

CHAPTER II

LITERATURE REVIEW

2.1 Coral Reef Ecosystem

In marine ecosystem, coral reef is distinctively an extremely complex habit and the most spectacular biodiversity. The reefs biologically formed by secreted calcium carbonate (CaCO_3) of the stony corals, which are invertebrate marine fauna and classified in:

Phylum: Cnidaria

Class: Anthozoa

Subclass: Hexacorallia

Order: Scleractinia

The calcareous structures, as called corallite, play an important role as natural habitat of tiny coral polyps. In general, the different characteristic of corallite depends on individual reef species. The establishment of coral reef ecosystems may primarily generate on near shore areas, where probably are on the ocean coastal shoreline or island. The reef development in each region is difference depending on the evaluated duration and environmental factors (Veron, 2000) such as geology, sea level, temperature, salinity, wave energy, light, nutrients and quantity of sediment. These physical and chemical factors must present at the appropriate levels, reflecting to the growth and the structural development of coral reefs (Basnes and Hughes, 1992)

Phuket Marine Biological Center (1995) reported that the distinctive coral characteristics in Thailand are fringing reefs, where are commonly found in several islands and coastal lines, developing initially on near shore within distance of 1 kilometers. As theory the classification of coral morphology (Darwin, 1842), coral zone, occurring from in-shore to off-shore areas, can be clearly divided into three types, namely (1) reef flat: where connects with coastal habitats, widespread flat area and presenting little slope, (2) reef edge: where is situated between reef flat and reef

slope, and (3) reef slope: where is situated downward location into ocean floor substrates.

2.1.1 Importance and utilization of coral reef ecosystem

Coral reefs are considerable as one of the significantly marine ecosystems, and the useful complexity of coral structures exactly served as suitable of habitats for plenty of marine fauna in order to existing, avoiding predators, nutrient resource and hatching. This incredible advantage obviously creates the adjacent areas, showing the splendid abundance in both quantities as well as biologically diverse. In addition to this, coral on shoreline can prevent the erosion of the direct effect from waves, and the calcareous structure of coral, especially, erosion portion serve as original rescue of refined sandy on sea beach. Moreover, humans also receive the outstanding profit from corals such as natural marine products and medical accommodation (UNEP, 2004)

Interestingly, the coral reef ecosystem is apparently a spectacular SCUBA diving spot for human recreation. Overall, it is clearly seen that humans have been obtaining several economic advantages from coral reefs both direct and indirect aspects (Dixon, 1997)

2.1.2 Coral reef degradation

In the present, plentiful studies have intensively been conducted concerning the coral reef degradation and the results have illustrated on the two major causes, that is, (1) Effect of natural process: for example, impact of storm surge, grazed by some marine animals, climate change, which influence a gradually increased temperature of sea water. Surprisingly, coral reefs can recovery from negative environmental impact into the nearly original condition (Garrison and Ward, 2008) (2) effect from human activities: for instance, collection of corals as souvenir, dropping and removing the boat anchors from coral reef, illegal fisher activities, dropping of waste into reef area, the effluent from industrial and domestic activities, and the enormous construction on the shoreline, leading to progressively loading sediment into seawater. Fabricius (2005) reported to enhance level of sedimentation from coastal erosion have severely degraded many coastal marine reefs around the

world, that coral reef can be died increase causing from the cumulative sediment on coral structure with amount of the grater than 100 mg dry weight cm^2 . Similarly, Makergrow *et al.* (2005) reported that the forming in physical landscape of shoreline into hill slope erosion is associated with the amount of water rainfall and sediment types. According to mention above, if this damaged condition cannot be reinstalled, these are defined as critical habitat for biological surviving or protectively needed species in communities (Gibson and Wellbelove, 2010).

Furthermore, the negative effects of SCUBA diving activity have been recently discussed about the annual capacity in enjoyment tourist in each location. This activity provides directly the terrible effect on the diminishing of live coral covering (Hawkins *et al.*, 1999). As regards the effect of SCUBA diving activity on coral ecosystem, Zakaia *et al.* (2002) reported that comparative information between the local activity utilization and level of coral reef degradation should be primarily taken into account to assess the feasible supporting of coral reef in each site.

2.2 Basic Information of Koh Tao

2.2.1 Topographic history

Koh Tao is situated on the east coast of Suratthani province. In the past, The department of correction used Koh Tao as prison, where the political prisoners in People's Party (Khana Ratsadon) era were imprisoned before 1933. Thereafter, Koh Tao was registered belonging to the public property of the Treasury Department. In recent, Koh Tao and Koh Nang Yuan are declared as the public national wealth for particular utilization. These two spectacular islands distinctively illustrate the highly potential for being the attractive tourist destination because numerous beaches and highlight SCUBA diving spots have rapidly been becoming well know places for domestic and international tourists, who are definitely interesting in diving activity. Additionally, Koh Tao is admired from many tourists as heaven of SCUBA diving place thanks to the varieties of magnificent color and fantastic biodiversity of coral reefs. In the fact that, Koh Tao is considerable the assemble groups of plentiful

islands, consisting of four islands, namely Koh Tao, Koh Hang Tao, Hoh Nang Yuan and Koh Sai Daeng. Geographically, the water depth ranges from 30 to 40 meters, and seafloor substrates present a steep slope. In the intertidal zone, the tidal characteristic is found as diurnal tide, which the low and high tide phenomenal occur once a day. (Prince of Songkla University, 2004)

2.2.2 Coral reef condition

The observation of the coral reef management project was conducted by department of Fisheries (Chansang *et al.*, 2004) found that there are various coral species appearing surrounded Koh Tao and the exceeding density of quantitative corals subsequently forms fringing reef community. In the eastern and northern regions corals are found settling on rock habitats, where the lengths of coral and the depth levels are commonly average between 50-300 meters and 3-12 meters, respectively. In the southern part, the overwhelming majority of coral reefs are seen on the coast especially inside of gulf. At the edge section, reef are observed establishing on rock substrates, where the lengths of coral trends and the depth levels are about 50-300 meters and 3-7 meters, accordingly. At the western location, the most corals occur on the almost total coastline. With excepting at the edge, coral communities develop on the rock habitats with the coral lengths between 50-200 meter and the depth ranging from 5-8 meters.

2.2.3 Water quality of coastal seawater

In 2010 (Appendix A), the analysis of coastal seawater quality of Koh Tao was carried out by Department of Marine and Coastal Resources and the results showed that the amount of Total Coliform Bacteria and Total Suspended Solids are not over the standard quality of coastal seawater in section 2, which clearly state this area as the conservative coral zone. In term of space, the total area covers the enormous regions in parallel radiant with water surface, amounting to 1,000 meters away from outer line of coral reef ecosystem. (Pollution Control Department, 2011) On the other hand, the suspension of fat and oil matter substances is detected in Mae Haad Bay, where has many rural communities and pier business. Likewise, this problem is observed in Leuk Bay, where the chemical suspended may be released

from various transport systems such as taxi boat or long tail boat, boat trip and small fishing boat. (OMCRC, 2012)

2.2.4 Patterns of activity entertainments

Obviously, one of the striking utilization patterns of reefs is used as the attractive tourist spots. In view of observation on Cayman island, the large number of visitors, who adore in SCUBA diving activity, sharply increase from 3,000 in 1960 to 500,000 in 1980 (Well and Hanna, 1992). Likewise, Koh Tao, where is known as renowned island owing to incredible coral ecosystem, has been supporting many tourists. In the past two decades, the number of tourists visiting this island, especially SCUBA diving purposes, have dramatically been facing an upward trend. The proportion rises from 30,462 people in 1993 to 71,395 people in 1999. Surprisingly, the number of visitors in 2010 is double numerous than in 1999, amounting to 122,862 people (Department of Tourism, 2012 and Angkasirisap, 2000)

On the other hand, the coastal area of Koh Tao consists of several crucial islands, served as recreational activity purposed. These islands include Sai Ree Bay, Mae Haad Bay, Chalok Baan Kao Bay, and Thian Og Bay with the Coastal length of (1,579.90), (985.15), (931.94) and (657.53) meters, respectively. For other bays, the utilization of coasts, where are considerable as small rock bay, was mainly used to build the resorts and hotels for tourist accommodation (Bennui, 2006).

From on overall perspective, SCUBA diving activity in coral reef ecosystem at Koh Tao is becoming more popular day-by-day and the number of visitors, who want to see the spectacular corals, have gradually been jumping up. Nonetheless, the quality of coastal seawater is considerable belonged in the standard level of seawater quality in section two as conservative coral area. From reasons mentioned above, the major effect of SCUBA diving activity may directly manipulate the adverse damaging on coral communities.

In addition, impact of tourism on coral from comparison between Koh Tao and Koh Larn are than identified as shallow reef area. In other words, shore diving activity could easily step on the coral structures, and this can seriously cause the worst risk on coral degradation more than boat diving (Kornkanitnan, 1998). Hence, the

observation and assessment of coral reef should be urgently taken into account to attain the basic information for coral reef zoning in the future.

2.3 Tools in Management Zoning

Generally, the tools in costal management can be divided into two main groups depending on information usage (Satumanatpan, 2010). Firstly, the tool is associated with data management and another tool is involved in management planning. Thus, tools for collecting data and assessment of problem condition are selected to approach the important information for coral reef zoning following several processes.

2.3.1 Procedure in coral reef exploration

In this study, the outcomes derive from field observation and data analysis of coral reef covering and these results subsequently are used for assessment of coral condition. Previously, the survey of coral reef is traditionally conducted using Line Intercept Transect (LIT) (English *et al.*, 1994), which the precisely observed data depends on the expert of investigators. Thereafter, the suitable tool for coral observation, as called photo belt transect, has been modified from belt transect (Brock, 1954). Technically, the contemporary method is associated with recording video or taking pictures under water condition. With regards to the advantages of this tool, it takes short-time in order to recording information and pictures can be traced on the coral variation without required expert, and it distinctively provides the useful vision for executives (OMCRC, 2011). Notable, the averaged values of outcomes, obtained using photo belt transect, are considerably similar with those results, which are attained using point intercept transect (Lam *et al.*, 2006).

On the other hand, data analysis from the sample pictures is carried out using random stratified point count techniques, which are based on counting the limited points on pictures, being the maximum at 9 points per area 1 square meter. Importantly, the reliable proportion of 1,000 random points per one study site is

required to achieved the genuinely precise outcomes with the standard deviation value less than 0.001 (Dumas *et al.*, 2009)

In conclusion, photo belt transect is considerable as suitable tool in coral survey because it is the modernized method and using short-time during observation, resulting to reduce the risk of being stay under water too long period. According to data analysis, from sample pictures, the classification of coral reefs into family and genus can be done in the laboratory room, and data are able to be rechecked for correction. Nevertheless, the identification of reefs into species level may be unclear due to incomplete sample pictures, displaying the coral structures, depending on the fine quality of camera.

2.3.2 Concept in management zoning

Management zoning or zoning of utilization is normally the first tool, which is applied in natural resource management by planners and emphasizes on the integrated two aspects between conservation of resource together with utilization (Forster, 1973). Regarding to management zoning, the vital objectives in regional type zoning are considerate on the appropriately potential of individual location upon various factors such as terms or policies of development, condition of environmental problems (i.e. physical and biological problems), utilization, and social economy (Satumanatpan, 2010)

Day (2002) reported that the most essential purposes in area management of Great Barrier Reef Marine Park are to zoning of regions, where encounter with confliction in term of area utilization and to regulate the certain activity patterns, which should be operated as optimal activities in each region. Basically, conceptual framework of coral in GBR priority limited the target location, significantly widespread area, for zoning. Afterward, the important information between marine ecosystem and utilization patterns are connected providing the wise data, which can aid on an important management from utilization activities patterns.

Besides, the data of map can help knowing about specifically protected area as well as declaring a distinctively condition for each activity.

Furthermore, it can also explain the types of protected zone and provides the general information in activity management for special regions and for group of

users, who have particular purposes. With regards to the (figure 2-1), zoning spectrum outlined of Great Barrier Reef Marine Park can be divided into seven zones, (1) Preservation Zone, (2) Scientific Research Zone, (3) Marine National Park Zone, (4) Buffer Zone, (5) Conservation Park Zone, (6) Habitat Protection Zone and (7) General Use Zone

ACTIVITIES GUIDE (see relevant Zoning Plans and Regulations for details)	Zoning Spectrum						
	General Use Zone	Habitat Protection Zone	Conservation Park Zone	Buffer Zone	Scientific Research Zone	Marine National Park Zone	Preservation Zone
Aquaculture	Permit	Permit	Permit 1	X	X	X	X
Bait netting	✓	✓	✓	X	X	X	X
Boating, diving, photography	✓	✓	✓	✓	✓ 2	✓	X
Crabbing (trapping)	✓	✓	✓ 3	X	X	X	X
Harvest fishing for aquarium fish, coral and beachworm	Permit	Permit	Permit 1	X	X	X	X
Harvest fishing for sea cucumber, trochus, tropical rock lobster	Permit	Permit	X	X	X	X	X
Limited collecting	✓ 4	✓ 4	✓ 4	X	X	X	X
Limited spearfishing (snorkel only)	✓	✓	✓ 1	X	X	X	X
Line fishing	✓ 5	✓ 5	✓ 6	X	X	X	X
Netting (other than bait netting)	✓	✓	X	X	X	X	X
Research (other than limited impact research)	Permit	Permit	Permit	Permit	Permit	Permit	Permit
Shipping (other than in a designated shipping area)	✓	Permit	Permit	Permit	Permit	Permit	X
Tourism programme	Permit	Permit	Permit	Permit	Permit	Permit	X
Traditional use of marine resources	✓ 7	✓ 7	✓ 7	✓ 7	✓ 7	✓ 7	X
Trawling	✓	X	X	X	X	X	X
Trolling	✓ 5	✓ 5	✓ 5	✓ 5,8	X	X	X

PLEASE NOTE: This guide provides an introduction to Zoning in the Great Barrier Reef Marine Park. Relevant Queensland Marine Park Zoning Plans or the Queensland Environmental Protection Agency should be consulted for confirmation of use or entry requirements.

ACCESS TO ALL ZONES IS PERMITTED IN AN EMERGENCY.

Figure 2-1 Table showing matrix zoning of Great Barrier Reef Marine Park: GBRMP
Source: Great Barrier Reef Marine Park Authority (2007)

2.3.3. Coastal management zoning in Thailand.

In Thailand, the coastal management zoning is involved in the declaration of laws and the acts, that is General Fisheries Act B.E. 2549, National Park Act B.E. 2504, and The Natural Forest B.E. 2507 (Satumanatpan, 2011) In B.E. 2535, the cabinets of Thai government had agreed with the first model of coral reef zoning, which was divided into three zones upon utilization of corals, normally (1) local

protection zone, (2) tourist utilization zones, consisting of two subdivisions (i.e. intensive tourist zone and natural tourist zone and 3 conservative ecosystem zone for research (Nateewathana, 2008).

According to the guide book for zoning in marine protected area (Ministry of Natural Resource and Environment, 2005), zoning plan for marine national park depends on environmental factors and feasible operation of plan in situ zone. Similarly, Satumanatpan (2011) reported that the procedure of zoning plan generally needs to assemble observed data, which play as important evidences 1) Initially scientific information, 2) critical problem analysis 3) offering suitable travel and standard zoning in each area, following the sustainable development and balancing between conservation and economical development concept with corresponding to social demanding and utilization in the future.

In addition to this, attaining the opinions and recommendations from participants and those receiving both positive and negative effects should be addressed issue, can result in modification in suitable zoning, ability in practicing and low regulation.

2.3.4. Coral promotion zoning

Indeed, reefs are considerable as one of the important marine ecosystems. Thus, the main targets of marine ecological management, responding on utilization and needed of humans, focus on protecting the healthy and productive of ecosystem and maintaining the resilient condition (McLeod *et al.*, 2005). With regards the Marine Protected Area Classification System (MPACS), Al-Abdulrazzak and Trombulak (2012) create the criteria in protected zoning into five sections (Table 2-1), insisting on preserving biodiversity and reasonable utilization patterns in each area.

Table 2-1 Table illustrating the five sections in Marine Protected Area Classification System (MPACS)

Criteria	Levels				
	I	II	III	IV	V
	Wilderness Management Area (WMA)	Research Management Area (RMA)	Ecological Management Area (EMA)	Human Recreation Management Area (HMA)	Sustainable Resource Management Area (SMA)
Designated use	Ecological, geological, historical, or cultural protection	Ecological protection and scientific research	Ecological protection and human enjoyment	Human recreation	Sustainable extraction of resource(s)
Quality of natural character	Least disturbed state	Some natural character remains	Some natural character remains	Natural character altered	Distinctly new character
Extent of Protection	Permanent year-round	Permanent year-round	Permanent year-round	Conditional or seasonal	Conditional or seasonal
Extent of zoning	Uniform no take, no access	Uniform no take	May be zoned for multiple use, but no take	May be zoned for multiple use	May be zoned for multiple use
Public access	No access	Restricted access for research only	Regulated access	No to few regulations regarding access	No to few regulations regarding access
Extraction of resources	No extraction	No extraction	No extraction	Public	Commercial and/or public
Size	Large enough to support ecological processes	Large enough to support ecological processes	Large enough to support ecological processes	Not large enough to support ecological processes	Not large enough to support ecological processes

Source: Abdulrazzak and Trombulak (2012)

According to table 2-11, the coral sites in Koh Tao can be classified as Ecological Management Area (EMA) in this study due to ecological protection announcement (following the first model of coral reef zoning in 1992) and entertaining utilization places supporting human enjoyment. In situ at Koh Tao, the vast majority of coral reef communities remain naturally and completely, and these ecosystems may

separately be used in various usages such as snorkeling area as well as no take zone, where all fishery activities are prohibited within protected area of three kilometers apart from shoreline.

In comparison, the qualitative rating of area protection in this study is considerably corresponding with the objectives of protected area of International Union for Conservation of Nature at the category VI, which is defined as protected area with sustainable use of natural resources and has the main purpose in the combination of conservative resources and sustainable utilization (IUCN, 2008)

Moreover, other criteria for conservation management rating (CMR) used in ecological reef studies are considerably based on (1) average value of hard corals covering, (2) the total number of target benthic fauna and (3) biodiversity index of benthic fauna. (Harding *et al.*, 2006) However, Sharman-Weiner diversity index was applied for assessment of coral protection rating in the present study because coral communities are very good condition.

This sophisticated condition may present in high cover rating of dominant species in entire study sites and may effect on biodiversity index declining, resulting in reduce significantly in area protection.

In Thailand, the healthy criteria of corals are used as indicator of coral reef condition in each area. These criteria computed on the proportion of living corals per dead corals (Department of Fisheries, 1999). With regards the strategy in the area management in Great Barrier Reef National Park, the degraded zone are urgently required the other locations, where are the productive marine ecosystem, for marine fauna and flora existing (Fernarndes *et al.*, 2010). Consequently, rehabilitation is successful by resetting down on substrates of pioneer coral larva, which are quickly settling and ability in metamorphoses in short period. (Magedorn *et al.*, 2006)

In marine ecosystem, the different characteristics and brittle of coral structures in each habitat are differences depending on coral species, which individual's exhibit specifically persistent on nature and human threatening (MNRE, 2005). On the other hand, the distinctive morphology is used as key in coral classification for conservation rating, but the number of coral fragments cannot clearly indicate about the degraded habitats because the zones with high coral covering have

greater chance to be broken by environmental and human effects than the zone with low coral covering (Edinger and Risk, 2000).

2.3.5 Process in Participation

Participating or citizen participation is defined as process in opinion displaying and attitude exchanging of inhabitants or stakeholders. The individually personal perspective is interpreted for searching the alternative may used decisions associated with the suitable plan management corresponding with acceptable together. Importantly, all participant parties should partly attend at beginning with the initial process following up and assessment, resulting to provide the ultimate utilization for all parties in order to obvious understanding and knowing and joining in modification of plan management. Regarding to this process, the manipulative participation is pathway, which all participants can enter into the process through interviewing some questions by researchers (Pretty, 1995).

In general, the classification of stakeholder types can be considerable in various methods depending on the main objective of study and attribution of stakeholder relationships, (Tungsiripat and Tangcharoensathien, 2003). In present study, the major objective in plan management on using corals as tourist supporting places focuses on identification of tourist activities around Koh Tao. Therefore, stakeholder characteristic can be divided into two groups following close to the interesting topic for study.

1) Primary stakeholder is defined as group of people who directing involved in system and normally attains positive and negative benefits, high risk on investment, or owing private business (investors) or employment (employees).

2) Secondary stakeholder is defined as agencies or organizations involved in system at the second place such as government agencies.

In situ observation, the key stakeholder should absolutely be derived from individual type of stakeholders, leading to establish understanding and minimize confusing in strategy planning. Portman (2007) reported that stakeholders could exactly have a right for classification of appropriate area, resulting in creating varieties of protection rating. Basically, the social and scientific information from questionnaires are implied in order to requesting and limiting the roles and rights of

stakeholders in each area. Obviously, the geographically observed data are applied and can result in satisfaction of basic protection rating, regulating underneath law. Likewise, the outstanding example of people demanding in various utilization of each area was observed on rural opinions using environmental information in usage zoning.

From an overall literature review, plenty of crucial relevancies such as natural resources condition at study site, critical problems from tourist activities and coastal management should be taken into account for researching on coral reef zoning. In present study, the significant processes are definitely carried out to achieve the goal. These include the selection of the reliable method in coral exploration, using the suitable international and domestic tools in zoning management and activity studies via participation processes. Eventually, the precise outcomes are obtained and severed as basic information for management and limitation of zoning management and also approaching the serious problems in each zone.