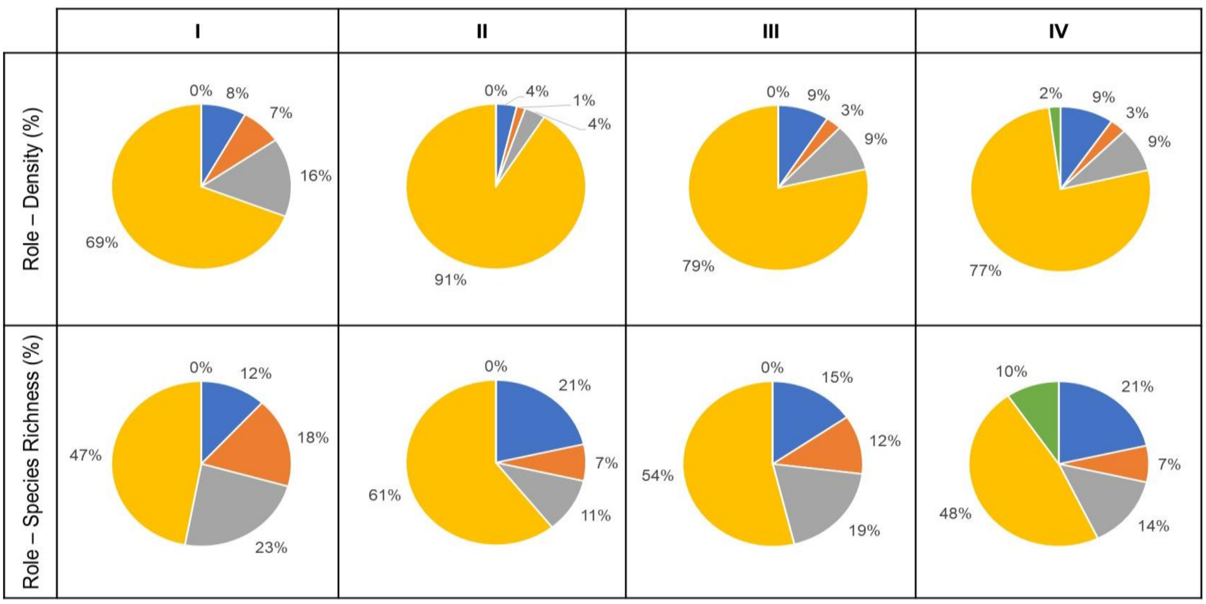

Fig 2. Coral reef fish community structure at each station, represented by their ecological roles based on population density (role-density%) and species richness (role-richness%). Chart colours indicate ecological roles: corallivores (■), cryptic species (■), herbivores (■), major/omnivores (■), and target species (■).

Such evidence supports the notion that buffer zones, particularly seagrass beds and mangroves, may offset human-induced stress and help sustain biodiversity. These findings align with the concept that habitat complexity—particularly in the form of substrate heterogeneity and the presence of supporting habitats such as seagrass beds and mangrove forests—is a primary driver of biodiversity patterns (Jaxion-Harm et al., 2012; Nasution et al., 2024). Buffer zones like seagrass beds have been shown to support 43% to 64% more fish species compared to unvegetated coastal areas (McHenry et al., 2021). Seagrass appears to play a more direct role in enhancing reef fish richness and density due to its importance as a foraging ground, while mangroves function more as protective nurseries (Vaslet et al., 2015; Dung et al., 2020).

The structural complexity provided by seagrass blades and mangrove roots offers essential shelter from predators and strong currents. This complexity also enhances microhabitat availability, which is vital for different life stages of reef-associated species. In the Indo-Pacific, juvenile reef fishes tend to utilize seagrass more frequently than mangroves, contrasting with patterns in the Caribbean (Jaxion-Harm et al., 2012). Verweij et al. (2008) found that up to 98% of reef fish species use seagrass habitats during their life cycle, compared to only 20% for mangroves.

The contribution of these supporting habitats also extends to socio-economic resilience. Buffer zones support fisheries productivity and ecotourism, which are critical for coastal communities (Dewsbury et al., 2016; Japa et al., 2020; Sukeri et al., 2024). This underscores the dual ecological and economic importance of maintaining buffer habitats in coastal regions. Their degradation not only threatens biodiversity but also undermines the livelihoods that depend on healthy reef ecosystems. The present study contributes to the growing literature emphasizing habitat complexity as a key determinant of biodiversity in coastal ecosystems. Future studies should explore more refined habitat metrics and examine temporal changes to better understand how structural features interact with anthropogenic disturbances in shaping biodiversity patterns.

Conclusion

Based on field observations and data analysis, it can be concluded that stations with greater habitat complexity and the presence of supporting habitats (Stations III and IV) exhibited higher coral reef fish diversity indices and species richness compared to other stations. Among the supporting habitats, seagrass beds appear to exert a stronger influence on coral reef fish diversity and richness than mangrove forests.

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