

Benthic Cover Composition and Fish Community Structure in Coral Reef Communities of Davao Oriental, Southeastern Mindanao, Philippines

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ABSTRACT

Coral reef ecosystems support marine biodiversity, fisheries, and coastal livelihoods but remain vulnerable to anthropogenic and environmental disturbances. This study assessed benthic cover composition and fish community structure in coral reef communities in Davao Oriental, Southeastern Mindanao, Philippines. Benthic cover was evaluated using transect-based photo quadrat methods, while reef fish communities were assessed through underwater visual census. Results showed substantial spatial variation in reef condition among sites. Live hard coral cover ranged from 3.8% to 60.3%, with most reefs classified under poor conditions category. Algal assemblages, dead coral with algae, and abiotic substrates dominated several reef areas, indicating varying levels of degradation. Fish abundance and biomass also varied considerably across sites. The findings provide baseline ecological information useful for reef conservation and management planning.

INTRODUCTION

Coral reefs are considered among the most productive and biologically diverse ecosystems in the world, supporting approximately 25% of all marine organisms despite occupying less than 1% of the ocean floor (Hoegh-Guldberg et al., 2017; Spalding et al., 2001). These ecosystems provide critical ecological services, including fisheries production, shoreline protection, nutrient cycling, and tourism opportunities that support millions of coastal residents globally (Hughes et al., 2017). Reef-associated fish communities are closely linked with coral reef habitats, where structural complexity and benthic composition strongly influence fish diversity, abundance, and biomass (Graham & Nash, 2013).

The Philippines lies within the Coral Triangle, a region recognized as the global center of marine biodiversity (Anugrah & Putra, 2020; Carpenter & Springer, 2005; Cinner et al., 2016). Philippine coral reefs provide significant ecological and economic benefits, particularly to coastal communities dependent on fisheries and marine resources (Licuanan et al., 2019). However, many reefs in the country have experienced substantial degradation due to overfishing, destructive fishing practices, sedimentation, pollution, coastal development, and climate-induced disturbances such as coral bleaching (Lesser, 2010). These stressors reduce live coral cover, alter reef community composition, and negatively affect reef-associated fish assemblages (Licuanan et al., 2019; Fox et al., 2005).

In many reef systems, declines in coral cover are often accompanied by increasing dominance of algae, dead coral substrates, and abiotic components, which may reduce habitat complexity and limit reef recovery (Hughes et al., 2018; Fong & Paul., 2010; Jackson et al., 2014). Fish communities are likewise affected by habitat degradation, as structurally simplified reefs tend to support lower biomass and reduced populations of ecologically and economically important fishes (Wilson et al., 2006). The relationship between benthic condition and fish community structure therefore provides important ecological insights into reef ecosystem health.

Marine Protected Areas (MPAs) have become one of the primary conservation strategies used to protect coral reef ecosystems and improve fish populations in the Philippines (Espinilla, 2020; Cabral et al., 2014; Rohrer, 2017). Properly managed MPAs can enhance coral reef resilience, increase fish biomass, and improve ecosystem recovery (Sala & Giakoumi, 2018). Nevertheless, the effectiveness of MPAs varies considerably depending on enforcement, community participation, management practices, and local environmental conditions (White et al., 2006).

Davao Oriental contains several coastal reef ecosystems that support local fisheries and marine biodiversity. Despite their ecological importance, updated ecological assessments of benthic cover and reef fish communities in the province remain limited. Existing studies in Southeastern Mindanao have primarily focused on selected reef systems within Davao Gulf, leaving several reef communities in Davao Oriental insufficiently documented.

This study aimed to assess the benthic cover composition and fish community structure across selected coral reef communities in Davao Oriental,

Southeastern Mindanao, Philippines. Specifically, the study sought to evaluate reef condition based on benthic composition and examine patterns of fish abundance and biomass across sites. The findings of this study may contribute baseline ecological information useful for reef conservation, fisheries management, and future monitoring initiatives in the province.

THEORETICAL REVIEW

This study is anchored on the Habitat Complexity Theory, Coral Reef Fish-Habitat Association Theory, and the principles of Ecosystem-Based Management (EBM). These frameworks collectively explain how variations in benthic cover composition influence the structure, abundance, diversity, and biomass of reef fish communities in coral reef ecosystems.

The Habitat Complexity Theory proposes that structurally complex habitats support higher biodiversity by providing greater niche availability, refuge from predators, feeding opportunities, and breeding habitats (MacArthur & MacArthur, 1961; Tews et al., 2004). In coral reef ecosystems, habitat complexity is largely determined by the composition and structural arrangement of benthic organisms, particularly reef-building corals. Branching, tabulate, and massive corals create three-dimensional structures that enhance habitat heterogeneity and increase the carrying capacity of reef-associated organisms (Graham & Nash, 2013; Richardson et al., 2017). Numerous studies have shown that reefs with greater structural complexity support higher fish abundance, biomass, species richness, and functional diversity than degraded reefs dominated by rubble, dead coral, or algal assemblages (Wilson et al., 2007; Darling et al., 2017).

The study is further supported by the Coral Reef Fish-Habitat Association Theory, which emphasizes the close ecological relationship between benthic habitats and reef fish assemblages. Reef fishes depend on coral reef habitats for food resources, shelter, nursery grounds, spawning sites, and protection from predation. Consequently, changes in benthic composition can directly influence fish community structure and ecosystem functioning (Jones et al., 2004; Pratchett et al., 2008). Coral-dependent species are particularly vulnerable to habitat degradation because declines in live coral cover often lead to reductions in fish abundance, diversity, and recruitment success (Munday et al., 2008; Graham et al., 2015). Studies conducted throughout the Indo-Pacific region have consistently demonstrated positive relationships between live coral cover and reef fish diversity, while increases in algal cover and reef degradation are frequently associated with shifts in fish community composition and reductions in ecological resilience (Wilson et al., 2006; Bellwood et al., 2019; Robinson et al., 2019).

The framework also draws from the concept of Ecological Resilience Theory, which explains how ecosystems respond to disturbances while maintaining their structure and functions (Holling, 1973). Coral reefs are dynamic systems that experience both natural and anthropogenic disturbances, including storms, coral bleaching, overfishing, sedimentation, and pollution. The resilience of reef ecosystems depends largely on the condition of benthic communities and their capacity to recover following disturbance events

(Nyström et al., 2008; Hughes et al., 2010). Healthy coral-dominated reefs generally support more stable fish assemblages and greater ecosystem resilience than degraded reefs characterized by algal dominance and reduced habitat complexity (Bellwood et al., 2004; Hughes et al., 2017). Understanding benthic composition therefore provides valuable insight into the ecological status and recovery potential of coral reef ecosystems.

In addition, this study is guided by the principles of Ecosystem-Based Management (EBM), which recognizes coral reefs as interconnected social-ecological systems where ecological processes, biodiversity, habitat condition, and fisheries productivity are closely linked (Espanilla, 2020; McLeod & Leslie, 2009; Long et al., 2015). Under EBM, maintaining healthy benthic communities is essential for sustaining reef fish populations, preserving ecosystem services, and supporting coastal livelihoods. Coral reefs provide food security, shoreline protection, tourism opportunities, and fisheries resources for millions of people worldwide (Moberg & Folke, 1999; Woodhead et al., 2019). Consequently, evaluating the relationship between benthic cover composition and fish community structure is critical for developing science-based conservation strategies, assessing Marine Protected Area (MPA) effectiveness, and supporting sustainable fisheries management.

Guided by these theoretical perspectives, this study assumes that variations in benthic cover composition influence habitat complexity, resource availability, and ecological functioning, which subsequently affect fish abundance, biomass, species richness, diversity, and community composition. Reefs with higher live hard coral cover and greater structural complexity are therefore expected to support more diverse and abundant fish communities compared with reefs characterized by high proportions of algal assemblages, dead corals, and abiotic substrates.

METHODOLOGY

Study Area

The study was conducted in coral reef communities of Davao Oriental, Southeastern Mindanao, Philippines. Survey sites included reef areas in Banaybanay, Lupon, San Isidro, Baganga-Kinablangan, Baganga-Sauquegui, Cateel, and Bobon. The sites were identified through Macro and Micro-Plastic Pollution (M2P2) Program, which was implemented by the Davao Oriental State University (DOrSU) under the auspices of the Commission on Higher Education (CHED). Three of these sites (Banaybanay, Lupon, San Isidro) were established MPAS and other four sites represent reef systems exposed to varying levels of anthropogenic influence, fishing pressure, and coastal disturbance.

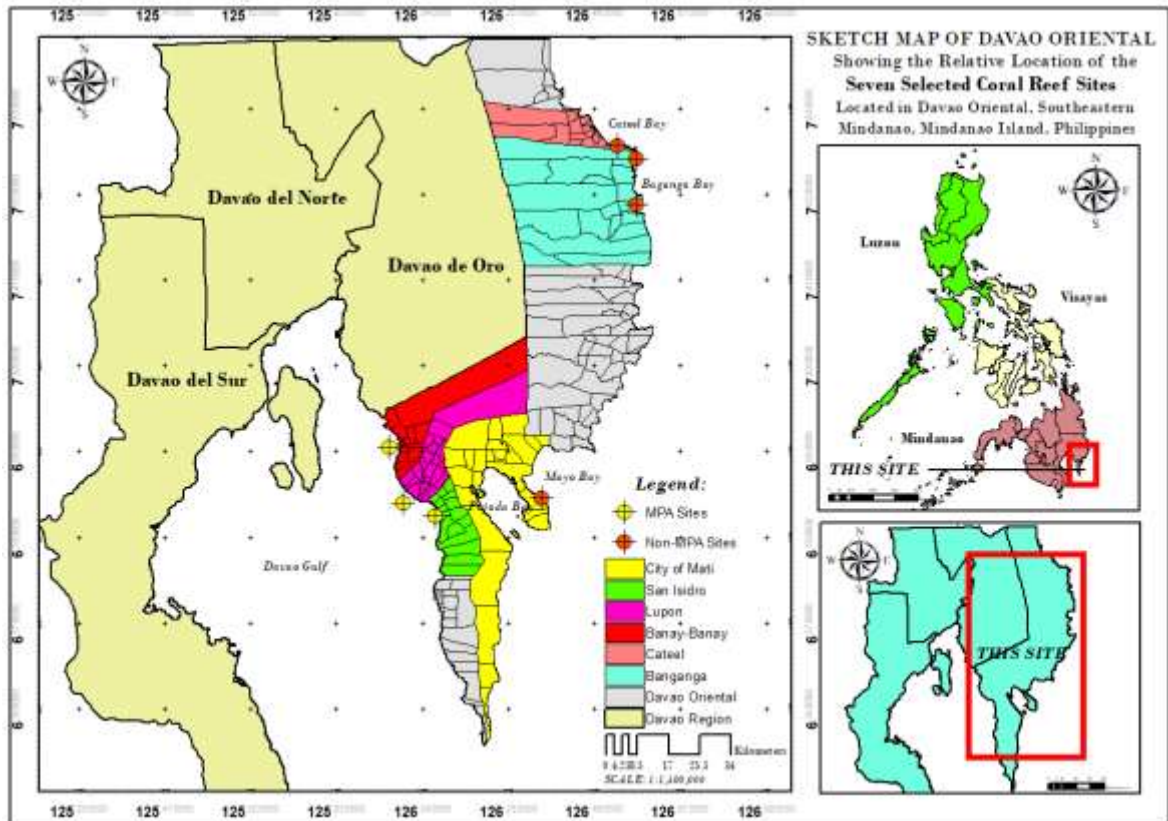


Figure 1. Map showing the study areas in Davao Oriental.

Research Design

The study employed a quantitative ecological assessment design to evaluate benthic cover composition and reef fish community structure across coral reef sites in Davao Oriental.

Benthic Cover Assessment

Benthic cover assessment was conducted using photo-quadrat and transect-based methods adapted from Wilkinson (2004). At each site, four 50-meter transects were established parallel to the shoreline along MPAs and representative reef areas, with 50 photos taken along each transect line. Benthic categories recorded included hard coral, soft coral, seagrass, algal assemblages, other organisms, abiotic substrates, and dead coral with algae.

Coral reef status was classified based on percent live hard coral cover using standard reef condition categories provided by Gomez and Alcala, 1979:

- Excellent = 75–100%
- Good = 50–74.9%
- Fair = 25–49.9%
- Poor = <25%

Fish Community Assessment

Reef fish communities were assessed through underwater visual census techniques. Fish abundance and biomass were recorded along established

transects. Observed fishes were identified and quantified within designated survey areas. Fish biomass estimates were calculated using standard reef fish assessment procedures.

Data Analysis

Descriptive statistics were used to summarize benthic composition, fish abundance, and fish biomass across study sites. Percent cover values were computed for each benthic category, while fish abundance and biomass were expressed as individuals per 500 m² and kilograms per 500 m², respectively.

RESULTS

Benthic Cover Composition and Reef Status Across Study Sites

Substantial variation in benthic cover composition was observed among reef sites in Davao Oriental (Figure 2A and 2B). Live hard coral cover ranged from 3.8% in Cateel to 60.3% in Baganga-Sauquegui. Based on standard coral reef condition classifications, most surveyed reefs were categorized under poor condition, while Baganga-Sauquegui was classified under good condition (Table 1).

Baganga-Sauquegui recorded the highest live hard coral cover (60.3%), followed by Baganga-Kinablangan (18.9%), Banaybanay (17.72%), and San Isidro (17.3%). In contrast, Cateel (3.8%) and Lupon (5.7%) exhibited the lowest live hard coral cover among all sites.

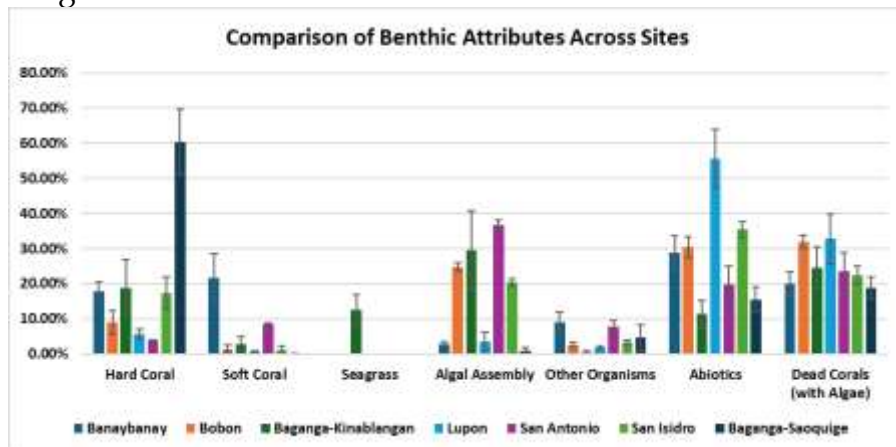


Figure 2. Benthic Attributes Across Sites of Davao Oriental, Southeastern Mindanao.

Algal assemblages were highly dominant in Cateel (36.7%), Baganga-Kinablangan (29.5%), and Bobon (24.7%). Similarly, dead coral with algae was observed across all sites, with highest values recorded in Lupon (32.8%), Bobon (31.9%), and Baganga-Kinablangan (24.5%). Abiotic substrates were likewise prominent in Lupon (55.6%), San Isidro (35.4%), and Bobon (30.4%).

Soft coral cover was highest in Banaybanay (21.72%), while seagrass presence was only observed in Baganga-Kinablangan (12.6%).

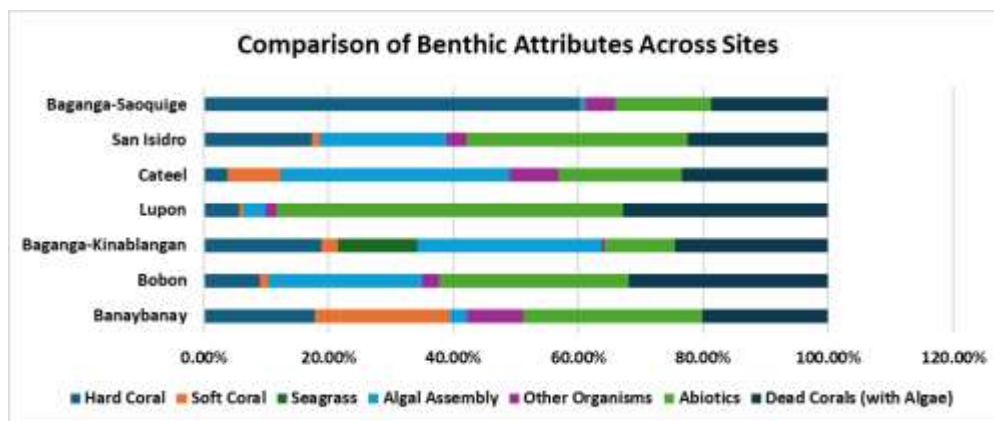


Figure 3. Benthic Attributes Across Sites of Davao Oriental, Southeastern Mindanao.

Table 1. Reef Status Across Study Sites in Davao Oriental.

Site	Hard Coral Cover (%)	Reef Classification Status
Banay-Banay	17.72	Poor
Lupon	5.70	Poor
San Isidro	17.30	Poor
Baganga-Kinablangan	18.90	Poor
Baganga-Saoquique	60.30	Good
Cateel	3.80	Poor
Bobon	9.00	Poor

Fish Abundance and Fish Biomass Across Study Sites

Fish abundance varied considerably among reef sites (Table 2). Banaybanay recorded the highest fish abundance with 1,964.25 individuals per 500 m², followed by Cateel with 875.25 individuals per 500 m² and San Isidro with 712.5 individuals per 500 m². Lower fish abundance values were observed in Baganga-Kinablangan (246 individuals/500 m²), Baganga-Sauquegui (186 individuals/500 m²), and Bobon (296 individuals/500 m²).

Fish biomass also differed across reef sites (Table 3). Banaybanay exhibited the highest fish biomass at 45.04 kg/500 m², followed by Lupon with 36.74 kg/500 m². In contrast, Baganga-Kinablangan recorded the lowest biomass value at 10.17 kg/500 m². Moderate biomass values were observed in San Isidro (22.81 kg/500 m²), Bobon (19.21 kg/500 m²), Baganga-Sauquegui (17.21 kg/500 m²), and Cateel (17.36 kg/500 m²).

Fish abundance and biomass were further classified to provide a clearer ecological interpretation of reef fish condition across the study sites. Because the present study expressed fish abundance and biomass as individuals and kilograms per 500 m², the values were converted to 1,000 m² to align with standard reef fish assessment categories used in previous Philippine coral reef assessments. Fish abundance was interpreted using the categories adopted by Aliño et al (2002), while fish biomass was interpreted following the biomass

classification used by Nañola et al. (2004) and applied in local reef fish assessments.

Based on the converted values, Banaybanay was classified under the high abundance category, indicating the greatest fish density among all surveyed reef sites. Lupon, San Isidro, and Cateel were classified under the moderate abundance category, while Baganga-Kinablangan, Baganga-Sauquegui, and Bobon were classified under the low abundance category. In terms of biomass, Banaybanay and Lupon were classified under the very high biomass category, whereas San Isidro, Baganga-Kinablangan, Baganga-Sauquegui, Cateel, and Bobon were classified under the high biomass category.

Table 2. Fish Abundance Across Selected Coral Reef Sites in Davao Oriental

Site	Fish Count (ind./500 m ²)
Banaybanay	1964.25
Lupon	469.5
San Isidro	712.5
Baganga-Kinablangan	246
Baganga-Saoquigue	186
Cateel	875.25
Bobon	296

Table 3. Fish Biomass Across Selected Coral Reef Sites in Davao Oriental

Site	Fish Biomass (kg/500 m ²)
Banaybanay	45.04
Lupon	36.74
San Isidro	22.81
Baganga-Kinablangan	10.17
Baganga-Saoquigue	17.21
Cateel	17.36
Bobon	19.21

DISCUSSION

The present study revealed substantial spatial variability in benthic cover composition and reef fish community structure across selected coral reef communities in Davao Oriental. The observed differences among sites likely reflect varying levels of anthropogenic disturbance, habitat condition, fishing pressure, and local environmental characteristics. Similar spatial heterogeneity has been widely documented in Philippine coral reef ecosystems, particularly in areas influenced by coastal development, fisheries exploitation, and sedimentation (Licuanan et al., 2019; Montañaño et al., 2021). Comparable findings were reported by Rapiz (2014), wherein coral reef assessments conducted in selected Marine Protected Areas (MPAs) in Davao Oriental revealed that most reef areas were likewise categorized under fair to poor reef conditions. The study documented live

hard coral cover ranging from 14.44% to 36.17% across reef sites, indicating that coral reef degradation has long been evident in several reef systems within the province.

Most surveyed reef sites in the present study exhibited low live hard coral cover, with values generally falling within poor to fair reef condition categories based on standard Philippine reef assessment classifications (Gomez et al., 1994). Live hard coral cover ranged from 3.8% in Cateel to 60.3% in Baganga-Sauquegui, with only one site reaching the good reef condition category. The generally low coral cover observed across several sites may indicate prolonged exposure to ecological stressors such as overfishing, coastal runoff, sedimentation, destructive fishing practices, and climate-related disturbances. Similar patterns of declining coral cover have been reported throughout the Philippines and Southeast Asia, where coral reefs continue to experience increasing degradation from cumulative human impacts and ocean warming (Hoegh-Guldberg et al., 2017; Hughes et al., 2017). The findings of Rapiz (2014) also support the present results, wherein only a few reef areas in Davao Oriental exhibited relatively fair coral condition while several sites remained under poor categories.

The dominance of dead coral with algae (DCA) in several study sites further suggests previous coral mortality followed by algal colonization. High DCA values recorded in Lupon, Bobon, and Baganga-Kinablangan may indicate ecological stress and reduced reef recovery potential. According to Hughes et al. (2018), elevated DCA commonly reflects reefs undergoing post-disturbance succession, where dead coral surfaces become rapidly colonized by algae after bleaching events, sedimentation, or physical damage. Similarly, Graham et al. (2015) noted that increasing algal colonization often suppresses coral recruitment and delays reef recovery. The study conducted by Rapiz (2014) likewise documented high proportions of dead corals in several reef areas in Davao Oriental, noting that dead coral cover in some sites exceeded live coral cover, particularly outside MPAs. These similarities suggest that reef degradation and coral mortality have persisted across several reef systems in the province over time.

High abiotic substrate cover observed in Lupon and San Isidro may also indicate reef degradation and structural simplification. Structural complexity is a major determinant of coral reef ecological functioning because it provides shelter, feeding grounds, and habitat niches for reef-associated organisms, particularly fishes (Graham & Nash, 2013). Reduced structural complexity caused by coral mortality often results in declining fish diversity and biomass (Wilson et al., 2006). Studies in degraded Philippine reef systems have similarly associated high abiotic cover with reduced ecological resilience and lower reef productivity (Diaz-Pulido & McCook, 2004).

Algal assemblages were particularly dominant in Cateel, Baganga-Kinablangan, and Bobon. Increasing algal cover is commonly linked to nutrient enrichment, sedimentation, reduced herbivory, and reef disturbance (Mumby et al., 2007). The high algal presence observed in these sites may indicate possible phase shifts from coral-dominated to algae-dominated reef states. Such ecological transitions are considered critical indicators of reef degradation because excessive

algal growth competes with corals for space and inhibits coral recruitment and recovery processes (Pandolfi et al., 2003; Graham et al., 2015). Similar observations were reported by Rapiz (2014), wherein several reef areas in Davao Oriental exhibited relatively high macroalgal cover ranging from 13.19% to 30.28%. Rapiz (2014) suggested that increasing macroalgal abundance may indicate declining reef resilience and potential shifts toward algae-dominated reef systems.

The occurrence of relatively high algal cover in several sites may also reflect reduced grazing pressure from herbivorous fishes. Herbivorous reef fishes play a critical role in controlling algal proliferation and maintaining reef resilience (Mumby et al., 2007). Declines in herbivore populations caused by overfishing may therefore contribute to increasing macroalgal dominance in disturbed reef ecosystems. Similar ecological conditions have been reported in several reef systems within Davao Gulf and other coastal areas in Mindanao, where fishing pressure and coastal disturbance have altered benthic community composition (Quibilan et al., 2018). In the study of Rapiz (2014), high macroalgal abundance was likewise associated with possible reductions in herbivory and increasing reef disturbance.

Among all surveyed sites, Baganga-Sauquegui exhibited the highest live hard coral cover and the lowest algal cover, suggesting relatively stable ecological conditions. Healthy coral dominance often reflects lower disturbance levels and favorable environmental conditions that support reef growth and recruitment (Sheppard et al., 2017). The comparatively better reef condition in Baganga-Sauquegui may also suggest localized protection effects or reduced anthropogenic pressure. Previous studies have shown that effective reef management and reduced fishing intensity can significantly improve coral cover and reef resilience (Sala & Giakoumi, 2018; Russ & Alcala, 2011). Similar observations were documented by Rapiz (2014), where reef areas with relatively better management and protection exhibited comparatively higher live hard coral cover.

Fish abundance and biomass varied considerably among study sites, indicating differences in habitat quality, reef productivity, and exploitation levels. Banaybanay recorded the highest fish abundance and biomass despite having only moderate hard coral cover. This pattern may suggest that fish community structure is influenced not only by coral cover but also by other ecological factors such as food availability, habitat heterogeneity, hydrodynamic conditions, and fishing intensity (Olds et al., 2012). Similar observations were reported by Nañola et al. (2012), who emphasized that reef fish assemblages in the Philippines are strongly influenced by both habitat condition and exploitation pressure.

The relatively high fish biomass observed in Banaybanay may indicate the presence of larger-bodied fishes or lower levels of fishing pressure compared to other sites. Fish biomass is widely recognized as an important ecological indicator because it reflects reef productivity and fisheries condition (McLeod et al., 2009). According to Halpern (2003), reef areas with reduced fishing pressure generally exhibit higher fish biomass and greater trophic complexity. Rapiz (2014) further emphasized that MPAs are expected to improve fish abundance and biomass over time as coral reef habitats recover under protection.

Interestingly, Baganga-Sauquegui exhibited high live hard coral cover but relatively lower fish abundance and biomass. This apparent mismatch between benthic condition and fish metrics may indicate selective fishing pressure targeting commercially important reef fishes despite the presence of structurally healthy coral habitats. Similar patterns have been documented in several Philippine reef systems where coral habitats remain relatively intact while fish populations become depleted due to overexploitation (Muallil et al., 2014; Nañola et al., 2011).

The comparatively low fish biomass recorded in Baganga-Kinablangan may be associated with degraded benthic conditions characterized by high algal assemblages and reduced live coral cover. Habitat degradation can reduce shelter availability, food resources, and breeding grounds for reef-associated fishes, thereby negatively affecting fish abundance and biomass (Jones et al., 2004; Wilson et al., 2006). Coral reef fishes are highly dependent on habitat complexity, and declines in live coral cover often result in reduced fish recruitment and altered community composition (Graham & Nash, 2013).

Fish abundance patterns observed in this study may also suggest dominance by small-bodied reef fishes in several sites. Philippine reef systems subjected to intensive fishing pressure commonly exhibit reductions in large predatory and commercially valuable species while smaller-bodied fishes become numerically dominant (Muallil et al., 2014). This trophic restructuring may reduce ecological resilience and affect ecosystem functioning.

These results show that fish abundance and biomass did not always follow the same pattern across sites. Banaybanay showed the most favorable reef fish condition because it recorded both high abundance and very high biomass. This suggests that the site supported not only numerous reef fishes but also individuals that contributed substantially to total biomass. Lupon, on the other hand, recorded only moderate abundance but very high biomass, indicating that fewer but relatively larger fishes may have been present. Similar interpretation was reported by Eballe (2014), who emphasized that biomass can remain relatively high even when abundance is lower when the fishes encountered are larger in size. Conversely, sites with higher abundance may still show lower biomass when fish assemblages are dominated by small-bodied individuals.

The contrasting pattern between abundance and biomass is important because abundance mainly reflects the number of individuals, while biomass reflects fish size structure, productivity, and fisheries value. Eballe (2014) observed this pattern in the Pujada Bay corridor, where Barangay Jovellar had poor fish abundance but medium biomass, suggesting that although fewer fishes were encountered, they were comparatively larger. The same study also noted that Barangay Lanca had moderate abundance but low biomass, implying dominance of smaller-bodied fishes. This supports the interpretation that reef fish abundance should not be evaluated separately from biomass when assessing reef condition and fishery potential.

In the present study, Baganga-Sauquegui and Bobon had low abundance but high biomass. This may indicate that the fish community in these sites was not numerically dense but still included individuals or species that contributed relatively high weight. However, low abundance may also suggest possible fishing

pressure, limited recruitment, or reduced habitat suitability. The present findings also suggest that reef fish condition is influenced by both habitat quality and fishing pressure. Reef fishes depend strongly on habitat structure, food availability, and refuge spaces. Degraded reefs with high algal cover, dead coral, rubble, or abiotic substrates may support fewer fishes because these conditions reduce shelter and recruitment areas. McCook (1999) and Hughes et al. (2007) similarly explained that increased algal dominance may indicate a shift from coral-dominated to algae-dominated reef systems, especially when herbivory is reduced or nutrient inputs increase.

The low abundance observed in Baganga-Kinablangan, Baganga-Sauquegui, and Bobon may also reflect exploitation pressure on reef fish communities. Eballe (2014) noted that small-bodied fishes were dominant in several Davao Oriental MPA sites and that top carnivores and herbivores were underrepresented, suggesting possible overexploitation. This interpretation is relevant to the present study because high biomass without high abundance may indicate that fish assemblages are unevenly structured, while low abundance may reflect reduced recruitment or fishing-related depletion. Studies cited by Eballe, including Jameson et al. (2002), Christie & White (2007), and McClanahan et al. (2006), emphasized that protection, governance, and sustained management are necessary for MPAs to improve reef fish assemblages and restore fishery productivity.

Compared with Eballe's (2014) assessment of reef fish abundance and biomass in the Pujada Bay corridor, the present study also demonstrates strong spatial variation among reef sites in Davao Oriental. Eballe reported that Barangay Luban MPA had the best reef fish assemblage, with moderate abundance and high biomass, while Barangay Lanca had the lowest abundance and biomass. Similarly, the present study found that Banaybanay had the strongest fish assemblage based on combined abundance and biomass categories, whereas Baganga-Kinablangan, Baganga-Sauquegui, and Bobon showed lower abundance despite maintaining high biomass.

The findings further support the importance of Marine Protected Areas and local fisheries management. Previous studies cited by Eballe, (2014) including Roberts et al., (2002), Roberts & Hawkins., (2000), Ward & Hegerl (2003), Maypa et al., (2012), and Christie (2004), emphasized that well-managed MPAs can help conserve reef fish populations, improve biomass, and support spillover benefits to adjacent fishing areas. Also, this study is consistent with broader reef assessments conducted in the Philippines and Southeast Asia, where many coral reef ecosystems remain under considerable ecological pressure despite the establishment of marine conservation initiatives (Burke et al., 2011; Wilkinson, 2008). Climate-related disturbances, including coral bleaching and ocean warming, further threaten reef resilience and may intensify ecological degradation in vulnerable coastal ecosystems (Hoegh-Guldberg et al., 2017; Wolff et al., 2018).

Marine Protected Areas (MPAs) remain important management tools for improving reef condition and enhancing fish populations. However, the effectiveness of MPAs largely depends on enforcement efficiency, governance, stakeholder participation, and long-term monitoring (Alcala & Russ, 2006; Sala &

Giakoumi, 2018). Previous studies in the Philippines have demonstrated that well-managed MPAs can improve fish biomass, coral recruitment, and ecosystem recovery over time (Russ & Alcala, 2011; Abesamis & Russ, 2005). Similarly, Rapiz (2014) emphasized that long-term monitoring and sustained management are essential because ecological improvements in coral reefs may take several years before becoming fully evident.

Overall, the present findings indicate that many reef ecosystems in Davao Oriental remain vulnerable to degradation and ecological stress. The widespread occurrence of low live coral cover, high algal dominance, elevated dead coral with algae, and relatively low fish biomass in several sites suggests declining reef resilience and habitat quality. These results highlight the need for strengthened reef conservation strategies, improved fisheries management, continuous ecological monitoring, and enhanced community-based coastal resource management initiatives.

Furthermore, the study provides updated baseline ecological information that may support future reef monitoring programs and policy development in Davao Oriental. Sustained conservation interventions, including stricter fisheries regulation, habitat rehabilitation, sedimentation control, and enhanced community participation, are essential to improve reef resilience and promote long-term sustainability of coral reef ecosystems in the province.

CONCLUSIONS AND RECOMMENDATIONS

The present study revealed considerable spatial variation in benthic cover composition and fish community structure among selected coral reef communities in Davao Oriental. Most surveyed reef sites were classified under poor to fair reef condition categories due to low live hard coral cover and the increasing dominance of algal assemblages, dead coral with algae, and abiotic substrates. These findings indicate that many reef ecosystems in the province are experiencing varying levels of ecological degradation and environmental disturbance. Among the surveyed sites, Baganga-Sauquegui exhibited the highest live hard coral cover and comparatively healthier reef condition, while Cateel and Lupon showed lower coral cover and greater indicators of reef degradation.

Fish abundance and biomass also varied substantially across sites, suggesting that reef fish communities are influenced not only by habitat condition but also by fishing pressure and other local ecological factors. Banaybanay recorded the highest fish abundance and biomass, whereas Baganga-Kinablangan exhibited relatively lower fish biomass associated with degraded benthic conditions. The findings further suggest that healthier reef habitats generally support greater fish productivity, although this relationship may become inconsistent in areas exposed to continued anthropogenic disturbance and exploitation.

Overall, the results highlight the vulnerability of coral reef ecosystems in Davao Oriental to both natural and human-induced stressors despite the presence of localized reef areas with relatively favorable ecological conditions. The study provides updated baseline ecological information that may support reef

conservation planning, fisheries management, and future monitoring initiatives in the province.

Based on the findings, strengthened coral reef conservation and management strategies are recommended in Davao Oriental. Local government units, marine resource managers, and coastal stakeholders should intensify the implementation and enforcement of Marine Protected Areas (MPAs), particularly in reef sites exhibiting poor coral condition and increasing algal dominance. Regular ecological monitoring should be conducted to evaluate long-term changes in reef condition and fish communities, as well as to assess the effectiveness of existing management interventions. Community-based coastal resource management initiatives, environmental education campaigns, and stricter fisheries regulation should also be strengthened to improve reef protection and sustainability. In highly degraded reef areas, habitat rehabilitation and sedimentation control measures may also be considered to support reef recovery and resilience.

FURTHER STUDY

Future studies are recommended to include more comprehensive assessments of reef ecosystem dynamics in Davao Oriental. Detailed analyses of reef fish diversity, coral genera composition, water quality parameters, and anthropogenic stressors may provide a deeper understanding of factors influencing reef condition and fish community structure. Long-term monitoring studies are also necessary to evaluate temporal changes in coral reef ecosystems and determine the effectiveness of Marine Protected Areas and other management interventions over time.

Further research may also focus on the relationship between fishing pressure, habitat complexity, and reef fish productivity across different reef conditions. Studies involving coral recruitment, reef resilience, sedimentation impacts, and climate-related disturbances such as coral bleaching may likewise contribute valuable ecological information for coral reef conservation and management in the province.

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