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Assessing potential sites for marine ecotourism in Chumphon Province, Thailand

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Abstract. Coral reefs provide various types of ecosystem services. However, rapid and intensive marine and coastal development without proper management cause adverse effects on coral reef ecosystems. The process of enhancing marine ecotourism through assessing potential sites and zoning arrangement is an effective strategy for reducing pressure on main dive sites. This study assessed the potential of marine ecotourism development at some coral reefs on non-popular islands and underwater pinnacles in Chumphon Province, Thailand. Several physical and biological factors criteria were assessed for the potential of ecotourism development by 36 experts. Field surveys were conducted at 62 coral communities in the Mu Ko Chumphon Marine National Park. Four study sites, i.e., Ko Ngam Noi, Hin Lak Ngam, Ko Thalu, and Hin Pae, exhibited high potential for ecotourism development. The analysis showed that the diversity of unique marine organisms and convenience to travel result in high scores of the study sites. This study provides an assessment methodology and identifies potential sites in non-popular islands and underwater pinnacles that can be promoted to ecotourism.

Keywords: coral reef, management, pinnacle, tourism, Thailand

1. Introduction

Coral reefs provide several aspects of ecosystem services that benefit humans, such as recreational activities (Moberg and Folke, 1999; Weijerman et al., 2018). Marine tourism illustrates an important economic received from coral reef ecosystem services in coastal communities globally (Barbier 2017; Elliff and Kikuchi, 2017; Robles-Zavala and Reynoso 2018). However, intensive tourism has been developed rapidly without proper management, consequently causes negative effects on the coral reef ecosystem such as damaged corals, coral diseases, death of benthic organisms, and anthropogenic pollution (Lamp and Willis, 2010; Au et al., 2014; Casoli et al. 2017; Cowburn et al., 2018). The increasing number of SCUBA divers and snorkelers in popular dive sites can accelerate reef degradation locally (Zakai et al., 2002; Hasler and Ott, 2008). Exploring new dive sites is one of the solutions that can reduce pressures on popular dive sites. Moreover, promoting the coral reefs at non-popular islands, underwater pinnacles, and artificial reefs as ecotourism sites could reduce accommodating tourists from major dive sites as well (Tynyakov et al., 2017).

Prior to the marine ecotourism development, a site assessment is needed to determine the suitability of potential areas for SCUBA diving and snorkeling. The proper methods are needed to assess the ecotourism potential for sustainable conservation and local culture (Heeger and Sotto, 2000; Rhormens et al., 2017). Marine ecotourism protects coastal and marine ecosystems and encourages the local community's economy (Walters and Samways 2001; Jobbins, 2006).

The Western Gulf of Thailand exhibits high diversity of marine ecosystems, including coral reefs, mangroves, and seagrass beds. However, the potential of these resources has been continuously affected by human activities and

unsustainable fisheries. A possible mitigation strategy to conserve marine and coastal resources is to shift, regulate, and plan its use through marine ecotourism to reduce pressure on overexploited dive sites. The ecological baseline data are required to support the dive site assessment. Therefore, this study aimed to evaluate the potential of ecotourism development and develop an assessment framework for coral reefs and underwater pinnacles in Chumphon province.

2. Materials and Methods

2.1. Location of study sites

The study areas are located in the Western Gulf of Thailand, between a geographic coordinate 9° 40’ 32” N, 99° 14’ 24” E (where an underwater pinnacle, namely “Hin Kan Thuree” marks the southernmost site) and 10° 51' 41” N, 99° 29' 10” E (where Ko Yo is the northernmost site), on the coast of Chumphon Province, Thailand. A total of 62 reef sites (35 non-popular islands and 27 underwater pinnacles) in Chumphon Province were investigated from February to July 2018.

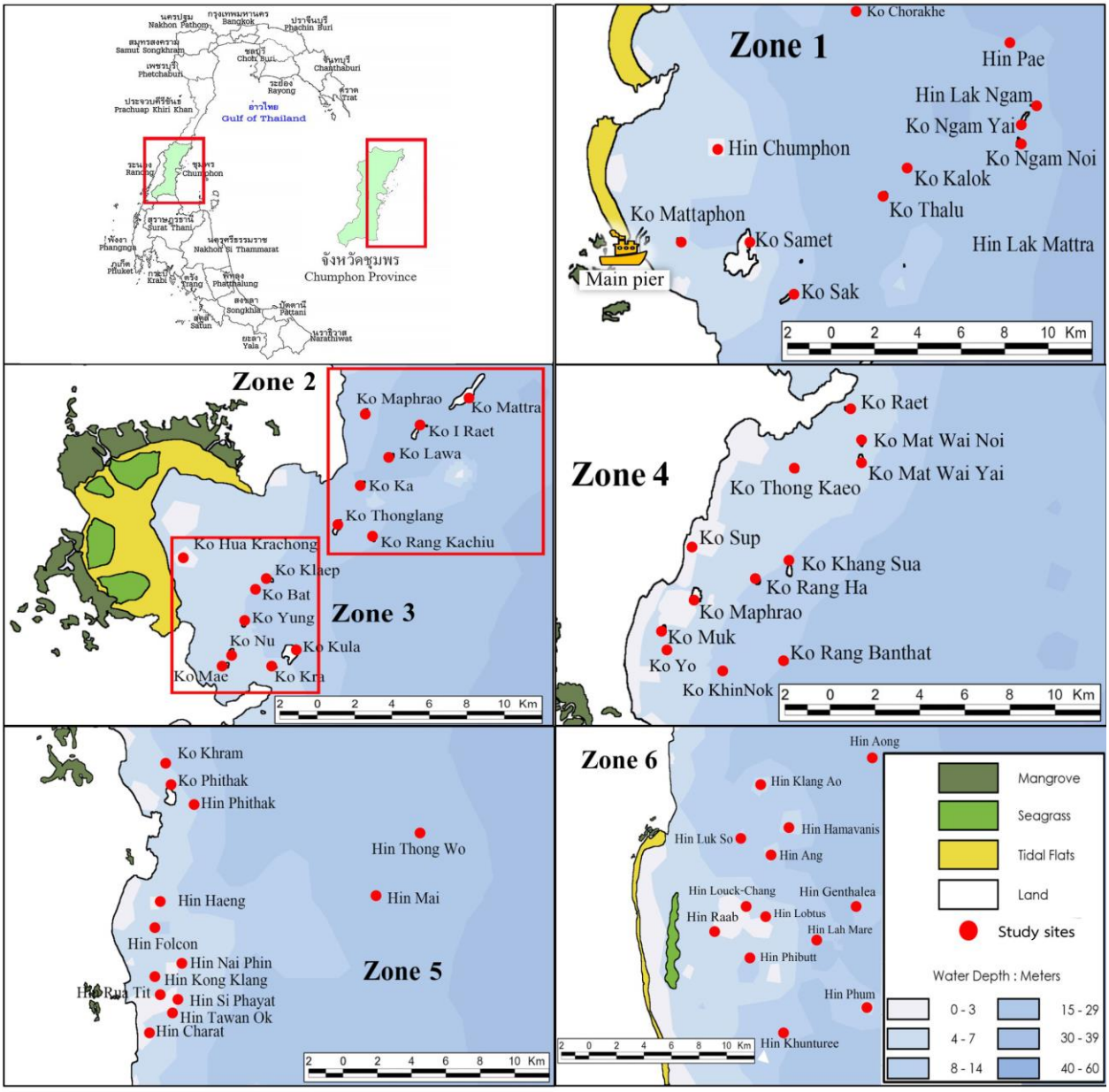

Figure 1. Six zones of the study area for assessment of potential ecotourism.

Table 1. Location of study sites

Zone	Number of study sites		Study sites
1 (11 sites)	Islands	8	Ko Ngam Noi, Ko Ngam Yai, Ko Thalu, Ko Chorakhe, Ko Samet, Ko Sak, Ko Kalok, Ko Mattaphon
	Pinnacles	3	Hin Lak Ngam, Hin Pae, Hin Chumphon
2 (7 sites)	Islands	7	Ko Mattra, Ko Maphrao, Ko I Raet, Ko Lawa, Ko Ka, Ko Thonglang, Ko Rang Kachiu
	Pinnacles	-	
3 (8 sites)	Islands	8	Ko Hua Krachong, Ko Klaep, Ko Bat, Ko Yung, Ko Nu, Ko Mae, Ko Kula, Ko Kra
	Pinnacles	-	
4 (10 sites)	Islands	10	Ko Raet, Ko Mat Wai Yai, Ko Mat wai Noi, Ko Thong Kaeo, Ko Sup, Ko Khang Sua, Ko Rang Ha, Ko Rang Banthat, Ko Maphrao (Sawee), Ko Muk
	Pinnacles	-	
5 (18 sites)	Islands	2	Ko Khram, Ko Phithak,
	Pinnacles	11	Hin Tawan Ok, Hin Haeng, Hin Thong Wo, Hin Mai, Hin Si Phayat, Hin Rua Tit, Hin Kong Klang, Hin Charat, Hin Phitak, Hin Falcon, Hin Nai Phin
6 (8 sites)	Islands	-	
	Pinnacles	13	Hin Ang, Hin Aong, Hin Klang Ao, Hin Genthalea, Hin Hemavanis, Hin Luk So, Hin Phum, Hin Kanthuree, Hin Lobtus, Hin Rab, Hin Pibat, Hin La Mae, Hin Luk Chang

2.2 Assessment of potential sites

At each study site, the physical and biological characteristics under the assessment framework were used to assess the potential as attractive points for tourism promotion. An assessment framework and criteria have been developed by modifying the method proposed by Flores-de la Hoya et al. (2018). A total of 52 factors can be divided into 12 physical factors and 40 biological factors (Table 2 and 3). The total score of each study site was calculated by the following equation:

Where: $\textbf{Score} = \sum \boldsymbol{R_i W_i}$

$\boldsymbol{R_i}$ = the score of factors i

$\boldsymbol{W_i}$ = weighing of factors i

Three levels of the potential of ecotourism development including high level (score range = 3.67–5.00), medium level (score range = 2.34–3.66), and low level (score range = 1.00–2.33) were constructed.

Table 2. Physical factors and criteria for assessing the potential of ecotourism development at some coral reefs and underwater pinnacles in Chumphon Province.

Type of Factors	Factors	Score (R)					Wi
		1	2	3	4	5	
Physical factors (30%)	Depth (suitable for diving) (m)	<1.5	1.5-2	2-2.5	2.5-3	>3	0.1
	Slope (degrees)	>40	31-40	21-30	10-20	<10	0.005
	Topographic complexity	Very Low	Below Average	Average	Above Average	Very High	0.005
	Sand cover (%)	>90	61–90	31–60	10–30	<10	0.005
	Rock cover (%)	>90	61–90	31–60	10–30	<10	0.005
	Topographic uniqueness	Rare	Scarce	Common	Abundant	Dominant	0.025
	Transparency of seawater (m)	<1	1-2	2-3	3-4	>4	0.1
	Water temperature (ºC)	<20	20.0-22.5	22.6-25.0	25.1-28.0	28.1–30.0	0.005
	Current (m/s)	>2.5	2.1-2.5	1.6-2.0	1-1.5	<1	0.01
	Wave height (m)	>1.5	1-1.5	0.5-1	0-0.5	0	0.005
	Distance from pier (km)	>10	8-10	6-8	3-5	<3	0.01
	Site accessibility	Difficult	Somewhat difficult	Normal	Somewhat easy	Easy	0.025

Table 3. Biological factors and criteria for assessing the potential of ecotourism development at some coral reefs and underwater pinnacles in Chumphon Province

Type Factors	Factors	Score					Wi
		1	2	3	4	5	
Biological Factors (60%)	**Reef Fishes**						
	Butterflyfish (ind./100 m^2)	1.0-5.0	6-10	11-15	16-20	>20	0.02
	Parrotfish (ind./100 m^2)	1.0-5.0	6-10	11-15	16-20	>20	0.015
	Anemonefish (ind./100 m^2)	1.0-5.0	6-10	11-15	16-20	>20	0.02
	Indo-Pacific sergeant (ind./100 m^2)	<10	10-20	21-30	31-40	>40	0.015
	Blue spotted stingray (ind./100 m^2)	1	2	3	4	>4	0.025
	Stonefish (ind./100 m^2)	1	2	3	4	>4	0.01
	Groupers (ind./100m^2)	1.0-5.0	6-10	11-15	16-20	>20	0.005
	Snappers (ind./100m^2)	1.0-5.0	6-10	11-15	16-20	>20	0.005
	Scorpion fish (ind./100m^2)	1	2	3	4	>4	0.025
	Angelfish (ind./100m^2)	1.0-5.0	6-10	11-15	16-20	>20	0.025
	Moorish Idol (ind./100m^2)	1.0-5.0	6-10	11-15	16-20	>20	0.025
	Barracudas (ind./100m^2)	1.0-5.0	6-10	11-15	16-20	>20	0.015
	Rabbitfishes (ind./100m^2)	1.0-5.0	6-10	11-15	16-20	>20	0.005
	Seahorse (ind./100m^2)	1	2	3	4	>4	0.025
	Occurrences of other marine species						
	Sea turtle (time/year)	1	2	3	4	>4	0.005
	Whale and whale shark (time/year)	1	2	3	4	>4	0.005
	Dolphin (time/year)	1	2	3	4	>4	0.005

Type Factors	Factors	Score					Wi
		1	2	3	4	5	
	Hard corals						
	Live coral cover (%)	<5	6–25	25–50	50–75	>75	0.025
	Acropora spp. (%)	<5	6-10	11–15	16–20	>20	0.02
	Pavona spp. (%)	<5	6-10	11–15	16–20	>20	0.005
	Plerogyra sinuosa (%)	<5	6-10	11–15	16–20	>20	0.02
	Platygyra spp. (%)	<5	6-10	11–15	16–20	>20	0.005
	Pocillopora spp. (%)	<5	6-10	11–15	16–20	>20	0.005
	Symphylia spp. (%)	<5	6-10	11–15	16–20	>20	0.005
	Fungia spp. (%)	<5	6-10	11–15	16–20	>20	0.005
	Goniopora spp. (%)	<5	6-10	11–15	16–20	>20	0.02
	Soft corals and macroinvertebrates						
	Soft corals (%)	<5	6–25	25–50	50–75	>75	0.02
	Mushroom anemones (%)	<5	6–25	25–50	50–75	>75	0.005
	Black corals (colonies/10 m^2)	<1	1.0-2.0	2.1-3.0	3.1-4	>4	0.005
	Gorgonian (colonies/10 m^2)	<1	1.0-2.0	2.1-3.0	3.1-4	>4	0.02
	Sea whips (colonies/10 m^2)	<1	1.0-2.0	2.1-3.0	3.1-4	>4	0.02
	Feather stars (ind./10 m^2)	<1	1.0-2.0	2.1-3.0	3.1-4	>4	0.005
	Sponges (colonies/10 m^2)	<1	1.0-2.0	2.1-3.0	3.1-4	>4	0.025
	Nudibranchs (ind./m^2)	<1	1.0-2.0	2.1-3.0	3.1-4	>4	0.02
	Christmas trees (ind./m^2)	<1	1.0-2.0	2.1-3.0	3.1-4	>4	0.02

Table 3. Biological factors and criteria for assessing the potential of ecotourism development at some coral reefs and underwater pinnacles in Chumphon Province (continued)

Type Factors	Factors	Score					Wi
		1	2	3	4	5	
	Soft corals and macro invertebrates						
Biological Factors	Giant clams (ind./m^2)	<1	1.0-2.0	2.1-3.0	3.1-4	>4	0.02
(60%)	Sea stars (ind./m^2)	<1	1.0-2.0	2.1-3.0	3.1-4	>4	0.02
	Sea anemones (ind./m^2)	<1	1.0-2.0	2.1-3.0	3.1-4	>4	0.02
	Sea cucumbers (ind./m^2)	<1	1.0-2.0	2.1-3.0	3.1-4	>4	0.005

3. Results

Our results revealed that most of the study sites showed low and medium potential for ecotourism development. However, four dive sites exhibited a high potential for ecotourism development (Table 4). The highest score of potential sites was recorded at Hin Lak Ngam, followed by Hin Pae, Ko Ngam Noi, and Ko Thalu. Hin Lak Ngam was characterized by 100-meter-long coral reefs found with a range of 5–15 meters in depth that suitable for SCUBA diving and snorkeling. The live corals were dominated by *Porites* spp., *Plerogyra sinuosa, Acropora* sp., and *Pocillopora* spp. Dominant macroinvertebrates were sea urchin (*Diadema setosum*), penguin's wing oyster (*Pteria penguin*), sea anemone (*Heteractis magnifica*), and sponge (*Xestospongia* sp.). A total of 34 reef fish species were recorded with a total density of 6,000 individuals/100 m^2. The dominant reef fish species were the blackcap butterflyfish (*Chaetodon wiebeli*) and anemonefish (*Amphiprion perideraion*). The underwater scenery at Hin Lak Ngam was attractive when compared to low score sites (Figure 2).

Hin Pae underwater pinnacle also showed a high score that revealing a high potential site for SCUBA diving, where a coral reef approximately 300 meters wide, with a depth range of 2–12 meters. Most of the areas were characterized by 50% of live coral cover. The dominant corals were *Galaxea* spp. and *Porites* spp. Various macroinvertebrate species, such as sea urchin (*D. setosum*), giant honeycomb oyster (*H. hyotis*), sea whip (*Viminella* sp.), soft coral (*Sarcophyton* spp.), and sea anemone (*H. magnifica*), were recorded. A total of 44 reef fish species were found with a density of 2,500 individuals/100 m^2. The blackcap butterflyfish (*C. wiebeli*) and the neon damselfish (*Pomacentrus coelestis*) were recorded as dominant species.

Ko Ngam Noi exhibited a high score with 100 meter-long of reef areas and a depth ranged from 1 to 9 meters, which are suitable for both snorkeling and SCUBA diving. Over 80% of live coral cover was observed. The dominant corals were branching corals (*Acropora* spp.), approximately 75% of the total live coral cover. The dominant macroinvertebrate found in this area was sea urchin *D. setosum*, soft coral (*Sarcophyton* sp.), sea anemone (*H. magnifica*), and mushroom anemone (*Discosoma rhodostoma*). A total of 42 reef fish species were recorded with density of 3,500 individual/100 m^2, where several species of butterflyfish and parrotfish were commonly found.

Table 4. Levels of potential for ecotourism development at each study site

High level (4 sites)		**Medium level (19 sites)**		**Low level (39 sites)**			
Station	**Score**	**Station**	**Score**	**Station**	**Score**	**Station**	**Score**
Hin Lak Ngam	4.26	Ko Mat Wai Noi	2.77	Ko Ka	2.12	Ko Khang Sua	1.71
Hin Pae	4.23	Hin Haeng	2.73	Hin Chumphon	2.10	Hin Rab	1.64
Ko Ngam Noi	4.19	Ko Chorakhe	2.65	Hin Hemavanit	2.10	Hin Kong Klang	1.60
Ko Thalu	3.95	Hin Thong Wo	2.64	Hin Charat	2.06	Hin Luk So	1.59
		Hin Phum	2.63	Ko Ka	2.05	Ko Sak	1.57
		Hin Ang	2.50	Hin Falcon	2.02	Hin Pibat	1.56
		Ko Lawa	2.49	Ko Klaep	1.97	Hin La Mae	1.52
		Hin Khunturee	2.47	Ko Samet	1.94	Hin Phithak	1.52
		Hin Mai	2.47	Hin Nai Phin	1.91	Ko Mattaphon	1.52
		Ko Rang Banthat	2.45	Hin Tawan Ok	1.89	Hin Luk Chang	1.50
		Hin Klang Ao	2.44	Ko Mae	1.88	Ko Bat	1.50
		Ko Rang Kachiu	2.44	Ko Thong Kaeo	1.85	Ko Muk	1.48
		Hin Genthalea	2.38	Ko Nu	1.84	Hin Aong	1.47
		Ko Ngam Yai	2.38	Hin Si Phayat	1.83	Ko Rang Ha	1.47
		Ko Kalok	2.36	Ko I Raet	1.81	Ko Khram	1.45
		Ko Thonglang	2.35	Hin Lobtus	1.80	Ko Phithak	1.42
		Ko Kula	2.34	Ko Hua Krachong	1.78	Ko Maphrao (Sawee)	1.37
		Ko Mattra	2.34	Ko Raet	1.78	Ko Sup	1.27
		Ko Mat Wai Yai	2.34	Ko Yung	1.75	Ko Maphrao	1.25
				Hin Rua Tit	1.74		

Figure 2. Comparing between high score and low score for potential sites to ecotourism development (Left: Hin Lak Ngam; Right: Ko Maphrao island)

Ko Thalu showed a high score suitable for snorkeling where approximately 120 meters-wide coral reefs were found with a depth range of 1 – 9 meters. About 60% of live coral cover was observed. The dominant coral species were *Porites* spp., *Galaxea* sp., *Favia* sp., and *P. damicornis*. Dominant macroinvertebrates found on this reef included bivalves (*Arca ventricosa*), sea urchin (*D. setosum*), and the half round cardita (*Beguina semiorbiculata*). Likewise sponge (*Xestospongia* sp.) polychaete (*Sabellastarte* sp.) and giant clam (*Tridacna squamosa*) were found at this site. Less diversity of reef fish was found compared to the other high score sites. Only 18 species were found with its total density of 335.6 ind.100 m^2, dominated by silver demoiselle (*N. anabatoides*).

4. Discussion

According to our analysis, the study sites that showed high scores resulted from having diverse marine organisms and uniqueness and ease of access. For example, Ko Ngam Noi had abundant branching corals making this area more interesting. The appearance of colorful fish and interesting macroinvertebrates, and rare marine species (whales, whale sharks, sea turtles) can also support the possibility of ecotourism development (Ramos et al., 2006; Flores-de la Hoya et al., 2018). Hin Pae showed a high score with suitable structure and environment supporting high diversity of reef fish and macroinvertebrates, although live coral cover was low. (Zulaiha and Badaruddin, 2014; Wijaya et al., 2018).

Hin Lak Ngam, Hin Pae, Ko Ngam Noi, and Ko Thalu are located far from the shoreline. However, it is convenient to travel because of the developed tourism infrastructure. Most tour boats have regular routes. A tour company operated by a group of tourists or divers has a route from the pier in Lang Suan to Ko Ran Kai and Ko Ran Pet. Structure complexity of dive sites is also an essential factor that has raised scores. For example, Ko Ngam Noi and Ko Ngam Yai have underwater caves measuring up to 15 meters tall and 10 meters wide.

A good management policy or the concrete promotion of tourism in these areas can reduce fishing pressures and shift to tourism activities (Needham and Szuster 2011; Wongthong and Harvey, 2014). Therefore, marine spatial planning is very important because the zoning will spread the tourists from high potential sites to lower potential sites and reduce conflicts among resource users (Eagles et al., 2002; Douvere, 2008; Pascoe et al., 2014; Zhang et al., 2015).

This study provides an assessment methodology and identifies coral reefs and underwater pinnacles that can be promoted to develop new ecotourism sites. We highlight that at least four study sites having a high potential for ecotourism activities, including Ko Ngam Noi, Hin Lak Ngam, Ko Thalu, and Hin Pae. However, nineteen study

sites showed medium scores that should be considered since they still hold interesting biological resources and can be used as tourism sites. This study also provides ecological baseline data of coral reefs and underwater pinnacles in Chumphon Province, the Western Gulf of Thailand, to support coral reef conservation and management.

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