Coral Reef Tourism, Sustainability and Development: how to Manage it All?

Sarawut Siriwong

A Thesis Submitted in Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Biology
Prince of Songkla University
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ABSTRACT

Coral reef-related tourism contributes to economic development and can provide local communities with non-extractive alternative livelihoods, however it is not an environmentally neutral solution, and it needs an integration of policy and management action to harmonize tourism benefits and coral reef health. This thesis aims to identify ecological impacts related to tourism and to examine perceptions of managers and users of coral reef management policy implementation, how they see their own roles, and the effects of policy /legislation on the way they function. The synthesis of findings suggests that there exists a suite of conceptual indicators that Thai authorities might employ to enhance the sustainability and effectiveness of management policy for reef areas in eastern Thailand.

In this study, I compared prevalence of coral diseases and prevalence of signs of compromised health to distinguish direct and indirect impacts between coral reefs that have different levels of visitation and infrastructure. Surveys of reefs throughout the Eastern of Thailand indicated poorer health of reefs near infrastructure rather than reefs at more isolated islands. Visitation intensity influenced reef health only where no physical infrastructure was present (or nearby). I also found significant increases in nitrate, ammonium, phosphate and total suspended sediment in gradients toward sites near

infrastructure, whereas different levels of visitation made no difference to these metrics. Managers necessarily must devise a compromise between the convenience of siting tourism infrastructure close to the desired location and the ecological consequences of doing so. They must also recognise that the marine ecosystem is an open system, such that activities nearby but outside MPAs will affect the ecosystems within the parks.

A socio-ecological study to answer the question of how stakeholder perceived the implementation of coral reef management policy implementation was undertaken to examine the perceptions of stakeholders who benefit from the reef resources. . The perceptions of coral reef managers and users of the planning, process and outcome of coral reef management policy and regulations were obtained using a mixed-method interview approach. DNP manages coral reef within the boundaries of gazetted Marine National Parks solely and independently of DMCR who are ultimately responsible for all reef and non-reef coastal areas elsewhere (apart from several small areas under the purview of the Royal Thai Navy). Unfortunately, the majority of resource managers are not sufficiently equipped with locally-suited conservation policy or planning. The plans that DNP managers had been using have not been substantively modified since they were drafted over a decade ago; a situation exacerbated by the paucity of feedback from local sites and stakeholders. DMCR managers were hampered until recently because the governing legislation was not ratified by parliament (and hence not truly enforceable). Users (hoteliers and tour operators) felt that they were seldom consulted about policy matters and had limited opportunity to participate in the making of decisions that involve coral reef management. Moreover, they are unlikely to participate in conservation activity

because of the dearth of communication between managers and users. The finding of this part suggests that success of marine resources management needs both effective management training, and comprehensive policy, together with close communication between managers and end users to ensure strong support from local communities.

Although this study was not intended to in any way evaluate management effectiveness nor performance of management agencies, it provides several insights into ways that resource management practice and policy might be improved. Fragmentation of policy implementation between and amongst agencies is a barrier to sustainable reef-based tourism management in Eastern Thailand's highly coastal tourism development. Stress factors stemming from tourism do not respect the MPA boundaries, so the integrity of MPAs requires management agencies to interact positively with stakeholders outside the park boundaries. The finding of this thesis suggest that best practice will incorporate Integrated Coastal Management (ICM) approach into existing management policy to enhance cooperation among agencies that are responsible for coral reef resources and also agencies responsible for the health of the marine environment.

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Sarawut Siriwong

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DMCR	Department of Marine and Coastal Resources
DNP	Department of National Park, Wildlife and Plant
DOF	Department of Fisheries
MCRM	Marine and Coastal Resources Management office
MCRR	Marine and Coastal Resources Research and Development Center
MNP	Marine National Park
MNPO	Marine National Park Operation Center
MONRE	Ministry of Natural Resources and Environment
MPA	Marine Protected Area
PA	Protected Area
PEO	Provincial Environment Office
PM	Pattaya Municipality
SAO	Sub-district Administration Organization
SCUBA	Self-Contained Underwater Breathing Apparatus

CHAPTER 1

INTRODUCTION: TOURISM, SUSTAINABILITY AND DEVELOPMENT – HOW TO MANAGE IT ALL?

1.1. THE PARADOX OF "SUSTAINABLY MANAGING" A TOURISM GOLD RUSH

Coastal tourism is seen an important source of economic development in many countries, often generating much-needed foreign income (Spalding et al. 2017). Thailand is among the top tourism destination in the world, hosting approximately 30 million international visitors during 2015 (TAT, 2015). A recent study estimated that coral reef related tourism in Thailand generates USD 2,410.2million per year, of which 1,079 million USD was from on-reef tourism and 1,331.6 million USD was from reef-adjacent tourism. This brought Thailand to the point where it is the recipient of 4th highest tourism expenditure of any country in the world (Spalding et al., 2017). Coral reef tourism activities and the real estate and infrastructure development generated by the tourism industry in many parts of Asia have been characterized by a "gold rush" mentality, in which coastal management, ecological impacts and the livelihoods of local people have been subjugated to the interests of rampant tourism development without regard to regulation or sustainability. Coral reef tourism in most of Asia is seldom environmentally neutral, and has been associated with ecosystem degradation and loss of biodiversity, and a perception of poor governance.

Coral reef tourism has pros and cons; while tourism contributes significant economic development, it was reported to be related to degradation of coral reef and

marine environment through impacts arising from tourist's activity, poorly planned coastal development, and overharvesting of marine life to support tourism-associated businesses (Wilkinson 2008; J. Zhang et al. 2013; Spalding, Burke, Wood, Ashpole, Hutchison, and Zu Ermgassen 2017; Zainal Abidin and Mohamed 2014). Studies of impacts from tourism on coral health indicate issues commonly associated with physical damage (Hardiman and Burgin 2010; S. Worachananant et al. 2008), change in live coral cover, increases in coral disease prevalence and signs of compromised health (Lamb and Willis 2011; Lamb et al. 2014), increase in coral competitor i.e. algae and sponge, and water parameters i.e. inorganics nutrient and sedimentation (Bruno et al. 2003; R. L. Vega Thurber et al. 2014; Reopanichkul et al. 2010).

Tourism activities on coral reefs are often associated with both direct and indirect impact (Hardiman and Burgin 2010) to the reef communities. Direct impact refers to physical damage to the components of coral reefs as consequences of tourist activities and poor anchoring practices in or around the reef (Lirman and Fong 2007). Damage is most often associated with inexperienced and unaware tourists breaking fragile reef structures by touching, holding, kicking and trampling on coral colonies and the behaviour (anchoring or grounding on the reef top, or use of inappropriate anchors) by ignorant or "cowboy" boat operators (Jameson et al., 1999; Platong et al., 2000; Hasler and Ott, 2008; Hardiman and Burgin, 2010).

Indirect impacts of tourism are generally found in coral reefs near to coastal activity. Impacts are most often associated with land-based stressors influencing water quality that resulted in decline health within the coral community (Lirman and Fong, 2007). Direct discharge of waste water and sediments from coastal activities may result

in coral degradation through a variety of affiliated processes, from introduction of human (or other terrestrial) pathogens, stimulus of algal competition via nutrification, or toxins, to direct burial in terrigenous or organic sediments (Meng et al. 2008; Reopanichkul et al. 2010). In addition, the presence of tourism facilities near coral reefs can be associated with a higher prevalence of coral diseases than that of reefs without any infrastructure (Lamb and Willis 2011). Degradation of coral reefs and marine environments associated with tourism has prompted calls for a proper review of "ridge to reef" integrated coastal zone management from responsible agencies in many parts of the world.

In Thailand, coastal areas fall under the administrative purview of both national and local government agencies, but the multitude of responsible agencies, and overlapping areas of interest have led to a certain amount of confusion and a lack of understanding about allowed activities, development priorities and administrative boundaries, not just amongst users, but also among agency personnel. At the national level, coastal and marine areas not gazetted as national parks are notionally overseen by the Department of Marine and Coastal Resources (DMCR), under the Ministry of Natural Resources and Environment (MONRE), which also includes the Department of National Parks, Wildlife and Plant Conservation (DNP). Fishing by local and commercial interests is notionally administered by the Department of Fisheries (under the Ministry of Agriculture and Cooperatives), but in practice, the focus this agency is almost exclusively on commercial fishing (predominantly offshore). Office of Natural resources and Environment Policy and Planning responses to natural resources and environmental conservation policy. Department of City Planning regulates coastal development. Department of Pollution Control responses of water quality along the

coastline of the country. At the provincial level, coastal and marine resources are supervised by Provincial Office of Natural resources and Environment is supported by a regional marine and coastal resources research center and regional marine and coastal resources management center under DMCR. Local administration authorities i.e. sub district administration authority and municipality, are notionally response for environment and natural resources well-being within their administrative boundaries, albeit with provincial and national agency oversight. Success of coral reef management in the areas outside MNP, therefore, requires an effective implementation of each agency as well as a good relationship among stakeholders as whole in order to conserve coral reef and environment.

Within national parks, only DNP is responsible for resources management policy in all Marine National Parks (MNP). Marine Protected Areas are regarded by governments and organizations around the world as the effective tools to protect and manage coral reefs (Wielgus et al. 2010). MPAs can benefit local communities, lead to empowerment, improved governance, and alternative livelihoods (Bennett and Dearden 2014). Yet the evaluation of management effectiveness of MPAs suggests that the practice of simply creating an MPA has not effectively met desired goals (Leverington et al. 2008), not only of biological, but also of social conservation (Christie 2005). Poverty and resource degradation are persistent features of the lives of a large proportion of coastal people in the absence of alternatives such as tourism.

Many studies have indicated that ineffective management of MPAs is often associated with lack of appropriate policy and fragmentation of policy implementation effort among agencies and an inability to deliver ecosystem benefits of MPAs to local

stakeholders. Unfortunately, the top-down approach to creating policy for managing protected areas in Thailand seldom seeks to predict the types of difficulties or problems that will affect stakeholders both traditional resource users and those seeking to benefit from tourism opportunities. The evaluations of MNPs performance in Thailand has mainly focused on the capacity of management agencies (Hockings, Shadie, and Suksawang 2012) to administer their responsibilities, rather than polling community/stakeholder perception and feedback. This deficit is probably symptomatic of the "top-down" resource management process that is ubiquitous amongst Thai agencies. Bennett & Dearden (2014) found that this habit tends to alienate stakeholders, and is further compounded by reactive rather than precautionary approaches to problem solving.

Community/stakeholder opinions can reflect the process and outcome of management policy implementation. A necessary first step in determining the success of policies is to assess the ways in which policies are perceived by stakeholders – not just whether they agree or disagree with the principles, but how these policies affect the stakeholders' ability to conduct their businesses. Understanding the issues associated with management of coral reef areas, both inside and outside MPAs from the point of view of the different levels of management and end users implies integrated management policy and implementation that encompasses the whole ecosystem, including humans, to maximize long term benefits.

The East coast of Thailand has long been a desired destination of those who love diving or seeing beautiful underwater life. Coral reefs in the East coast of Thailand can be found along the coastline fringing around the islands in Chonburi, Rayong and

Trad provinces (Yeemin et al. 1999) where diving activities (both snorkeling and SCUBA) have become popular. Coral reefs in Eastern Thailand are vulnerable to direct impact as well as impact related to tourism infrastructures. The magnitude of tourism activity in tourism hotspot along Eastern Thailand is extremely high compare to and other famous destinations in other parts of Thailand. During the past 5 years, the income generated from tourism has increased up to 4 billion USD (approximately 300% increase) and the annual tourist has increases up to 20 million (approximately 200% increase) (http://service.nso.go.th). To meet such a high demand, coastal areas in Eastern Thailand have been turned over to vast hotel, restaurant and other tourism facilities to serve the influx of tourists, as well as an increase in coral reef-based activity such as snorkeling and recreational diving.

It is clear that intelligent, integrated management of fragile coastal ecosystems is of paramount importance for agencies keen to develop and distribute the benefits of coastal tourism according to the overarching economic development interests of the Thai government. What this process has so far lacked is an integrated study that examines perspectives of both the ecological and socio-ecological consequences of management policy. In this thesis, I attempt to bridge this knowledge gap and to integrate ecological examination of putative impacts commonly associated with tourism in other localities with perceptions of the efficaciousness of environmental stewardship and policy from the perspectives of both user and manager stakeholders. It is not an exhaustive analysis of the effectiveness of agencies, nor does it attempt to evaluate the quality or appropriateness of management policy or structures, since these are more properly undertaken by the administrative agencies themselves (or, at least, under their auspices). What is presented here represents a starting point for such

evaluation, and a preliminary indication of potentially useful avenues by which policy makers and agencies might better understand the ways in which policy intersects with both stakeholders and the environment.

1.2. RESEARCH QUESTIONS

In this thesis, I raise three questions related to sustainable management of tourism-focused coral reef.

Question 1. Is coral reef tourism associated with reef environmental degradation? How?

Question 2. What are stakeholders' perceptions of coral reef management policy in the Eastern coast region of Thailand?

Question 3. Are there ways that coral reef management in coral reef tourism-focused areas might be made more sustainable?

1.3. OBJECTIVES OF THE THESIS

To answer those questions, I have conducted two study in response to the question.

Objective 1. To identify impacts related to tourism on coral reefs in eastern Thailand.

Objective 2. To determine stakeholders' perception toward coral reef management policy implementation in the Eastern coast region of Thailand.

Objective 3. To provide suggestions to coral reef management in MNP and non-MNP areas in East coast of Thailand in order to enhance sustainable tourism.

1.4. STRUCTURE OF THE THESIS

The thesis is structured primarily to address the question of identifying ecological impacts related to tourism and to elucidate perceptions of stakeholders on coral reef policy implementation. . This study was not intended to in any way evaluate management effectiveness nor performance of management agencies. Finally the finding of both ecological study and socio-ecological study will summarized and suggestion will be synthesized. To address these objectives, the thesis is structured as follows:

Chapter 1 – **Introduction -** provides an overview of the thesis and the rationale behind. It identifies that coral reef based tourism is important to the economic development but it places pressures on coral reef resources. Then it provides a brief context of coral reef management in Thailand involve institutional structure and regulation of coral reef management in Marine National Park and in the area outside MNP and propose some constraint of coral reef management in Thailand. It describes general context of tourism business and coral reef in study area; the eastern coast of Thailand. Finally research questions and objectives were present.

Chapter 2 - **Literature review** - provides reviews of coral reef related tourism context, the benefits that gained from tourism and potential impact of tourism and coral reef management context. It shows development of tourism and the policy to support tourism. It illustrates the impacts of tourism in ecological aspect including direct and indirect impact on coral reef based on literature worldwide. It provides context of law and regulations and institutions involve coral reef management in Thailand.

Chapter 3 - Tourism and coral reef health - illustrate how MPAs and tourism infrastructure interact with intensity of tourist visitation on reefs in eastern Thailand from a coral health perspective. The study in this chapter point out the ecological impact of tourism that undermine coral health and water quality.

Chapter 4 – **Stakeholder perceptions** – a socio-ecological study examining the ways in which managers and users view reef management policy and how they see their roles and the effects of policy /legislation on the way they function. It also provides how end users perceived threats, condition and importance of natural resources.

Chapter 5 – **General discussion** – a synthesis of the findings of the previous chapters and examination of lessons learned from the experience of tourism in Thailand and elsewhere that might serve as conceptual indicators as to where Thai authorities might look to enhance the sustainability and effectiveness of management policy for reef areas in eastern Thailand.

CHAPTER 2

MANAGEMENT OF TOURISM-FOCUSED REEFS MANAGEMENT

2.1. IS REEF BASED TOURISM IN THAILAND SUSTAINABLE?

Coral reef-based tourism is widely credited with the ability to contribute to economic development which can improve quality of life of a local community faced with declining fisheries and lack of alternative livelihoods. The rapid increase of tourism demand triggers an increase of coastal development and – somewhat paradoxically – increases the use of coral reef resources. Coral reef tourism in most of Asia is seldom environmentally neutral. Tourist activity such as snorkelling and diving placed direct impact on coral reef, as well as indirect impact from poorly plan coastal development consequences loss of biodiversity. This led to degradation of tourism resources which may finally deteriorate reef-based tourism and would make reef based tourism unsustainable.

The term “sustainable tourism” is widely recognized as tourism that provides economic, social and ecological benefits (Edgell, et al., 2008). The World Tourism Organization (2007) has defined sustainable tourism as “*Tourism that takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment and host communities*". It has to seek for balance of both the sustainable growth of tourism’s contribution to the economy and society and the sustainable use of resources and environment (Z. Liu 2010). Sustainable coral reef-based tourism need to keep balance between economics gain and ecological lost.

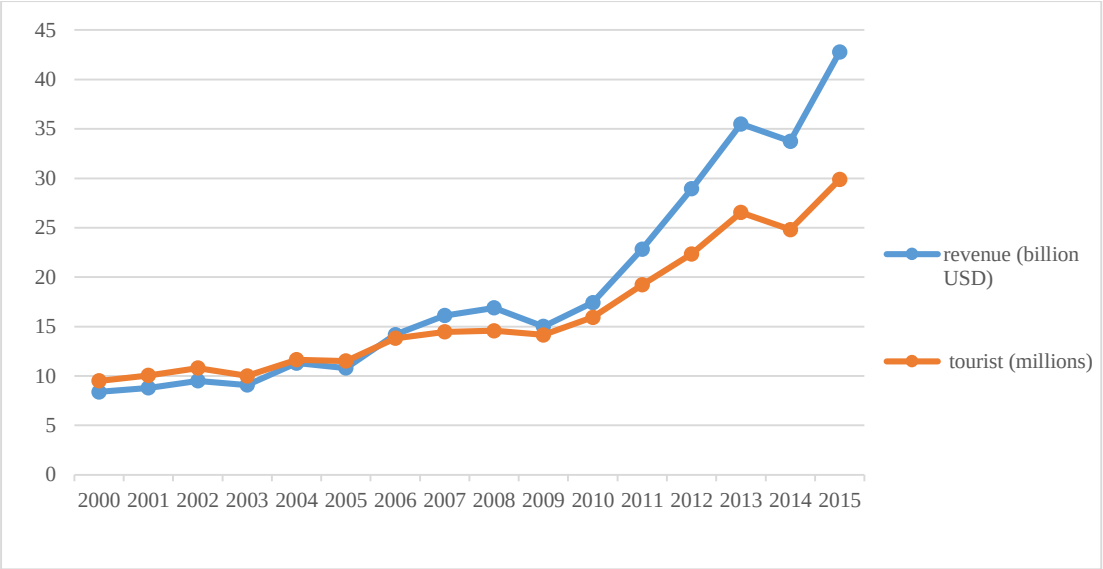

Figure 2.1. An increase of total inbound tourist and income in Thailand during past 15 years. (Source: http://service.nso.go.th/nso/web/statseries/statseries23.html)

2.1.1. Economic gain

Thailand has national policy to increase benefit derived from tourism sectors. As of 2016 tourism revenue was 2.51 trillion Baht (~76 billion USD), which is 17% of country's gross domestic product. The Thai Authority of Tourism has expected tourism revenue 2.71 trillion Baht in 2017 (http://www.bangkokbiznews.com). The top tourism destinations (that exhibited the highest increase) were coastal provinces in the Andaman Coast and in the East Coast of Thailand.

Coral reef-related tourism is one of a suite of popular marine-based tourism themes which contribute 36 billion USD per year in terms of economic benefits and social development to coral reef nations (Spalding et. al, 2017). Spalding et al., (2017) noted that reef-related tourism (reef-coast tourism) income is generated from both on-reef business and reef-adjacent business. "On-reef business" refers to direct, site-specific activities, such as SCUBA diving, snorkeling and boat tours. "Reef-adjacent

business" refers to the use of the coastal area within 30 km of coral reef; these activities involve beach activities, thematic retail (especially souvenirs), hotels and restaurants. Thailand is one among those countries in which reef-related tourism plays an essential role in economic development of coastal provinces and contributes strongly to the net economic wealth of the country. It is estimated that reef-related tourism in Thailand generates approximately 2.4 billion USD per year, which represents 32.5% of total country's tourism income.

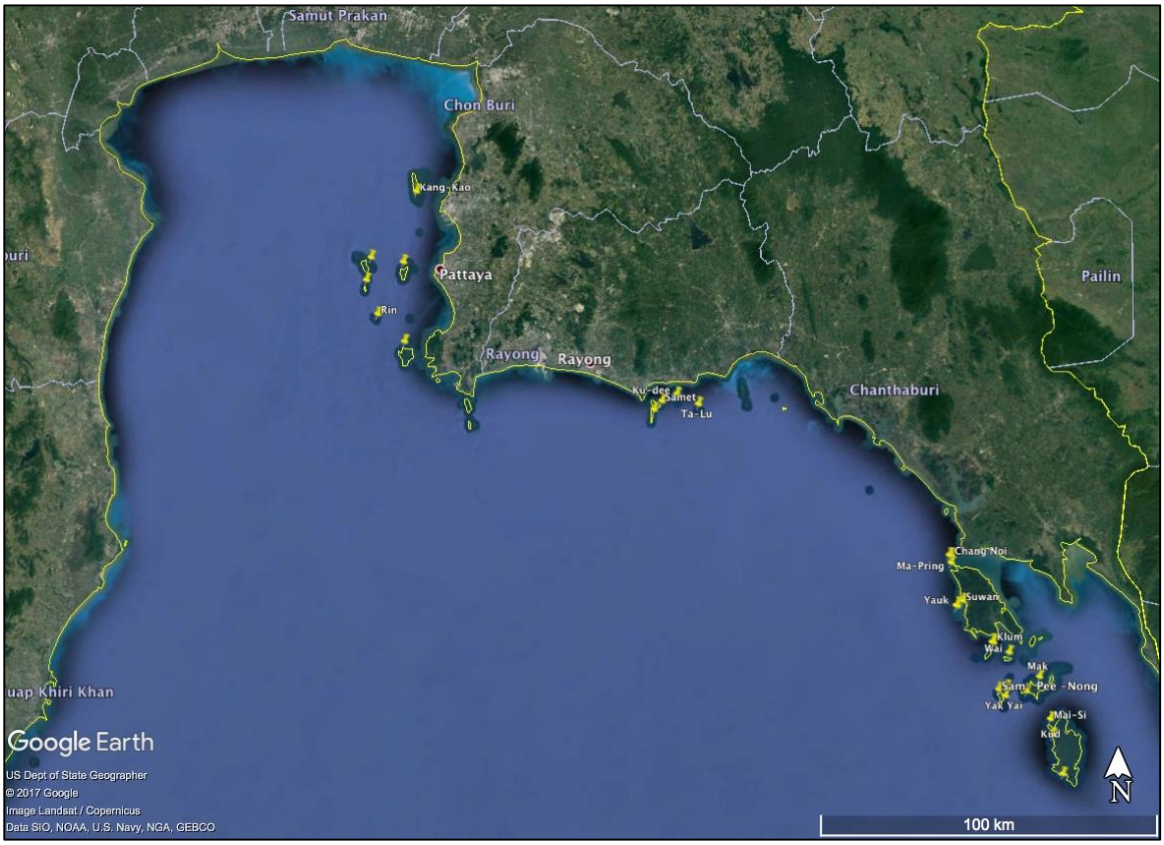

Figure 2.2. Distribution of coral reefs in East Coast of Thailand. Yellow pins indicate location of coral reef. (Source: satellite image is a copy of Google earth, the yellow pins indicate coral reefs that have been surveyed in this study).

Eastern Coast of Thailand comprise coral reefs fringing around islands along the coast (Phongsuwan 1999) (Fig.2.2). There are three coastal provinces being popular

tourist destinations; Chonburi province, Rayong province and Trad Province. During 2015 the average number of tourists has growth twice as was in 2009; from 9.8 to 18 million tourist, and the income has increased up to 3-folds; from 1.8 to 5.3 Billion USD (Table 2.1).

Table 2.1. Annual tourist visitation to coastal provinces in the Eastern Thailand (A) and annual income in each province (B). (Source: http://service.nso.go.th)

Province	Visitor		Δ (%)	Revenue (Billion USD)		Δ
	2009	2015		2009	2015	(%)
Chonburi	5,649,895	11,742,224	207.8	1,406,716,471	4,060,380,294	288.6
Rayong	3,417,196	6,650,710	194.6	317,660,588	834,695,882	262.8
Trat	749,150	1,864,064	248.8	114,544,706	424,854,547	370.9
Total	9,818,242	20,259,013	212.4	1,838,923,766	5,319,932,734	289

Of which 800,000 tourist has visit two Marine National Parks and other islands where nice reefs are known to be in Eastern Thailand (Fig. 2.3) (the maximum was exceed 1,000,000 in 2013 before political crisis) (source: http://tourism2.tourism.go.th).

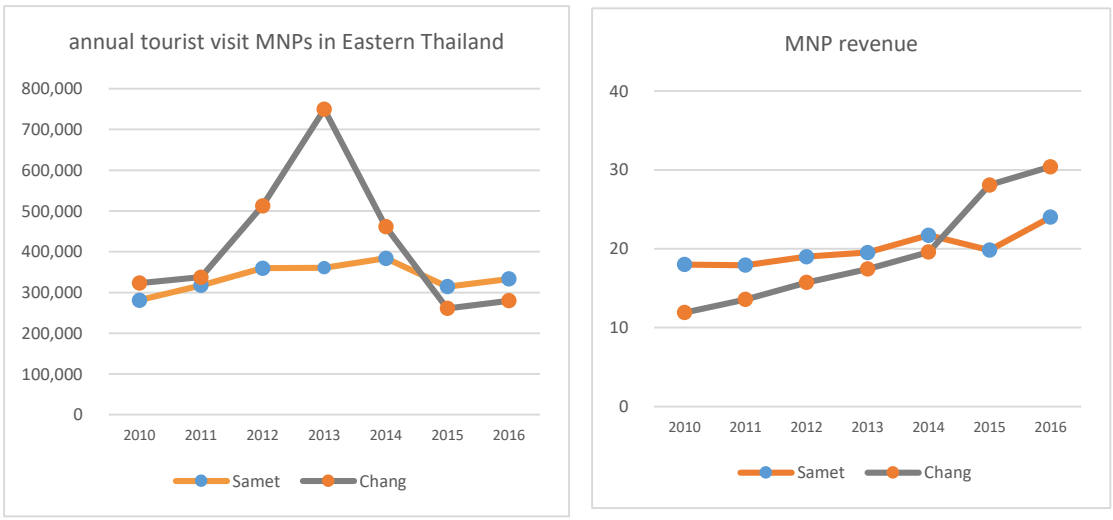

Figure 2.3. Annual tourist visit to two MNPs in eastern coastal Thailand (A) and annual revenue (B). Samet = the Khaolaemya and Mu ko Samet Marine National Park, Chang = Mu ko Chang Marine National Park. (Source: http://www.dnp.go.th)

2.1.2. Ecological cost of tourism

Quality of coral reef resources is a major determinant of the long-term viability of the tourism sector, degradation of reef resource can lead to a decline in overall tourist revenue that can deteriorate local economies. These linkages and feedbacks require assessment to inform decision-making and the trade-offs between ecological, social and economic impacts (Brown et.al, 2001). Reef related tourism has pros and cons. Though it plays an important role on economic development, it has been concerned as anthropogenic activities that negatively impact coral health (Wilkinson 2004; J. Zhang et al. 2013). Impacts of tourism activities on coral reefs associate with direct impact and indirect impact (Hardiman and Burgin 2010).

Direct impact refers to physical damage of coral reef as consequences of tourist activities and anchoring practice around coral reefs (Lirman and Fong 2007). The term usually encompasses damage associated with inexperienced and unaware tourists breaking fragile reef structures by touching, holding, kicking and trampling on coral colony and anchoring practice in coral reef from tour boat (Jameson et al. 1999; Plathong Inglis, G.J., & Huber, M.E. 2000; Hasler and Ott 2008; Hardiman and Burgin 2010). Snorkelling and SCUBA diving are perceived by managers as activities that potentially damage coral, even though they are regarded as the most "eco-friendly" uses of reef areas. Snorkelers and divers were reported to damage coral during their trip by trampling, re-suspension or mobilisation of sediment (by aggressive finning), holding onto and scraping coral colonies, and mechanical damage from accidental contacts with corals (Worachananant et. al (2008), Sluka, Cowburn, & Jackson, 2012). Hannak et al. (2011) found that approximately 84% of coral colony in snorkel hotspots show sign of damage – either breakage or partial mortality. Some studies on behaviour of divers demonstrate how tourists's behavior affect coral reef: 74 percent of snorkelers made at least one contact to the reef at during a survey in St. Lucia, Caribbean (Barker and Roberts 2004). SCUBA diver are percieved to be more reef-friendly, however Worachananant et al. (2008) reported that 81% of SCUBA diver made at least 5 contacts to coral colonies within 10 miniutes result in 19 damages per dive. Actvities such as photography (in which photographers will often lie on or secure themeselves to coral), rather than diver inexperience or incompetence result in higher numbers of physical contacts with coral (S. Worachananant et al. 2008; Rouphael and Inglis 2001). Spearfishing around coral reefs (either on snorkel or SCUBA) is quite rare in Thailand, since the majority of popular reef areas are within MPAs. SCUBA-fishing is known to

occur on non-MPA sites, although it tends to be discouraged strongly by most tour companies (pers obs.). Extractive use by tourists (fishing, spearfishing, gleaning of shore animals and shells), while popular with Korean, Chinese and Russian tourists, and directly impacting reef communities, is much less pervasive than fish-feeding (immensely popular with Asian and European tourists) and the dumping of food scraps by tour boats (Di Iulio Ilarri et al. 2008). Dumping of food and non-food rubbish by locals, tourists and affiliated businesses comprises both a direct impact and a considerable list of indirect impacts (http://www.naturalnews.com/2017-02-16-ocean-of-trash-an-island-of-garbage-is-moving-in-on-thailands-tourist-resorts.html).

Indirect impacts of tourism generally found in coral reefs proximate to coastal activity. Impacts associated with land-based stressors influencing water quality have frequently resulted in localized declines of coral communities (Lirman and Fong 2007). Percentage cover of both fragile and tolerant coral decreased in nutrient rich and turbid water (Reopanichkul et al. 2009). Sedimentation and nutrients are key factors that receive attention from scientists (Browne et al. 2015). Direct discharge of wastewater and sediments loaded from coastal activities result in coral degradation (Meng et al. 2008) and decreased live coral cover (P.-J. Liu et al. 2012). Discharged wastewater is generally rich in both phosphorus and nitrogen, and has led to eutrophication, enhancing turf and macro algae development (Zaneveld et al. 2016). Zaneveld et al. 2016). Increase macro algae in coral reef associated with decrease coral growth rate (R. Vega Thurber et al. 2012) and increase prevalence of coral disease, as macro algae can trigger coral disease (Nugues et al. 2004) and it can be a reservoir of pathogen (Sweet, Bythell, and Nugues 2013). Sewage and household waste elevating putative pathogen loads and increased prevalence of coral diseases (Sheridan et al. 2013; Lamb et al. 2017;

Zaneveld et al. 2016). Nutrient enrichment in coral reef has negative impact to coral physiochemical. Corals exposed to high total oxidized nitrogen (TON) has significantly lower live coral cover and low abundance, and higher partial mortality (Wielgus, Chadwick-Furman, and Dubinsky 2004), develop fewer embryo and decrease growth rate (Koop et al. 2001). Moreover, disturbance of microbial nitrogen cycling may be tightly linked to coral bleaching and disease (Rädecker et al. 2015). Coral exposed to high concentration of phosphorus has a decreased density of skeletal material (phosphate is a calcification poison (Cohen and McConnaughey 2003), making coral vulnerable to breakage (Koop et al. 2001). Coral diseases, partial mortality and tissue loss also related to human impact (Raymundo et al. 2008) and are among causes of coral degradation. Lamb & Willis (2011) found that the presence of tourism facilities in coral reef sites was associated with 15-times higher prevalence of coral disease than coral reefs without tourist platforms. It should be noted that that corals exhibit a diverse array of immune responses to environmental and anthropogenic stressors, which is potentially concurrent with seasonal increases in growth of pathogens or pathogen virulence (Lamb and Willis 2011) (van der Water et al. 2015).

The level of impact of tourism activities is apparently correlated positively to intensity of use and negatively with coral health. Coral reefs located in high use area have higher number of physical damaged-colony than coral reefs in low use areas (Au et al. 2014) and lower live coral cover (P.-J. Liu et al. 2012). A study from Grand Cayman, in the Caribbean, shows that sites that a high intensity of SCUBA diver activity results in a doubling of the incidence of dead coral, a higher proportion of coral rubble and lower percentage cover of soft coral when compared to low intensity sites (Tratalos and Austin 2001). Zakai and Chadwick-Furman (2002) study the impact of

scuba diving in the northern Red Sea also revealed that the percentage of broken coral and tissue abrasion damage to colonies increased toward the high use site; overall proportion of damage amongst stony coral was 8% in low use site and increased up to approximately 60% in high use site. Lambet al. (2014) report that prevalence of coral disease prevalence and other ill health signs in high use area were higher than that of low use area by SCUBA diving.

2.1.3. Ongoing degradation of coral reefs

While the tourism business has increased coral reefs are conversely decreasing. Coral reefs around the world are under pressure and has been significantly decreased at accelerated rate during the last two decades. Average coral cover in Caribbean region decreased by 50%, from 34.8% in 1980 decreased to 16.3% in 2011 (Jackson, 2012). Average coral cover in Great Barrier Reef decreased by 50.7% in the past two decades (De'ath et al. 2012). Similarly, coral cover in the Indo-Pacific region decreased from 42.5% to 22.1% within 23 years (Bruno and Selig 2007). A decade ago, Wilkinson (2008) reported that 19% of original coral reefs have been lost worldwide; a further 15 % are predicted to be lost within 10-15 years and warming temperatures and ocean acidification are likely drive the elimination of most warm-water coral reefs by 2040–2050 (Hoegh-Guldberg et al. 2017). Decline of coral reefs has been reported to be more serious in Southeast Asia, the largest coral reef area of the world, where 40% of coral reef has already been lost, 25% are at critical stage, 20% are under threaten level and only 15% are at low threat level (Burke et al. 2011)

Coral reefs in Thailand are increasingly under both environmental and anthropogenic pressures. Living coral has been declining over past two decades

(Phongsuwan et al. 2013). Currently average living coral covered of Thai coral reef was estimated at 50% of that of the original coral reefs (Phongsuwan et al. 2013). To date, declining of coral reef has been associated with catastrophic storms, elevation of sea surface temperature, coastal development and expanding of tourism (DMCR, 2009). The widespread degradation of Thai coral reefs has also been associated with the introduction of bottom trawlers and blast fishing in the early 1960s, offshore tin mining in the 1970s, and the expansion of tourism industry and other coastal developments beginning in the late 1970s (Hale and Olsen 1993). According to the first completed survey made by Department of Fisheries during 1995-1999 to produce the Map of Coral Reef of Thailand (Chansaeng et al, 1999: in Thai), the average condition of 60 % of coral reefs in Andaman coast were fair to poor and approximately 60% of coral reefs in Gulf of Thailand were fair to healthy.

The mass coral bleaching event in 1998 and 2010 were the most severe natural disaster to befall coral reefs in Thailand (Phongsuwan et al. 2013). After the 2010 mass coral bleaching event, coral mortality in west coast was estimated at 50-60% and 30-40% coral mortality in the Gulf of Thailand (Thamasak Yeemin 2012). The 1998 bleaching in Thailand resulted in loss of 30% of coral reefs in Andaman sea, however coral reef had fully recovered after 5 years; live coral cover in Andaman sea had increased to 15% higher than that recorded prior to the 1998 bleaching event, although there was no information collected regarding potential changes to community composition (Phongsuwan et al. 2013). The 2010 event was undoubtedly more severe on both sides of the Thai peninsula, and caused unrecoverable mortality in several areas. Coral reefs in Andaman coast within Mu Koh Surin MNP, Mu Koh Similan and Noppatatara beach and Mu Koh Pipi retained only 30-50% live coral after the event

(table 2.2). Live coral cover at Mun Island in the Eastern in the Gulf of Thailand (GoT), decreased by 50% after the 2010 bleaching event. Coral reefs further south at Tao Island, and at lower GoT reefs suffered proportionately less, although significant local mortality amongst vulnerable species was reported. As of 2015 total live coral cover in Thailand was 23% (table 2.3) (Phonsuwan, 2016; available at http://marinegiscenter.dmcr.go.th/).

Table 2.2. Decreased live coral cover of popular coral reefs in Thai water during the past two decades. Sources; Phongsuwan et al. (2013)

Site	Live coral cover (%)			
	1989	1998	2006	2010-2011
Andaman coast				
Surin MNP	42.5	35.3	55.1	10.7
Similan MNP	25.4	25	30.6	8.5
PiPi MNP	40	36	41	22.5
Rok island	26.4	39	-	17.6
Gulf of Thailand				
Mun island	39.1	37.4	33.3	22.2
Tao island	35	36	35	35
Lower GoT	39.1	39.1	36	32.1

Fortunately coral reefs that suffered from natural disasters can potentially recover during the "undisturbed period" between events. Great Barrier Reef has withstand a number of mass coral bleaching events, during 1998 - 2002, there was 70% of near shore reefs and 21 - 41% of offshore reefs suffered from bleaching but 95% of bleached coral survived (AIMS, 2016). The 1998 bleaching in Thailand resulted in loss of 30% of coral reef in Andaman sea, coral reef had full recovered after 5 year and even

more healthy than that of pre-bleaching event (Phongsuwan et al. 2013). Although, coral reef can potentially recover, anthropogenic impacts on coral reef had undermined reef recovery. Anthropogenic impacts are typically limited to certain areas, but the impacts had been accumulated and continued as long as humans can benefit from the reefs.

Table 2.3. Current condition of coral reef in Thailand as of 2015 (source: http://www.dmcr.go.th)

Location	Province	Area (rai)	Condition of coral reef (%)				
Gulf of Thailand			Excellence	Good	Fair	Poor	Very poor
East. Got	Trad	17,758	1.5	2.1	18.5	33.5	44.5
	Chantaburi	766	0	7.4	28.8	49.1	14.7
	Rayong	3,151	5.6	17.5	37.2	28.7	11
	Chonburi	6,472	2.7	9.3	32.0	26.3	29.7
Central Got	Prachaubkirikan	1,550	0.1	2.6	22.7	50.3	24.3
	Chumporn	9,165	2.9	3.5	13.1	30	50.5
	Suratthani	36,169	0.5	1	10.4	33.3	54.9
Lower Got	Nakornsrithammarat	412	56.9	24.6	11.5	0.0	7.0
	Songkhla	167	22.4	15.2	36.7	0	25.6
	Pattani	80	66.7	33.3	0	0	0
	Total	75,590	1.8	3.2	16.0	32.2	46.7
Andaman Coast							
North Andaman	Ranong	2,828	0	0	2.6	18.3	79.1
	Phanga	26,126	1.0	0.7	7.1	20.8	70.3
	Phuket	13,932	0.3	1.2	15.6	20.6	62.3
South Andaman	Krabi	14,039	0.2	0.7	13.4	37	48.8
	Trang	3,013	0.6	0.4	14.7	28.1	56.3
	Satun	13,428	9.8	19	38.3	20.4	12.5
	total	73,365	2.3	4.1	15.8	24.0	53.8
Total Country		148,955	2.0	3.7	15.9	28.3	50.1

2.1.4. Can reef-related tourism be sustainable?

It is now widely accepted that tourism development may have profound impacts on local environments, and it is necessary for management agencies to consider how much impact tourism places on coral reefs and how much benefit tourism gain in return. There are measures to limit direct impact of human activity to coral reef such as periodic closure (Cinner et al. 2006), site rotation (Worachananant 2007), management of visitor behavior , create artificial reef as alternative dive site (Carter and Grimwade 1997) and limited the number of tourist under reef carrying capacity (Hughes et al. 2011). All of which measure mentioned above are developed to protect coral reef base on ecological background. There is a method to assess the capacity of coral reef to support human use within certain area and time; carrying capacity. Carrying capacity is the management metric most commonly implemented in Thai MNP to constrain tourism impact by using an arbitrary threshold of ecological change as a trigger to restrict tourist numbers. Most of studies conducted on the tool note that the level of use in coral reefs is already over the capacity of the reefs to sustain. Carrying capacity is a deeply flawed tool (although few "easy" alternatives are available for managers with little understanding of reef ecology or vulnerability), but its very introduction as a management tool indicates an awareness amongst management authorities that tourism *per se* is not without its costs. The challenge for management agencies is in finding an appropriate balance between tourism-related economic development, environmental protection, and the satisfaction of the needs and desires of tourists and local residents. The most common definition of sustainable development includes this putative trade-off, however in practice, the weight of the argument lies firmly on the side of development, rather than sustainability.

2.2. CORAL REEF MANAGEMENT IN THAILAND

Management of coral reef in Thailand involves a number of different laws and involve various agencies from national level to local level to enforce. the multitude of responsible agencies, and overlapping areas of interest have led to a certain amount of confusion and a lack of understanding about allowed activities , development priorities and administrative boundaries, not just amongst users, but also among agency personnel.

2.2.1. Laws and regulations

There are five laws had been enforced to protect coral reefs in Thailand such as the Fisheries Act of 2015 & 2017, the National Park Act of 1961, the Wildlife Conservation and Protection Act of 1992, the Enhancement and Conservation of National Environmental Quality Act of 1992 (Anuwat Nateewatana, 2008; in Thai) and the Enhancement of Marine and Coastal Resources Management Act of 2016. The objective of the laws that can apply to coral reef are as follows.

The Fisheries Act of 2015

The Fisheries Act aims to regulate fishing practice and to conserve aquatic animal. Section 5 of the act define that any living or dead of marine organism as “aquatic animal”.

Section 58 prohibits dumping of waste, waste water, toxin or other substance that poison to aquatic animal. Ministerial Regulations and Notifications to conserve aquatic animal have been issued pursuant to the Fisheries Act that relevance to coral management involve;

- Prohibition of collecting coral, soft coral, gorgonian, sea anemone, blue coral, fire coral, giant calm and Chiton in entire Thai water except for research purpose which require permission.
- Prohibition of destructive fishing practices in coral reefs and artificial reefs i.e.; *muro ami*, trawling, push-net, gill net, blasting, electric shock and toxic substances.
- Prohibition of fishing in fisheries reserve area which some of the area are include coral reef.
- Prohibition of exporting any live or dead coral.
- Prohibition of possession of any live or dead coral.

The Fisheries act has been adopted to manage coral reef by key agency such as Department of Fisheries, Department of National Park and Department of Marine and Coastal Resources.

The Wildlife Conservation and Protection act of 1992

The Wildlife Conservation Act aims to protect preserved animal and protected animal from hunting, collecting and culture. Section 4 of the act has identified scleractinian coral **(** Order Scleractinia), soft coral **(** Order Alcyonacea), gorgonian **(** Order Gorgonacea and Antipatharia), blue coral (Order Helioporacea), fire coral (Genus Millepora), sea anemones (Order Actinaria), giant calm (family Tridacnidae) and triton (*Charonia tritonis*) as "protected" animal. Section 16 prohibits collection of living and dead of protected animal, culture, sell, import-expert of protected animal without permission. The act is applicable to protect coral reef resources outside MNP boundary by Department of Fisheries.

The national park Act of 1961

The National Park Act established to protect plant and animal in the designated area. Coral and other organism both living and dead (skeleton) was defined as “animal”. Section 16 prohibit any activity that harm animal in MNP boundary. Therefore, breaking, trampling and collection of coral colony, feeding any animal, waste disposal, draining any sewage from tour boat into coral reef and anchor in coral reefs are illegal and sentence to be fined and prisoned. Implementation the NP act is a responsibility of MNP authorities solely within MNP boundary.

The Enhancement and Conservation of National Environmental Quality Act of 1992

The Enhancement and Conservation of National Environment Act aims to enhance environment quality and to control anthropogenic impact to environment. The act involve establishment standard of coastal water, standard of waste and waste water management and standard of pollution control. Section 43 of the Act provides measures to solve to environmental problems in vulnerable ecosystems through designation of Environmental Protected Area (EPA). The EPA enable an implementation of measures and regulations to conserve natural resources and the environment (Satumanatpan et al. 2014).

The Enhancement of Marine and Coastal Resources Management Act of 2015

The Enhancement of Marine and Coastal Resources Management Act establish to enable effective conservation of marine and coastal resources through integration and participatory process. Section 16 promote participation of local community and local government in marine and costal resources management. Section 20 enable

designation of Marine and Coastal Resources Protected area to protect vulnerable marine ecosystem. Section 22 enable DMCR to designate temporary protected area where coastal resources are under severe threat. This protected Area can be applied to the ecologically important reef (section 20) and threaten reefs (section 22)

Other laws that indirectly affect coral reefs include

The City planning Act of 1975, establishes a certain area for inhabitants and identifies particular zones for specific activity. This act attempts to control expansion of coastal cities located near coral reefs.

The petroleum act of 1971, aims to regulate all petroleum company to avoid a leakage of oil and gas into marine environment.

The Navigation Act of 1913 that prohibits all construction in coastal and sea and prohibit a discharge of petroleum and chemical substance into the sea.

There is considerable overlap between laws that protect coral reef resources between and amongst responsible ministries. The Fisheries Act and The Wildlife Preservation and Protection Act both prohibit collecting of coral, soft coral, gorgonian, sea anemone and giant clams, but the penalty provisions of these two Acts are different. Agencies which are responsible for enforcement must therefore question which particular law was supposed to be used, and in which situation. Moreover, the National Park Act prohibits collecting of animal and prohibits any activity that might harm animals (including coral reef organisms) within the park boundary. The National Park Act does not stipulate how this law is supposed to be enforced since the Fisheries Act and the Wildlife Preservation and Protection Act ostensibly protect coral reef organisms, and neither law mentions any boundary within which they are suspended or

superseded. In general, officers are not familiar with the legal complexities and jurisdictional overlaps, and to a large degree, it doesn't greatly affect the way they operate; within MNPs, National Parks officers are given ultimate authority. Outside park boundaries, the issues are more complex, with officers of different agencies often assuming that another agency has authority if they are unsure of their own.

2.2.2. Institutional Arrangements

Coral reef in Thailand is under supervision of various agencies from national to local level. At the national level, Department of marine and coastal resources (DMCR; under Ministry of Natural Resources and Environment (MONRE)) responsible for coastal and marine areas not gazette as national parks. Department of National Parks, Wildlife and Plant Conservation (DNP; under MONRE) administer coral reef and other marine resources within the Park boundary. Department of Fisheries (DOF; under the Ministry of Agriculture and Cooperatives), overseen fishing of marine animal by local and commercial interests in the sea.

At the provincial level, coastal and marine resources are supervised by Provincial Office of Natural resources and Environment supported by regional marine and coastal resources research center and regional marine and coastal resources management center under DMCR. Institutional arrangement in coral reef management can be categorized according to their authority as agency responsible for coral reef management in MNPs boundary and agency responsible for coral reef management outside MNP.

Coral reefs outside national parks are mainly the administrative responsibility of DMCR but the resources potentially extractable from them are the responsibility of

the DOF. DMCR has mandate on conservation, research and monitoring of coral reef and designation of protected area applicable to protect coral reef. According to the Enhancement of Marine and Coastal resources Act of 2015, DMCR has authority to designate area, which has not been designated as protected area under other laws, to be Marine and Coastal Resources Protected area which is applicable for ecological-important reefs (section 20) and vulnerable reefs (section 22) (the Enhancement of Marine and Coastal resource Act B.E. 2558 available at http://www.dmce.go.th). DOF is responsible for fishing practice and aquatic animal including coral reef organism under the Fisheries act of 2015. Coral reef resources, therefore, are legally under supervision of DOF.

Within national parks, only DNP policy is supposed to be extant. Coral reefs situated in Marine National Park boundary fall under the responsibility of the Department of National Parks, Wildlife and Plant conservation (DNP). The primary objectives of gazette MNP in Thailand is the preservation of species and genetic diversity, maintenance of environmental services and tourism and recreation in designated area (Emphandhu and Chettamart 2003). Every single colony of living coral as well as coral skeletal and other reef organism in MNP boundary are protected under the National Park Act.1961 and The Wildlife Conservation and Protection act B.E. 2535 (1992). Coral reef management within MNP boundaries rely on MNP staff, supported by the specialist staff from the regional Marine National Park Operation Center (MNPO). There are 26 MNPs and 4 MNPO in Thailand; each MNPO supports more than 5 MNPs in its area of responsibility. MNPO is responsible for monitoring, research and to provide technical support for MNP in management and protection of natural resources. MNP staff both superintendent and park ranger were former staffs of

Terrestrial Park they seem to applied management practice which was success in terrestrial park to MNP (Worachananant 2007). In addition, most of national park staff had graduated from school of forestry and faculty of forestry which concentrate on forestry (detail of courses available at http://www.forest.ku.ac.th), therefore MNP staff has insufficient background on marine ecosystem. Due to the limited of coral reef specialist and limited resources to take care over the entire area, MNP has cooperated with DMCR research center and university experts to conduct specific research and monitoring. Some MNPs have a boundary adjacent to or overlapping with local community areas in which a local government authority (most often the Sub-district Administration Organization) is responsible for environmental planning and management in the areas that lie within or immediately around MNP (Emphandhu and Chettamart 2003).

2.2.3. Policy involve coral reefs management in Thailand

The first management project was developed in 1987 under the Thailand Coastal Resources Management Project: CRMP. CRMP project had been established under the cooperation between department of Fisheries, Thailand and the government of United State of America. The purpose of CRMP project was to identify and formulate the policy reform and guidelines necessary for effective coral reefs management in Thailand (Lemay, Ausavajitanon, and Hale 1991). The outcome of the CRMP project was the first “National coral reef management strategic plan” (Thailand coastal resources management project 1991) that was formally approved by the cabinet on 2 march 1992. The plan aims to manage all coral reefs in Thailand based on 6 principles as follows:

1. To manage coral reef according to their different ecological value, density and diversity of coral reef in order to maintain a balance of human uses.
2. Consider the important of coral reef as national economic value and local community need to maintain a balance of use.
3. Promote community participation in coral reef management and support local management activity.
4. To keep balance between law enforcement and stakeholder participation campaign.
5. Promote integration among stakeholders including central and local government, private sector, researcher and all users.
6. Manage coral reef based on database of coral reef ecology, uses of coral reef and carrying capacity of coral reef.

In addition, the plan had classified coral reef into 3 zones including **Local management zone;** small coral reefs situated outside of protected areas that had been used for local fisheries, **Tourism and recreation zone**; moderate reef for development of tourism better reef for eco-tourism activity and **Conservation zone** which are potential healthy reefs preserved for research purposes and for maintain biodiversity.

After 15 years since the first strategic plan had been implemented, Department of Marine and Coastal resources (DMCR) and Office of National Environment Policy and Plan (ONEP) had reviewed and improved the strategic plan according to an increasing impact of climate change and increasing of human use. The new plan suggest multiple use zone in coral reef in accordance to condition of reefs and the use context, and propose the allowed activity in each zone. The “National Strategic and Action plan

of coral reef management" has been documented in 2009 (office of marine and coastal resources management 2009). However, this plan has not approve by the cabinet, therefore it is use mainly by DMCR as strategy for coral reef management. The plan proposes systematic strategies for coral reef management including;

1. Coral reef management principles for zoning and multiple use.
2. Plan to tackle coral reef degradation
3. Enhance public participation
4. Revision of laws and regulations.
5. Coral reef monitoring plan for an entire Thai water.
6. Research and development of rehabilitation and management techniques

However, this plan has not approve by the cabinet, therefore it is use mainly by DMCR as strategy for coral reef management.

During 2010, DMCR has launched the Coral reef rehabilitation plan (office of marine and coastal resources management 2010) in response to the rapid degradation of coral reef because of an increase of coastal development and tourism. This rehabilitation plan suggests 4 strategies to mitigate threats to coral reef problems including

- Mitigation of tourism impact.
- Waste water management to protect coral reef.
- Mitigation of excessive sediment transported to coral reef.
- Strategy to control fishing practice in coral reef.

The rehabilitation plan also provides measures of each strategy and suggests key management and support agency to implement the measures.

The strategic plan and the rehabilitation plan can be regards as the most comprehensive plan for coral reef management available in Thailand of which can potentially be the National policy for coral reef management, however it need to be revised against current issues and international agreement and need formal adoption from all relevance agencies.

Coral reef management in thailand often implement in response to emerging threat and urgent issue. Coral bleaching event is the severed threat that trigger active management to manager in thailand. During 2010 bleaching event, all Thai coral reef sciencetist were enganged by DMCR to conduct comprehensive survey in entire thai water to assess extend and severity of coral bleaching and to brainstorming for response plan, finally came up with development of the coral reef management strategy under coral bleaching crisis (Thamasak Yeemin 2012). This collaboration provide a platform among thai marine sciencetist for coral reef research and managment, as of 2016 bleaching event the Coral Bleaching Taskforce was established. However the comprehensive and long term plan for coral reef management in the entire Thai water remain in need. It is of high cost to revert consequence of threats or it is irreversible, therefore precautionary approach should be considered.

> The Precautionary Principle is based on the recognition that a false prediction that a human activity *will not* result in significant environmental harm will typically be more harmful to society than a false prediction that it *will* result in significant environmental harm. (IUCN, 2007)

The Precautionary Principle aims to anticipate, avoid and mitigate potential threat to environment consequences of threats (IUCN 2007). As the precautionary approach is based on scientific-based prediction of negative consequences, it requires a strong science-based information to make a proper decision. Aronson and Precht (2006) noted that falsely concluding that there is an effect when in fact there is none, is better than falsely concluding that there is no effect when in fact there is one. However, manage beforehand costs a certain amount of resources, there are suggestions that precautionary approach would worth when there is a predictable threat and its consequence is irreversible. It is of no use when there is no indication of threat and/or its consequence is easily reversible (IUCN 2007).

2.2.4. Management of coral reef for sustainable tourism

Management of coral reef for tourism rely heavily on the balance of resources use and the preservation of ecosystem. Carter and Grimwade (1997) suggest two strategies to balance between use and conservation purpose based on managers' determination including raising the site's capacity for use or reducing the amount of use of the site. Raising the site's capacity involve modification based on how the site is used by visitor, and alter the character of the site. Reducing the amount of use involve reduce the attractiveness or access of site and increase attractiveness of other alternative sites.

There are three components to implement this strategy including development, control and communication. Development refers to site modification to increase or decrease capacity of the site. Modify access to limit number of tourist or to enhance access of tourist. Control refers to limitation of tourist through installation of physical

structure i.e. a limit number of mooring buoy, and establish regulation i.e. limit the number of tourist under site's carrying capacity and establish zoning to limit tourist within allowed area. Communication refers to increase stakeholders' awareness about benefits of conservation and consequences of conservation failure.

These strategies rely upon conservation goal and tourism interest. The conflict between these two expectations can undermine success of coral reef management. Control measure such as Zoning is recognized as tools for conflict resolution in the area of multiple uses (Worachananant 2007). Zoning enable to divide managed area into different areas base on objective of management scheme which allow manager to specify activity that are prohibited or allowed (Roman, Dearden, and Rollins 2007) . Zoning is applicable in all area both in the MNPs boundary and in the areas outside MNP. For example, in the busiest tourism hotspot in central Gulf of Thailand, Koh Tao, dive operators and local community, with supported by DMCR and expert from university, have established local marine protected area with zoning plan to control impact of fishing and dive tourism on coral reef (Hein et al. 2015). Zoning is a potential tools to enhance coral reef management, particular where there is an intensive tourism development as the Eastern coast of Thailand.

CHAPTER 3

TOURISM AND CORAL REEF HEALTH

3.1. INTRODUCTION

Marine tourism activity and the real estate and infrastructure development generated by the tourism industry can exact a significant toll on coastal ecosystems in Thailand, mainly the coral reefs, which are at the very heart of the ecosystem wealth and attractiveness of the coastline. Even where ecosystem-based management approaches are applied for coral reefs, they have focused overwhelmingly on reducing fishing pressure, with little attention being paid to other ecologically threatening human activities (Birkeland, C., 2017; Gil, Renfro, Figueroa-Zavala, Penie, I & Dunton, K.H., 2015; Norris-Pandolfi et al., 2005). Where fishing is not the primary focus, artificial and portmanteau metrics such as carrying capacity of reefs have been attempted (e.g. Zhang, Chung, & Qiu, 2016), based on the concept that the number of tourists visiting a site is ipso facto related to the severity of perceived impact. The problem with such metrics (and the thinking behind them) is that the links between tourism and coral reef health are understandable in relatively simple terms. Flaws in such simplistic methodologies are evident when the complexities of reef ecosystems are incorporated into surveys of reef condition (e.g. Díaz-pérez, Rodríguez-zaragoza, Ortiz, & García-rivas, 2016) and when the differences between localities and tourism intensity overwhelm the signal of the impact (Norris-Ferrigno et al., 2016; Nepote, Bianchi, Chiantore, Morri, & Montefalcone, 2016). Regardless of how one measures impacts or stress, however, the perceived economic benefits of reef-based tourism make it attractive for resource managers as a source of income and employment for

stakeholders. Almost universally, managers are aware that excessive tourism is likely to be detrimental to the coral reef resource upon which it is predicated, but feel that limiting the amount or nature of the tourism will provide an acceptable balance between impact and income, often referred to as "sustainable tourism" (Lucrezi et al., 2017). The concept of sustainability, however, requires that managers have a willingness to sacrifice services and activities in order to reduce the harm caused to biodiversity (de-Miguel-Molina, de-Miguel-Molina, and Rumiche-Sosa 2014) since often the value of the resource is tied to the perception that activities there are sustainable (van Beukering, Sarkis, van der Putten, & Papyrakis, 2015). But what should they sacrifice? Should they forgo the income of large numbers of guests, or the convenience of siting resorts and pontoons at the most desirable locations, or should they limit the types of activities they provide on-site?

Studies on the Great Barrier Reef have shown that even quite low-key infrastructure can negatively impact coral reef health (Lamb and Willis 2011), especially in places where overall visitation is low. Likewise, the number of visitors at a site can reflect a level of physical damage (e.g. Zhang et al. 2016) or degradation (Lamb et al. 2014). While these factors have been investigated separately, it is difficult to find areas where the combined or separate effects of tourism support infrastructure and visitation intensity may be discriminated. Here, I examine the effects of both visitor numbers and nearby tourism infrastructure along the east coast of Thailand, in a region which has invested heavily in intensive coastal tourism.

Question

Question 1: Are there differences in prevalence of coral diseases and signs of compromised health between coral reefs located close to tourism infrastructure and coral reefs at isolated islands?

Hypothesis: Prevalence of coral diseases and prevalence of signs of compromised health of reefs located near infrastructure are not different to those of coral reefs located at sites isolated from infrastructure.

Question 2: Are there differences in prevalence of coral disease and sign of compromised health of coral reefs that receive different levels of tourist visitation?

Hypothesis: Prevalence of coral diseases and prevalence of signs of compromised health of reefs that have high visitation do not differ from that of coral reefs that have low visitation.

3.2. MATERIALS AND METHODS

3.2.1. Site selection

I conducted systematic surveys in 24 selected coral reefs along the Eastern coast of Thailand (Fig. 3.1). The surveyed sites were assigned to two groups by proximity to coastal tourism infrastructure (defined as hotel or resort developments, especially beachside or a tourist pier):

1) “Near Infrastructure” (NI) refers to coral reefs that occur adjacent to the beach or coast where the physical presence of tourism infrastructure is obvious.

2) “Isolated from Infrastructure” (IS) refers to coral reefs situated at islands where there is no extensive tourism infrastructure.

Each group comprised 12 sites. In each infrastructure category, some sites identified by local tour operators as receiving relatively few (<50) tourists each day were categorized as “low visitation sites” (LV: n=6 sites); those exposed to higher levels of tourism (more than 50 tourists per day) were placed in the “high visitation sites” (HV: n=6 sites) category.

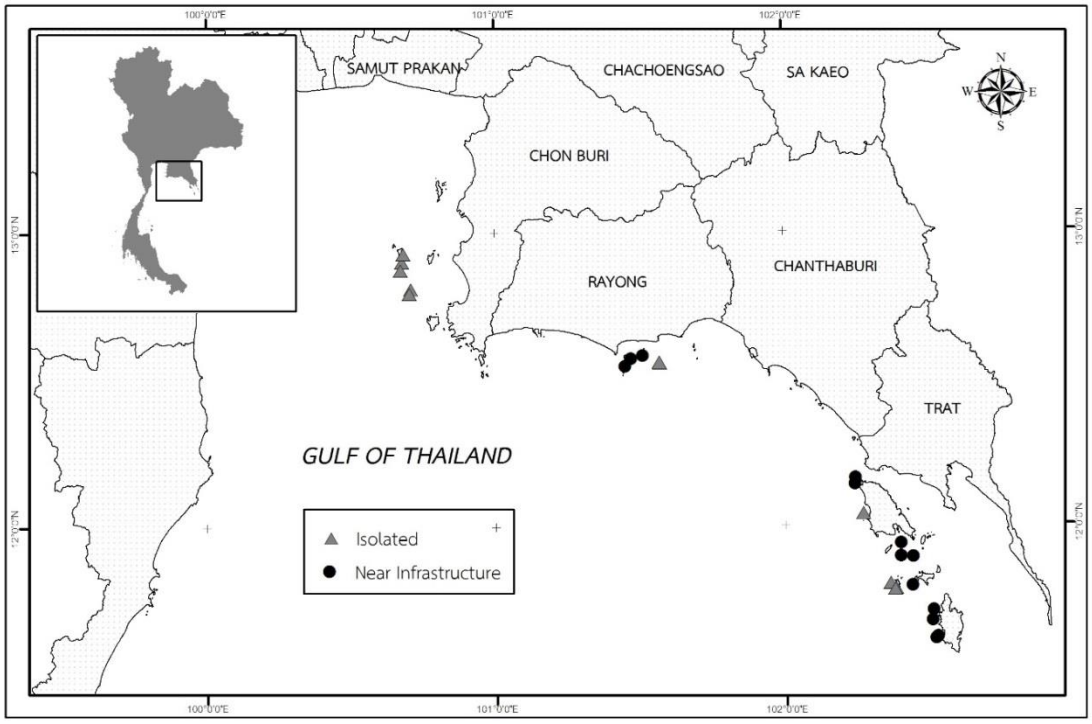

Figure 3.1 A total 24 coral reefs were surveyed throughout Eastern coast of Thailand. Study sites were assigned into 2 groups: near infrastructure groups (bold circle), and Isolated from infrastructure group (triangle).

I recorded the number of visitors at each site over the 3 hour peak-visitation period to verify visitation intensity. This period was usually mid-late morning, or early afternoon, depending on site. Since the groups overlap in space and are otherwise indistinguishable in terms of ecology, it is reasonable to assume that both infrastructure

categories receive equal impact from broad scale stressors and impacts such as mass bleaching, and are thus independent replicates.

3.2.2. Data collection

Field surveys were undertaken over a one-month period in late 2013 during the tourism peak season in the eastern coast of Thailand. I collected data of coral disease and other signs of compromised health following the protocol described by Raymundo et al. (2008). At each study site, I randomly placed four 25x1m belt transects just below the reef crest, parallel to the shore at 4-6 m depth. All coral colonies that were encountered within the belt transect were counted and identified to genus level. For each coral colony, I noted occurrence of coral disease (i.e. white syndrome and growth anomaly) and other signs of compromised health (i.e. focal and non-focal bleaching, algal or sponge overgrowth, partial mortality and pigmentation response). For the most part, it was not possible to attribute direct causes to observed lesions, although bites from parrotfish (Scaridae) and puffer fish (Tetraodontidae) were distinctive. Colonies with ambiguous or unusual signs and symptoms were photographed for later study.

At each site, I collected a water sample from 1m below the water surface using Nansen bottles, which were then stored on ice. The water samples were later analyzed at Burapha University (Chantaburi) to obtain quantitative measures of nutrient concentration, including nitrate, nitrite, phosphate, ammonia, as well as estimates of total suspended sediment and total coliform bacteria. Water parameters were analyzed following a standard protocol described by Pollution Control Department (PCD, 2004).

3.2.3. Data analysis

"Community prevalence" of coral disease incidence and signs of compromised health at each site was calculated by dividing the number of observed cases (from all transects) by total number of coral colonies (Raymundo et al. 2008). The association of overall diseases and signs of compromised health in all locations were investigated using Principle Component Analysis (PCA) (Clarke and Warwick 1994) based on square rooted transformed data for all sites. The principle Component Analysis was perform in Primer (v6, PRIMER-E Ltd, Plymouth, UK)

Since the disease prevalence and prevalence of signs of compromised health included many zero values and failed to meet the assumption of variance homogeneity, and thus was ill-suited to standard ANOVA, I used a non-parametric Kruskal-Wallis test (Ruxton & Beauchamp, 2008; Zar, 1999) to investigate differences in of mean coral diseases and health indicator prevalence and signs of compromised health prevalence between infrastructure and visitation groups.

I investigated difference in concentration of water parameters between groups using Analysis of Similarity (ANOSIM) (Blaud et al. 2015) based on square square-rooted transformed data. The distribution of sites was illustrated using non-metric Multidimensional Scaling based on Bray-Curtis similarity. Data were ordinated using logarithm-transformed data. Comparison of different concentrations of water parameters between sites with differing levels of visitation within groups were obtained using Kruskall-Wallis Test. I tested the correlation between water parameters and prevalence of coral disease and signs of compromised health using Spearman's rho test (Zar 1999).

3.3. RESULTS

3.3.1. Association of infrastructure to coral diseases and sign of compromised health

Two common diseases, namely coral growth anomaly (GA) and white syndrome (WS) and six signs of compromised health, viz. bleaching (BL), predation scarring (PRED), sponge overgrowth (SP), algae overgrowth (AL), partial mortality (PM) and pigmentation response (PR) were encountered during this study.

Table 3.1. Eigenvalues, cumulative percent variation (Cum. %), and eigenvectors of a PCA examining prevalence of diseases and prevalence of signs of compromised health.

Variable	PC1	PC2	PC3	PC4	PC5
Eigenvector					
GA	0.325*	0.006	0.007	0.329	0.669
WS	0.070	-0.168	0.479*	-0.496	0.477
BL	0.113	0.297*	0.135	-0.306	0.014
PRED	0.397*	0.608*	-0.169	-0.442	-0.177
SP	-0.196	0.010	-0.060	-0.338	0.323
AL	0.808*	-0.305	-0.153	0.074	-0.068
PM	0.148	0.174	0.831*	0.268	-0.279
PR	-0.069	0.625*	-0.074	0.406	0.327
Eigenvalues	4.55	3.27	2.5	1.77	0.986
%Variation	29.4	21.1	16.2	11.4	6.4
Cum.%Variation	29.4	50.5	66.7	78.1	84.4

(* indicate Pearson's correlation of axes to prevalence data; $r > 0.5$). Coral diseases: GA = Growth anomaly, WS = white syndrome. Signs of compromised health: BL = uncommon Bleaching, PRED = Predation scar, SP = Sponge overgrowth, AL= Algae overgrowth, PM = Partial mortality, PR = Pigmentation response.

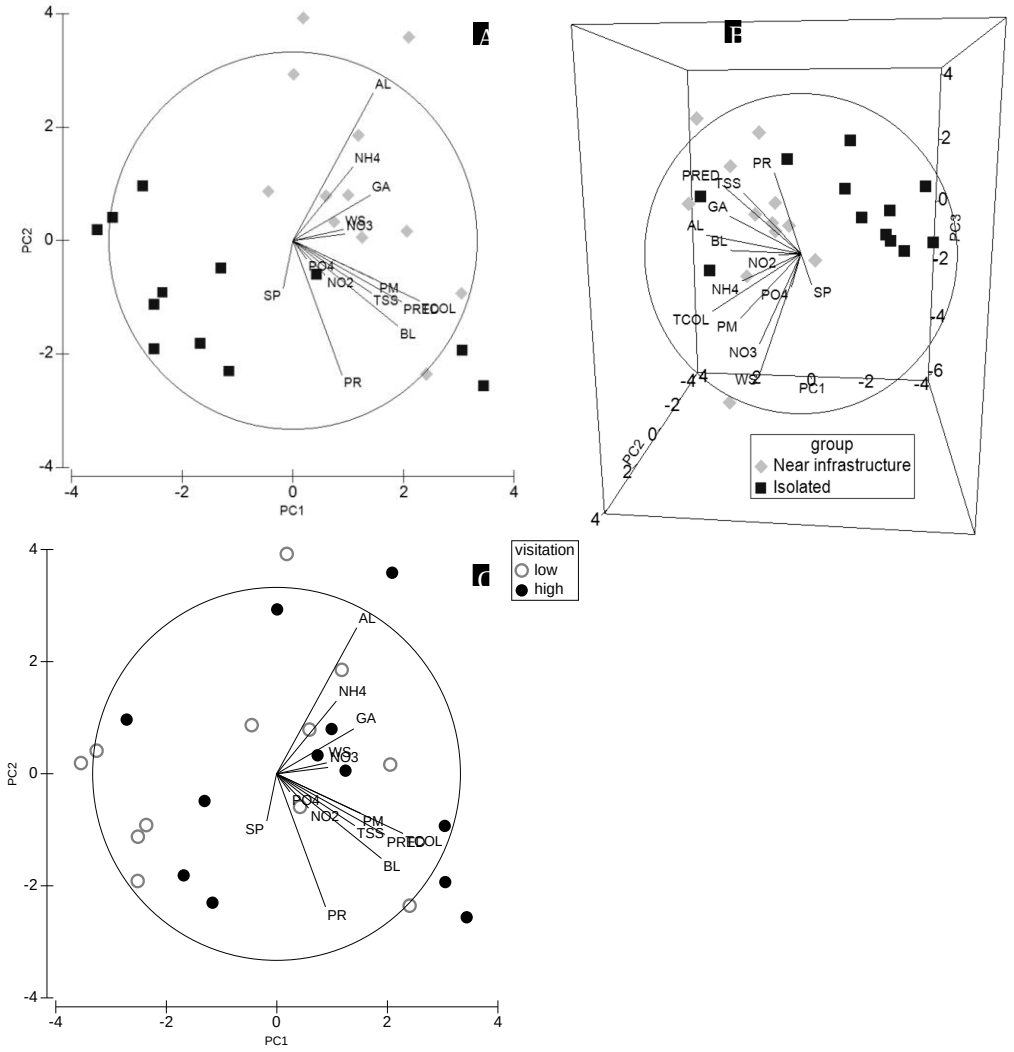

Figure 3.2 Principle component analysis of prevalence of coral diseases, signs of compromised health and water parameters in different groups (3.2A and 3.2B); near infrastructure group (light diamond) and isolated group (solid rectangular) and in different visitation (3.2C); low visitation (open circle) and high visitation (solid circle). PCO1, PCO2 and PCO3 account for 29.4 %, 21.1 % and 16.2 % of total variance respectively. WS = white syndrome, GA = Growth anomaly. Signs of compromised health: PR = Pigmentation response, PM = Partial mortality, BL = uncommon Bleaching, AL= Algae overgrowth, SP = Sponge overgrowth, PRED = Predation scar. Water parameters; NO3 = nitrate, NO2 = nitrite, PO4 = phosphate, NH4 = ammonia, TSS = total suspended sediment, TCOL = total coliform bacteria.

The PCA result shows that mean prevalence of coral diseases and signs of compromised health are associated rather more with sites nearby tourism infrastructure than they are with sites in the isolated group (Fig. 3.2, first 3 component axes accounted for approximately 66.7 % of variation). PCO1 appears to be driven mostly by prevalence of GA, PRED and AL, whereas PCO2 was driven mostly by prevalence of BL, PRED and PR. The third component PCO3 was driven by prevalence of WS and PM (table 3.1, Fig 3.2A, 3.2B). The 3-D PCA's diagram illustrated a separation between NI and IS group. The "near Infrastructure" group was characterized by a combination of high prevalence of algae overgrowth, partial mortality, growth anomaly, white syndrome and predation scar. Whereas the isolated group was associated with a high prevalence of pigmentation response, and sponge overgrowth.

I found that, although bites from parrotfish (Scaridae) and puffer fish (Tetraodontidae) were distinctive, areas of tissue loss due to other predation (e.g. Drupella) were indistinguishable from other sources of partial mortality (such as mechanical abrasion by divers' fins) at these sites. The category PM may thus include sources of mortality from several factors.

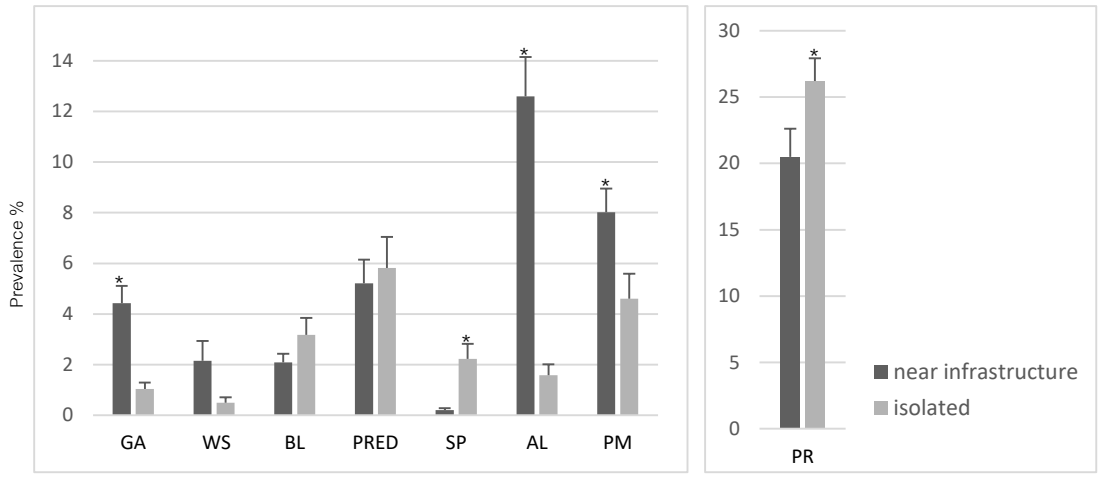

Figure 3.3. Mean prevalence of coral diseases and compromised health signs of near infrastructure group and isolated group. (* indicates significant level α = 0.05) GA = Growth anomaly, WS = white syndrome. Signs of compromised health: PR = Pigmentation response, PM = Partial mortality, BL = uncommon Bleaching, AL= Algae overgrowth, SP = Sponge overgrowth, PRED = Predation scar.

This separation of disease prevalence at the sites close to and further from infrastructure is illustrated by direct comparison if incidence rates of each indicator. Coral reefs located close to tourism infrastructure were susceptible to algae overgrowth, partial mortality, growth anomaly and possible pathogen related to white syndrome (Fig 3.3; table 3.2). Mean prevalence of algae overgrowth at near infrastructure group (mean ± se = 12.60 ± 1.55%) was 8-fold higher than that of the isolated group (mean ± se = 1.59 ± 0.43%). Mean prevalence of partial mortality at the near infrastructure group (mean ± se = 8.02 ± 0.94%) was twice as high as that of the isolated group (mean ± se = 4.61 ± 0.98%). Likewise mean prevalence of growth anomaly at NI group (mean ± se = 4.43 ± 0.68%) was 4-fold higher than that of isolated group (mean ± se = 1.04 ± 0.26%). Although the prevalence of white syndrome at near infrastructure group (mean

± se = 2.16 ± 0.78%) was 4-fold higher than that of the isolated group (mean ± se = 0.50 ± 0.21%), the very patchy distribution of the disease across sites meant that the difference was not statistically significant between categories; at some sites, prevalence of WS was very high, at others it was largely absent. There appears to be no direct correlation between prevalence of WS and coastal infrastructure, although there is a clear tendency for this syndrome to be present at higher than normal rates at these sites.

Mean prevalence of pigmentation response within the isolated group (mean ± se = 26.21 ± 1.71%) was higher than that of the near infrastructure group (mean ± se = 20.08 ± 2.14%). Likewise, the mean prevalence of sponge overgrowth within the isolated group (mean ± se = 2.24 ± 0.59%) was higher than that of near infrastructure group (mean ± se = 0.21 ± 0.07 %).

Table 3.2. Mean prevalence of coral diseases and signs of compromised health compare between groups and between low and high visitation within each group.

Variables	Between Groups			Between low and high visitation sites					
				Near infrastructure group			Isolated group		
	Chi-Square	df	Sig.	Chi-Square	df	Sig.	Chi-Square	df	Sig.
GA	16.86262	1	0.000*	0.922492	1	0.34	2.4599	1	0.12
WS	1.962305	1	0.161	0.516328	1	0.47	0.072197	1	0.79
BL	0.065528	1	0.798	0.888108	1	0.35	1.27899	1	0.26
PRED	1.124343	1	0.289	0.501486	1	0.48	9.522038	1	0.00*
SP	10.85494	1	0.001*	0.004036	1	0.95	2.561744	1	0.11
AL	46.32672	1	0.000*	0.287524	1	0.59	1.680032	1	0.19
PM	9.45485	1	0.002*	0.154501	1	0.69	1.808271	1	0.18
PR	7.959086	1	0.005*	3.877868	1	0.05*	0.224964	1	0.64
Nitrate	13.23691	1	0.000*	0.986014	1	0.32	5.387135	1	0.02*
Nitrite	0.495868	1	0.481	2.738928	1	0.10	21.54854	1	0.00*
Ammonia	55.54063	1	0.000*	0.109557	1	0.74	0.438228	1	0.51
Phosphate	1.11716	1	0.291	0.687135	1	0.41	0.986014	1	0.32
TSS	11.58906	1	0.001*	1.752914	1	0.19	1.351526	1	0.25
TCOL	20.42292	1	0.000*	6.131737	1	0.01*	10.2753	1	0.00*

(* indicates significant level at $\alpha = 0.05$) Coral diseases: GA = Growth anomaly, WS = white syndrome. Signs of compromised health: BL = uncommon Bleaching, PRED = Predation scar, SP = Sponge overgrowth, AL= Algae overgrowth, PM = Partial mortality, PR = Pigmentation response. Water parameters; NO3 = nitrate, NO2 = nitrite, NH4 = ammonia, PO4 = phosphate, TSS = total suspended sediment, TCOL = total coliform bacteria.

3.3.2. Prevalence of coral diseases and sign of compromised health attributable to levels of visitation

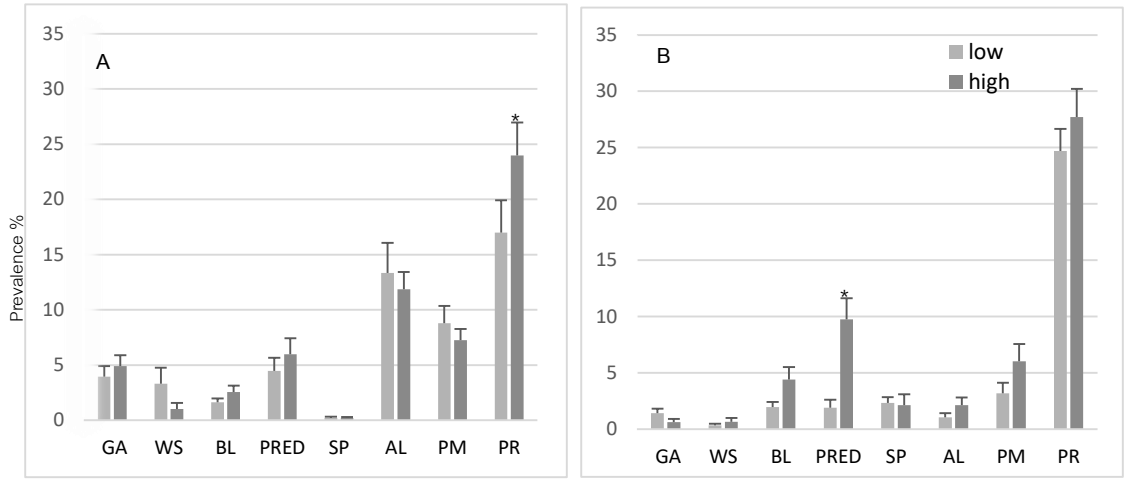

Figure 3.4. Mean prevalence of coral diseases; GA, WS, and signs of compromised health; BL, PRED, SP, AL, PM, PR, between low and high visitation sites within near infrastructure group (A) and isolated group (B). (* indicates significant level at $\alpha = 0.05$) Coral diseases: WS = white syndrome, GA = Growth anomaly. Signs of compromised health: PR = Pigmentation response, PM = Partial mortality, BL = uncommon Bleaching, AL= Algae overgrowth, SP = Sponge overgrowth, PRED = Predation scar.

Using level of tourism activity as the PCA ordination focus showed no particular distribution pattern that could be explained by level of visitation across infrastructure categories, whereas low visitation and high visitation sites within the isolated group had different distributions along PCO1, PCO2 and PCO3 (Fig 3.2C). It is likely that the ill-health signal attributable to the presence of nearby infrastructure masks any influence of visitor numbers.

3.3.2.1. Near infrastructure group

Within the group nearby infrastructure, the mean prevalence of coral diseases and compromised health signs between low visitation sites and high visitation sites was not significantly different, with the exception of pigmentation response (Table 3.2). Prevalence of pigmentation response at high visitation sites (mean ± se = 23.97 ± 2.93) was significantly higher than that of low visitation sites (mean ± se = 16.99 ± 2.99).

3.3.2.2. Isolated from Infrastructure group

Reefs in the isolated group subject to high visitation levels were susceptible to disturbance to a greater degree than low visitation reefs. There were significant differences in prevalence of coral disease and sign of compromised health within the isolated group. High visitation sites of isolated group were associated with a high prevalence of BL, PRED, PR and a low prevalence of SP. In contrast, low visitation sites were associated with a low prevalence of GA, BL, PRED and PR and a high prevalence of SP (Fig 3.4B and Table 3.2). Mean prevalence of growth anomaly at high visitation sites was approximately 4-fold higher than that of low visitation sites (mean ± se = 7.08 ± 1.54% versus 1.43 ± 0.39%). Mean prevalence of predation scars at high visitation sites was approximately 4-fold higher than that of low visitation sites (mean ± se = 9.74 ± 1.03%, 1.89 ± 0.51%). There was also a (non-significant) trend for mean prevalence of white syndrome, bleaching, algae overgrowth partial mortality and pigmentation response at high visitation sites to be higher than that of low visitation sites (Fig 3.4B).

3.3.2.3. Concentration of water parameters

Coral reefs nearby infrastructure exhibited a high degree of similarity in terms of water parameters and differed from those in the isolated group (Fig 3.5). In general, water quality indicators were worse for the near infrastructure reefs than for the reefs further away. Mean concentrations of Nitrate, Ammonia, total suspended sediment and total coliform of near infrastructure group were significant higher than those of the isolated group, although Nitrite and Phosphate were not significantly different between the groups (Table 3.2).

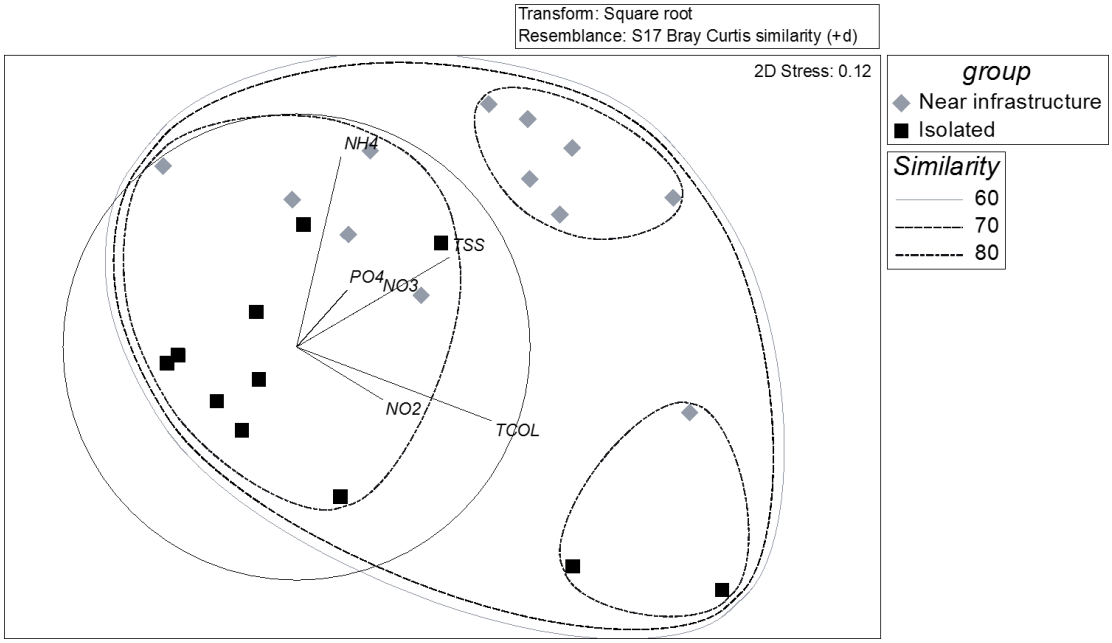

Figure 3.5. nMDS plot illustrate separated distribution of sites in near infrastructure group and isolated group based Bray-Curtis similarity of water parameters. The separation supported by one-way ANOSIM (global R = 0.36, p = 0.002) NO3 = nitrate, NO2 = nitrite, PO4 = phosphate, NH4 = ammonia, TSS = total suspended sediment, TCOL = total coliform bacteria.

Coral reefs of the isolated group which experienced high visitation rates had mean concentrations of Nitrate, Nitrite and total coliform significantly higher than those of sites with low visitation. Mean concentration of total coliform at high visitation sites was 5-fold higher than that of low visitation sites (mean ± se = 14.8 ± 3.01 µg/L; 2.70 ± 0.24 µg/L, $p < 0.001$). Water quality parameters of Near Infrastructure reefs were not significantly different between the high and low usage sites, suggesting that the source of the pollutants was land-based.

Increasing nutrient enrichment potentially increases prevalence of coral diseases and is often associated with an increase in algae cover. Prevalence of white syndrome was significantly correlated to nitrate concentration ($r = 0.55$, $p < 0.001$). Prevalence of pigmentation response was significant correlated to total suspended sediment ($r = 0.40$, $p < 0.001$). Prevalence of algae overgrowth was significant correlated to ammonia ($r = 0.41$, $p < 0.001$).

3.4. DISCUSSION

Sustainable tourism respects the fragile environmental balance that characterizes many tourism destinations, particularly in environmentally sensitive areas ("UNESCO Office in Venice Sustainable Tourism Development in UNESCO Designated Sites in South-Eastern Europe Ecological Tourism in Europe -ETE" 2017). It relies heavily on the heath of the reef environment and socio-economic environments of destinations. Tourism development can be of great benefit to the economy of coastal provinces, but it could also have negative impacts on the biophysical environment if not well planned, developed, and managed (Harriott, 2002). In this study, I found that the mere presence of tourism-related infrastructure adjacent to a coral reef can have

negative effects on the health and viability of the reef environment. Studies on the Great Barrier Reef have shown that even quite low-key infrastructure can negatively impact coral reef health (e.g. Lamb and Willis, 2011), especially in places where overall visitation is low. However, our surveys indicate that in eastern Thailand, these negative effects occur regardless of the intensity of visitation (Fig. 3.2C).

In the absence of tourism infrastructure, it is clear that visitor numbers (and types of activities) have some effect on the health of coral reefs, a relationship which previously has been noted in Thailand (S. Worachananant et al. 2008; Lamb et al. 2014). The effects of high visitor numbers are different than the consequences of placing tourism-related infrastructure adjacent to reef areas, however. The PCA result shows that mean prevalence of coral diseases and signs of compromised health are associated rather more with sites nearby tourism infrastructure than they are with sites in the isolated group (Fig 3.2A, 3.2B). Coral reefs located close to tourism infrastructure were susceptible to algae overgrowth and partial mortality and to white syndrome-related pathogen to a far greater degree than those reefs isolated from infrastructure. Mean prevalence of algae overgrowth at near infrastructure group was 8-fold higher than that of the isolated group; partial mortality from all sources was twice as high, and the incidence of white syndrome averaged 4-fold higher (although it was not ubiquitous). All of these symptoms of reef ill-health have been associated with poor water quality (Lamb, Water, Bourne, & Altier, 2017;Redding et al., 2013), and in areas of high water quality, tourism infrastructure has been shown to be the smoking gun of disease outbreaks (e.g. Lamb & Willis, 2011). The coast of eastern Thailand has seldom claimed to have pristine water quality, with several large metropolitan areas adjacent to river mouths that pump out large amounts of sediment and pollution from

activities occurring further inland. Yet even in this region of apparently low signal to noise for the effects of lowered water quality, the results reported here are unambiguous: siting resorts and hotels nearby reefs will have detrimental effects on the coral community.

Although regulations stipulating pollution mitigation measures to be undertaken when constructing and operating tourist facilities have been in existence for many years i.e. the Improvement and conservation of the national environmental quality Act., B.E.2535 (1992) and building control Act., B.E.2522 (1979), these apply mainly to large operations. For the most part, however, pollution regulations have been developed to protect public health and to minimise physical degradation of the environment; there has – so far – been no evidence to indicate that nutrient loading and export of pathogens to the reef community will occur even in areas where the regulations appear to have been applied rigorously. Moreover, it is not clear to what extent these regulations are applied across jurisdictions, especially in regards to areas within National Parks, which operate somewhat independently of municipal and provincial regulations, and have their own development management criteria. Unfortunately, our results show that nutrient loading and pathogen export do occur in all locations where tourist facilities have been constructed, suggesting that the regulations (or their implementation) may need to be renovated to enhance the sustainability of the industry.

Low visitation sites were associated with a lower prevalence of GA, BL, PRED and PR and a higher prevalence of SP (Fig 3.4B and Table 3.2) than sites with high visitor numbers. Growth anomalies, bleaching and pigmentation response have all been linked with tourism in other parts of the world, and are probably responses to micro-

pollutants such as sunscreens, boat paints and human wastes <ref>. In areas with normally high water quality, such links have been used to restrict the number of visitors to a given site, establishing a reef community carrying capacity for humans. Here, we have seen that – in the absence of point sources of pollution associated with tourism infrastructure – visitor numbers are also correlated to increases in known tourism-related syndromes. Against a background of relatively poor water quality in eastern Thailand, the impact of excessive numbers of tourists is still evident. The increase in predation scars at highly visited sites seems at first incongruous, until one recalls the now-illegal, but still common practice of fish feeding at snorkelling sites. This has long been discouraged by Thai authorities, because of its many detrimental effects (Milazzo, Anastasi, and Willis 2006; Di Iulio Ilarri et al. 2008) yet is strongly desired by tourists, who often disregard advice to refrain from the practice. Changes in the behaviour and composition of reef fish communities due to feeding activities in highly visited sites in eastern Thailand are likely to reflect the same consequences reported elsewhere in the world.

Reef-based tourism has been regarded as a marginal activity for fragile ecosystems for some years (Hall 2001; Barker and Roberts 2004; S. Worachananant et al. 2008; Gil et al. 2015). Especially for small island locations, Intensity of tourism development has been linked to often dramatic declines in the quality of the very reef resource that the tourists seek (van Beukering et al. 2015). In eastern Thailand, the tourism value of the resource is less tied to the perception that activities there are sustainable, but it is not entirely unrelated. While the value of reef-based activities (snorkelling, diving, site-seeing) relies largely on the perception that the activity is sustainable and that the environment is kept in relatively good condition, the value of

tourism infrastructure does so to a much lesser degree. So long as tourists perceive that the facility and its immediate environment are clean, operators of shore-based tourist facilities are largely independent of the consequences of reef degradation (Siriwong & True, in prep). This places the managers of marine resources in somewhat of a predicament: tourism development is seen (mostly) as a key to economic development, reflected by the increased construction of shore-based facilities. The consequences of this development, however, are reflected in both socio-ecological terms (e.g. Green, 2005; Wongthong & Harvey, 2014) and in ecological terms (this Chapter). Managers necessarily must devise a compromise between the convenience of siting tourism infrastructure close to the desired location and the ecological consequences of doing so.

CHAPTER 4

STAKEHOLDER PERCEPTION OF CORAL REEF MANAGEMENT POLICY IMPLEMENTATION IN MARINE PROTECTED AREAS OF EASTERN THAILAND

4.1. INTRODUCTION

In Thailand, coastal areas fall under the administrative purview of both national and local government agencies, but the multitude of responsible agencies, and overlapping areas of interest have led to a certain amount of confusion and a lack of understanding about allowed activities, development priorities and administrative boundaries, not just amongst users, but also among agency personnel. Tourism has long been a focus of tourism marketing for countries such as Thailand, largely because has been of perceived economic benefits for coastal communities (Kim, Uysal, and Sirgy 2012), many of which have been disadvantaged by the impacts of industrial fishing (Pomeroy and Cruz-Trinidad 1996). Marine tourism activities and the real estate and infrastructure development generated by the tourism industry are seen as an especially important source of economic development in coastal Thailand, where they attract an abundance of foreign income without the necessity to grow other economic or municipal infrastructure.

Marine Protected Areas (MPAs) are regarded as effective tools to protect and manage coral reefs; in the best case, such management can yield a significant increase of coral reef resources (McClanahan et al. 2015). Thailand long ago recognised a need to manage and restrict the rampant coastal development seen in other tropical nations (and the concomitant rapid decline in their ecosystem services), and in the last quarter

of the 20th century placed as many of the coastal islands as possible under explicit management. MPAs can benefit local communities, lead to empowerment, improved governance, and alternative livelihoods (Bennett and Dearden 2014). A successful MPA benefits not only resources conservation, it also benefits local stakeholders, and leads to empowerment, improved governance, and alternative livelihoods (Bennett and Dearden 2014). Yet, studies reveal that management of more than half of world's MPA have not effectively met desired goals (Leverington et al. 2008). Ineffective management of MPA is frequently a result of a lack of appropriate policy, fragmentation of policy among relevant agencies and produces an MPA unable to deliver the expected improvement in ecosystem goods and services to local stakeholders; poorly-managed MPAs engender a diminishment of local support for protective measures (Bennett and Dearden 2014).

Management effectiveness evaluation aims to assess the capacity of the management agency to manage designated protected area (PA), and to determine the degree to which the protected area has achieved its management goals and objectives (Hockings et al. 2006). However, there is an argument that the independence or clarity of data on PA management effectiveness might be criticized because it relies on the responses of PA managers, and achievement ratings based on their own perceptions (Eklund & Cabeza, 2017). The weakness in relying solely on managers' perceptions is that the managers may be entirely unaware of the effectiveness of the PA in a wider stakeholder context; they may in fact be delivering on their own (internal) management goals without ever addressing the concerns of local stakeholders, or potential threats to the PA that originate outside their area of immediate control. Effective management not only depends on the capacity of PA managers, but also on the degree of local

support, influenced by perceptions of stakeholders affected by the PA (Bennett and Dearden 2014). Effective management needs to communicate to and, in return, to provide stakeholder an opportunity for feedback and involvement in management implementation. Top-down policy is a centralized policy that constraint of success full management which end stakeholder often excluded.

The study in this chapter examines the perception of coral reef managers and users – mainly business stakeholders who access or otherwise benefit from the resource – towards coral reef policy implementation in managed or protected areas of eastern Thailand.

4.2. METHODS

4.2.1. Study sites

The east coast of Thailand has long been a desired destination of those who love diving or seeing beautiful underwater life. Coral reefs can be found scattered along the coastline and around many of the islands in Chonburi, Rayong and Trad provinces (Phongsuwan, 2010). Water-based activities that exploit the perceived aesthetic values of the coastline, especially diving activities (both snorkeling and SCUBA) have become popular. Non-diving activities – beachside sunbathing, outdoor restaurants and souvenir shopping – provide additional opportunities for local businesses to benefit from ecosystem management by local authorities in those areas. Additionally, dormitory businesses, both within and outside national parks are lucrative businesses; within national parks, accommodation is a monopolistic enterprise administered by agents of the DNP; outside parks, large and small hotel chains and local businesses provide a wide range of accommodation.

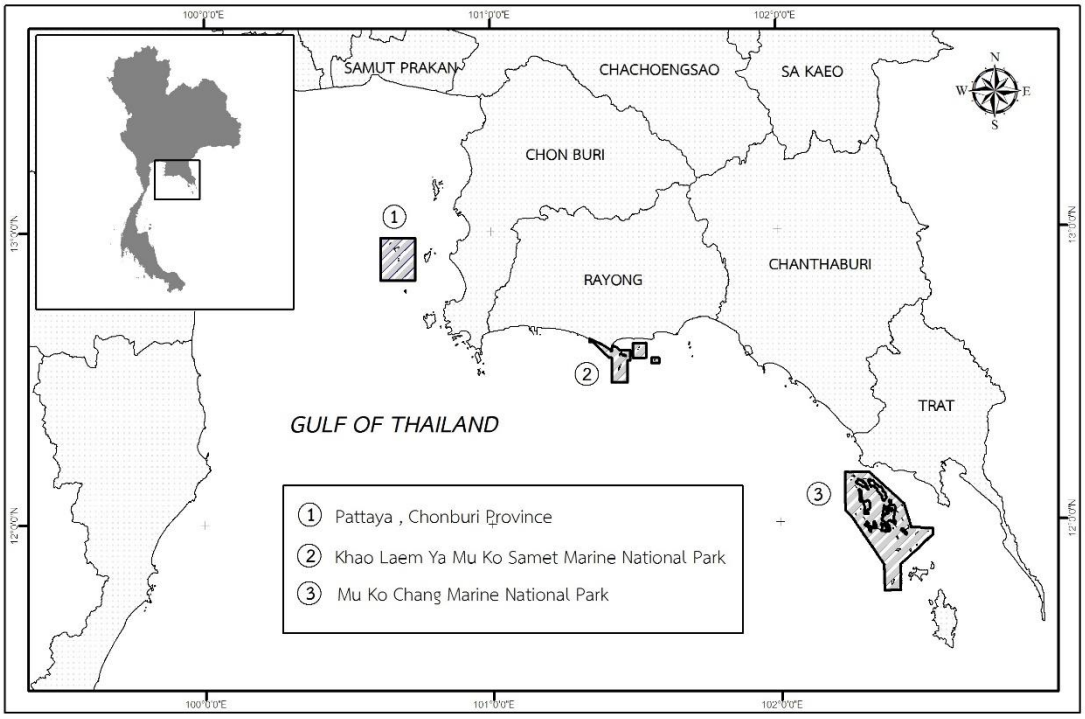

Figure 4.1. Study sites where stakeholder perceptions were polled, including 1. Pattaya City, Chonburi; 2 Khao Laem Ya Mu Ko Samet MNP in Rayong province; 3 Mu Ko Chang MNP in Trad province

This study was carried on in three well known destinations for reef-related tourism (Fig. 4.1): Pattaya City in Chonburi Province, Khao Laem Ya Mu Ko Samet MNP (hereafter; KS) in Rayong province and Mu Ko Chang MNP (hereafter; KC) in Trad province. Pattaya city is the busiest tourist city in the east which received over 9 million tourist per year. Being the closest reefs to Bangkok, Pattaya reefs have become a prime location for recreational divers and SCUBA training courses. Coral reefs in this study are located mainly at the group of islands 20 km away off shore. They are being the dive sites of Recreational diver from Pattaya city and Bangkok. Adjacent to these

islands, there is a designated Environmental Protected Area (EPA) covering the coastal area of Pattaya city toward the group of islands (9 km away off shore). The EPA is a management tool that aims to control a discharge of land-based pollution to the environment and to regulate coastal development in the coastal area (defined as solely the terrestrial area above high tide), therefore it is not responsible for coral reef management.

KS and KC are popular marine national parks; each receives more than 300,000 tourist per year (www.dnp.go.th). KS and KC have been recognized by their nice coral reefs and beautiful beaches. KS and KC both have areas that overlap with the local community, where there has been a great expansion in tourism business development during last two decades. KS comprises a group of islands surrounded by fringing coral reefs. The biggest island of the group is Samet Island, which is partly occupied by a local community and extensive tourism development along the beaches. Tourism is the major livelihood of local community members on this 13km^2 Island. KC comprises of group of 40 islands where surrounded by fringing coral reefs. The biggest island; Chang Island, is the second largest island in Thailand, with a total area of 429 km^2. Chang Island is partly administered as a district: Koh Chang district. It comprises two sub-districts with total population of 7,000 (http://kohchang.trat.doae.go.th/kochang.htm) and additionally 20,000 of non-registered population. Local community members in these MNPs are former fishermen who changed their livelihood to a tourism-related business (tour boats, accommodation, etc.). A large proportion of the coastal area in both locations was converted into tourism infrastructure to serve an increasing demand. In this study I conduct structure interview with stakeholders; an in-depth interview with the coral reef managers and a face-to-face interview with coral reef users in three study

areas; Pattaya city in Chonburi province, Khao Laem Ya Mu Ko Samet MNP in Rayong province and Mu Ko Chang MNP in Trad province (Fig 4.1).

4.2.2. Defining stakeholders

In this study, I define **stakeholders** as managers and users (who include business owners who derive benefit from the resource). Coral reef management in Eastern of Thailand involves various national level agencies, including Department of National Department of National Parks, Wildlife and Plant Conservation (DNP) and Department of Marine and Coastal Resources (DMCR) and local level agencies, including provincial Environment Office, Sub-district Administration Organization (SAO) and Pattaya Municipality (PM).

DNP and DMCR both under the Ministry of Natural Resources and Environment (MONRE). These national agencies are supported by provincial and local agencies including Provincial Environment Office (PEO), Sub-district Administration Organization (SAO) and Pattaya Municipality (PM). Fishing by local and commercial interests is notionally administered by the Department of Fisheries (DOF), under the Ministry of Agriculture and Cooperatives, but in practice the focus this agency is almost exclusively on commercial fishing (predominantly offshore), and the Fisheries Department and their local agents are not generally regarded as stakeholders in coral reef management.

The local agencies under DNP responsible for coral reef management in eastern Thailand are two Marine national parks (MNP); “Koh Chang MNP (KC)” and “Khao-Laemya and Mukoh Samet MNP (KS)”, and a Marine National Park Operation Center (MNPO). The mandates of the MNP were to protect and conserve coral reef resources

in order to enhance ecological value, esthetic value and recreational value. The marine park has full authority in National park area to manage coral reef as a single agency. MNPO is responsible for technical support to MNP such as research and monitoring. Coral reefs outside national parks are the administrative responsibility of Department of marine and coastal resources (DMCR) at the national level. DMCR is the agency responsible for management, conservation and rehabilitation of coral reef resources in Thailand. The structures of DMCR in Eastern Thailand consist of Office of Marine and Coastal Resources Management (MCRM) and the Marine and Costal Resources Research and Development center (MCRR). The MCRM has mandate to protect and conserve coral reefs, the control and surveillance of illegal practice in coral reef and promote public participation and awareness in coral reef management. The MCRR has a mandate that involves research for conservation and rehabilitation of coral reef resources. The jurisdiction of DMCR literally is over marine and coastal area of Thailand except marine national park area.

The Provincial Environment Office (PEO) is the agency assigned as a coordinating body for any agency under Ministry of Natural Resources and Environment (MONRE) at the province level. The PEO has no specific mandate on coral reefs management but acts by being a coordinating body among relevant agencies for environmental management according to the requirements of MONRE and province policy, and during urgent issues i.e. oil spill. The Sub-district Administration Organization (SAO) and Pattaya Municipality (PM) are local administrative body at sub-district level. Their mandates involve regulation of construction, solid waste and waste water management: the planning, design and deployment of infrastructure.

The **users** in the tourism sector were defined for the purposes of this study as tour operators and hotel operators who gain benefit from coral reef. The majority of tour operators in the east are dive operators whose business relies entirely on coral reefs. In many parts of the world, such businesses are often associated with damage to coral, anchoring damage, feeding of marine fish and waste discharged from the boat (Hannak et al. 2011; Dinsdale and Harriott 2004; Milazzo, Anastasi, and Willis 2006; Reopanichkul et al. 2009). The remainder of the "user" group comprises hotel operators who provide dormitory services for tourists who travel to access the services of the tour operators. A considerable body of literature exists documenting the extent to which coastal infrastructure creates impacts to coral reef and its immediate environment associated with sedimentation during construction, waste water and solid waste discharged to the sea (Bessell-browne et al. 2017; Reopanichkul et al. 2010).

4.2.3. Collection method

To collect the socio-ecological data for this study, I employed a structured interviews with the resources managers and resources users to examine perceptions of management policy implementation. I did an in-depth interview with coral reef managers and a face to face interview with users. Over the three provinces, a total of 7 resource managers and 72 users were interviewed.

A questionnaire to elicit perceptions of key management indicators was designed according to IUCN-WCPA management effectiveness framework (Hockings et al., 2006). It was possible to frame the study in terms of three major indicators: context and planning for intended use, implementation process and perceived outcome (table 4.1) Coral reef managers were interviewed on all of those three elements and

users were interviewed with focus on process and outcome, since early interviews revealed that they uniformly had no insight at all into the planning and contextual elements.

4.2.4. Data analysis and interpretation

Likert-type items represent the frequency of each category (in this case stakeholder perception of a given metric) which is expressed as a "greater than" relationship. Likert-type items fall into the ordinal measurement scale. Therefore descriptive statistics were recommended include a mode or median for central tendency and frequencies (Boone and Boone 2012), particularly with the skewed data distribution. Mode represent the most frequent data whereas median represent central tendency of data. In this study I determine mode and median; when there are two modes available, to presence perception of stakeholder in each question, percentage of each category was obtained to presence proportion of perception in each category to total sample. I use chi-square test to compare a distribution of data between type of stakeholder; manager and user and between type of users; tour operator and hotel operator. All statistic test were performed in SPSS V.11.5 (SPSS Inc. 2002).

4.2.5. Limitations

This study was not intended to in any way evaluate management effectiveness nor performance of management agencies. The result of the study was the perception of stakeholder on policy implementation doesn’t reflect actual performance of any given agency or agent. The result of the study was the perception of stakeholders on policy implementation which is based on their personal experience and attitude. The

study is necessarily limited to the agencies and stakeholders identified above, and does not reflect the opinions or perceptions of other groups of stakeholders (such as local fishermen or tourism-affiliated businesses) who may peripherally benefit or be disadvantaged by the policies described here. It was initially considered that a survey such as this should be as inclusive as possible, but – after preliminary surveys were undertaken – I found that expansion of the survey beyond the present set of respondents did not improve the clarity of the data, and served only to dilute the story discovered here.

Table 4.1. Questions used to interview stakeholder

Question	Target respondents	
	manager	user
1. **Perception on context and planning**		
1.1 Is there policy and action plan for coral reef management available	/	
1.2 What are threats to coral reef and to what level the threat harm coral?	/	/
1.3 Are there plan to prevent or to manage consequence of threats?	/	
1.4 Are there plan for stakeholder engagement?	/	
2. Perception on process		
2.1 Whether the users were aware of the existence of the MPA?		/
2.2 How often has user joint conservation activities?	/	/
2.3 How often has user joint activity involve management decision making?	/	/
2.4 Has the management regulation impacted to user's business?		/
3. Perception on outcome		
3.1 Do users agree the management can conserve coral reef.		/
3.2 Whether the resources important to user's business?		/
3.3 What is the current condition of resources?	/	/
3.4 Has the resources condition changed overtime?	/	/
4. Perception on proposed measures to manage coral reef environment.		
Do you oppose or support to;		
4.1 Increased enforcement of existing rules/regulations?	/	/
4.2 Stricter control of sources of pollution to preserve water quality	/	/
4.3 More restrictions on construction practices to prevent sediment going to sea	/	/
4.4 Limits on recreational use	/	/

4.3 RESULT

4.3.1. Perception on plan for coral reef management.

The area of most concern discussed among managers was that, while there is policy involving natural resources management, there is no specific plan for coral reef management (57 % response). DMCR had policy related to coral reef management, but primarily focus on research, monitoring and rehabilitation. It is the only agency that has a 5-year master plan and annual action plan for their day-to-day management activity following the 20-year master plan of MONRE. The objective related to coral reef is “to increase coral and coral reef area”, which is the currently implemented policy of the DMCR. To meet this objective DMCR has promoted rehabilitation project and promote designation of MPA according to the Enhancement of Marine and Coastal Resources Management Act B.E. 2558 (2016). Therefor coral reef transplantation is the priority task for coral reef management of MCRR and MCRM.

MNP (a subset of DNP) and DMCR are the key management agencies directly involved in coral reef management. Each MNP has a resources management policy but no specific plan for coral reefs. The master plans that MNP use for day-to-day management were prepared by DNP head office, and are comprised of certain common tasks for local managers; as such they represent more of a “general practice” policy rather than explicit statements of intent, and contain no performance assessment criteria or priority actions. Several “emerging issue” codices were added to the basic master plan documents, in response to policy updates from the head office (Bangkok) of the National Parks department, or as a reflection of new policies the department had adopted in response to international agreements.

Table 4.2 Perception on policy and plan involve coral reef management.

Agencies	Level of policy availability*				Total
	1	2	3	4	
MCRM	0	0	1	0	2
MCRR	0	0	0	1	3
MNP	0	1	0	0	1
MNPO	0	1	0	0	1
PEO	1	0	0	0	1
SAO	0	1	0	0	1
PM	0	1	0	0	1
Total	1	4	1	1	7

*Level of policy available; 1 = no policy available for coral reef management, 2 = there is policy for management natural resources but no specific policy for coral reef, 3 = there is policy involve coral reef management but strategy and objective are insufficient to guide day-to-day management, 4 = there is a specific policy for coral reef management, strategy and objective are sufficient to guide day to day management.

The park managers interviewed mentioned that the DNP central authority complete the drafting of the new 5-year master plan that local Park will adopt as their action plan to guide day-to-day management. Currently, there is no up-to-date master plan available; the current plan has been used since 2003-2008. Additionally, the prioritization of policy has changed over time due to a somewhat unstable governance system; for example, the superintendent of KS was directed to solve problems in

tourism sector i.e. encroachment of crown land, construction and renovation of hotel without permission; “our priority is to get all business in order under the national park regulations, therefore we don’t have enough staff for coral reef management for a while”. All were in agreement that clear and long-term policy is needed in order to secure a continuity of MNP management.

Other managers, PEO, SAO and PM had no mandate on coral reef management. PEO is the coordinator among all levels of relevant agencies under MONRE at the province level. PEO is responsible for “the provincial environment management plan” and “provincial natural resources management plan”. As the provincial coordinator, PEO would have opportunity to make a comprehensive plan for natural resources management in province. In fact, PEO has been transformed from the provincial forestry office for this purpose; the problem that interviewees mentioned it that there are insufficient staff and funding to achieve this aim. SAO and PM have policy to conserve natural resources but no specific policy for coral reef management. SAO and PM are the local administrative unit in the sub-district level responsible for community’s wellbeing, waste management and management of infrastructure within its jurisdiction. Ko Chang Tai SAO (the southern portion of Chang Island) is located in the middle of MNP area. It is inevitable that their policy and management output would have direct impact to Mu Ko Chang MNP.

4.3.2 Perception of threats potential to harm coral reefs.

Perceived threats to coral reefs were similar across all groups of respondents (table 4.3). Resource Managers and tour operators have similar perceptions of the threats that directly impact coral, whereas hotel operators experience a slightly different

perception. The result may indicate experience of respondents in coral reef environments. Tour operators who have direct experience on coral reef responded that any threats that impact directly to coral would be perceived to have large impact. Hotel operators appear to have least experience on coral reef, and their typical response was that only threats (such as garbage) that they are familiar with were perceived to have large impact. Perception of respondents on tourism ($\chi^2 = 23.46$, $p = 0.003$) and feeding of reef fish ($\chi^2 = 24.91$, $p = 0.002$) were difference across type of respondents. Manager perceived that tourism has extreme impact on coral reef but hotel operator perceived that its impact is unremarkable. Manager perceived that feeding of reef fish has strong impact on coral reef but tour operator and hotel operator perceived that impact fish feeding is unremarkable.

Table 4.3 Perception on threats to coral reef of manager and user.

Threats	Perceived level of impact*						χ^2	Sig.
	Manager		Hotel operator		Tour operator			
	Median	mode	Median	mode	Median	mode		
Coral Bleaching	3.5	3	3	5	3	2	6.77	0.561
Tourism	4	4	2	2	3	3	23.46	0.003**
Trampling	3	2	2	2	3	3	8.81	0.391
Feeding of reef fish	4	3	2	2	3	2	24.92	0.002**
Anchoring	2	2	2.5	2	2	2	3.68	0.884
Waste water	3.5	3	3	2	3	3	7.35	0.499
Coastal development	3	3	2	2	2	1	6.51	0.589
Garbage	3	3	3	2	3	3	10.44	0.235
Fishing	2	2	2	2	3	2	7.09	0.526

*Level of impact; 1 = no impact, 2 = impact is unremarkable, 3 = strongly impact, 4 = impact is extreme, 5 = no idea.

** indicate significant level $\alpha = 005$

4.3.3 Perception on level of participation.

MNP, MCRR and MCRM have a policy for stakeholder engagement, NPOC has no policy to engage stakeholder participation but they have occasionally requested particular stakeholder for participation, PEO, SAO and PM have no policy and plan to engage stakeholder. The results of this survey showed that manager was unlikely to experience any significant success in engagement of local people to take part in coral

reef management. Perceptions of manager on level of participation they have received from user were significantly different from what user perceived they have participated in both conservation activity (χ^2 = 16.83, p = 0.002) and activity involve decision making for management regulation implementation (χ^2 = 26.64, p < 0.001) (table 4.4).

Table 4.4 perception of manager and user on participation in conservation activity and decision making activity.

respondents	Level of participation in conservation activity (%)*					χ^2	sig
	1	2	3	4	5		
managers	10	30	20	10	30	16.83	0.002**
user	22	49	11	17	1		
respondents	Level of participation in decision making (%)*					χ^2	sig
	1	2	3	4	5		
managers	10	20	50	0	20	26.64	0.000**
user	40.3	45.8	4.2	5.6	4.2		

*Level of participation; 1= never, 2 = occasionally, 3 = almost all activity, 4 = all activity, 5= no idea

** indicate significant level α = 005

Users (49 %) perceived that have occasionally participated in conservation activities hosted by manager. The common reason is they have not been informed when activities are going to be held; such events are usually corporate social responsibility (CSR) programs of private companies (often with no other links to the areas). Tour

operators at KC mention that the conservation campaigns such as “reef cleaning is a kind of conservation activity that yields no concrete outcome, the amount of food containers that were left behind on the island was even more than garbage they have collected and since there was low enforcement in control sources of those garbage, you will be always see garbage in coral reefs”.

Perceptions of user on involvement in making decision on policy implementation were occasionally (46 %) or never (40 %), as were mentioned among user “they (MNP) did what they want to do, just informed us” whereas manager perceived that they received participation from user in almost all activity. Each MNP has a group known as Protected Area Committee (PAC) as the park’s consultants in planning, implementation and evaluation. The typical PAC consists of representatives from various stakeholders including government sector, local community, academics and business sectors. However, typical MNP was unlikely to success in engagement of user for coral reef management.

DMCR agencies (MCRR and MCRM) have policy and strategy to promote stakeholder participation, particularly involving representatives from the local coastal community, according to the Enhancement of Marine and Coastal Resources Management Act. 2015. Local stakeholders have opportunity to be the “provincial marine and coastal resources committee” and opportunity to gain technical and funding support from DMCR in aid of resources management. Since coral reef management policy of DMCR is skewed significantly to more specifically involve research and conservation, rather than control and regulation, it is more possible for DMCR policymakers to get collaboration and compliance from local stakeholders.

4.3.4 Perception on impact of management regulation implementation on users' business.

The study areas fall into two MNP boundary: KS and KC and area outside MNP; Pattaya area. In the MNP areas, perception of user was determined against MNP regulation, whereas perception of user in Pattaya area was determined against DMCR regulation. Perceptions by users of the impact of MNP regulations on their business were diverse, ranging from no impact (33%), unremarkable impact (23%) and significant impact (28%). Although it was statistically insignificant (because of bimodality amongst some groups), perception of management regulation by users varies across type of user. Hotel operators generally perceived that MNP regulations have "none or unremarkable impact" to their business. They mention only a long process they must undertake when they request permission to modify or renovate their hotel. Tour operator perception equally fell into two categories: "no impact" and "impact is remarkable". Tour operators at Ko Chang MNP complained of loss of access to certain coral reefs due to the park regulations, whilst the reefs they were allowed to access were over-crowded. SCUBA operators have had to move to the other dive sites out of the MNP area to accommodate the desire of tourists to dive at relatively uncrowded sites. The other complaint made was a lack of transparency for outcome and method of collection entrance fee. Tour operators expect that the entrance fee is collected for the purpose of improving infrastructure for their benefit, but there were still not enough mooring buoys at dive sites. Others complained that the method of collection of entrance fee is inappropriate, since their customers need to pay for diving and for accessing waterfalls separately, even though both attractions are in the same MNP. Perception by users of the impact of DMCR's regulations ranged from "no

impact" to "unremarkable" impact, because there is no regulation that actually affects their business directly.

Table 4.5 Perception of user on impact of PA regulation on their business. Level of impact; 1= no impact, 2 = unremarkable, 3 = remarkable, 4 extreme, 5 = no idea.

Location	Level of impact of management regulation on business (%)				
	1	2	3	4	5
MNP jurisdiction area					
KS	42.1	21.1	15.8	5.3	15.8
KC	26.7	23.3	33.3	10.0	6.7
Total MNPs	32.7	22.4	26.5	8.2	10.2
Extra jurisdiction area (Pattaya)	30.4	30.4	17.3	4.3	17.3

4.3.5 Perception on current condition of natural resources.

Stakeholders perceived that coral, fish, beaches and adjacent water are all in good condition (table 4.6). However perceptions of change of resources were different between managers (mode = perceived to be good) and user (mode = perceived to have become worse) (table 4.7).

Table 4.6 perception on current condition of natural resources.

Resources	Perceived current condition of natural resources				
	manager	Hotel	Tour	χ^2	sig
Coral	3	3	3	5.80	0.66
Fish	3	3	3	9.13	0.33
Beach	3	3	3	10.9	0.20
Water	3	3	3	7.5	0.47

Manager perceived current condition of coral reef, fish and water were better than 10 years past and that the quality of beaches had not changed. DMCR interviewees mentioned that coral reefs were degraded after the 2010 bleaching event, and recovered afterward to the extent that now they are healthier than at any time in the past 10 years. All groups of user perceived coral reefs, fish, beach and water to be worse compared to the last 10 years.

Table 4.7 perception on change of condition of natural resources.

Resources	Perceived change of natural resource* = Mode (median)				
	manager	Hotel	Tour	χ^2	sig
Coral	3 (3)	1 (2)	1 (2)	4.3	0.82
Fish	3 (3)	1 (2)	1 (2)	5.8	0.66
Beach	2 (2.5)	1 (2)	1 (2)	5.05	0.75
Water	3 (2.5)	1 (2)	1 (2)	4.92	0.76

*Level of change; 1 = worse, 2 = no change, 3 = better

4.3.6 Perception of user on value of natural resources.

There were differences in the perception of the importance of resources to users' business. Perception of the importance of coral reef ($\chi 2$ = 20.93, p < 0.001) and coral reef fish ($\chi 2$ = 10.96, p = 0.004) were different between tour operators and hotel operators. Tour operators perceived that coral reef and coral reef fish were important to their business, whereas hotel operators perceived coral reef and coral reef fish were unlikely to be important to their business. Although it was not significant, the condition of adjacent beaches was much more important to hotel operators (61.4 %) than tour operators (46.4%). They were all agreed that good water quality is important to their business. Tour operators offer snorkeling and scuba diving to their customers, and so the condition of coral reefs, abundance of fish and cleanliness of the water have a strong influence on the satisfaction of customers. Tour operators therefore perceived these parameters were important to their business. Hotel operators offer their customers nice accommodation and pleasant environments, which include a clean beach and clear water, therefore, they perceived beach and water cleanliness to be important to their business.

Table 8 Perception of users –tour operators and hotel operators – on importance of natural resources to their business.

Whether the following resources are important to user's business?	Hotel (%)		Tour (%)		$\chi 2$	Sig. 2-tailed
	yes	No	Yes	no		
Coral	38.6	59.1	92.9	7.1	20.93	0.000**
Coral reef fish	31.8	65.9	71.4	28.6	10.96	0.004**
Beach cleanliness	61.4	34.1	46.4	53.6	3.51	0.318
Water cleanliness	52.3	45.5	53.6	46.4	0.645	0.724

** indicate significant level α = 005

4.3.7 Recognition by users of management practice.

The users in two MNPs boundary agree that being a MNP can protect coral reef resources from illegal fishing and excessive tourist activity, since there were patrols for illegal fishing, and collection of entrance fee might limit the number of foreign tourists. Sixty seven percent of local users within MNP recognized MNP as management practice they are being regulated. The interviewed users mentioned that obvious regulations of MNP were collection of entrance fee and the prohibition of particular activity i.e. fishing in MNP, construction and renovation of houses and hotel along the coast. Fifty seven percent of user outside MNP boundary (Pattaya area) recognized that Pattaya Municipality is the agencies responsible for coral reef management, 20% mentioned that EPA is responsible for coral reef management and none of respondents mention DMCR.

4.3.8 Perception of proposed management measures to manage coral reef environments

When respondents were asked whether they support or oppose proposed management measures for coral reefs, there was general support for increased efficiency of enforcement, for control of point sources of pollution, and for strict control of sediment originating from coastal construction. There was a difference of perception between managers and users, however, in terms of a willingness to limit use of coral reefs for tourism ($\chi 2$ 17.56, p = 0.025). Thirty percent of users were opposed to limited use of coral reefs, 12% were neutral, and 50% supported usage caps. On the other hand, 100% of managers strongly supported this measure. It is noted that whereas 23% of hotel operators were opposed to controls on coastal development, none of the tour operators involved in this survey opposed such measures.

Table 9 Perception on proposed management measure to manage coral reef environment. Perception; 1 = oppose, 2 = neutral, 3 = support, 4 = strongly support, 5 = I have no idea.

Proposed conservation measures	respondents	Perception of respondents (%)					median	$\chi 2$	sig.
		1	2	3	4	5			
Increase enforcement	Manager	20	0	40	20	20	3	11.55	0.172
	Hotel	7	16	55	14	9	3		
	Tour	11	7	46	32	4	3		
Control pollutant sources	Manager	0	10	30	30	30	4	27.05	0.000**
	Hotel	0	5	45	50	0	3.5		
	Tour	0	7	29	64	0	4		
Control coastal development	Manager	0	0	40	30	30	4	9.20	0.326
	Hotel	23	9	39	18	11	3		
	Tour	0	14	43	36	7	3		
Limit tourism use	Manager	0	0	50	10	40	3.5	17.56	0.025**
	Hotel	23	9	39	18	11	3		
	Tour	39	18	32	7	4	2		

4.4 DISCUSSION

Sequestration of marine resources into Marine National Parks represents an important policy mechanism for conservation of the marine environment, and they have positively contributed to social and economic development for local communities, however there are curtain caveats to their success. For instance, it matters greatly if they are effectively managed and governed, and if local peoples' considerations are taken into account (Bennett and Dearden 2014). Our finding here has identified some potential constraints to coral reef management in the East coast of Thailand, which were reflected through the perceptions of managers and users.

Users expressed a perception that MNP can protect marine resources from destructive fishing and untoward tourism activity. Perceived importance of the value of coral reef ecosystem resources varies across type of user. Tour operators perceived that coral reefs and coral reef fish are important to their business, whereas hotel operators did not. This possibly indicates that the end user is concerned only about resources that directly benefit their own business, or indicates their limited ecology background. However the lack of ecological concern is a barrier to resources management, since hotel operators may not be aware of the adverse consequences of untreated waste water drained into the sea adjacent to their facility. This is particularly true for small hotels and homestays, which seldom have a water treatment facility. Siriwong et al. (in pres.) report that in the Eastern coast of Thailand, coral reefs situated close to tourism infrastructure have higher prevalence of coral diseases and ill-health signs than coral reefs isolated from infrastructure. This presents a severe difficulty for the managers of marine resources, since tourism development is seen (mostly) as a key to economic development, reflected by the increased construction of shore-based facilities.

Coral reef managers are not sufficiently equipped with locally-suited conservation policy or planning, something which possibly constrains success of coral reef management in the East. DMCR is seen to have comprehensive policy and plans for coral reef management, following MONRE's 20 year strategy plan, which is applied to all agencies under MONRE (including DNP). The plan that MNP had been using is not up-to-date and was not modified or enhanced by the paucity of feedback from local sites and stakeholders. Perceptions of local stakeholders regarding level of participation involving decision-making and conservation activity were relatively low as manager only inform them before implement any regulation. To inform is the lowest level of public participation which is no expectation for feedback (International Association for Public Participation 2017).

Another potentially constraint on management success is that MNP that is notionally responsible for coral reef management in MNP boundary has insufficient coral reef expert. MNP staff have a strong foundation in management of terrestrial National Parks, but generally have insufficient background in the ecology and environmental dynamics of marine ecosystems. This is unlikely to be appropriate for marine ecosystems where current-based connectivity plays an essential role in transporting larvae and pollutants to a much greater distance compared to the terrestrial environment (Carr et al. 2003).

It is known that stakeholder support and compliance are essential for success management, however, it is influenced by their perception (Bennett and Dearden 2014). Users felt that they had limited opportunity to make decision involve coral reef management and they are unlikely to participate conservation activity due to there was little communication between manager and users. This was highlighted by park

manager's response that despite there is a mechanism to engage stakeholder but user had been engaged only when there is an important issue, in manager's perspective.

Perception of stakeholders can compromise the health of marine ecosystems. As long as tour operators feel that the immediate environment is still in a good condition, they are likely to continue their business as usual, however destructive or cynical. Tour operators in KC keep advertising popular activities (such as the feeding reef fish) to their customers because they perceived that feeding fish has little impact to coral reef health or viability. Moreover, there is a strong disconnect between their perception of the impact of pollution in a marine system. Small hotels and restaurants at KS allowed the sewage from their businesses to drain directly into the adjacent sea (pers. obs). These small operators were unable to connect the small point source of raw sewage with the concept of "pollution", and did not see how even many such small outfalls would make a difference in something as vast as the sea, although they were aware of issues such as industrial pollution. The reluctance of local people to comply with regulations that they see as unimportant or inexplicable greatly increases the difficulty of resource managers to develop and apply proactive conservation policies, and suggests that management agencies should expend resources to develop interpretive and explanatory material to educate and inform local people.

Protected areas contribute to improve marine environment and natural resources, and improve security of local livelihoods (Russi et al. 2016; Lopes et al. 2015; Lunn and Dearden 2006; Gell and Roberts 2003). The result of the study in this chapter suggest that success of marine resources management need effective management and comprehensive policy together with close communication between managers and end users to get strong support from local communities.

CHAPTER 5

GENERAL DISCUSSION: SUSTAINABLE CORAL REEF MANAGEMENT IN EASTERN THAILAND

5.1. CORAL REEF DEGRADATION IN EASTERN THAILAND ASSOCIATED WITH TOURISM INFRASTRUCTURE

The consequences of tourism development are reflected in both socio-ecological terms (e.g. Green, 2005; Wongthong & Harvey, 2014) and in ecological terms (Siriwong et. al 2017). This study has provide insight into the potential root cause of coral reef degradation along eastern coast of Thailand. Presence of tourism infrastructure can have negative effects on the health and viability of the reef environment regardless of the intensity of visitation. However, in the absence of point sources of pollution associated with tourism infrastructure, intensity of visitations are also correlated to increases in known tourism-related syndromes.

Coral reefs adjacent to tourisms infrastructure have higher prevalence of coral disease and prevalence of ill-health signs as well as higher concentration of nutrients and suspended sediment than coral reef isolated from infrastructure. Average water parameters at coral reefs from this study fall below the standard of coastal water for coral reef conservation (cf. the announcement of the National Environmental Committee; Standard of sea water, available at http://infofile.pcd.go.th), the accumulation and repeated impact on coral arising from coastal waste water and sediment may contribute to the difference.

So long as tourists perceive that the recreational or accommodation facility and its immediate environment are clean, operators of shore-based tourist facilities are

largely independent of the consequences of reef degradation (Siriwong & True, in prep). I found that hotel operators primarily are concerned about a clean beach and apparently clear water to satisfy their customers and disregard the importance of coral reef resources as assets for their business. This perception might led to an ignorance of the proper treatment of waste water before being released into the adjacent coastal area, particularly for small hotels and homestays, which seldom have a water treatment facility. The Improvement and Conservation of the National Environmental Quality Act. B.E.2553 has strict guidelines governing hotel and restaurant release of sewage and pollutants to the environment; however this regulation is enforced primarily for hotels that have 60 rooms or more, or restaurants which have service areas over 2,500 m^2. In fact, the majority of hotels, guesthouses, and home stays in the study areas have fewer rooms than the minimum requirement of the laws. The same is true of restaurants. Moreover, I have witnessed direct discharge of sewage into adjacent beaches from all study sites during my site survey through the east; always there were small water ways that collected sewage from houses, restaurants and hotels that led directly to the beach. Some of the interviewees pointed out that small hotels and restaurants do not have the resources to invest for their own water treatment facility and the public facility cannot support daily waste for an entire area.

Despite the Improvement and Conservation of the National Environmental Quality Act., B.E.2553 stating that local government, municipality and SAO must provide a public waste water treatment facility to serve the local community, in fact (as per interviewees) the capacity of the available water treatment facilities in the study area is not sufficient to serve daily sewage requirements, although some are being renovated to increase capacity (http://wqm.pcd.go.th/). Moreover, treatment facilities

are subject to usage beyond their design parameters: for instance, the water treatment facility on Lan Island, Chonburi has temporarily been shut down because the system was designed to treat fresh water sewage, but restaurants often use sea water to clean kitchen wares in order to save the cost of (importing) fresh water; sea water sewage has already destroyed the treatment facility. Although Lan Island is not included amongst the study sites, it is likely that the pollution stressors affect the coral reef at islands further offshore through transportation by surface currents.

Impacts related to infrastructure are commonly associated with coastal areas that have high concentrations of inhabitants. This has become a constraint to natural resources management of Marine National Parks in the East coast of Thailand where their boundary overlaps or is adjacent to a local community. Principle components analysis of data collected from the study in Chapter 3 shows that prevalence of coral diseases, prevalence of ill health signs and water quality in MNP and non-MNP overlap, indicating that coral health metrics and water quality in MNP are not different to those of non-MNP areas (Fig. 5.1). MNP has regulations to manage a visitor's behavior and to prohibit any activity that potentially harms natural resources inside the MNP boundary. Unfortunately, there are pollutants from adjacent areas outside MNP that are being transported into MNP boundary through surface water currents that generally are outside the control of managers (Day et al. 2012). Marine surface currents are important transporters in the marine environment: the same current can transport larvae or pollutants for a greater distance compared to terrestrial environment (Carr et al. 2003). MPA should provide buffer area to protect important resources in core area, however this concept is difficult to implement in MNPs s in east coast of Thailand because their boundary are adjacent to local community. Mitigation measures of land based stressors

must be based on a cooperation of policy and work plan between MNP and the agencies responsible for environment outside MNP boundary should be concerned.

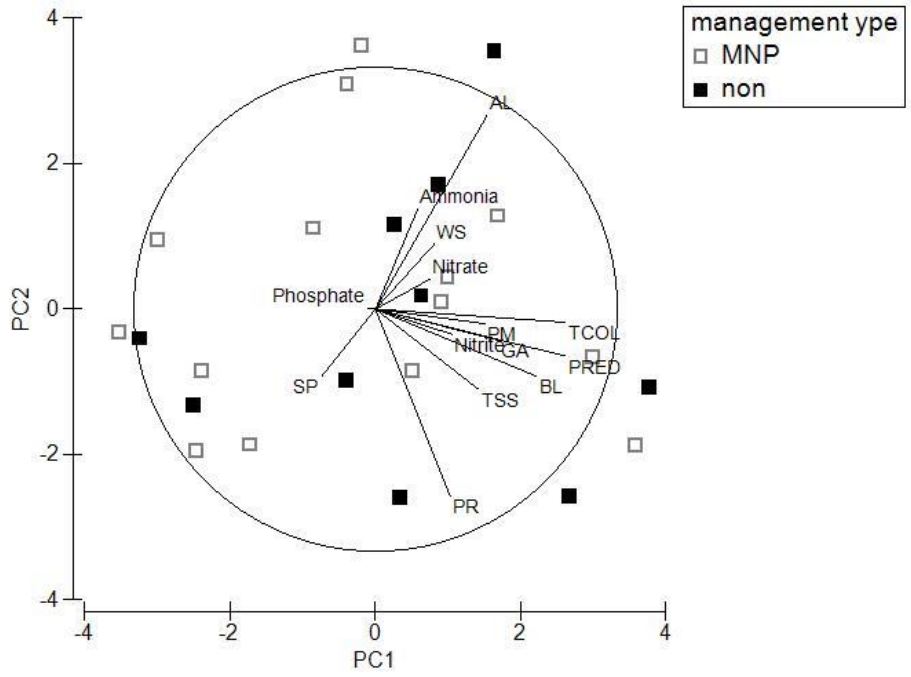

Figure 5.1. Principle component analysis of prevalence of coral diseases, signs of compromised health and water parameters in coral reef situated in MNP (open rectangles) and non-MNP area (solid rectangles). PCO1 and PCO2 account for 29.4 %, 21.1 % of total variance respectively. WS = white syndrome, GA = Growth anomaly. Signs of compromised health: PR = Pigmentation response, PM = Partial mortality, BL = uncommon Bleaching, AL= Algae overgrowth, SP = Sponge overgrowth, PRED = Predation scar. Water parameters; NO3 = nitrate, NO2 = nitrite, PO4 = phosphate, NH4 = ammonia, TSS = total suspended sediment, TCOL = total coliform bacteria.

In the absence of point sources of pollution associated with tourism infrastructure, high prevalence of coral diseases and ill-health signs were found at high visitor sites. This incident indicated there were probably responses to micro-pollutants

such as sunscreens, boat paints and human wastes associated with high number of tourist during peak hour (the maximum number of tourists was approximately 1,000 tourist within the two hour observation period). A higher prevalence of fish bite scar at high use sites may represent effect of fish feeding in coral reef, yet feeding program still advertises in brochures at sell counters in Chang Island and Samet Island (per obs). Value of reef-based activities (snorkelling, diving, site-seeing) relies on the perception that the activity is sustainable and that the environment is relatively in good condition. As found from this study, users perceived that condition of coral reefs and coral reef fish to be in good condition and that feeding coral reef fish has no to little impact to coral reef. Moreover, there was a general opinion that operators could gain more benefits – despite official prohibition of the practise – because the popularity of feeding activity attracts more tourists to buy trips. This perception decreases sensitivity of operators to potential threats to ecological integrity and its prevalence is likely something that jeopardizes reef based tourism's sustainability. Managers, on the other hand, perceived that feeding coral reef fish had large negative impacts on coral reefs, but the results indicate that managers are unlikely to experience success in convincing users of this opinion, or of obtaining voluntary compliance with restrictions on tourist behaviours.

Coastal tourism in Thailand has remained largely unplanned and *ad hoc*; developers of resorts have ignored the negative environmental consequences and government authorities have been too slow to react to the rapid rate of development (Seenprachawong 2003). Tourism income has been increasing over the last 15 years, to the extent that it contributed approximately 17 % of Thailand country GDP in 2016 (https://www.thairath.co.th/content/828186). Whereas other business sectors may have

struggles, the tourism sector provides huge stimulus in tourism-led economic growth (Ubonrat et al. (2015) in Thailand Future Growth (in Thai)). Tourism Authority of Thailand (TAT) expected 2.7 trillion baht for 2017, and indicate Thailand would welcome even more tourists. The policy to increase tourism has remained the driving force of coastal development and has resulted in an increase of recreational activity in areas known for nice reefs and beaches. The strategy used to balance exploitation and conservation of coral reefs (Carter and Grimwade 1997) in the east coast of Thailand is obviously biased to accommodate the high tourist demand by increase capacity of coastal area (to place more infrastructure) and disregard to neither increase nor decrease capacity of coral reef in which tour operator can bring as much as possible to the sites.

This thesis has provide evidence both biological and sociological. Coral reefs adjacent to infrastructure have higher prevalence of health metrics than reef isolated from infrastructure regardless to area of jurisdiction; MPA or non MPA. The distribution of algae overgrowth has clearly indicated nutrient is dispersed through boundary (fig.5.2). This trend is additionally pronounced through perception of user in the east coast of Thailand. Hotel operators perceived that threats potentially associated to tourism, including trampling, feeding of fish, anchoring, waste water, coastal development and garbage, have little impact on coral reefs (chapter 4, table 4.3). Tour operators, moreover, had the impression that feeding reef fish has little impact on coral reef ecology and coastal development has no impact to coral reef at all.

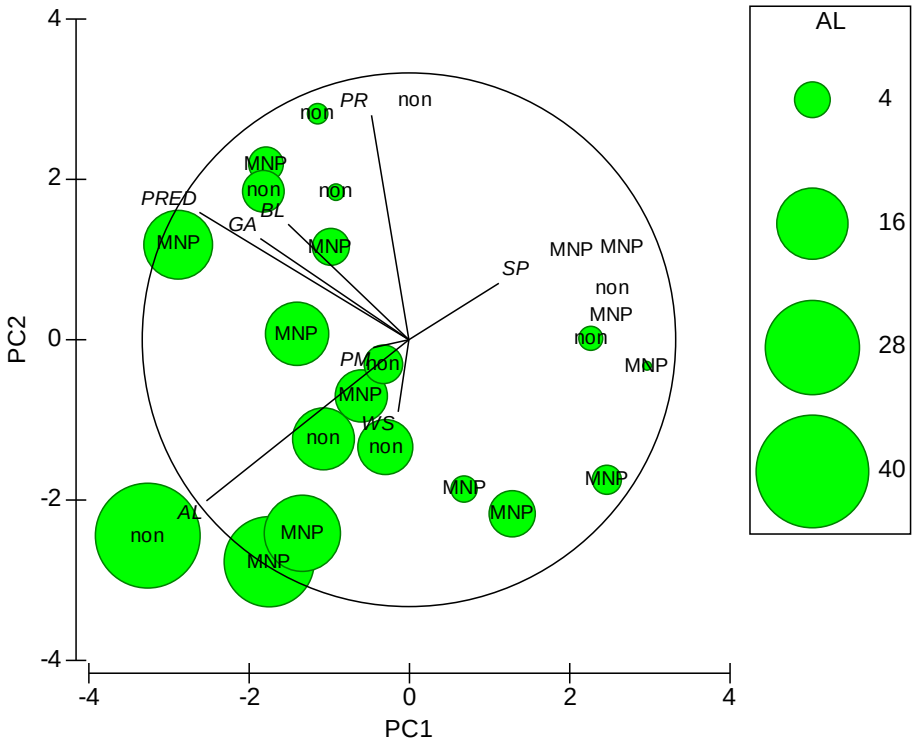

Figure 5.2. Distribution of algae overgrowth in all study sites. PCO1 and PCO2 account for 29.4 %, 21.1 % of total variance respectively. Green bubble represent prevalence of algae overgrowth. Size of bubble indicate prevalence of algae overgrowth (%). Letter in bubble indicate area of jurisdiction; MNP = site located within Marie National Park and non = site located outside Marine National Park.

Coral reefs in Thailand are under the supervision of various agencies, from national to local level. At the national level, Department of Marine and Coastal Resources (DMCR; under Ministry of Natural Resources and Environment (MONRE)) are responsible for coastal and marine areas not gazette as national parks. Department of National Parks, Wildlife and Plant Conservation (DNP; under MONRE) administer coral reefs and other marine resources within the Park boundary. Department of Fisheries (DOF, under the Ministry of Agriculture and Cooperatives), oversees fishing

of marine animals by local and commercial interests in the coastal seas. DMCR and DNP are the key agencies responsible for development of access and usage policy, landscape planning and management implementation, whereas DOF is the sole agency responsible for fisheries (or extractive resource) policy enforcement.

The result of investigations conducted as background for this thesis indicated that DMCR is the only national marine resource management agency that has both policy and extant action plan for coral reef management. This study has a limitation as I have opportunity to interview only the superintendent of Khaolaemya and Mu Ko Samet Marine National Park. Marine National Parks (KS in this study) has extant policy and is working to update management plans, there is no general action plan to guide day to day coral reef management (pers. interview).

Approximately 42% of coral reefs in Thailand lie within MNP boundaries (Thamasak Yeemin, Sutthacheep, and Pettongma 2006) and the proportion is greater in the eastern coast of Thailand. Interview with the MNP superintendents (KS) revealed that they felt there are constraints to their ability to successfully manage coral reef areas within their fiat, including the lack of an approved action plan for day to day management, the general lack of coral reef experts within the organization, and perhaps most critically, that there is an insufficient pool of skilled staff for management jobs. The prioritization of policy has changed over time due to a somewhat unstable and reactive governance system at the national level; for example, the superintendent of KS was directed to solve encroachment problems and problems in the tourism sector as the leading priorities. This constraint has put coral reefs in MNP in a high risk condition and MNP seem not to have the built-in protocols, doctrine and policies to handle this risk.

5.2. RECOMMENDATIONS ARISING FROM THIS THESIS FOR CONSIDERATION

5.2.1. Incorporate integrated approach to control land based stressors

In the perspective of coastal management, ICM has been recognized by managers as a tool which aids in working toward sustainable development of coastal area. The ICM is the process to avoid policy fragmentation among responsible agencies that overlap in the area of interest. Cicin-Sain & Belfiore (2005) suggest that "ICM enables to create a governance system to manage multiple uses in an integrated way, through the cooperation and coordination of government agencies at different levels of authority, with nongovernmental organizations and among different economic sector". This framework is well-suited to the context of the east coast of Thailand, where coral reefs stretch across the boundaries of MNPs and into adjacent non-jurisdictional areas. The two MNPs in the east coast have a boundary adjacent to local communities around which the coastal areas are intensively developed into tourism poleis. As the results of surveys presented in this thesis (chapter 3) have illustrated, stress factors stemming from tourism do not respect the MPA boundaries.

It therefore behooves MPA managers in the East coast of Thailand to take into account the question of how to mitigate impacts of these stressors from outside that are being transported into MPAs. MNPs and DMCR should enhance their collaboration in coral reef resource management as DMCR has strong foundation on research and monitoring of coral reef in the Eastern Coast of Thailand, and MNPs has full authority to manage coral reef as well as to control visitors and tour operators in MNPs boundary. Synergic of DMCR's expertise and MNP authority will enhance coral reef management

in MNPs in the Eastern Coastal of Thailand. To mitigate stressor form tourism infrastructure, MNP may need to consider strengthen the cooperation with agencies responsible for the health of the marine environment, such as Department of Pollution Control, Department of City Planning, Provincial Environment Office, District and Sub-district Administration Organization.

5.2.2. The demand of national coral reef management policy and steering committee to drive policy implementation

To enhance integration among managers, there is a need for mechanisms to mobilize cooperation and coordination amongst responsible agencies and stakeholders, especially government agencies within the same or different ministerial organizations. This mechanism should involve National policy for coral reef management and a Steering committee to drive policy implementation. There are three plans currently in existence for coral reef management in Thailand: the national coral reef management master plan of 1992 (ONEP, 1992), the strategic and management plan for coral reef management of 2009 (Office of Marine and Coastal Resources Management, 2009) and the coral reef rehabilitation plan (Office of Marine and Coastal Resources Management, 2010). The master plan was formally approved by the cabinet resolution on 3rd March, 1992 and has been used ever since. The strategic and management plan (2009) is a revision of the master plan (1992) undergone by experts from DMCR and university academics, however it was not approved by the cabinet, so management of coral reefs under the revised plan is mainly implemented by DMCR in the area that is not gazette as protected area under the Marine Park Act and the Fisheries Act, and hence management of coral reefs is somewhat fragmented. The coral reef rehabilitation plan

(2010) has proposed comprehensive measures to mitigate anthropogenic impacts to coral reef including, tourist activity, coastal waste water, suspended sediment and fishing practices. The strategic and management plan (2009) and the rehabilitation plan (2010) have potential to apply for management of coral reef and coral reef environment in Thailand, however they need a formal adoption to implement at national level by all relevant agencies. The agencies have to see the same goals, to understand their role and responsibility and to prescribe how the agency cooperates with others. And this policy should be drive by a national steering committee that comprised of representatives from relevant stakeholder groups. The national steering committee should have the potential and authority to drive national policy implementation at the national level.

5.2.3. Encourage local communities to manage environmental stressors at their sources

Discharge of sewage into the sea adjacent to coastal tourism infrastructure is associated with degradation of coral reefs and altered water quality (Reopanichkul et al. 2009, 2010). Important sources of land based stressor in study area included small hotels and local community infrastructure, which have no wastewater treatment facility, and discharged sewage directly into the sea. The public treatment facility provided by local government has insufficient capacity to treat the daily sewage of even small metropolitan areas. To encourage local communities and small hotel operators not to discharge waste water to adjacent coastal water and install small treatment system for household sewage i.e. grease trap (http://www.pcd.go.th/info_serv/water_wt.html#s4) should be a key recommendation for easy victories by management policy agencies vested in water quality issues. Educating local people to understand the consequences

of waste water discharged to the marine environment, and to understand the impact of degraded environment to their livelihood will illustrate negative impact of simply releasing waste water and also may enhance local stewardship of the marine environment.

5.2.4. Incorporate a precautionary approach to define zoning plan for coral reef management.

The Precautionary Management approach enables management agencies to avoid many of the negative consequences of threats to coral reef. The threats related to tourism infrastructure in coral reefs of the East coast of Thailand described in this study are relatively predictable and overseas experience suggests that they are manageable through a sound revision of practice in particular coral reefs that are isolated from infrastructure. For instance, Zoning is a tool that many MNPs have used to control anthropogenic impacts and to limit activity in particular zones. Coral reefs at islands isolated from infrastructure have lower prevalence of disease and most other health metrics and are predominantly affected by high intensity of tourist visitation. These reefs, particular in KC (especially coral reefs around Kra Island, Tian Island Yak Lek Island and Yak Yai Island), should be considered as reefs with potential to be preserved before the degree of impact is over threshold. According to the master plan of KC, these four islands fall in the so-called “primitive zone” where tourism and recreation activities are controlled. However the primitive zone in this master plan refers to the forest on the islands and no such zone was applied in marine area, particularly coral reef. Currently Kra and Tian islands in are strictly preserved (no substantive access for tourism) but Yak Lek Island and Yak Yai Island are badly overcrowded. Based on the

current zoning plan, KC supposed to limit access to this four island and promote alternative sites for tourist activity to preserve biodiversity of coral reef. Incorporating a precautionary approach with zoning plan may enhance MPAs to gain more success in coral reef management.

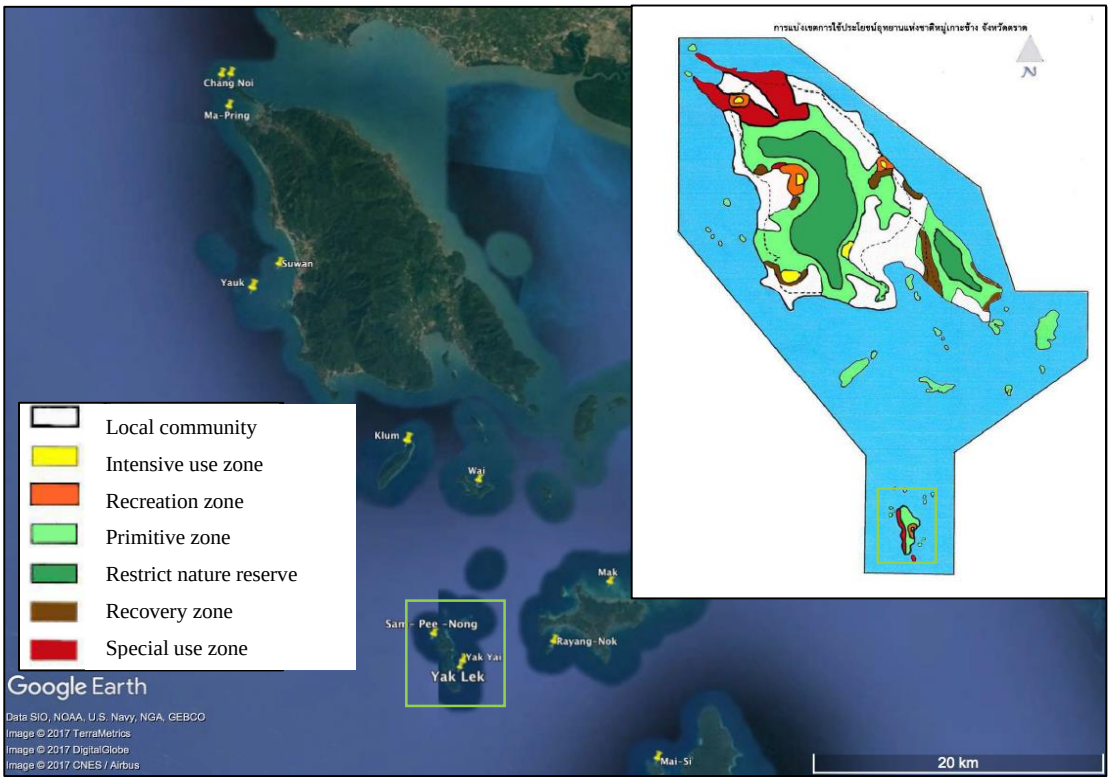

Figure 5.3. Zoning plan of Ko Chang Marine National Park. Sources; zoning plan is modified from the master plan of Ko Chang Marine National Park (in Thai), satellite image copy from Google earth.

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