ORIGINAL PAPER

Community Structure of Scleractinian Corals on Shallow Reef Flats at Mu Ko Surin, Phang Nga Province, Thailand

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Abstract. Shallow reef flats serve as ecologically significant habitats within coral reef ecosystems, supporting a high diversity of scleractinian corals that contribute to reef accretion, structural complexity, and the provision of habitats for associated marine organisms. These areas are typically characterized by dynamic environmental conditions, including fluctuations in temperature, salinity, light penetration, and sedimentation. Such variability makes reef flats important indicators for assessing coral reef health and resilience, particularly in the face of climate change and local anthropogenic stressors. This study examines the community structure of scleractinian corals on shallow reef flats within Mu Ko Surin National Park, Phang Nga Province. The coral communities were examined using permanent belt transects to ensure consistency and accuracy in data collection. The highest percentage of live coral cover was found at Ao Mai Ngam (24.6%), while the lowest was observed at Ao Pak Kaad (17.8%). The most dominant coral species were *Porites lutea*, followed by *Porites rus*, *Diploastrea heliopora*, *Montipora aquituberculata*, *Ctenactis echinata*, *Cyphastrea microphthalma*, *Leptoria phrygia*, and *Coelastrea aspera*. The dominance of *Porites lutea* across all sites reflects its remarkable resilience to elevated temperatures, sedimentation, and reduced light conditions, making it a key species for reef stability in disturbed environments. These findings provide important ecological baselines for reef flat habitats in Mu Ko Surin and contribute to broader regional efforts to monitor coral reef health under changing environmental conditions. The findings emphasize the importance of shallow reef flats for monitoring reef health and guiding management. Using resilient coral species in restoration can enhance reef adaptability, supporting long-term conservation goals. These ecosystems are vital for biodiversity and local communities. Further research on their ecological processes and resilience will inform future conservation strategies.

Keywords: Shallow reef flats, coral bleaching, stress-tolerant species, Mu Ko Surin National Park.

1. Introduction

Coral reefs are among the most biologically diverse and ecologically significant ecosystems on Earth, offering a range of crucial ecosystem services including coastal protection, fisheries support, and tourism opportunities (Hoegh-Guldberg et al., 2007; Tranter et al., 2022; Bartelet et al., 2024;). Scleractinian corals, commonly referred to as stony corals, are the primary reef-builders, depositing calcium carbonate to form complex three-dimensional habitats that support a myriad of marine species (Hughes et al., 2017).

Shallow reef flats, typically located within intertidal and subtidal zones, are critical components of coral reef ecosystems. These areas are characterized by dynamic environmental conditions, including fluctuations in temperature, light intensity, sedimentation, and salinity, making them unique and challenging habitats for coral communities (Brown & Warwick, 2002; Rangseethampanya et al., 2021). However, their proximity to coastal areas also makes shallow reef flats particularly vulnerable to anthropogenic stressors such as coastal development, overfishing, pollution, and climate change (Hughes et al., 2003; McDonald et al., 2020).

One of the most profound threats to coral reefs worldwide is coral bleaching, a phenomenon primarily triggered by elevated sea surface temperatures. Coral bleaching occurs when stressed corals expel their symbiotic zooxanthellae, leading to a loss of pigmentation and disruption of essential metabolic processes (Curran et al., 2021; Ghallab et al., 2024). Repeated or prolonged bleaching events can result in significant coral mortality, altering community structures and reducing reef resilience (Hughes et al., 2018; Sully et al., 2019; Walker et al., 2023). In recent decades, the frequency and severity of mass bleaching events have increased dramatically, driven largely by climate-induced ocean warming (Hughes et al., 2017; Licuanan et al., 2021; Souza et al., 2023). Shallow reef flats, with their exposure to extreme environmental variability, are particularly susceptible to bleaching impacts, and monitoring their community dynamics provides critical insights into reef ecosystem health.

Thailand's Andaman Sea coastline hosts several important coral reef systems, including Mu Ko Surin National Park, which is renowned for its high marine biodiversity and relatively well-preserved reef habitats (Yeemin et al., 2021). Long-term monitoring has indicated that shallow reef flats in Thailand, including those at Mu Ko Surin, play a crucial role in maintaining coral diversity and resilience under environmental pressures (Yeemin et al., 2006; Aunkhongthong et al., 2019).

Recent research has shown that certain coral taxa, particularly those inhabiting shallow reef flats, possess remarkable tolerance to extreme and fluctuating environmental conditions such as high temperatures, elevated turbidity, and sedimentation. Species such as *Porites lutea*, *Porites cylindrica*, *Goniastrea* spp., and *Favites* spp. are recognized for their high stress tolerance and ability to survive in marginal reef environments (Palumbi et al., 2014; Schoepf et al., 2015; Camp et al., 2018; Quigley et al., 2022). These stress-tolerant corals have demonstrated greater resistance to bleaching events compared to more sensitive species, making them critical targets for reef restoration and resilience-building initiatives (Grottoli et al., 2021; Helgoe, et al., 2024). Restoration programs increasingly focus on utilizing such resilient coral species to rehabilitate degraded reef areas, particularly in shallow, high-stress environments where traditional coral species may fail to thrive (Hein et al., 2020; Lange et al., 2024).

Understanding the distribution and dominance of stress-tolerant coral species within shallow reef flats not only provides insights into current reef health but also informs future conservation planning, including the selection of candidate species for active restoration efforts. Therefore, documenting the presence and abundance of these resilient species at Mu Ko Surin is vital for enhancing the adaptive capacity of local reef ecosystems under future climate scenarios.

Given the increasing environmental pressures, this study aims to examines the community structure of scleractinian corals on shallow reef flats within Mu Ko Surin National Park, Phang Nga Province. Specifically, we focus on assessing live coral cover, identifying dominant coral species, and evaluating substrate composition to infer habitat conditions and potential environmental drivers affecting these reefs.

2. Materials and Methods

2.1 Location of study sites

The study was conducted on shallow reef flats at Mu Ko Surin National Park, located in the Andaman Sea, approximately 60 kilometers off the coast of Phang Nga Province, Thailand. The area is characterized by extensive coral reefs, particularly fringing reefs with shallow reef flats that are exposed during low tide. (Figure 1).

2.2 Data collection

Coral communities were surveyed along permanent belt transects measuring 30 meters in length and 1 meter in width, with three replicates established at each study site. Along each transect, photographs were systematically taken using a 50 × 50 cm² quadrat positioned at regular intervals. A high-resolution digital camera was used to capture images for subsequent validation and detailed analysis in the laboratory. During field observations, live coral cover was assessed in situ, and all coral colonies within the quadrats were identified to the species level following the classification system described by Veron (2000). In addition to live coral, the covers of dead coral, rubble, sand, algae, and other benthic components were also recorded as percentage cover for each quadrat.

2.3 Data analysis

Scleractinian corals were identified to the genus or species level based on field guides and photo documentation. The percent cover of each coral taxon was calculated and subsequently used to estimate species diversity (Shannon-Wiener index, H'), dominance, and evenness (Pielou's evenness index, J'). Differences in coral community structure among study sites were analyzed using one-way analysis of variance (ANOVA), followed by Tukey's Honest Significant Difference (HSD) post hoc tests where significant differences were detected.

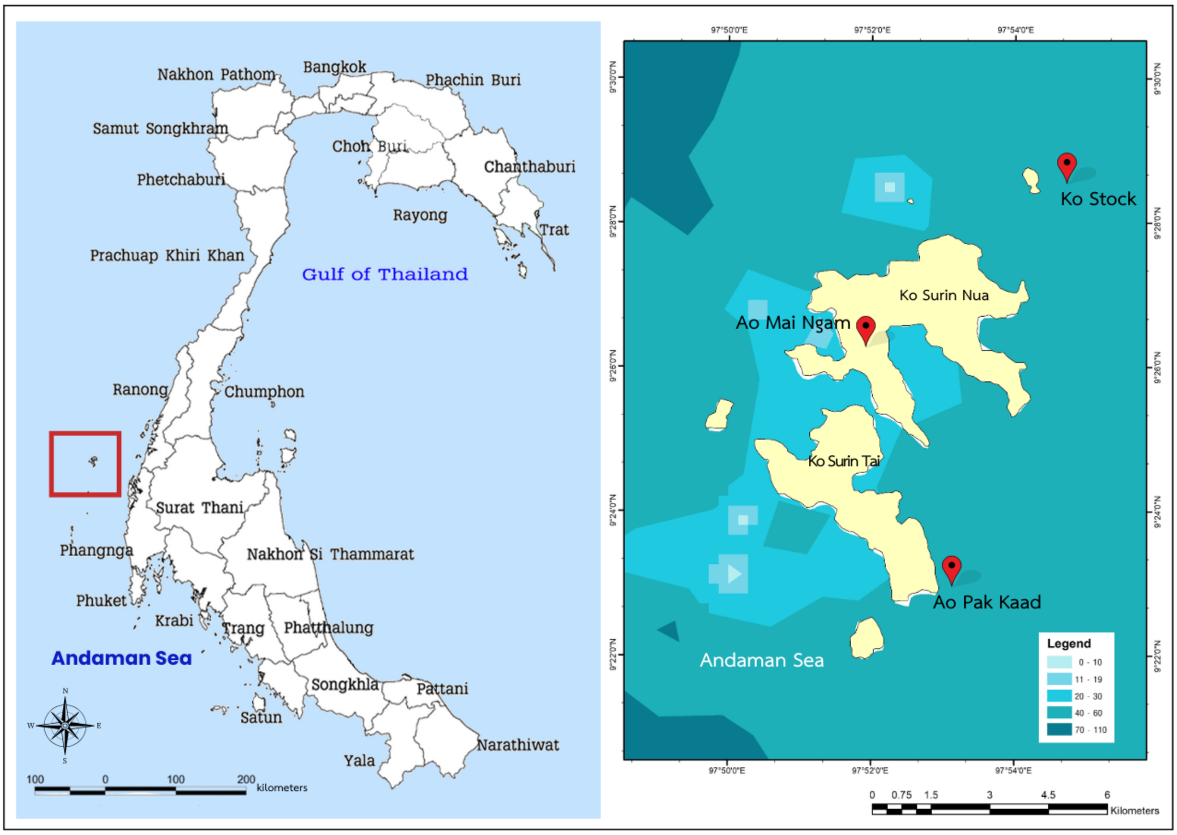

Figure 1. The location of study sites at Mu Ko Surin

3. Results

3.1 *Live Coral Cover*

The results indicated that the highest percentage of live coral cover was found at Ao Mai Ngam (24.62±3.10), while the lowest one was found at Ao Pak Kaad (11.79±1.48). The statistical analysis revealed that the species diversity index was significantly different among the study sites (One-way ANOVA, $F = 48.85$, $p < 0.00$). (Figures 2 and 3). The elevated dead coral cover at Ko Stork may be linked to recent bleaching or physical damage. Meanwhile, the higher live coral cover at Ao Mai Ngam suggests more favorable environmental conditions and lower anthropogenic stress

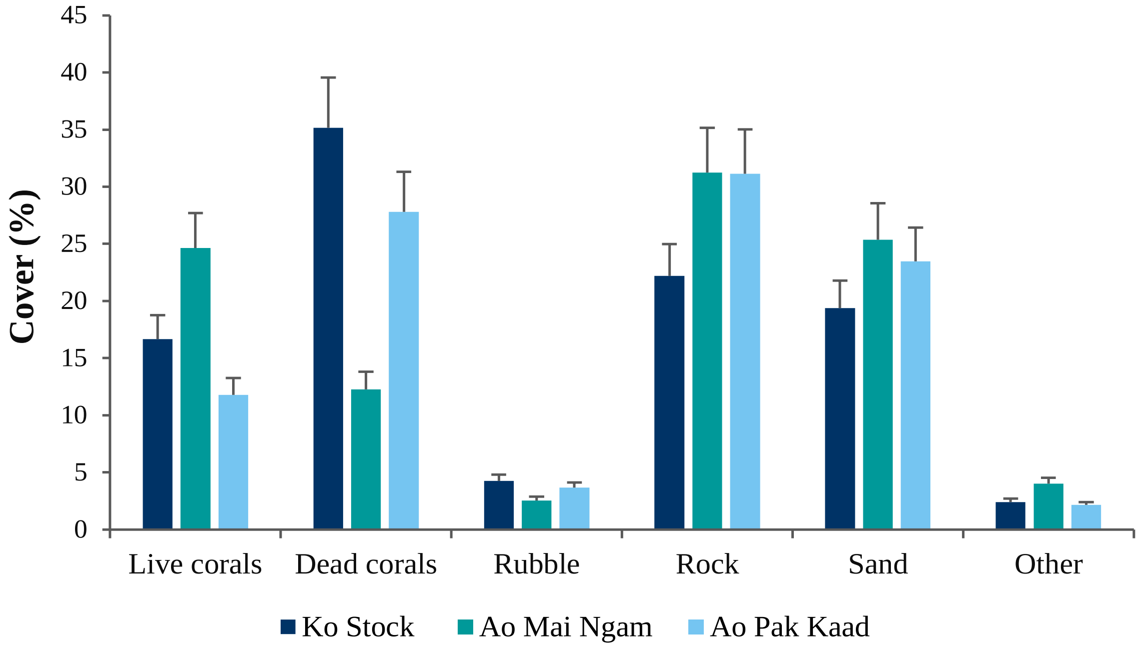

Figure 2. Average percentage cover of live corals, dead corals and other benthic components at the study sites. Error bars indicate standard error of the mean.

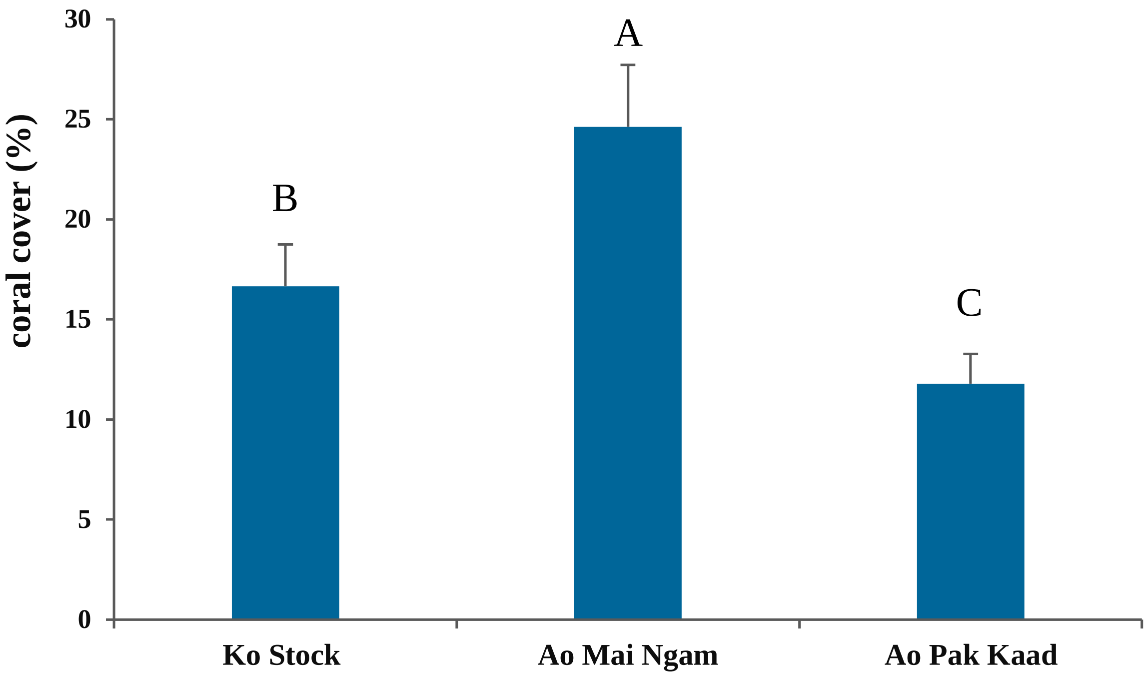

Figure 3. Live coral cover on shallow reef flats at the study sites. Different letters above indicate statistical differences (one-way ANOVA, $p < 0.05$), as determined by Tukey's HSD.

3.2 Coral Species Composition and Distribution

A total of 47 coral species were recorded across the three study sites. The most dominant species was *Porites lutea*, followed by *Porites rus*. Other commonly encountered species included *Diploastrea heliopora*, *Montipora aquituberculata*, *Ctenactis echinata*, *Cyphastrea microphthalma*, *Leptoria phrygia*, and *Coelastrea aspera*. The heatmap analysis clearly illustrated differences in species composition among sites. Ko Stork demonstrated the highest species richness, with a broad range of coral taxa observed at low to moderate abundance levels. In contrast, Ao Mai Ngam was dominated by a single taxon, *Porites lutea*, which exhibited the highest relative abundance of all recorded species. Porites rus was also consistently present across all sites, particularly abundant at Ko Stork and Ao Pak Kaad, suggesting its broad environmental tolerance and potential as a stress-resilient species.

Ao Pak Kaad exhibited the lowest overall species richness and relative abundance, yet *Porites lutea* and *Porites rus* remained detectable, reinforcing their ecological role as potential foundation species under stress-prone conditions. These patterns underscore the ecological heterogeneity among shallow reef flats in Mu Ko Surin and highlight the importance of resilient coral species in sustaining community structure and function in disturbed reef environments. (Figures 4 and 6).

3.3 Coral Diversity Index

The diversity and evenness of coral communities varied markedly among the three surveyed sites. Ko Stork exhibited the highest species diversity with a Shannon–Wiener index (H′) of approximately 2.77, indicating a relatively rich coral assemblage. However, the corresponding Pielou's evenness index (J′) was the lowest at 0.05, suggesting that the community was dominated by a few coral taxa. In contrast, Ao Pak Kaad had the lowest species diversity (H′ ≈ 1.47) but showed the highest evenness (J′ ≈ 0.13), reflecting a more equitable distribution of coral species within the community. Ao Mai Ngam exhibited intermediate values for both indices (H′ ≈ 1.76, J′ ≈ 0.06), indicating moderate diversity and low evenness. These patterns suggest differences in community structure and ecological balance across sites, which may reflect varying degrees of disturbance, habitat stability, or recovery stages. (Figure 5).

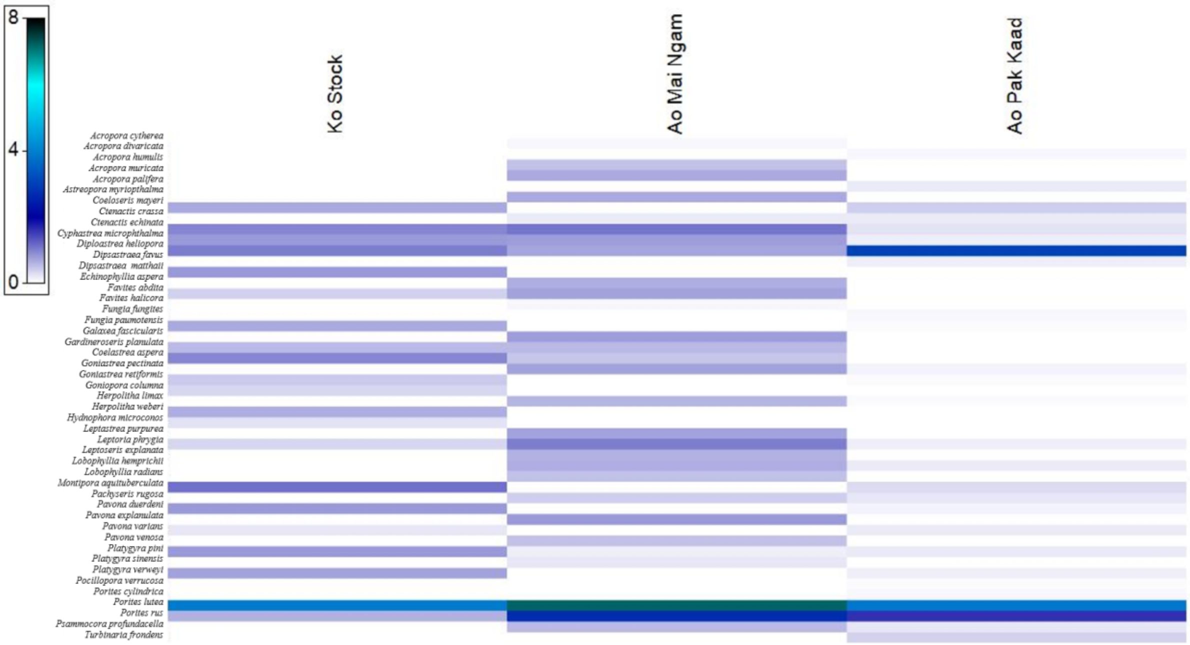

Figure 4. Species composition of live corals at the study sites.

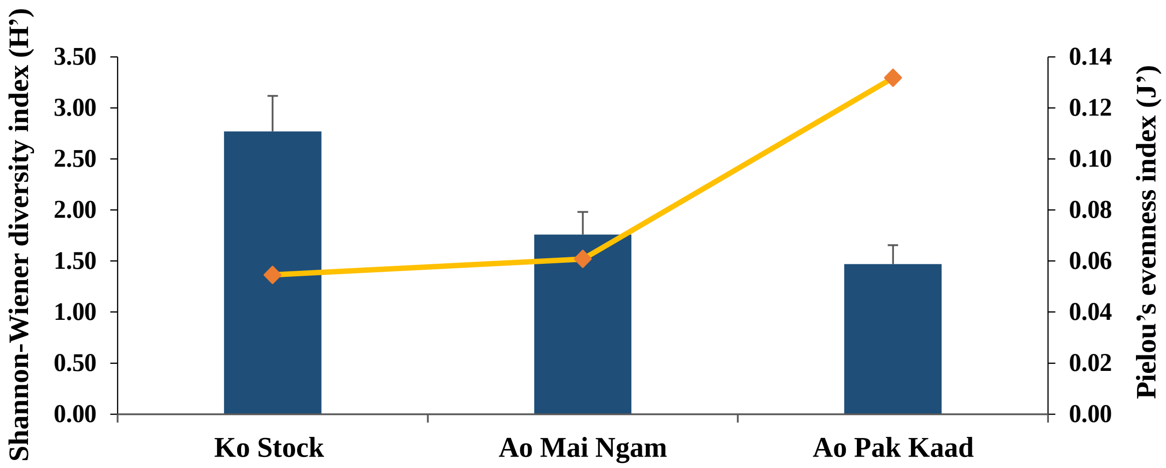

Figure 5. Shannon's diversity index (H') and Pielou's evenness index (J') at each study site

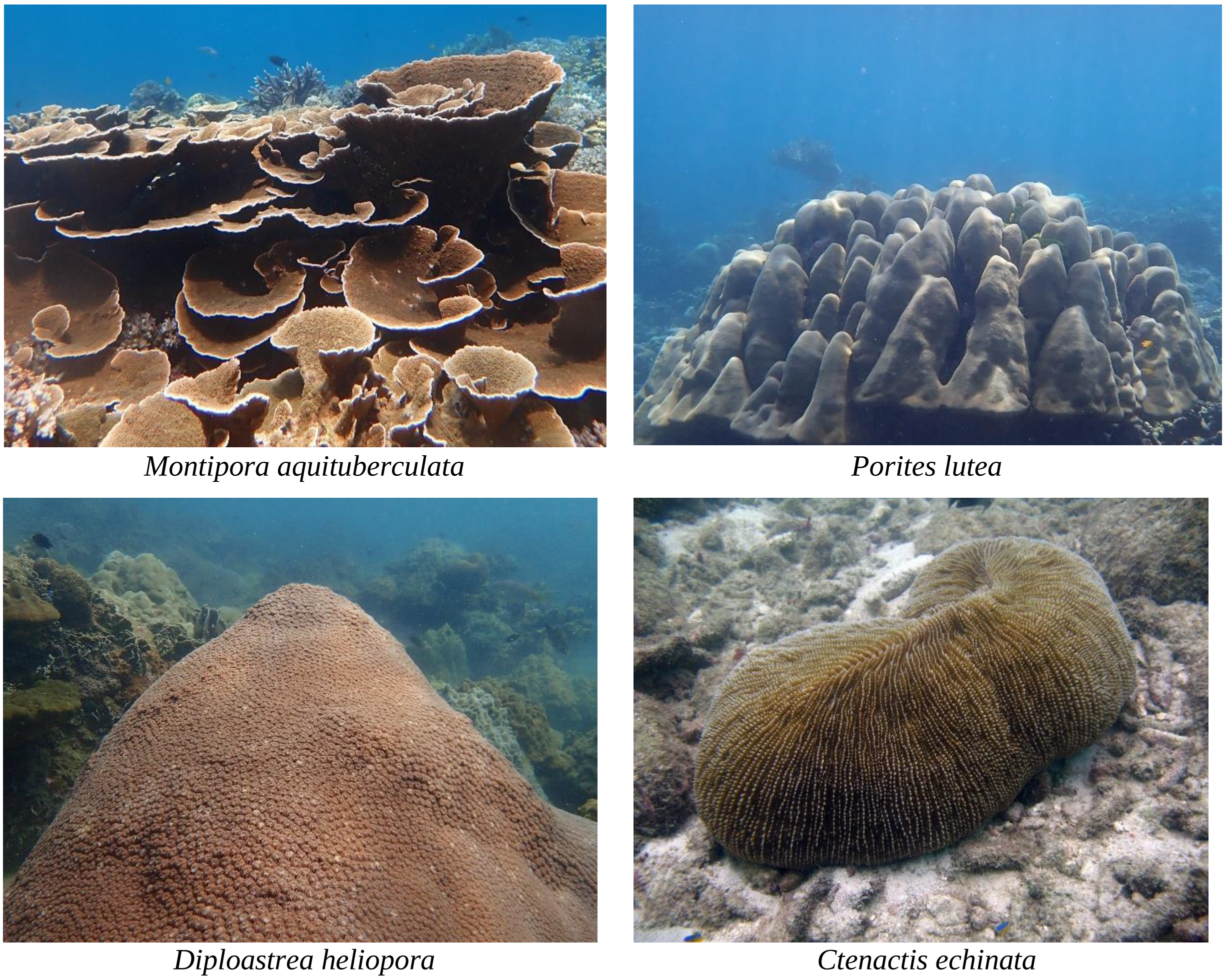

Figure 6. Shallow reef flat photographs showing dominant coral species at the study sites

4. Discussion

The community structure of scleractinian corals on shallow reef flats at Mu Ko Surin demonstrates distinct spatial variation in coral cover, species dominance, and biodiversity across different bays. The live coral cover ranged from 11.79% at Ao Phakkat to 24.62% at Ao Mai Ngam, indicating a gradient in habitat condition likely influenced by environmental and anthropogenic factors. Dominance of *Porites* *lutea* across all sites reflects its ecological resilience and adaptability. This species was the most abundant at every surveyed site, with the highest cover recorded at Ao Mai Ngam (7.69%). *Porites lutea* is known to tolerate sedimentation, turbidity, and thermal stress, allowing it to dominate shallow reef flat environments that are subject to fluctuating conditions (Huang et al., 2022; Yeemin et al., 2023; Sadhukhan et al., 2024). Its prevalence supports previous findings from other regions in Thailand, such as Ko Chumphon and Ko Phuket, where *Porites* spp. was also dominant (Aunkhongthong et al., 2019)

Shallow reef flats, which form the interface between intertidal and subtidal zones, are known for their exposure to dynamic environmental conditions, including temperature fluctuations, sedimentation, and light variability (Reid et al., 2020; Roelvink et al., 2021; Li et al., 2023). These ecosystems serve as early indicators of environmental stress and are particularly vulnerable to coral bleaching and other anthropogenic disturbances (Hughes et al., 2003; Richardson et al., 2020).

The current study reveals marked spatial heterogeneity in coral community structure among shallow reef flats at Mu Ko Surin, reinforcing findings from previous surveys in Thailand (Yeemin et al., 2006; Aunkhongthong et al., 2019). Among the three sites, Ao Mai Ngam demonstrated the highest live coral cover and a relatively stable substrate composition, likely reflecting more favorable environmental conditions and lower anthropogenic impacts. In contrast, Ko Stork exhibited the highest dead coral cover and the lowest evenness, suggesting historical disturbance events such as bleaching or physical damage that have resulted in the dominance of a few resilient species. Ao Pak Kaad, while showing lower overall coral cover and richness, still maintained the presence of stress-tolerant species such as *Porites lutea* and *Porites rus*, indicating a potential role of these taxa in maintaining reef structure under disturbed conditions.

Coral bleaching, primarily driven by elevated sea surface temperatures, remains a major threat to reef ecosystems, particularly in shallow reef flat habitats (Hoegh-Guldberg et al., 2007; Hughes et al., 2018). These habitats often exhibit pronounced bleaching responses due to their shallow depth and limited water exchange (Suggett et al., 2020; Rich et al., 2022; Van et al., 2022). However, certain coral taxa have shown remarkable tolerance to such stress. Notably, *Porites lutea* and *Porites rus*, which dominated across all study sites, are known to persist under elevated turbidity, sedimentation, and thermal stress (Palumbi et al., 2014; Schoepf et al., 2015). The consistent presence of these species across all sites highlights their ecological importance and potential as foundation species in reef resilience.

Given the ongoing impacts of climate change and the increasing frequency of mass bleaching events (Sully et al., 2019), resilience-based restoration approaches have gained momentum. These strategies prioritize the use of stress-tolerant corals in active restoration, particularly in marginal environments such as shallow reef flats (Guest et al., 2018; Mahzarnia et al., 2020; Alkhaleel et al., 2022; Wei et al., 2024). In Thailand, shallow reef flats in areas like Mu Ko Surin have been identified as critical zones for coral survival and long-term monitoring (Yeemin et al., 2021). Incorporating locally adapted, stress-resilient taxa into restoration frameworks may enhance recovery outcomes and sustain ecosystem functions under future climate scenarios.

The ecological importance of reef flats as recruitment grounds, nursery habitats, and buffers against wave energy, their protection is critical. Conservation efforts should prioritize sites with relatively high diversity and coral cover while also implementing restoration and management strategies in degraded areas. These may include sediment control, visitor management, reef zoning, and periodic ecological monitoring to track changes and resilience potential (Hughes et al., 2017; Sutthacheep et al., 2019; Kusumoto et al., 2020; Edmunds et al., 2023;).

Shallow reef flats in Thailand, particularly in Mu Ko Surin, are highly vulnerable to the combined effects of global warming and local disturbances, as highlighted by studies that have emphasized their role in supporting diverse marine life (Yeemin et al., 2006; Chamchoy et al., 2021). These ecosystems provide critical ecosystem services, including coastal protection, fisheries support, and tourism opportunities. As such, integrating long-term ecological monitoring with proactive restoration strategies is essential for preserving these valuable habitats in the face of climate change. (Westoby et al., 2020; Howlett et al., 2022)

This study highlights significant spatial variability in coral community composition and substrate conditions across shallow reef flats in Mu Ko Surin National Park. The observed patterns reflect varying degrees of environmental stability and disturbance history among the sites. The dominance of stress-tolerant species such as Porites lutea and Porites rus suggests their ecological role as foundation species, particularly in environments exposed to bleaching and sedimentation stress.

These findings emphasize the importance of shallow reef flats as sentinel habitats for monitoring reef health and guiding adaptive management. Promoting the use of resilient coral taxa in restoration programs may strengthen the adaptive capacity of reef systems, contributing to long-term conservation goals under increasing environmental pressures. The resilience of these ecosystems is critical not only

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References

Alkhaleel BA, Liao H, Sullivan KM (2022) Risk and resilience-based optimal post-disruption restoration for critical infrastructures under uncertainty. Eur J Oper Res 296(1):174-202

Aunkhongthong W, Yeemina T, Mue-sueaa O, Niyomthaia P, Jungraka L, Ruangthongb L, Sutthacheep M (2019) Assessing population densities of Pocillopora acuta on shallow reef flats in the Western Gulf of Thailand. Ramkhamhaeng Int J Sci Technol 2(1):17-23

Bartelet HA, Barnes ML, Cumming GS (2024) Estimating and comparing the direct economic contributions of reef fisheries and tourism in the Asia-Pacific. Mar Policy 159:105939

Brown B, Clarke K, Warwick R (2002) Serial patterns of biodiversity change in corals across shallow reef flats in Ko Phuket, Thailand, due to the effects of local (sedimentation) and regional (climatic) perturbations. Mar Biol 141:21-29

Camp EF, Schoepf V, Mumby PJ, Hardtke LA, Rodolfo-Metalpa R, Smith DJ, Suggett DJ (2018) The future of coral reefs subject to rapid climate change: lessons from natural extreme environments. Front Mar Sci 5:4

Chamchoy C, Sutthacheep M, Ruengthongb C, Klingklaob C, Pengsakuna S, Klinthonga W, Yeemin T (2021) Demographic composition of juvenile corals on shallow reef flats and reef slopes in Mu Ko Ang Thong National Park, the Western Gulf of Thailand. Ramkhamhaeng Int J Sci Technol 4(1):8-18

Curran A, Barnard S (2021) What is the role of zooxanthellae during coral bleaching? Review of zooxanthellae and their response to environmental stress. South Afr J Sci 117(7-8) de Souza MR, Caruso C, Ruiz-Jones L, Drury C, Gates RD, Toonen RJ (2023) Importance of depth and temperature variability as drivers of coral symbiont composition despite a mass bleaching event. Sci Rep 13(1):8957

Edmunds PJ (2023) Coral recruitment: patterns and processes determining the dynamics of coral populations. Biol Rev 98(6):1862-1886

Ghallab A, Hussein HN, Madkour H, Osman A, Mahdy A (2024) Status of coral reefs along the Egyptian Red Sea coast. In: Coral Reefs and Associated Marine Fauna around the Arabian Peninsula, CRC Press, pp 32-46

Grottoli AG, Toonen RJ, van Woesik R, Vega Thurber R, Warner ME, McLachlan RH, Wu HC (2021) Increasing comparability among coral bleaching experiments. Ecol Appl 31(4):e02262

Guest JF, Fuller GW, Vowden P (2018) Venous leg ulcer management in clinical practice in the UK: costs and outcomes. Int Wound J 15(1):29-37

Hein MY, Beeden R, Birtles A, Gardiner NM, Le Berre T, Levy J, Willis BL (2020) Coral restoration effectiveness: multiregional snapshots of the long-term responses of coral assemblages to restoration. Diversity 12(4):153

Helgoe J, Davy SK, Weis VM, Rodriguez-Lanetty M (2024) Triggers, cascades, and endpoints: connecting the dots of coral bleaching mechanisms. Biol Rev 99(3):715-752

Hoegh-Guldberg O, Mumby PJ, Hooten AJ, Steneck RS, Greenfield P, Gomez E, Hatziolos ME (2007) Coral reefs under rapid climate change and ocean acidification. Science 318(5857):1737-1742

Howlett L, Camp EF, Edmondson J, Agius T, Hosp R, Suggett DJ (2022) Adoption of coral propagation and out-planting via the tourism industry to advance site stewardship on the northern Great Barrier Reef. Ocean Coast Manag 225:106199

Huang W, Yang E, Yu K, Meng L, Wang Y, Liang J, Wang G (2022) Lower cold tolerance of tropical Porites lutea is possibly detrimental to its migration to relatively high latitude refuges in the South China Sea. Molecular Ecology 31(20):5339-5355

Hughes DJ, Lee A, Tian AW, Newman A, Legood A (2018) Leadership, creativity, and innovation: A critical review and practical recommendations. The Leadership Quarterly 29(5):549-569

Hughes K, Bellis MA, Hardcastle KA, Sethi D, Butchart A, Mikton C, Dunne MP (2017) The effect of multiple adverse childhood experiences on health: a systematic review and meta-analysis. The Lancet Public Health 2(8):e356-e366

Hughes K, Bellis MA, Hardcastle KA, Sethi D, Butchart A, Mikton C, Dunne MP (2017) The effect of multiple adverse childhood experiences on health: a systematic review and meta-analysis. The Lancet Public Health 2(8):e356-e366

Hughes TP, Baird AH, Bellwood DR, Card M, Connolly SR, Folke C, Roughgarden J (2003) Climate change, human impacts, and the resilience of coral reefs. Science 301(5635):929-933

Hughes TP, Kerry JT, Álvarez-Noriega M, Álvarez-Romero JG, Anderson KD, Baird AH, Wilson SK (2017) Global warming and recurrent mass bleaching of corals. Nature 543(7645):373-377

Kusumoto B, Costello MJ, Kubota Y, Shiono T, Wei CL, Yasuhara M, Chao A (2020) Global distribution of coral diversity: Biodiversity knowledge gradients related to spatial resolution. Ecological Research 35(2):315-326

Lange ID, Razak TB, Perry CT, Maulana PB, Prasetya ME, Lamont TA (2024) Coral restoration can drive rapid reef carbonate budget recovery. Current Biology 34(6):1341-1348

Li J, Asner GP (2023) Global analysis of benthic complexity in shallow coral reefs. Environ Res Lett 18(2):024038

Licuanan WY, Mordeno PZB (2021) Citizen science reveals the prevalence of the 2020 mass coral bleaching in one town. Philipp J Sci 150(3):945-949

Mahzarnia M, Moghaddam MP, Baboli PT, Siano P (2020) A review of the measures to enhance power systems resilience. IEEE Systems Journal 14(3):4059-4070

McDonald J, McGee J, Barnes R (2020) Oceans and coasts in the era of Anthropogenic climate change. In Research Handbook on Climate Change, Oceans and Coasts (pp. 2-26). Edward Elgar Publishing

Palumbi SR, Barshis DJ, Traylor-Knowles N, Bay RA (2014) Mechanisms of reef coral resistance to future climate change. Science 344(6186):895-898

Quigley M, Bradley A, Playfoot D, Harrad R (2022) Personality traits and stress perception as predictors of students' online engagement during the COVID-19 pandemic. Personality and Individual Differences 194:111645

Rangseethampanya P, Chamchoy C, Yeemin T, Ruengthong C, Thummasan M, Sutthacheep M (2021) Coral community structures on shallow reef flat, reef slope and underwater pinnacles in Mu Ko Chumphon, the Western Gulf of Thailand. Ramkhamhaeng Int J Sci Technol 4(1):1-7

Reid EC, Lentz SJ, DeCarlo TM, Cohen AL, Davis KA (2020) Physical processes determine spatial structure in water temperature and residence time on a wide reef flat. J Geophys Res Oceans 125(12):e2020JC016543

Rich WA, Carvalho S, Berumen ML (2022) Coral bleaching due to cold stress on a central Red Sea reef flat. Ecology and Evolution 12(10):e9450

Richardson LE, Graham NA, Hoey AS (2020) Coral species composition drives key ecosystem function on coral reefs. Proc R Soc B 287(1921):20192214

Roelvink FE, Storlazzi CD, Van Dongeren AR, Pearson SG (2021) Coral reef restorations can be optimized to reduce coastal flooding hazards. Front Mar Sci 8:653945

Sadhukhan K, Dixit S, Reddiar ST, Shekar R, Chatragadda R, Murthy MR (2024) Resilience-Based Assessment of Shallow Water Patchy Reefs in Palk Bay of South East Coast of India. Ocean Sci J 59(3):36

Schoepf V, Stat M, Falter JL, McCulloch MT (2015) Limits to the thermal tolerance of corals adapted to a highly fluctuating, naturally extreme temperature environment. Sci Rep 5(1):17639

Suggett DJ, Smith DJ (2020) Coral bleaching patterns are the outcome of complex biological and environmental networking. Global Change Biol 26(1):68-79

Sully S, Burkepile DE, Donovan MK, Hodgson G, Van Woesik R (2019) A global analysis of coral bleaching over the past two decades. Nature Commun 10(1):1264

Sutthacheep M, Chamchoy C, Pengsakun S, Klinthong W, Yeemin T (2019) Assessing the resilience potential of inshore and offshore coral communities in the Western Gulf of Thailand. J Mar Sci Eng 7(11):408

Tranter SN, Ahmadia GN, Andradi-Brown DA, Muenzel D, Agung F, Ford AK, Beger M (2022) The inclusion of fisheries and tourism in marine protected areas to support conservation in Indonesia. Mar Policy 146:105301

Van Woesik R, Shlesinger T, Grottoli AG, Toonen RJ, Vega Thurber R, Warner ME, Zaneveld J (2022) Coral-bleaching responses to climate change across biological scales. Global Change Biol 28(14):4229-4250

Walker NS, Nestor V, Golbuu Y, Palumbi SR (2023) Coral bleaching resistance variation is linked to differential mortality and skeletal growth during recovery. Evol Appl 16(2):504-517

Wei Y, Cheng Y, Liao H (2024) Optimal resilience-based restoration of a system subject to recurrent dependent hazards. Reliab Eng Syst Saf 247:110137

Westoby R, Becken S, Laria AP (2020) Perspectives on the human dimensions of coral restoration. Reg Environ Change 20(4):109

Yeemin T, Sutthacheep M, Pettongma R (2006) Coral reef restoration projects in Thailand. Ocean Coast Manag 49(9-10):562-575

Yeemin T, Sutthacheep M, Chamchoy C, Nakajima Y, Sakai K, Pengsakun S, Aunkhongthong W (2023) Assessing genetic diversity and connectivity of the dominant massive coral Porites lutea in the Gulf of Thailand. Ramkhamhaeng Int J Sci Technol 6(2):45-58

Yeemin T, Sutthacheep M, Klinthong W, Sangmanee N, Chamchoy C, Jungrak L (2021) Abundance of the magnificent sea anemone (Heteractis magnifica) and its marine ecotourism potential at Mu Ko Chumphon National Park, Thailand. Ramkhamhaeng Int J Sci Technol 4(2):11-18