ORIGINAL PAPER

Coral diseases outbreaks for massive coral (*Porites lutea*) at reef communities of Samui Island, and the adjacent area, Surat Thani province

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Abstract. Coral disease surveys were conducted using belt transect method in two shallow reefs of Samui Island group, Surat Thani province: Ban Thongkrut Bay, Samui Island and Auk Bay, Tan Island. Six diseases and syndrome were found; White Plague (WP), Pink Line Syndrome (PLS), Porites White Patch Syndrome (PWPS), Pacific Yellow Band Disease (YBD), White Syndrome (WS), and Growth Abnormalies (GA). *Porites lutea* is a major species on our surveyed reefs and showed the highest infected (5 diseases). Mean disease prevalence of *P. lutea* in Tan Island (19.64 ± 2.25%) was higher than Thongkrut Bay (16.57 ± 2.21%). PWPS was the highest occurrence in both areas, followed by WP and PLS. The results of this study provided baseline knowledge of coral diseases outbreaks for massive coral (*Porites lutea*) at shallow water reef communities of Samui Island, to be used for further monitoring programs of coral disease outbreaks in Thai waters

Keywords: coral disease, disease prevalence, *Porites lutea*

1. Introduction

Coral reef ecosystems are now being degraded at an accelerated rate. The underlying causes of reef decline are diverse, and include pollution, sedimentation, fishing impacts, habitat destruction, invasive species, bleaching, disease, global climate change, and other factors. In recent years, disease outbreaks have caused widespread mortalities to scleractinian corals, gorgonians, sea urchins, reef fish, sponges, algae and associated coral reef organisms (Bruckner 2000). Coral disease caused by both biotic and abiotic stressors. Biotic stressors are those caused by a living organism (e.g., pathogen, parasite) and abiotic stressors are environmental stressors (e.g., changes in salinity, temperature, light). Research suggests that important drivers of coral disease include climate warming and other anthropogenic stressors such as land-based pollution, sedimentation, overfishing, and human use. Over the last two decades, coral reef communities have experienced increasingly stressful conditions due to a combination of natural and anthropogenic factors (Mohamed et al. 2012).

Coral disease potentially acts as a bioindicator of reef health and recent increases in coral disease events have been linked to environmental stress and climate change. Coral disease diagnosis is primarily macroscopic, taking into account characteristics such as the extent of tissue loss, tissue color and exposure of coral skeleton. Up to date, very little is currently known about the prevalence, distribution and pathology of coral disease in Gulf of Thailand (Kenkel 2007, Putchim et al. 2012). The number of diseases has all increased within the last decade (Porter et al. 2001; Green and Bruckner 2000; Weil 2004). There is a lot of information being reported from widely studied regions however, little is known about coral disease in Thailand. To understand the role of coral diseases in effecting change in coral communities.)

The aims of this study were to provide baseline knowledge of coral diseases outbreaks and their dominant diseases for massive coral (Porites lutea) at shallow water reef communities of Samui Island, Surat Thani province, to be used for further monitoring programs of coral disease outbreaks in Thai waters

2. Materials and Methods

2.1 Location of study sites

Field surveys were conducted at two study sites: Samui Island (N 10° 40’ 40.6” E 6° 4’ 98.3”) and Tan Island (N 10° 36’ 21.0” E 6° 5’ 18.2”) with the average depth of 2 - 8 meters in dry season, 2017) (Figure 1).

2.2 Data collection

SCUBA diving was used to survey disease prevalence between seasons. Surveys on the reef flat were conducted along 2 x 20 m^2 belt transects with three replicates (following English et al. 1997). Number of the massive coral *Porites lutea* colonies with signs of disease were counted, described, photographed and identified based on diseases using Beeden et al. (2008) and Weil and Hooten (2008). The disease prevalence was calculated as follows:

$$\text{Disease prevalence} = \frac{(\text{number of diseased colonies}) \times 100}{(\text{total number of colonies})}$$

2.3 Data analysis

Mean prevalence and standard errors were calculated from all three replicate transects per site. Differences in the prevalence of disease and compromised health signs among affected hard coral species and sites were tested using one-way analyses of variance (ANOVA). Water samples were collected at surface and bottom from all study sites.

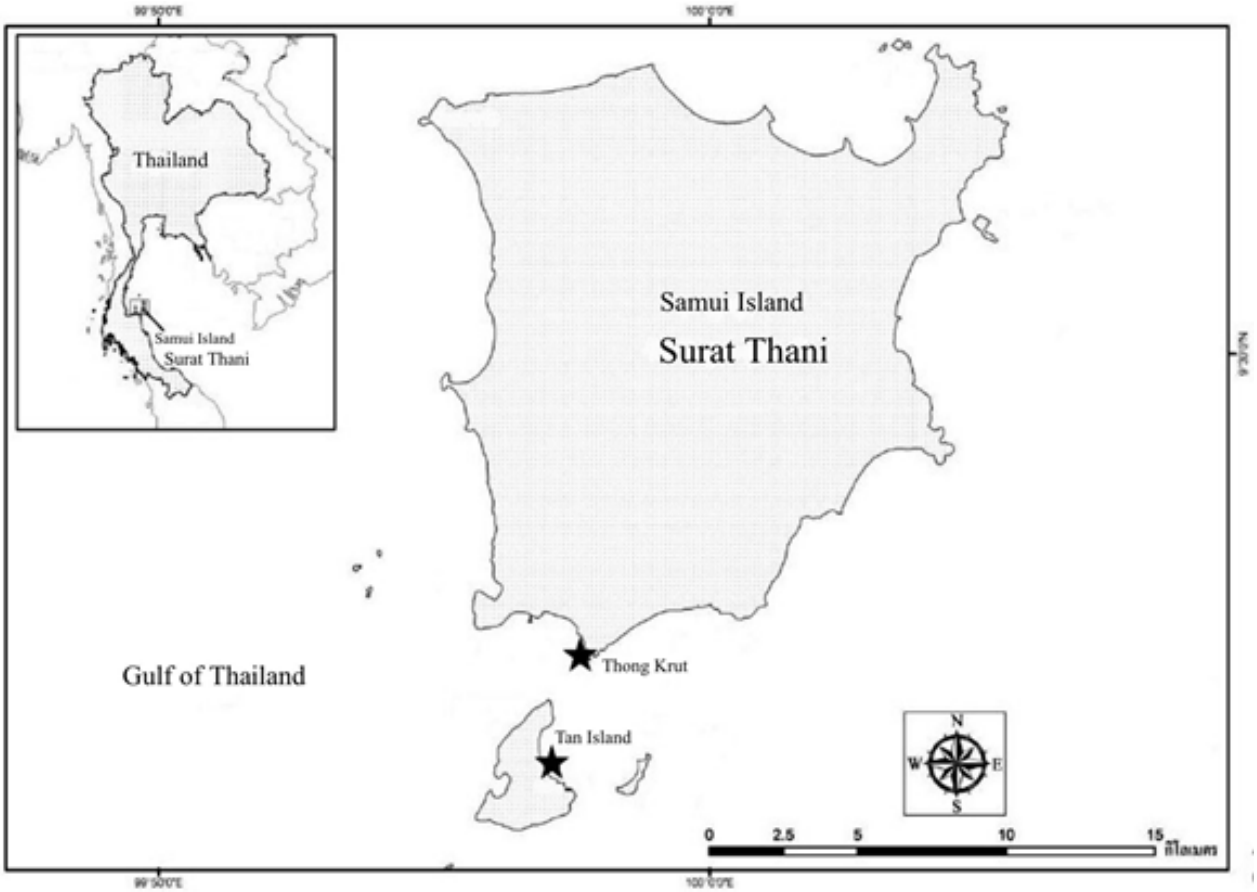


Figure 1. Shallow water reef communities at Ban Thong Krut Bay, Samui Island and Auk Bay, Tan Island, Surat Thani province

3. Results

3.1 Coral disease status

The shallow water reef communities at Ban Thong Krut Bay, Samui Island and Auk Bay, Tan Island were classified as deteriorated reefs with the average percentage coverage of living coral of 24% and 37%, respectively. These study sites were dominated by the massive coral (*P. lutea*), *Pavona decussata*, *Goniastrea* spp., and this reef was covered with 3 seaweeds; *Turbinaria* spp. *Padina* spp. and *Sargussum* sp. The occurrence of coral diseases showed that a total of 6 coral diseases were found consisting of White Plague (WP), Pink Line Syndrome (PLS), Porites White Patch Syndrome (PWPS), Pacific Yellow Band Disease (YBD), White Syndrome (WS) and Growth Abnormalies (GA) (Figure 2). The dominant diseases are PWPS, WP, PLS, and WS occurring in both study sites (Table 1).

3.2 Coral disease status

Six infected corals were found in the two study sites consisted of were *Porites lutea*, *Pavona decussata*, *Goniastrea* sp., *Dipsastraea* sp., *Fungia* sp., and *Platygyra* sp. The massive coral *Porites lutea* was the dominant species in these areas and a total of five diseases (83.33% of total coral diseases) were found White Plague (WP), Pink Line Syndrome (PLS), Porites White Patch Syndrome (PWPS), White Syndrome (WS) and Growth Abnormalies (GA), while other corals were found only 1 disease (Table 2).

Table 1 Coral disease at two shallow water reef communities at Samui Island and Tan Island, Surat Thani province

Study site	Coral diseases						Occurrence (%)
	WP	PLS	PWPS	YBD	WS	GA	
Samui Island	X	X	X	-	X	X	83.33
Tan Island	X	X	X	X	X	-	83.33

Remarks: White Plague (WP), Pink Line Syndrome (PLS), Porites White Patch Syndrome (PWPS) Pacific Yellow Band Disease (YBD), White Syndrome (WS), Growth Abnormalities (GA)

Table 2. Coral diseases and infected corals at two shallow water reef communities at Samui Island and Tan Island, Surat Thani province

Types of corals	Coral diseases						Occurrence (%)
	WP	PLS	PWPS	YBD	WS	GA	
Porites lutea	X	X	X	-	X	X	83.33
Pavona decussata	-	-	-	-	X	-	16.67
Goniastrea sp.	X	-	-	-	-	-	16.67
Dipsastraea sp.	-	-	-	-	X	-	16.67
Fungia sp.	-	-	-	-	X	-	16.67
Platygyra sp.	-	-	-	X	-	-	16.67
Occurrence (%)	16.67	16.67	16.67	33.34	66.68	16.67	

Remarks: White Plague (WP), Pink Line Syndrome (PLS), Porites White Patch Syndrome (PWPS), Pacific Yellow Band Disease (YBD), White Syndrome (WS), Growth Abnormalies (GA)

Table 3. Disease prevalence of massive coral (*P. lutea*) at two shallow water reef communities at Samui Island and Tan Island, Surat Thani province

Study sites	Total colony	Normal colony (%)	Infected colony (%)					Total (%)
			WP	PLS	PWPS	WS	GA	
Samui Island	187	83.42±2.34	4.43±1.12	3.4±2.22	5.9±1.19	2.17±1.29	0.67±0.4	16.57±2.21
Tan Island	168	80.36±2.55	5.74±3.23	4.29±3.12	6.72±3.0	2.89±1.78	-	19.64±2.25

Remarks: White Plague (WP), Pink Line Syndrome (PLS), Porites White Patch Syndrome (PWPS), White Syndrome (WS), Growth Abnormalies (GA)

3.3 Disease prevalence

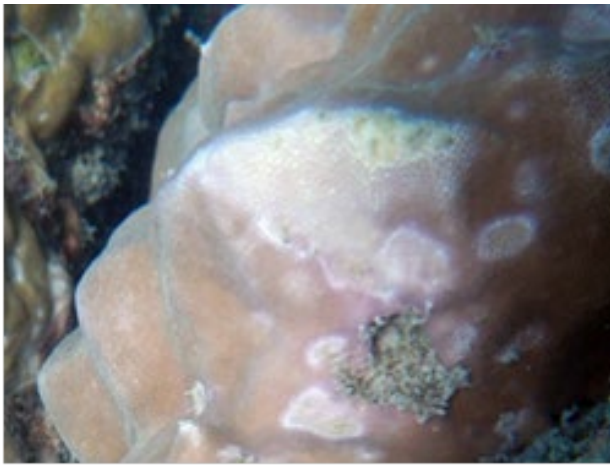
Disease prevalence of *Porites lutea* at Tan Island and Samui Island was found 19.64±2.25% and 16.57±2.21%, respectively. Porites White Patch Syndrome was the dominant diseases for all study sites as 6.72±3.0% at Tan Island and 5.9±1.19% at Samui Island, followed by White Plague and Pink Line Syndrome (Table 3).

4. Discussion

The present study showed coral diseases status in two shallow reefs of Samui Island group, Surat Thani province: Ban Thongkrut Bay, Samui Island and Auk Bay, Tan Island. Six diseases and syndrome were found; White Plague (WP), Pink Line Syndrome (PLS), Porites White Patch Syndrome (PWPS), Pacific Yellow Band Disease (YBD), White Syndrome (WS), and Growth Abnormalies (GA). *Porites lutea* is a major species on our surveyed reefs and showed the highest infected (5 diseases). Mean disease prevalence of *P. lutea* in Tan Island was higher than Thongkrut Bay. PWPS was the highest occurrence in both areas, followed by WP and PLS. Furthermore, the dominant coral (*P. lutea*) was the only species infected in Samui Island and Tan Island. This surveys for coral disease in shallow water reefs of Samui Island and Tan Island was agree with the study of Kritsanapuntu and Angkhananukroh (2014) at four adjacent islands showed that a total of 6 coral diseases were found consisting of White Plague, Pink Line Syndrome, Porites White Patch Syndrome, *Porites Trematodiasis*, White Syndrome and Pacific Yellow Band Disease. The most significant syndrome detected was Pink Line Syndrome, which affected 6 different coral genera. Genus Porites in shallow water reefs of Samui Island and the adjacent areas is a dominant host of coral diseases particularly Pink Line Syndrome. Daengyaem et al. (2017) also reported that a total of four coral diseases were found, comprising White Syndrome (WS), Porites White Patch Syndrome (PWPS), Ulcerative White Spot (UWS), and Pink Line Syndrome (PLS). WS and PLS were found during the wet season while WS, PWPS, and UWS were found during dry season shallow water reef communities at Tan Island, Surat Thani Province. WS was the dominant disease found during the wet season while PWPS was dominant in the dry season. Angkhananukroh (2015) also reported that a total of 5 coral diseases (Pink Line Syndrome, White Plague disease, White Patch disease, Yellow Band disease and Growth anomaly) occurred in *P. lutea*. PLS was the most prevalent disease occurred in *P. lutea* in three reef communities of Sichang Island group in Chon Buri province.

This result also agreed with the study in Indian coral reef (Thinesh et al. 2009) but not for the study of coral diseases in Indonesia reefs (Erinn et al. 2012) and Red Sea reefs (Mohamed 2012). Thinesh et al. (2009) reported that most common coral host for disease was Porites sp. and the most common disease was pink spot, followed by black band. Sutthacheep et al. (2009) reported that major coral bleaching phenomena have resulted in widespread coral mortality in recent decades. The assessment of coral reef resilience to climate change is an important task but has been difficult to carry out because of a lack of empirical scientific data. Coral reef resilience at twenty study sites in Thai waters was quantitatively assessed, approximately two years following the 2010 severe bleaching event, based on the percentage of nonbleached coral colony, the percentage of surviving coral colonies and the density of juvenile corals. Coral reef resilience varied greatly among the study sites and major reef groups according to their community structure, largely due to the differing bleaching resistance and tolerance of the dominant coral species. Most study sites in the Gulf of Thailand had much lower coral recruitment rates compared to other reef sites in Thai waters. The study sites in the Inner Gulf of Thailand had the highest resilience while the study sites in the Andaman Sea had the lowest.

White Plague (WP)



Pink Line Syndrome (PLS)

Porites White Patch Syndrome (PWPS)

Pacific Yellow Band Disease (YBD)

White Syndrome (WS)

Growth Abnormalies (GA)

Figure 2. Six coral diseases infected *P. lutea* at two shallow water reefs of Ban Thongkrut Bay, Samui Island group, and Auk Bay, Tan Island.

However, although overall coral disease prevalence was low in all reefs surveyed, there is the potential for greater impacts of coral disease as anthropogenic influences increase and the oceans continue to warm. Mohamed (2012) showed that the highest prevalence of coral diseases in northern Red Sea, Egypt was recorded on the coral *Dipsastraea stelligera*, followed by *P. lutea*, and *Goniastrea edwardsi*. Enhanced local anthropogenic stresses and increasing sea surface temperature due to global warming are the suggested potential factors responsible for the initiation and the persistence of some coral diseases in the studied reefs. Various factors both natural and human impacts from the main land may cause in infection of coral diseases such as climate changes (Sokolow 2009, Looney et al. 2010), rainfall and freshwater runoff (Haapkyla et al. 2011), nutrient loading (Bruno et al. 2003), physical contacts, ballast water (Macedo et al. 2008), physical contact of seaweeds (Maggy et al. 2004) and human impacts (Bruno et al. 2003). Haapkyla et al. (2011) suggest that rainfall and associated runoff may facilitate seasonal disease outbreaks, potentially by reducing host fitness or by increasing pathogen virulence due to higher availability of nutrients and organic matter. In the future, rainfall and seawater temperatures are likely to increase due to climate change which may lead to decreased health of inshore reefs. Thurber et al. (2014) provide that coastal nutrient loading is one of the major factors contributing to the increasing levels of both coral disease and coral bleaching these data also suggest that simple improvements to water quality may be an effective way to mitigate some coral disease epizootics and the corresponding loss of coral cover in the future. Maggy et al. (2004) also showed that physical contact with the macroalga Halimeda opuntia can trigger a virulent disease known as white plague type II that has caused widespread mortality in most Caribbean coral species. The climate variables likely alter coral epidemiology through effects on pathogen growth rates, transmission, virulence, and susceptibility. The causes of coral disease emergence at large spatial and temporal scales had been hindered by several factors including (1) the inability to rely on Koch's postulates for diseases with multifactorial etiologies, (2) the paucity of long-term, coordinated, coral disease data, and (3) the difficulty in detecting correlations in inherently non-linear, dynamic disease systems.

Most of the causative factors of emerging diseases contributing to their occurrence and spread, and consequences on coral populations remain incompletely understood, however. A long-term, multi-disciplinary research and monitoring program for coral diseases is necessary to assist resource managers in identifying and responding to emerging coral diseases. This study provides preliminary baseline data on the impact of coral disease within the shallow water reefs of Samui Island and the adjacent islands. Further prediction of disease outbreaks, appropriate monitoring of physical and chemical parameters of seawater should be done in relation with disease prevalence at all sites which affected by natural and human impacts. The results of this study provided baseline knowledge of coral diseases outbreaks for massive coral (*Porites lutea*) at shallow water reef communities of Samui Island, Surat Thani province, to be used for further monitoring programs of coral disease outbreaks in Thai waters.

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