Contrasting abundance of juvenile corals at two national parks in the Andaman Sea

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Abstract Understanding the patterns and relationship of coral larval supply and juveniles are crucial in enhancing reef biodiversity, recovery and resilience in response to disturbances. The objective of this study is to compare diversity and abundance of juvenile coral colonies on natural substrates and recovery trends in Mu Ko Surin and Mu Ko Phi Phi in the Andaman Sea. Results showed that the highest density of coral recruits was found at Ao Suthep (Mu Ko Surin) while the lowest density was at Ao Loh Samah (Mu Ko Phi Phi). Among study sites, Ao Suthep had the most diverse coral (at the genus level) while Ao Loh Samah had the least. Generally, *Fungia* was the dominant coral recruit at Mu Ko Surin while *Porites* was the dominant juvenile coral at Mu Ko Phi Phi. Species composition of coral recruits was significantly different between Mu Ko Surin and Mu Ko Phi Phi. Coral recruits and percentages of live coral cover were positively correlated (r=0.25, p<0.01) in all sites. This suggests that coral recovery following the bleaching events at Mu Ko Phi Phi would require a longer period of time

Keywords: coral recruitment, bleaching, recovery, marine protected area, Andaman Sea

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Introduction

Studies on spatial and temporal variation in coral recruitment patterns are important in understanding coral population dynamics and reef resilience in response to anthropogenic and natural disturbances (Hughes et al. 2010; Yeemin et al. 2012a; Salinas-de-León et al, 2013; Yucharoen et al. 2015). Understanding coral population dynamics is necessary for managing coral reef ecosystems that are threatened by multiple stressors at local, regional and global scales (Mumby 1999; Crabbe and Smith 2005; Obura 2005; Yeemin et al. 2013).

Approximately 75% of coral reefs worldwide are affected by local stresses and ocean warming due to climate change (i.e. mass coral bleaching) (Burke et al. 2011).

Recruitment pattern is recognized as one of the key factors controlling the ecology of marine benthic organisms. It plays a major role in maintenance of coral reef populations and recovery following disturbances (Connell et al. 1997; Hughes et al. 2000; Salinas-de-León et al, 2013; Johns et al. 2014). Coral recruitment is affected by several factors such as live coral cover on the reefs, abundance and diversity of planula larvae, recruitment cues, inhibition and competition from other benthic organisms, grazing intensity, hydrodynamic condition, reef connectivity, temperature, light intensity, nutrients and sedimentation (Sammarco 1980; Benayahu and Loya 1985; Potts et al. 1985; Babcock and Davies 1991; Tomascik 1991; Maida et al. 1995; Roberts 1997; Mundy and Babcock 1998; Hughes et al. 2000; Harrington et al. 2004; Amar et al. 2007; Nozawa and Harrison 2007; Salinas-de-León et al. 2013; Yeemin et al. 2013).

Overfishing, destruction of coral reefs, mangrove forests, seagrass beds and other coastal ecosystems are a number of stressors on marine and coastal resources in the Southeast Asian countries, particularly in Thailand (Sutthacheep et al. 2013; Weeks et al. 2010; Tupper et al. 2015). An important management strategy to cope with overfishing, habitat destruction, and other impacts on marine and coastal ecosystems and socio-economics of coastal communities is the establishment and implementation of marine protected areas (White et al. 2014; Tupper et al. 2015). Most coral reefs in Thailand's Andaman coast are managed by several national parks, such as Mu Ko Surin, Mu Ko Similan, Hat Noppharat Thara - Mu Ko Phi Phi, Had Chao Mai, and Mu Ko Tarutao. An effective management of these marine national parks based on scientific data sources, particularly long-term ecological monitoring data is crucial for conservation of the marine and coastal resources (Cicin-Sain and Belfiore 2005; Harris et al. 2014; Addison 2015).

This study aims to compare diversity and abundance of coral recruits on natural substrates and coral recovery trends at Mu Ko Surin National Park and Hat Noppharat Thara - Mu Ko Phi Phi National Park in the Andaman Sea.

Materials and methods

Study sites

Two popular dive sites in the Andaman Sea were selected in this study.

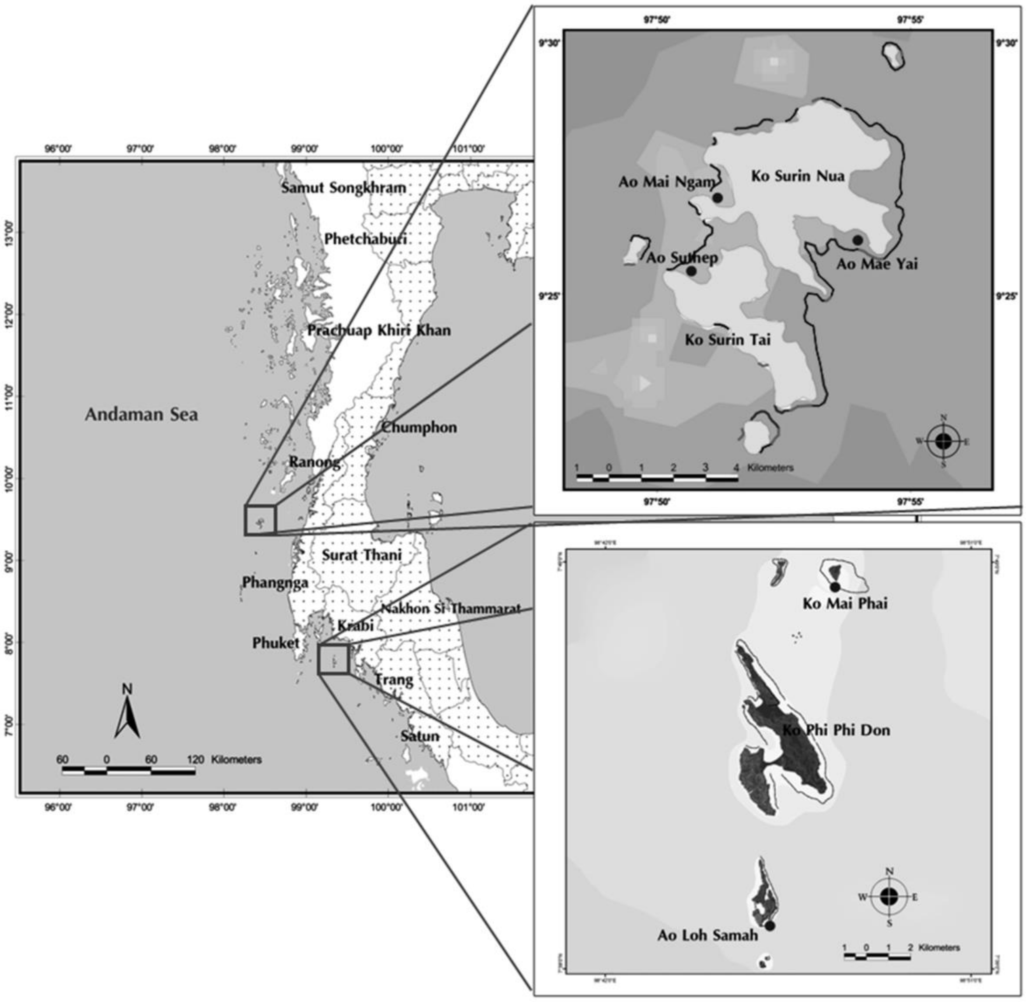

Fig. 1 Map of the study sites in Mu Ko Surin and Mu Ko Phi Phi in the Andaman Sea

Mu Ko Surin

Mu Ko Surin is a group of island in the Andaman Sea, about 60 km off the coast of Phang-Nga Province in the southern Thailand. It was recognized as the 29th National Park of Thailand in 1981 and is now administered by the Department of National Parks, Wildlife and Plant Conservation and Royal Thai Navy. The park is usually closed during May – September each year because of strong southwest monsoon. The park comprises 5 main islands, i.e. Ko Surin Nua, Ko Surin Tai, Ko Ree (or Ko Stork), Ko Glang (or Ko Pachumba) and Ko Khai (or Ko Torinla). Ko Surin Nua and Ko Surin Tai are relatively large islands and are located on a north-south axis. Our study sites are Ao Mai Ngam, a sheltered bay on the east side of Ko Surin Nua, Ao Mae Yai, an exposed bay on the southeast of Ko Surin Nua and Ao Suthep, a sheltered bay on the north of Ko Surin Tai (Fig. 1).

Mu Ko Phi Phi

Mu Ko Phi Phi is a group of island in the Andaman Sea off the coast of Krabi Province, about 50 km south-east of Phuket. It was established as a part of the 47th national park of Thailand, Hat Noppharat Thara-Mu Ko Phi Phi National Park in 1983. It is partly managed by the Department of National Parks, Wildlife and Plant Conservation. Mu Ko Phi Phi consists of 6 islands, i.e. Ko Phi Phi Don, Ko Phi Phi Le, Ko Mai Phai, KoYung, Ko Bida Nai and Ko Bida Nok, and is a popular tourist destination for all year round. The study sites were Ko Mai Phai and Ao Loh Samah, on the south of Ko Phi Phi Le (Fig. 1).

Coral community surveys

Coral communities were found at approximately 5-15 m in depth. The coral community surveys were conducted in 2014 to 2015. At each study site, quadrats (16x16 cm^2) were randomly placed on substrates using scuba diving. Number of visible coral recruits (≤ 5 cm in diameter) were counted. All coral recruits were identified to genera level. Live coral cover at each study site was also quantified using a 50 × 1 m^2 belt-transect and coral colonies (≥5 cm in diameter) were counted and identified to genera level. The data were analyzed using one-way ANOVA to detect if coral recruit density is significantly different between the study sites. Fisher's Least Significant Difference (LSD) post-hoc test was used to determine where differences occurred. Dendrogram and two-dimensional MDS configuration species composition for coral recruits and live corals at each study site were constructed through clustering and ordination methods based on the Bray-Curtis Similarities using the PRIMER version 7.0. Pearson correlation analysis was also performed to determine the relationship between coral recruit density and live coral cover.

Results

Coral recruit densities were in the range from 3.9 to 33.1 recruits/m^2. The highest density and most diverse of coral recruits were found at Ao Suthep (Mu Ko Surin) while the lowest density and few taxa of coral recruits were recorded at Ao Loh Samah (Mu Ko Phi Phi). Significant differences of coral recruit densities among the study sites at Mu Ko Surin and Mu Ko Phi Phi (p<0.05) except for Ao Mai Ngam vs Ao Suthep and Ao Mai Phai vs Ao Loh

Samah (Fig. 2). The coral recruits at Mu Ko Surin were more diverse than Mu Ko Phi Phi (Fig. 3). Coral recruits were composed of Porites, Goniastrea, Favites, Pocillopora, Acropora, Lithophyllon and Favia. Bray-Curtis Similarity Index showed that species composition of juvenile corals was different between Mu Ko Surin and Mu Ko Phi Phi (Fig. 4).

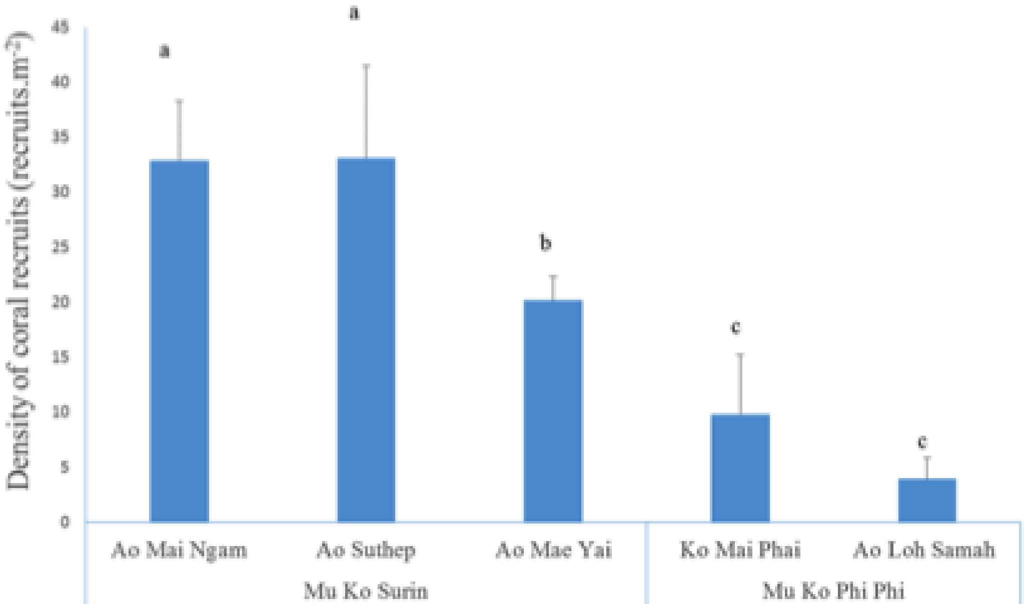

Fig. 2 Densities of coral recruits (mean ± SE) at five study sites, letters indicates significant difference determined by Fisher's LSD test ($p < 0.05$)

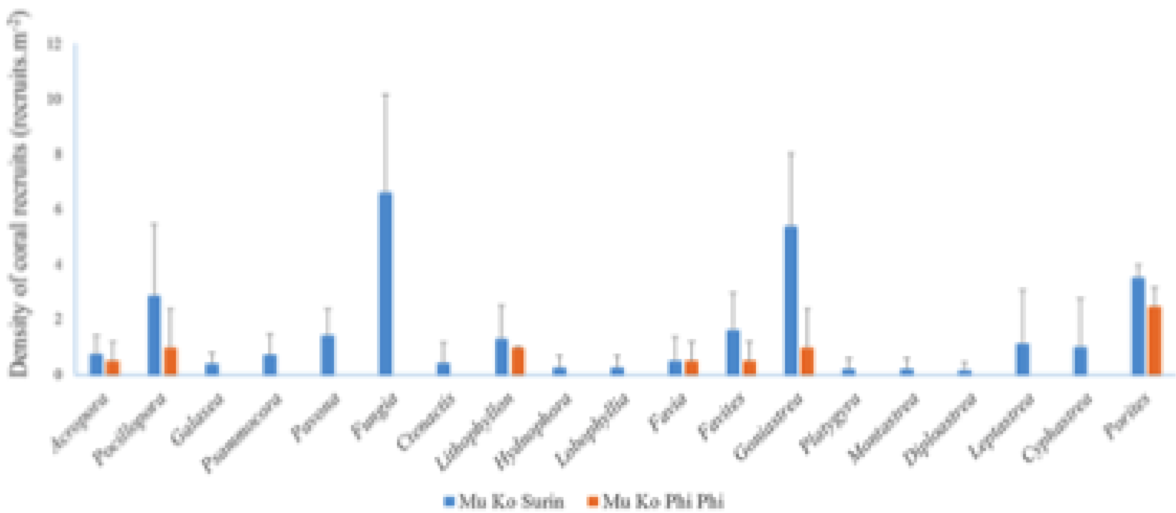

Fig. 3 Densities of coral recruit at the genera level (mean ± SE) found at the study sites

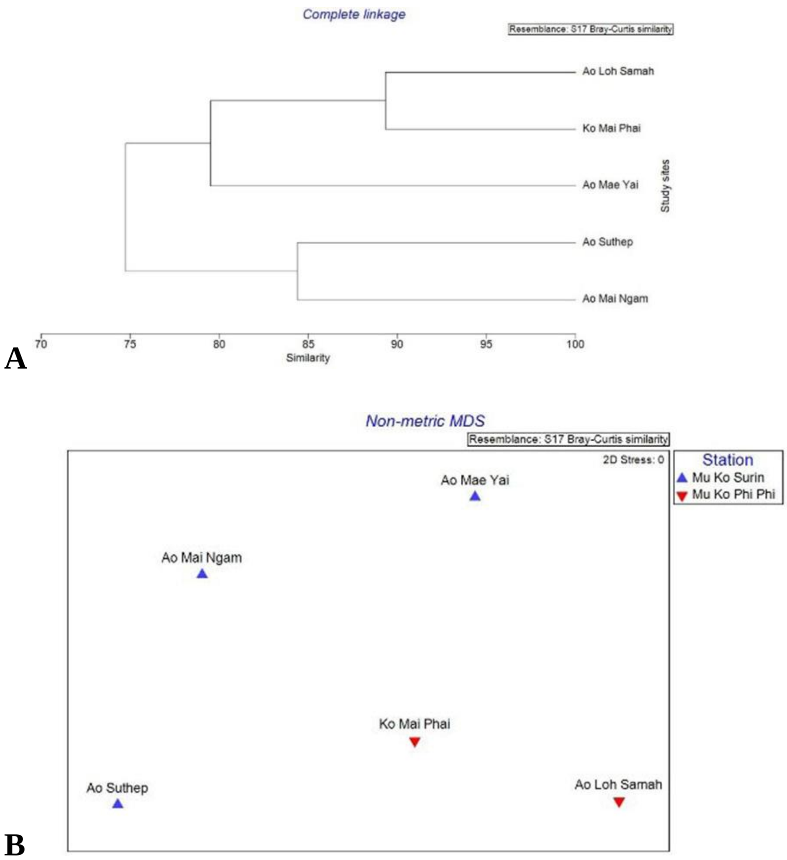

Fig. 4 A) Dendrogram and B) nMDS ordination showing similarity of species composition of coral recruits at each study site

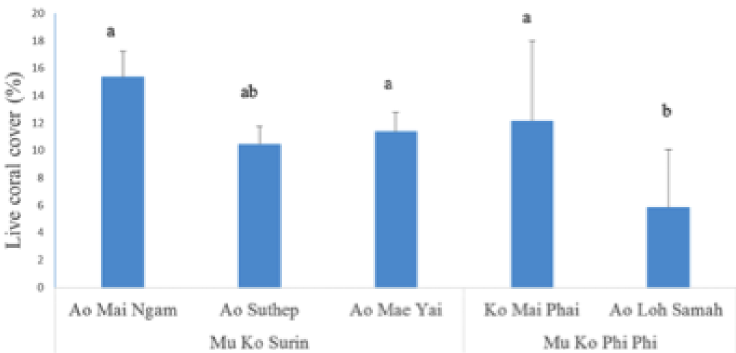

Fig. 5 Percent live coral cover (mean ± SE) at five study sites, different letters indicate significant difference by Fisher's LSD test ($p < 0.05$)

The percentages of live coral cover were in the range from 5.8 to 15.3 (Fig. 5). The highest percentage of live coral cover was found at Ao Suthep while the lowest one was recorded at Ao Loh Samah. The common corals found at both Mu Ko Surin and Mu Ko Phi

Phi were Porites, Diploastrea, Lobophyllia, Goniastrea, Montipora, Goniopora, Leptrastrea and Acropora (Fig. 6). Based on the Bray-Curtis Similarity, species composition of live coral cover between Mu Ko Surin and Mu Ko Phi Phi was distinct (Fig. 7).

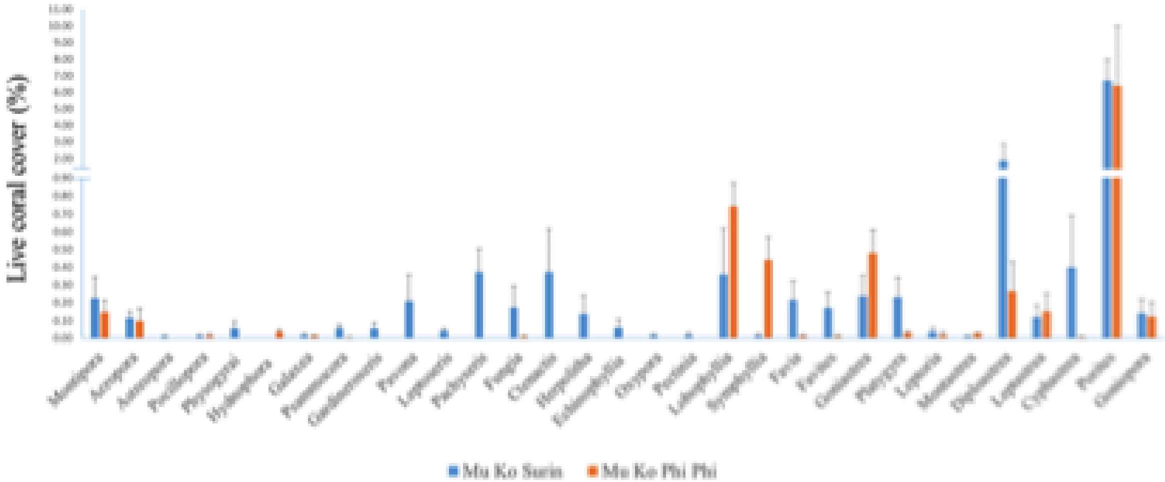

Fig. 6 Percent live coral cover (mean ± SE) (at the genera level) at five study sites

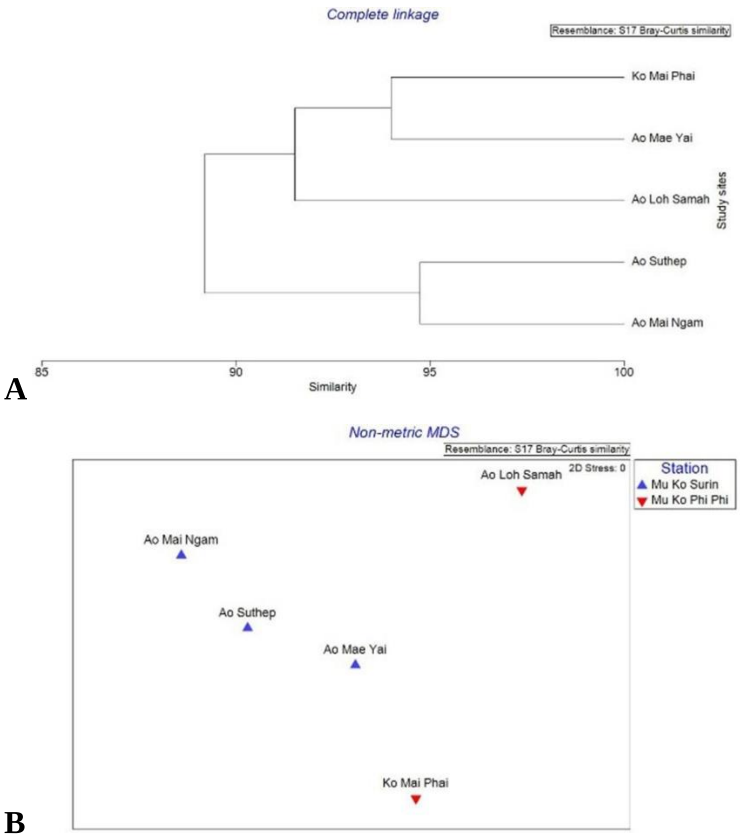

Fig. 7 A) Dendrogram and B) nMDS ordination graph of species composition of adult corals at each study site

There was a positive correlation between coral recruits and percent live coral cover in all study sites (r=0.25, p<0.01, Fig. 8).

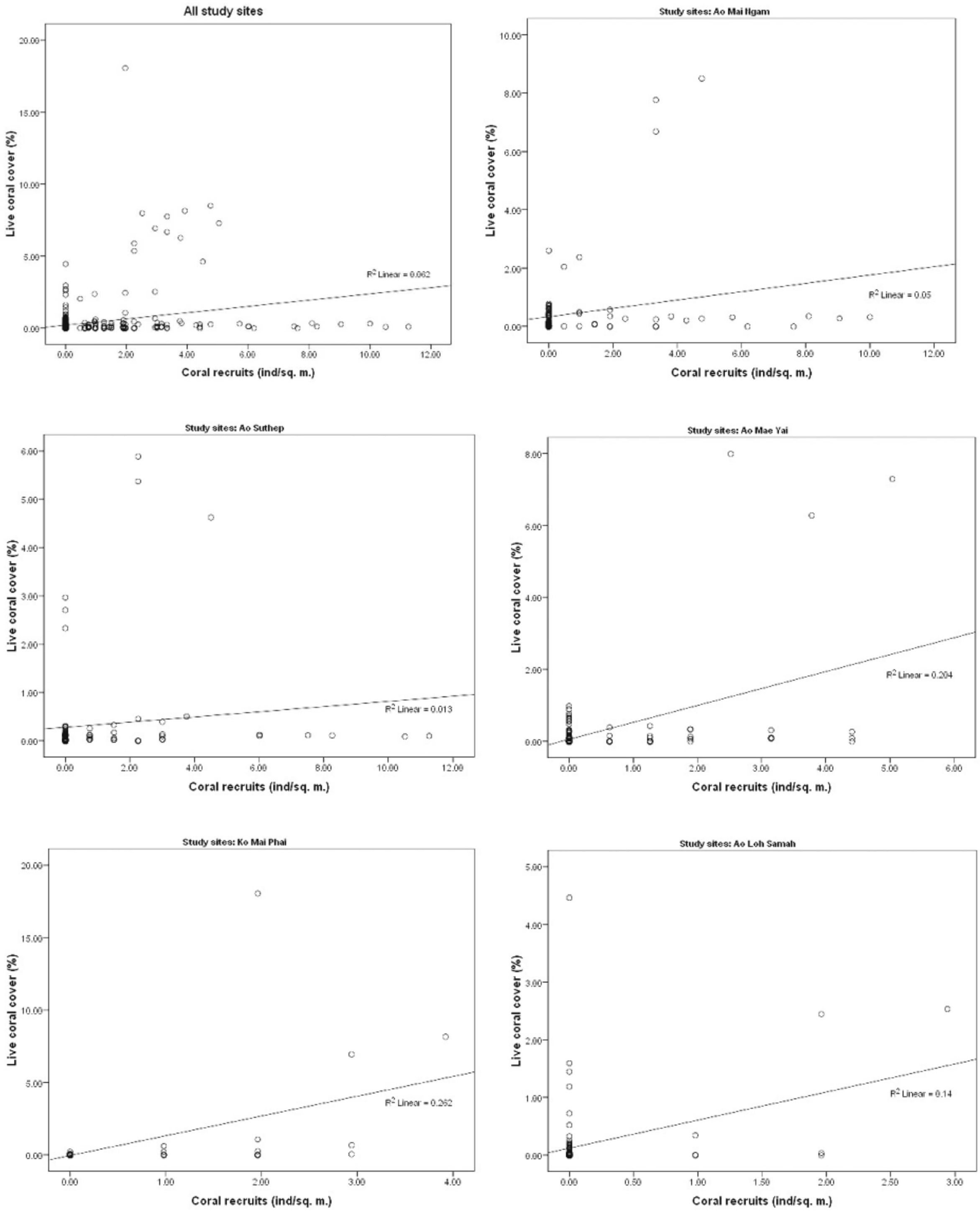

Fig. 8 Relationship of live coral cover and coral recruits at each study site (* = *p* value < 0.05, ** = *p* value < 0.01)

Discussion

Low recruitment of scleractinian corals in Mu Ko Phi Phi might be attributed to the reef degradation caused by local and international tourists. Another reason of low recruitment rates was coral bleaching in 2010 in Mu Ko Phi Phi and Mu Ko Surin that resulted to high coral mortality (Yeemin et al. 2012b; Yuchareon et al. 2015). In response, the Department of National Parks, Wildlife and Plant Conservation (DNP) of Thailand has temporarily closed several reef sites in the Andaman Sea except our study sites in Mu Ko Phi Phi (Yeemin et al. 2012b). Corals that were not affected by severe disturbances such as coral bleaching and heavy storm are the main sources of coral larval supply. Knowledge on coral recruitment dynamics and the environmental factors controlling spatial and temporal variation is important to effectively manage coral populations on the reefs (Salinas-de-León et al. 2013).

In this study, the composition of adult corals and recruits were similar (i.e. Acropora, Fungia, Pocillopora, Porites, Goniastrea, Favia and Favitesin the study sites. This is an indication that Mu Ko Phi Phi and Mu Ko Surin reefs are self-recruiting (Figueiredo et al. 2013; Yuchareon et al. 2015). Recruits of few adult corals such as Montipora, Goniopora and Lobophyllia were not found in Mu Ko Phi Phi and Mu Ko Surin. Long term recruitment studies on these reefs are necessary to substantiate the present observation.

Diversity of adult corals and recruits in Mu Ko Phi Phi were lower than Mu Ko Surin. This suggests slower coral recovery in Mu Ko Phi Phi. It took 7-10 years for the reefs in the western Pacific to recover from coral bleaching events (Baker et al. 2008; Adjeroud et al. 2009; Johns et al. 2014). Shortage of larval supply, settlement inhibition and post-settlement mortality could be the factors contributing to recruitment failure thereby limiting coral recovery (Chong-Seng et al. 2014).

Coral reefs in Mu Ko Phi Phi are currently being managed by the Hat Noppharat Thara-Mu Ko Phi Phi National Park under the DNP. There is an urgency implementing effective management mechanisms to conserve the reefs as well as assist in corals recovery from multiple stressors. Certain coral reef management measures under the coral bleaching crisis should be effectively implemented in Mu Ko Phi Phi such as coral reef zoning for utilization, temporary closure of particular reef sites for tourism, control water quality from land-based, islands and tour vessels.

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