ORIGINAL PAPER

Assessment of Coral Recruitment on Shallow Reef Flats at Mu Ko Surin, Phang Nga Province, Thailand

Wanlaya Klinthong[a], Wiphawan Aunkhongthong[a], Charernmee Chamchoy[a], Laongdow Jungrak, Sittiporn Pengsakun,[a] Maneerat Sukkeaw[a], Wirat Banleng[b], Thamasak Yeemin[a], Makamas Sutthacheep[a]*

[a]Marine Biodiversity Research Group, Faculty of Science, Department of Biology, Huamak, Bangkapi, Thailand, 10240
[b]Mu Ko Surin National Park,Kuraburi,Phungnga,Thailand 82150

*Corresponding author: *smakamas@hotmail.com*

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Abstract. Coral recruitment is a key ecological process underpinning reef recovery, structural complexity, and long-term ecosystem functionality. Shallow reef flats, despite their harsh physical conditions, can provide diverse microhabitats that support coral settlement and early survival. This study aimed to quantify the density and composition of coral recruitment on shallow reef flats in Mu Ko Surin National Park, Phang Nga Province. Field surveys were conducted in 2024 at five reef sites, where live coral cover was quantified using 30 × 1 m belt transects, and coral recruitment was assessed with 16 × 16 cm quadrats at 1–2 m depth. Coral recruits (≤ 5 cm in diameter) were identified to the genus level. Live coral cover ranged from 11.8% to 34.5%, with the highest cover observed at Ao Jaak (34.5%), followed by Ao Suthep (25.9%) and Ao Mai Ngam (24.6%). In contrast, Ao Mae Yai (14.2%) and Ao Pak Kaad (11.8%) exhibited degraded reef conditions. Coral recruitment density varied significantly among sites ($F = 48.17$, $p < 0.05$). Ao Mai Ngam functioned as a recruitment hotspot (15.79 ± 1.94 recruits/ m^2), supporting higher recruit densities and broader taxonomic representation, while Ao Suthep exhibited intermediate recruitment. Other sites, including Ao Jaak, Ao Mae Yai, and Ao Pak Kaad, showed consistently low recruit densities and limited taxonomic diversity. Our findings reveal pronounced spatial heterogeneity in coral cover and recruitment across Mu Ko Surin reef flats. Recruitment hotspots play a critical role in sustaining connectivity and resilience, whereas degraded sites remain recruitment-limited. Site-specific management that integrates conservation, restoration, and long-term monitoring is essential to enhance recovery and ensure the sustainability of coral reef ecosystems under intensifying climate and anthropogenic pressures.

Keywords: Andaman Sea, Coral recruitment, Mu Ko Surin, Reef resilience, Restoration, Shallow reef flats

1. Introduction

Coral recruitment, the process by which coral larvae settle onto benthic substrates and develop into juvenile colonies, is a fundamental ecological process underpinning reef recovery, structural complexity, and long-term ecosystem functionality. Successful recruitment maintains population connectivity, genetic diversity, and ecosystem resilience following disturbances such as bleaching events, storms, or anthropogenic degradation (Hughes et al., 2010; Doropoulos et al., 2015; Yeemin et al., 2020; Carlson et al., 2024). Consequently, understanding the environmental conditions and biological interactions that govern coral recruitment is critical for conservation and restoration efforts.

Among the mosaic of reef habitats, shallow reef flats represent uniquely dynamic and ecologically significant environments. These low-gradient platforms, typically located on the landward margins of reef structures, are characterized by periodic aerial exposure, high irradiance, and pronounced fluctuations in temperature and salinity (Price et al., 2020; Dela Cruz et al., 2020; Radford et al., 2024). Despite these harsh physical conditions, reef flats provide diverse microhabitats, including consolidated reef frameworks, coral rubble, algal turfs, and crustose coralline algae (CCA) mats, that support larval settlement and early coral survival (Wakwella et al., 2020; Tebbett et al., 2022). Their proximity to spawning adult colonies further enhances larval delivery and retention following mass spawning events (Doropoulos et al., 2016; Price et al., 2019; Cresswell et al., 2024).

Hydrodynamic conditions in reef flats can enhance larval retention and settlement, while

elevated light availability may facilitate the rapid establishment of endosymbiotic dinoflagellates (Symbiodiniaceae), crucial for energy acquisition in early life stages (Abrego et al., 2012; Dela Cruz et al., 2020; Cook et al., 2024). Substrate availability and chemical cues from CCA or microbial biofilms are also strong determinants of settlement success (Brandt et al., 2011; Miranda et al., 2018; Leonard et al., 2022; Pascoe et al., 2024). However, recruitment in reef flats is highly variable and context-dependent, often inhibited by sedimentation, nutrient loading, and algal overgrowth (Gouezo et al., 2021; Marcelino et al., 2024), as well as episodic thermal stress during spring tides and aerial exposure that drive high post-settlement mortality (van Woesik et al., 2011; Fordyce et al., 2019; Fordyce et al., 2020).

Despite their ecological importance, shallow reef flats have received comparatively less scientific attention than reef slopes, crests, or lagoons in coral recruitment studies. Previous research has highlighted factors such as substrate stability, early post-settlement mortality, and fine-scale heterogeneity as key regulators of recruitment success (Bellwood et al., 2018; Reid et al., 2020; Tebbett et al., 2022; Matthews et al., 2024; Rich et al., 2022). Importantly, recruitment dynamics are often decoupled from adult coral cover, underscoring the need to examine local ecological drivers rather than using adult abundance as a proxy (Gouezo et al., 2021; Cresswell et al., 2024). These gaps highlight the necessity of targeted research on reef flats to improve our understanding of recruitment processes in these vulnerable habitats.

Coral communities around Mu Ko Surin National Park in the Andaman Sea have experienced multiple catastrophic disturbances over the past two decades, including mass bleaching events, outbreaks of crown-of-thorns starfish (Acanthaster planci), and storm damage (Yeemin et al., 2006; Phongsuwan & Chansang, 2012; Helgoe et al., 2024). The 2010 and 2016 bleaching episodes caused extensive mortality in shallow reef habitats, reducing coral cover and altering community structure (Phongsuwan et al., 2013; Sutthacheep et al., 2013; Lesser et al., 2024). Long-term monitoring indicates variable recovery trajectories, with some sites showing coral recruitment and regrowth, while others remain dominated by macroalgae or degraded substrates (Yeemin et al., 2013; Sutthacheep et al., 2015; Pozas-Schacre et al., 2024).

This spatial heterogeneity in recovery underscores the importance of site-specific management and conservation strategies, including no-take zones, regulation of tourism, and restoration interventions (Boström-Einarsson et al., 2020; Hein et al., 2021; Gudka et al., 2024). Strengthening conditions that promote coral recruitment, particularly on degraded reef flats, is therefore central to sustaining reef resilience. To address this knowledge gap, the present study aims to quantify the density and composition of coral recruits on shallow reef flats in Mu Ko Surin National Park, Phang Nga Province. Specifically, it examines spatial variability in recruitment and provides insights to inform reef conservation and restoration strategies in the Andaman Sea.

2. Materials and Methods

2.1 Location of study sites

The study was conducted on shallow reef flats within Mu Ko Surin National Park, located in the Andaman Sea approximately 60 kilometers off the coast of Phang Nga Province, Thailand. The coral reefs around Mu Ko Surin are primarily fringing reefs that develop along sandy bottoms and rocky coastlines. This area is characterized by extensive and well-developed coral reef systems, particularly dominated by branching Acropora species, which create high habitat complexity and provide essential shelter and resources that support a diverse community of reef-associated organisms.

2.2 Data collection

Coral community surveys were conducted in 2024 within shallow reef habitats at depths of approximately 1–2 m. To assess coral recruitment, SCUBA divers haphazardly placed 16 × 16 cm quadrats on the benthic substrate at each site. All visible coral recruits (≤ 5 cm in diameter) within each quadrat were enumerated and identified to the genus level. To quantify

benthic cover and community composition, three replicate belt transects (30 × 1 m) were surveyed at each site. Along each transect, all coral colonies ≥ 5 cm in diameter were recorded, and their percent cover was calculated. Live coral cover was used as an indicator of benthic condition and adult coral abundance.

2.3 Data analysis

Prior to statistical analysis, the data were examined for compliance with the assumptions of analysis of variance (ANOVA), including normality of residuals and homogeneity of variances. Normality was assessed using the Shapiro–Wilk test, while homogeneity of variances was evaluated with Levene's test.

Once these assumptions were confirmed, live coral cover and juvenile coral density were analyzed using one-way ANOVA to detect differences among study sites. When significant effects were detected, post hoc pairwise comparisons were conducted using Tukey's Honest Significant Difference (HSD) test in order to identify which sites differed significantly from one another.

3. Results

3.1 Live Coral Cover and Community Composition

The live coral cover on shallow reef flats across the five study sites in Mu Ko Surin National Park exhibited marked spatial variability, ranging from 11.8% to 34.5% (Figure 2). Ao Jaak supported the highest live coral cover (34.5%), followed by Ao Suthep (25.9%) and Ao Mai Ngam (24.6%). In contrast, Ao Mae Yai (14.2%) and Ao Pak Kaad (11.8%) showed substantially lower values. These results indicate considerable heterogeneity in live coral cover among the surveyed sites.

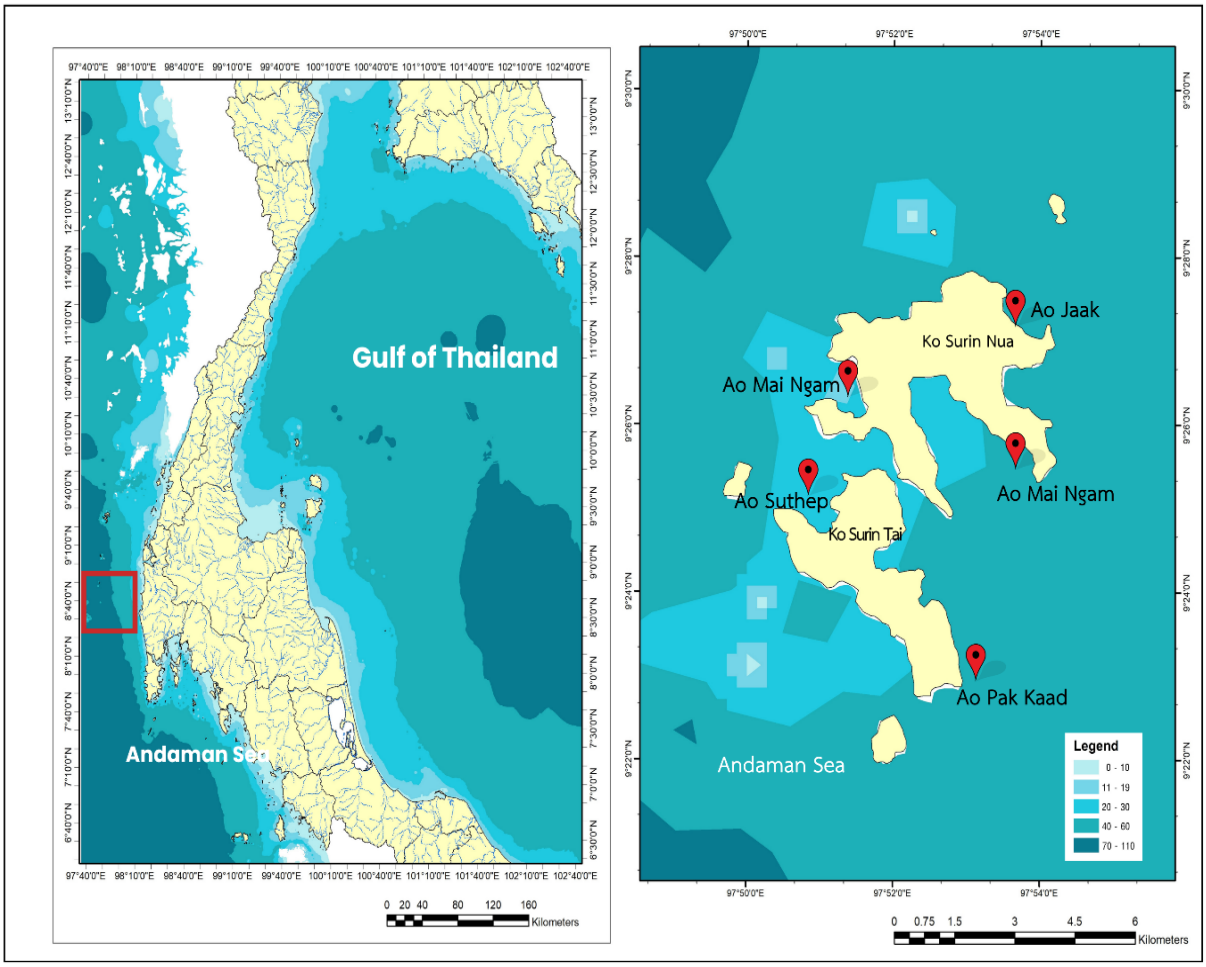

Figure 1. The location of study sites at Mu Ko Surin National Park

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3.2 Density of coral recruitment

The analysis revealed pronounced spatial variability in coral recruitment among the study sites (Figure 3). The highest density of coral recruits was recorded at Ao Mai Ngam (15.79 ± SD colonies m^{-2}), whereas the lowest density occurred at Ao Jaak (8.68 ± SD colonies m^{-2}). Coral recruit density differed significantly among sites (one-way ANOVA, $F = 48.17$, $p < 0.001$). Tukey's HSD post hoc comparisons showed that densities at Ao Mai Ngam were significantly higher than those at the other sites ($p < 0.05$). Ao Suthep exhibited an intermediate density, greater than Ao Jaak and Ao Pak Kaad but lower than Ao Mai Ngam. In contrast, Ao Jaak, Ao Mae Yai, and Ao Pak Kaad consistently showed lower recruit densities (8–10 colonies m^{-2}).

3.3 Composition of coral recruitment

The composition and density of coral recruits varied considerably among sites (Figure 4). Ao Mai Ngam exhibited the highest density (15.79 ± 1.94 recruits m^{-2}), with recruits representing a broad range of genera. Ao Suthep supported a moderately high density (15.79 ± 1.66 recruits m^{-2}), dominated by *Porites*, P*ocillopora*, and *Favites* spp. In contrast, Ao Mae Yai, Ao Pak Kaad, and Ao Jaak recorded comparatively lower densities (8–10 recruits m^{-2}), with recruits belonging to fewer genera. These results indicate pronounced spatial heterogeneity in recruitment density and taxonomic composition across the study sites.

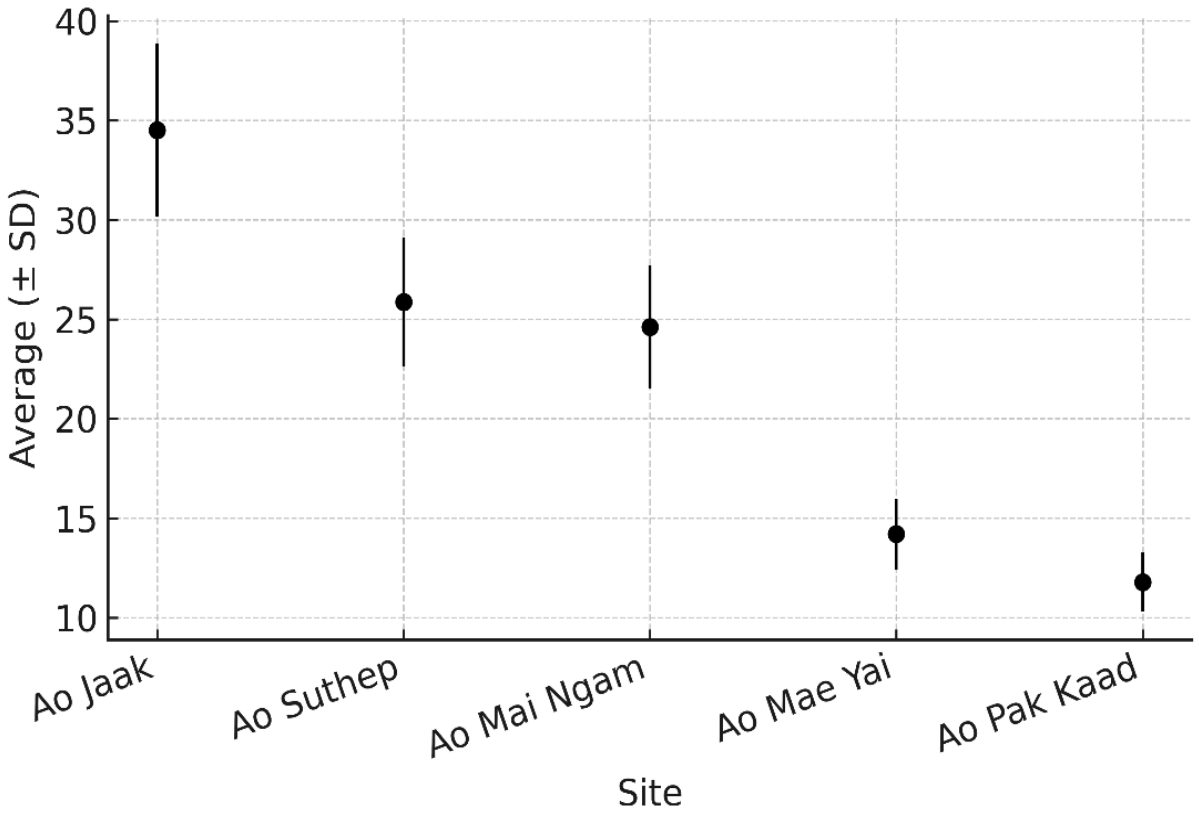


Figure 2. Live coral cover at each site.

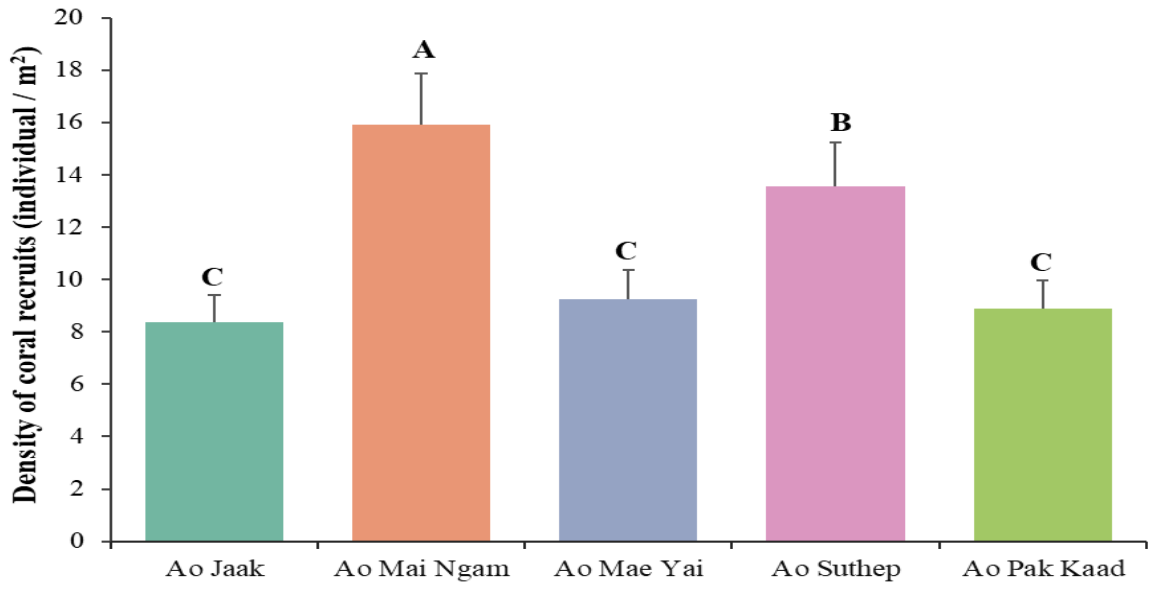


Figure 3. Density of coral recruitment at each site.

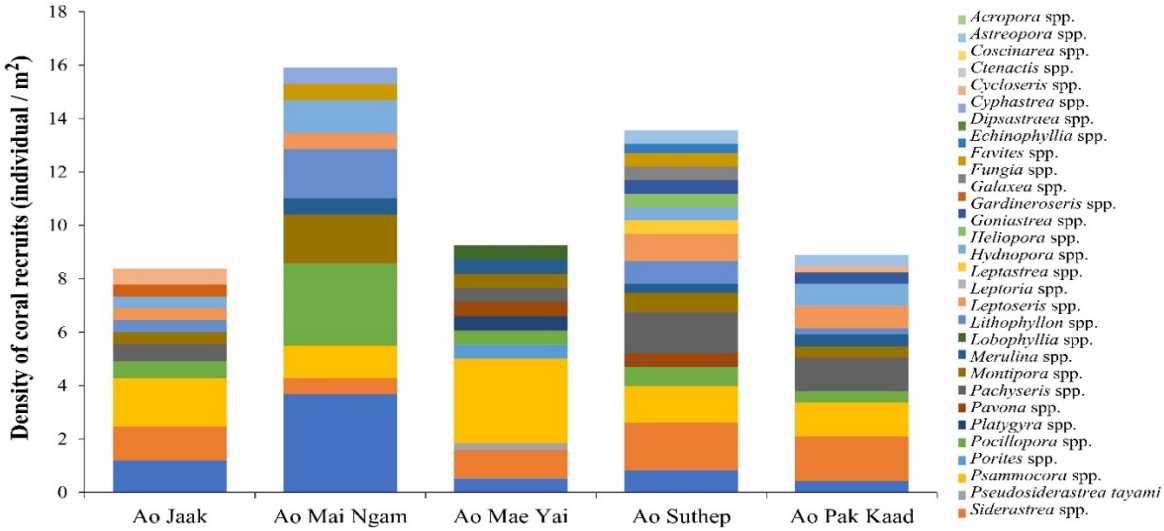


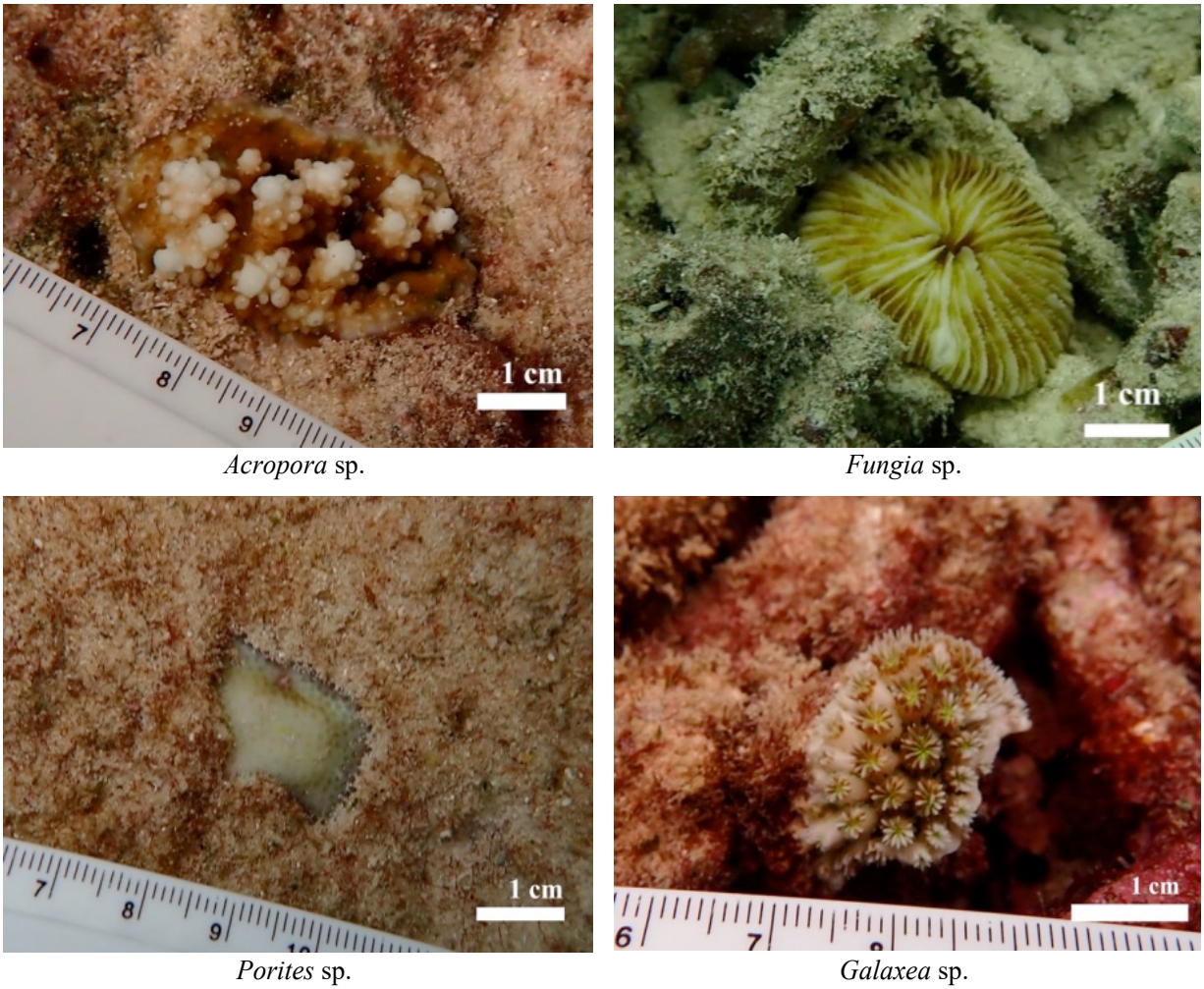
Figure 3. dominant of coral species at each site.

4. Discussion

This study revealed pronounced spatial heterogeneity in both live coral cover and coral recruitment across shallow reef flats in Mu Ko Surin National Park. Coral cover ranged from relatively healthy conditions at Ao Jaak, Ao Suthep, and Ao Mai Ngam to substantially degraded states at Ao Mae Yai and Ao Pak Kaad. Recruitment patterns also varied, with Ao Mai Ngam emerging as a recruitment hotspot, while other sites exhibited consistently low densities. These findings highlight the spatially variable nature of reef resilience within the park.

The elevated recruitment density at Ao Mai Ngam may be linked to the availability of suitable settlement substrates, favorable hydrodynamic flow, and proximity to spawning coral populations, which together enhance larval supply and settlement success. In contrast, the reduced recruitment observed at Ao Jaak, Ao Mae Yai, and Ao Pak Kaad likely reflects a combination of degraded reef structure, limited microhabitat availability, sedimentation, algal overgrowth, and elevated post-settlement mortality. Such site-specific constraints suggest that recruitment processes are strongly governed by localized ecological conditions rather than simply reflecting adult coral abundance.

Similar patterns of coral decline and variable recruitment success have been reported from shallow reef flats in the Andaman Sea and the Gulf of Thailand, where sedimentation, nutrient enrichment, and overfishing intensify coral mortality (Yeemin et al., 2018; Streit Heery et al., 2024). At broader scales, global drivers such as ocean warming and recurrent bleaching events have accelerated coral loss across Southeast Asia (Hughes et al., 2018; Ulfah et al., 2021; Cetina-Heredia et al., 2023; Sutthacheep et al., 2024). Importantly, the decoupling between adult cover and recruit density observed here aligns with Indo-Pacific studies that emphasize the influence of fine-scale processes, including substrate stability, settlement cues, and hydrodynamics, on recruitment dynamics (Sakai et al., 2018; Brandt et al., 2019; Nozawa et al., 2020; Edmunds et al., 2024).



Acropora sp. *Fungia* sp.

Porites sp. *Galaxea* sp.

Figure 5. Underwater photographs showing dominant coral recruitment at the study sites

The higher recruit density at Ao Mai Ngam indicates that some reef flats may function as larval sources, contributing to metapopulation connectivity and potentially enhancing reef resilience at larger spatial scales. Conversely, degraded sites with limited recruitment may act as demographic sinks, with low natural recovery capacity under current disturbance regimes. These contrasting trajectories underscore the importance of maintaining recruitment hotspots while addressing the constraints that limit recovery in other areas. From a management perspective, three priorities emerge from this study. First, spatially explicit conservation strategies should prioritize the protection of recruitment hotspots such as Ao Mai Ngam to safeguard natural recovery processes. Second, degraded reef flats with low recruitment potential, including Ao Mae Yai and Ao Pak Kaad, require targeted restoration interventions such as structural enhancement or substrate stabilization to facilitate coral settlement. Third, effective reef governance must integrate local-scale stressor mitigation (e.g., controlling anchor damage,

pollution, and fishing pressure) with strategies to address climate-driven disturbances that undermine coral resilience (Lamb et al., 2014; Dixon et al., 2022; Donovan et al., 2023; Matthews et al., 2024).

Overall, this study demonstrates that coral reef recovery in the Surin Islands is strongly mediated by site-specific recruitment processes and habitat conditions. Protecting and enhancing these processes through integrated conservation and restoration strategies is critical for sustaining reef resilience under ongoing environmental change. By linking ecological understanding with site-specific management, the findings provide an evidence-based foundation for adaptive reef governance and reinforce the ecological importance of shallow reef flats in supporting biodiversity and long-term reef recovery.

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References

Abrego D, Ulstrup KE, Willis BL, van Oppen MJ (2008) Species–specific interactions between algal endosymbionts and coral hosts define their bleaching response to heat and light stress. Proceedings of the Royal Society B: Biological Sciences, 275(1648): 2273–2282

Andrello M, Darling ES, Wenger A, Suárez-Castro AF, Gelfand S, Ahmadia GN (2022) A global map of human pressures on tropical coral reefs. Conservation Letters, 15(1): e12858

Aunkhongthong W, Phoaduang S, Wongnutpranont A, Sutthacheep M, Sangmanee K, Yeemin T (2020) Population densities of a sea urchin Diadema setosum on shallow reef flats in the Gulf of Thailand. Ramkhamhaeng International Journal of Science and Technology, 3(3): 13–20

Bellwood DR, Tebbett SB, Bellwood O, Mihalitsis M, Morais RA, Streit RP, Fulton CJ (2018) The role of the reef flat in coral reef trophodynamics: Past, present, and future. Ecology and Evolution, 8(8): 4108–4119

Boström-Einarsson L, Babcock RC, Bayraktarov E, Ceccarelli D, Cook N, Ferse SC, ... McLeod IM (2020) Coral restoration – A systematic review of current methods, successes, failures and future directions. PLoS One, 15(1): e0226631

Brandt ME, Olinger LK, Chaves-Fonnegra A, Olson JB, Gochfeld DJ (2019) Coral recruitment is impacted by the presence of a sponge community. Marine Biology, 166(4): 49

Carlson RR, Crowder LB, Martin RE, Asner GP (2024) The effect of reef morphology on coral recruitment at multiple spatial scales. Proceedings of the National Academy of Sciences, 121(4): e2311661121

Cetina-Heredia P, Allende-Arandía ME (2023) Caribbean marine heatwaves, marine cold spells, and co-occurrence of bleaching events. Journal of Geophysical Research: Oceans, 128(10): e2023JC020147

Cook DT, Holbrook SJ, Schmitt RJ (2024) Patterns of spatial covariation in herbivore functions on coral reefs: Implications for reef resilience. [Journal details pending]

Cresswell AK, Renton M, Langlois TJ, Thomson DP, Lynn J, Claudet J (2024) Coral reef state influences resilience to acute climate-mediated disturbances. Global Ecology and Biogeography, 33(1): 4–16

Datta AW, Wyborn C, Chaffin BC, Barnes ML (2024) Imagining reef futures after mass coral bleaching events. Environmental Science & Policy, 151: 103625

Dela Cruz DW, Harrison PL (2020) Enhancing coral recruitment through assisted mass settlement of cultured coral larvae. PLoS One, 15(11): e0242847

Dixon AM, Forster PM, Heron SF, Stoner AM, Beger M (2022) Future loss of local-scale thermal refugia in coral reef ecosystems. PLoS Climate, 1(2): e0000004

Donovan MK, Alves C, Burns J, Drury C, Meier OW, Ritson-Williams R, ... Asner GP (2023) From polyps to pixels: understanding coral reef resilience to local and global change across scales. Landscape Ecology, 38(3): 737–752

Doropoulos C, Roff G, Bozec YM, Zupan M, Werminghausen J, Mumby PJ (2016) Characterizing the ecological trade-offs throughout the early ontogeny of coral recruitment. Ecological Monographs, 86(1): 20–44

Edmunds PJ, Maritorena S, Burgess SC (2024) Early post-settlement events, rather than settlement, drive recruitment and coral recovery at Moorea, French Polynesia. Oecologia, 204(3): 625–640

Emslie MJ, Ceccarelli DM, Logan M, Blandford MI, Bray P, Campili A, ... Sinclair-Taylor TH (2024) Changing dynamics of Great Barrier Reef hard coral cover in the Anthropocene. Coral Reefs, 43(3): 747–762

Fordyce AJ, Ainsworth TD, Heron SF, Leggat W (2019) Marine heatwave hotspots in coral reef environments: physical drivers, ecophysiological outcomes, and impact upon structural complexity. Frontiers in Marine Science, 6: 498

Good AM, Bahr KD (2021) The coral conservation crisis: interacting local and global stressors reduce reef resiliency and create challenges for conservation solutions. SN Applied Sciences, 3(3): 312

Gouezo M, Olsudong D, Fabricius K, Harrison P, Golbuu Y, Doropoulos C (2020) Relative roles of biological and physical processes influencing coral recruitment during the lag phase of reef community recovery. Scientific Reports, 10: 2471

Gouezo M, Wolanski E, Critchell K, Fabricius K, Harrison P, Golbuu Y, Doropoulos C (2021) Modelled larval supply predicts coral population recovery potential following disturbance. Marine Ecology Progress Series, 661: 127–145

Gudka M, Obura D, Treml EA, Nicholson E (2024) Strengthening resilience potential assessments for coral reef management. Methods in Ecology and Evolution, 15(4): 612–627

Guest JR, Baird AH, Maynard JA, Muttaqin E, Edwards AJ, Campbell SJ, Yewdall K, Affendi YA, Chou LM (2016) Coral bleaching responses to climate change across reef ecosystems in Southeast Asia. Marine Ecology Progress Series, 551: 261–271

Hein MY, Vardi T, Shaver EC, Pioch S, Boström-Einarsson L, Ahmed M, ... McLeod IM (2021) Perspectives on the use of coral reef restoration as a strategy to support and improve reef ecosystem services. Frontiers in Marine Science, 8: 618303

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

Hughes TP, Barnes ML, Bellwood DR, Cinner JE, Cumming GS, Jackson JBC, Kleypas J, van de Leemput IA, Lough JM, Morrison TH, Palumbi SR, van Nes EH, Scheffer M (2017) Coral reefs in the Anthropocene. Nature, 546(7656): 82–90

Hughes TP, Graham NA, Jackson JB, Mumby PJ, Steneck RS (2010) Rising to the challenge of sustaining coral reef resilience. Trends in Ecology & Evolution, 25(11): 633–642

Hughes TP, Kerry JT, Baird AH, Connolly SR, Chase TJ, Dietzel A, ... Woods RM (2019) Global warming impairs stock–recruitment dynamics of corals. Nature, 568(7752): 387–390

Klinthong W, Yeemin T, Sutthacheep M, Aunkhongthong W, Rongprakhon S (2021) Abundance of coral recruits on settlement plate experiments from Mu

Ko Angthong, the Western Gulf of Thailand. Ramkhamhaeng International Journal of Science and Technology, 4(2): 19–27

Lamb JB, True JD, Piromvaragorn S, Willis BL (2014) Scuba diving damage and intensity of tourist activities increases coral disease prevalence. Biological Conservation, 178: 88–96

Leonard C, Hédouin L, Lacorne MC, Dalle J, Lapinski M, Blanc P, Nugues MM (2022) Performance of innovative materials as recruitment substrates for coral restoration. Restoration Ecology, 30(7): e13625

Lesser MP (2024) Irradiance dependency of oxidative stress and coral bleaching. Coral Reefs, 43(5): 1393–1403

Marcelino LA (2024) EAGER: Biophotonic technologies to design new strategies for coral reef resilience to warmer oceans. NSF Award Number 2427519. Directorate for Engineering, 24(2427519): 27519

Matthews SA, Williamson DH, Beeden R, Emslie MJ, Abom RT, Beard D, ... Quincey R (2024) Protecting Great Barrier Reef resilience through effective management of crown-of-thorns starfish outbreaks. PLoS One, 19(4): e0298073

Mellin C, Peterson EE, Puotinen M, Schaffelke B (2020) Representation and complementarity of the long-term coral monitoring on the Great Barrier Reef. Ecological Applications, 30(6): e02122

Miranda RJ, Tagliafico A, Kelaher BP, Mariano-Neto E, Barros F (2018) Impact of invasive corals Tubastrea spp. on native coral recruitment. Marine Ecology Progress Series, 605: 125–133

Nozawa Y, Lin CH, Meng PJ (2020) Sea urchins (diadematids) promote coral recovery via recruitment on Taiwanese reefs. Coral Reefs, 39(4): 1199–1207

Pascoe S, Anthony K, Scheufele G, Pears RJ (2024) Identifying coral reef restoration objectives: A framework. Ocean & Coastal Management, 251: 107081

Peixoto RS, Voolstra CR, Staab S, Ribeiro B, Duarte G, Suggett DJ (2025) Building coral reef resilience through assisted restoration. In: Coral Reef Microbiome. Springer Nature, Cham, pp 235–243

Phongsuwan N, Chansang H (2012) Repeated coral bleaching in the Andaman Sea, Thailand, during the last two decades. Proceedings of the 12th International Coral Reef Symposium, 9C

Phongsuwan N, et al. (2008) Status and trends of coral reefs in Thailand. Proceedings of the 11th International Coral Reef Symposium, 1061–1065

Pozas-Schacre C, Bischoff H, Clerissi C, Nugues MM (2024) Negative parental and offspring environmental effects of macroalgae on coral recruitment are linked with alterations in the coral larval microbiome. Royal Society Open Science, 11(7): 240187

Price NN, Muko S, Legendre L, Steneck R, van Oppen MJ, Albright R, ... Edmunds PJ (2019) Global biogeography of coral recruitment: tropical decline and subtropical increase. Marine Ecology Progress Series, 621: 1–17

Radford B, Puotinen M, Sahin D, Boutros N, Wyatt M, Gilmour J (2024) A remote sensing model for coral recruitment habitat. Remote Sensing of Environment, 311: 114231

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. Journal of Geophysical Research: Oceans, 125(12): e2020JC016543

Rich WA, Carvalho S, Cadiz R, Gil G, Gonzalez K, Berumen ML (2022) Size structure of the coral Stylophora pistillata across reef flat zones in the central Red Sea. Scientific Reports, 12: 13979

Sakai K, Yeemin T, Pensakun S, Klinthong W, Samsuvan W (2018) Assessing coral reef resilience to climate change in Thailand. Ramkhamhaeng International Journal of Science and Technology, 1(1): 22–34

Sarribouette L, Pedersen NE, Edwards CB, Sandin SA (2022) Post-settlement demographics of reef building corals

suggest prolonged recruitment bottlenecks. Oecologia, 199(2): 387–396
Smith HA, Brown DA, Arjunwadkar CV, Fulton SE, Whitman T, Hermanto B, ... Bourne DG (2022) Removal of macroalgae from degraded reefs enhances coral recruitment. Restoration Ecology, 30(7): e13624
Streit RP, Morrison TH, Bellwood DR (2024) Coral reefs deserve evidence-based management not heroic interference. Nature Climate Change, 14(8): 773–775
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. Journal of Marine Science and Engineering, 7(11): 408
Sutthacheep M, et al. (2013) Impacts of the 2010 mass coral bleaching event in the Andaman Sea, Thailand. Phuket Marine Biological Center Research Bulletin, 72: 51–65
Sutthacheep M, et al. (2015) Recovery patterns of coral communities in the Andaman Sea after mass bleaching. Marine and Freshwater Research, 66(6): 541–551
Sutthacheep M, Jungrak L, Chamchoy C, Aunkhongthong W, Sasithorn N, Suebpala W, ... Yeemin T (2024) Low impacts of coral bleaching in 2024 on the underwater pinnacles from Krabi Province, the Andaman Sea. Ramkhamhaeng International Journal of Science and Technology, 7(2): 1–14
Tebbett SB, Siqueira AC, Bellwood DR (2022) The functional roles of surgeonfishes on coral reefs: past, present and future. Reviews in Fish Biology and Fisheries, 32(2): 387–439
Thomson DP, Babcock RC, Evans RD, Feng M, Moustaka M, Orr M, ... Hoey AS (2021) Coral larval recruitment in north-western Australia predicted by regional and local conditions. Marine Environmental Research, 168: 105318
Ulfah M, Siswanto A, Agustina S, Purnawan S (2021) Recruitment of hard coral after coral bleaching in Krueng Raya Water, Aceh Besar. IOP Conference Series: Earth and Environmental Science, 869(1): 012043
van Woesik R, Sakai K, Ganase A, Loya Y (2011) Revisiting the winners and the losers a decade after coral bleaching. Marine Ecology Progress Series, 434: 67–76
Wakwella A, Mumby PJ, Roff G (2020) Sedimentation and overfishing drive changes in early succession and coral recruitment. Proceedings of the Royal Society B: Biological Sciences, 287(1941): 20202575
Wang C, Roeroe KA, Zhou Z, Niu G, Du J, Hu W, Zheng X (2024) Gene expression plasticity governing symbiosis during natural coral bleaching. Science of The Total Environment, 953: 176046
Yeemin T, et al. (2006) Long-term changes of coral communities under stress from tourism-related activities in Thailand. Proceedings of the 10th International Coral Reef Symposium, 1074–1080
Yeemin T, et al. (2013) Coral community recovery following the 2010 bleaching event in the Andaman Sea, Thailand. Phuket Marine Biological Center Research Bulletin, 72: 67–77
Yeemin T, Ruangthong C, Pengsakun S, Chamchoy C, Jungrak L (2020) Coral recruitment and self-seeding potential in Mu Ko Samet National Park, the Gulf of Thailand. Ramkhamhaeng International Journal of Science and Technology, 3(1): 7–16
Yeemin T, Sutthacheep M, Klinthong W, Sangmanee K, Pengsakun S (2018) Long-term changes in coral communities under stress from sedimentation in the Gulf of Thailand. Marine and Freshwater Research, 69(8): 1256–1264