

## CHAPTER IV

### RESULTS

#### 4.1 The coral condition of Koh Tao

The study on the condition of Koh Tao coral reef applied Photo Belt Transect method. It was conducted at two depths, including flag and edge coral community within 1.5–8.0 meters, totally 56 stations from 14 bays, in August 2010. The researcher will present the information of coral condition in each area (figure 4-1). This includes the percentage of coral life form and seabed form, coral diversity index, and coral fragment as follows.

##### 4.1.1 Sai Ree Bay

The coral reef of Sai Ree Bay is located at the west of Koh Tao. The collection was conducted at 6 stations at the depth between 4.0–6.0 meters. From the exploration, it was found that coral condition of all 6 stations were *very good*. On the average, the ratio of coral life form was 52.41%. (There were corals in massive and encrusting type 26.89%, plating type 13.79%, branching type 7.52%, mushroom type 1.11%, sub-massive type 2.77% and *Acropora* spp. type 0.32%). The rest were sand 28.50%, dead corals 12.18%, and old rubbles 6.91%.

Diversity indexes of corals in Sai Ree Bay from 1–6 stations were 2.27, 2.01, 2.11, 1.33, 1.99 and 2.42 respectively. The amount of coral fragments found at 1–6 stations were 1.42, 9.87, 1.73, 2.76, 0.98 and 0.82 pieces/ m<sup>2</sup> respectively. Coral fragments were mostly found at station 2. The ratios of corals were: plating type 43.47%, branching *Acropora* spp. type 36.94% and branching 19.59%.

In the overall of coral reef around Sai Ree Bay at 6 stations, most were plain coral reef. Corals were found in coral massive form and coral plating form. Most of the area was sand.

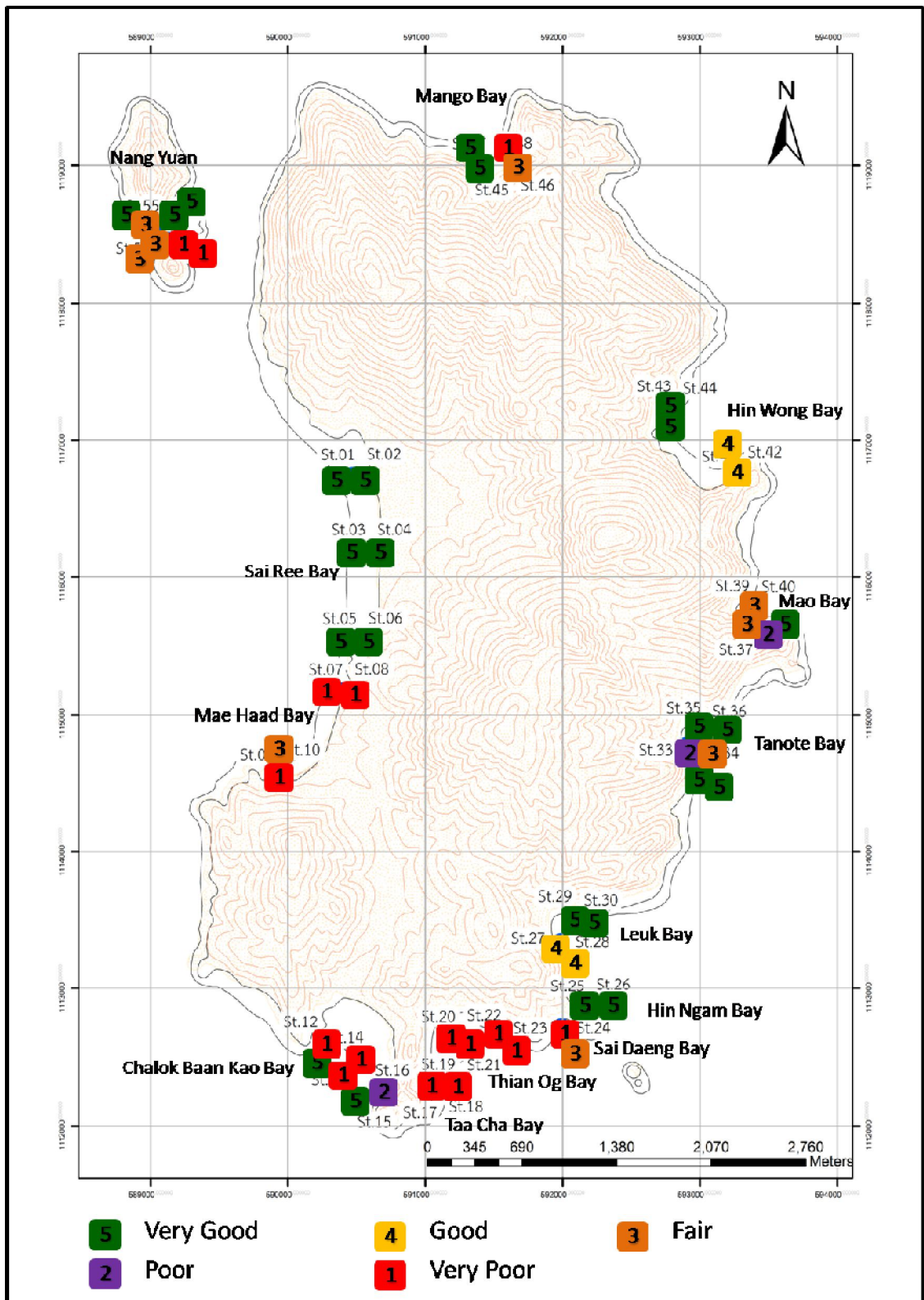


Figure 4-1 Map showing coral condition of Koh Tao

#### 4.1.2 Mae Haad Bay

Mae Haad coral reef is located at the west of Koh Tao. The collection was conducted at the depth between 1.5–4.5 meters. From the exploration on coral reef at station 7, 8 and 9, dead corals were mostly found. The coral conditions were *very poor*. On the average, the ratio of coral life form was 14.80%. (There were corals in plating type 8.10%, massive and encrusting type 4.78%, mushroom type 1.39%, sub-massive type 0.30% and branching 0.23%). The rest were dead corals 57.40%, old rubbles 27.23% and sand 0.57%.

At station 10, the coral condition was *fair*. The ratio of coral life form was 40.57%. (There were corals in plating type 20.57%, massive and encrusting type 12.00%, branching type 5.71% and mushroom type 2.28%). The rest were dead corals 46.86%, old rubbles 11.43% and sand 1.14%.

Diversity indexes of corals at Mae Haad Bay from station 7–10 were 1.64, 1.42, 1.64 and 1.75 respectively. The amount of coral fragments found at station 7–10 were 3.02, 2.27, 2.82 and 3.44 pieces/m<sup>2</sup> respectively. At station 10, coral fragments were mostly found. The ratio of corals were: plating type 67.10%, branching *Acropora* spp. 14.19%, branching type 10.97%, Tabulate *Acropora* spp. 7.10% and other coral fragments 0.64%.

In the overall of coral reef around Mae Haad Bay at station 7 and station 8 close to the pier, dead corals were mostly found. At station 9, dead corals were also found. It was better at station 10, which was far away from the coast. Plating corals were mostly found.

#### 4.1.3 Chalok Baan Kao Bay

Chalok Baan Kao Bay coral reef is located in the south of Koh Tao. The collection was conducted at 6 stations at the depth between 3.5–5.0 meters. From the exploration, it was found that coral condition of station 11, 13, 14 and 15 were *poor to very poor*. On the average, the ratio of coral life form was 19.14%. (There were corals in *Acropora* spp. type 7.18%, plating type 7.12%, branching 1.90%, massive and encrusting type 1.48%, mushroom 1.04% and sub-massive 0.42%). The rest were dead corals 51.54%, old rubbles 27.39% and sand 1.93%.

The coral condition of station 12 and 16 were *very good*. On the average, the ratio of coral life form was 45.66%. (There were corals in plating type 20.77%, mushroom type 9.89%, massive and encrusting type 6.70%, branching type 4.07%, sub-massive 2.47% and *Acropora* spp. type 1.76%). The rest were old rubbles 37.69%, dead corals 9.73% and sand 6.87%.

Diversity indexes of corals at Chalook Baan Kao from station 11–16 were 0.96, 2.14, 1.35, 2.10, 1.08 and 1.46 respectively. The amount of coral fragments found at station 11–16 were 1.98, 4.56, 3.11, 2.24, 4.98 and 3.13 pieces/m<sup>2</sup> respectively. Coral fragments were mostly found at station 15. The ratio of corals were: branching *Acropora* spp. type 55.36%, branching type 36.16%, plating type 7.59% and tabulate *Acropora* spp. type 0.89%.

In the overall of coral reef around Chalok Baan Kao Bay at station 11 and station 15 close to the coast and station 13 and station 14 in the middle of the bay, the corals were deteriorated. Many coral fragments were found on shallow area due to the tide and wind. This area is influenced by southwestern trade-wind. Station 12 and station 19 are on deep areas, thus the coral reefs are fertile.

#### **4.1.4 Taa Chaa Bay**

The coral reef of Taa Cha Bay is located at the south of Koh Tao. The collection was conducted at 2 stations at the depth between 3.0–4.5 meters. From the exploration, it was found that the coral condition at station 17 and station 18 were *very poor*. On the average, the ratio of coral life form was 2.5%. (There were corals in sub-massive type 1.38%, *Acropora* spp. type 0.94% and plating type 0.17%). The rest were old rubbles 70.16%, dead corals 19.12% and sand 7.90%.

Diversity indexes of corals at Taa Cha Bay from station 17 and station 18 were 0.70 and 0.95 respectively. Coral fragments found at station 17 and station 18 were 1.78 and 1.33 pieces/m<sup>2</sup> respectively. Similar amount of coral fragments were found at station 17 and station 18. On the average, the ratios of corals were: plating type 53.75%, branching type 25.63% and branching *Acropora* spp. type 5.62%. Other coral fragments were 15.00%.

In the overall of coral reef around Taa Cha Bay, the corals were deteriorated. Old rubbles covered by seaweed were mostly found. This is influenced by natural disaster. Currently, the corals have attached on some points in the area.

#### 4.1.5 Thain Og Bay

Coral reef of Thian Og Bay is located at the south of Koh Tao. The collection was conducted at 4 stations at the depth between 2.0–3.5 meters. From the exploration, it was found that the coral condition at station 19, 20, 21 and 22 were *very poor*. On the average, the ratio of coral life form was 5.81%. (There were corals in sub-massive type 4.36%, *Acropora* spp. 0.64% and plating type 0.80%). The rest were dead corals 48.79% and old rubbles 45.40%.

Diversity indexes of corals at Thian Og Bay from station 19–20 were 0.81, 1.07, 0.52 and 0.98 respectively. The amount of coral fragments found at station 19–22 were 0.24, 0.44, 0.89 and 0.20 pieces/m<sup>2</sup> respectively. Few coral fragments were found around Thian Og Bay. On the average, the ratios of corals were: plating type 51.25%, branching *Acropora* spp. type 33.75%, branching type 8.75%, tabulate *Acropora* spp. type 5.00% and other coral fragments 1.25%.

In the overall of coral reef around Thian Og Bay, dead corals and old rubbles covered by macro algae were mostly found in the area. This is affected by natural disaster similarly to Taa Cha Bay.

#### 4.1.6 Sai Daeng Bay

Coral reef of Sai Daeng Bay is located at the south of Koh Tao. The collection was conducted at 2 stations at the depth between 1.7–4.0 meters. From the exploration, it was found that coral conditions of station 23 and station 24 were *poor to very poor*. On the average, the ratio of coral living form was 1.31%. (There were corals in plating type 0.55%, sub-massive type 0.44%, mushroom type 0.27% and *Acropora* spp. type 0.05%). The rest were dead corals 2.19% and old rubbles 96.50%.

About diversity index of corals at Sai Daeng Bay from station 23, there was no diversity since only *Pocillopora* spp. was found. At station 24, the value was 1.18. The amount of coral fragments found at station 23 and 24 were 0.22 and 0.04 pieces/m<sup>2</sup> respectively. On the average, the ratios of corals were: plating type 55.00%

and other coral fragments 45.00%. In this area, there were few coral fragments. Most of them were old rubbles.

In the overall of coral reef around Sai Daeng Bay, old rubbles were found with seaweed covering most of the area. This is affected by natural disaster. At station 23, a few corals were beginning to settlement.

#### **4.1.7 Hin Ngam Bay**

Coral reef of Hin Ngam Bay is located at the east of Koh Tao. The collection was conducted at 2 stations at the depth between 1.5–4.0 meters. From the exploration, it was found that coral conditions at station 25 and station 26 were *very good*. On the average, the ratio of coral life form was 69.86%. (There were corals in massive and encrusting type 48.60%, plating type 7.71%, sub-massive type 7.71%, *Acropora* spp. type 5.79% and branching type 0.05%). The rest were sand 11.24%, bedrock 7.60%, dead corals 7.44% and old rubbles 3.86%.

Diversity indexes of corals at Hin Ngam Bay from station 25 and station 26 were 2.62 and 2.15 respectively. The amount of coral fragments found at station 25 and station 26 were 0.60 and 1.09 pieces/m<sup>2</sup> respectively. Few coral fragments were found at both stations. On the average, the ratios of corals were: plating type 71.05% and branching type 28.95%.

In the overall of coral reefs around Hin Ngam Bay were highly fertile. Dominant massive type, including *Porites* spp., *Favites* spp., and *Diploastrea* sp., could be found.

#### **4.1.8 Leuk Bay**

Coral reef of Leuk Bay is located at the southeast of Koh Tao. The collection was conducted at 4 stations at the depth between 1.5–3.5 meters. From the exploration, it was found that coral conditions at station 27 and station 28 were *good*. On the average, the ratio of coral living form was 54.75%. (There were corals in massive and encrusting type 32.10%, branching type 10.46%, plating type 6.58%, *Acropora* spp. type 4.66% and sub-massive 0.95%). The rest were dead corals 32.10%, sand 8.43% and old rubbles 4.72%.

Coral conditions at station 29 and station 30 were *very good*. On the average, the ratio of coral living form was 51.53%. (There were corals in massive and encrusting type 26.78%, plating type 14.24%, *Acropora* spp. type 5.42%, branching type 2.37%, sub-massive 1.70%, and mushroom type 1.02%). The rest were sand 18.31%, old rubbles 16.61% and dead corals 13.56%.

Diversity indexes of corals at Leuk Bay from station 27–30 were 2.22, 2.32, 2.36 and 2.21 respectively. Coral fragments were found at station 27 and station 28 only. The amounts were 1.33 and 0.64 pieces/m<sup>2</sup> respectively. A few coral fragments were found at both stations. On the average, the ratios of corals were: branching type 46.07%, plating type 44.94%, branching *Acropora* spp. type and other coral fragments 6.74%. At station 29 and 30, no coral fragment was found during exploration.

In the overall of coral reefs around Leuk Bay were fertile at station 27 and station 28. The coral reefs were highly fertile at station 29 and station 30. Most of them were massive type.

#### **4.1.9 Tanote Bay**

Coral reef of Tanote Bay is located at the east of Koh Tao. The collection was conducted at 6 stations at the depth between 1.5–6.0 meters. From the exploration, it was found that coral conditions at station 31, 32, 35 and 36 were *very good*. On the average, the ratio of coral living form was 44.54%. (There were corals in massive and encrusting type 21.48%, plating type 16.74%, mushroom type 4.92%, *Acropora* spp. type 0.77%, branching type 0.33% and sub-massive type 0.30%). The rest were old rubbles 17.80%, dead corals 15.82%, bedrock 14.75% and sand 7.09%.

Coral conditions at station 33 and station 34 were *poor* and *fair* fertile respectively. On the average, the ratio of coral living form was 43.10%. (There were corals in plating type 14.03%, massive and encrusting type 13.19%, *Acropora* spp. type 8.67%, branching type 3.91% and sub-massive 3.30%). The rest were dead corals 43.71%, sand 11.74% and old rubbles 1.45%.

Diversity indexes of corals at Tanote Bay from station 31–36 were 2.35, 1.26, 1.80, 2.38, 1.60 and 1.48 respectively. Coral fragment was not found at station 31 and 32. At station 33–36, the amounts of corals were 0.76, 0.73, 1.16 and 0.93

pieces/m<sup>2</sup> respectively. On the average, the ratios of corals were: plating type 72.05%, branching type 22.36%, tabulate *Acropora* spp. type 3.10%, branching *Acropora* spp. type 1.87%, and other coral fragments 0.62%.

In the overall of coral reefs around coastal shallow area of Tanote Bay at station 33 and station 34 were deteriorated. Old rubbles were found. However, the coral reef at deeper offshore area was highly fertile.

#### 4.1.10 Mao Bay

Coral reef of Mao Bay is located at the east of Koh Tao. The collection was conducted at 4 stations at the depth between 2.5–6.0 meters. From the exploration, it was found that coral condition at station 37 was *poor*. The ratio of coral living form was 16.38%. (There were corals in massive and encrusting type 13.67%, sub-massive type 1.69% and plating type 1.02%). The rest were bedrock 44.86%, dead corals 26.10%, sand 11.98% and old rubbles 0.68%.

Coral condition at station 38 was *very good*. The ratio of coral living form was 40.11%. (There were corals in massive and encrusting type 34.44% and sub-massive type 5.67%). The rest were bedrock 30.45%, dead corals 18.11%, sand 10.22% and old rubbles 1.11%.

Coral conditions at station 39 and station 40 were *fair*. The ratio of coral living form was 20.75%. (There were corals in massive and encrusting type 13.80%, sub-massive type 4.87%, plating type 1.74% and *Acropora* spp. type 0.34%). The rest were bedrock 23.39%, dead corals 20.75%, sand 31.46% and old rubbles 3.59%.

Diversity indexes of corals at Mao Bay from station 37–40 were 2.09, 1.88, 1.66 and 1.48 respectively. The amount of coral fragments found at station 37, 39 and 40 were 0.87, 0.64 and 0.42 pieces/m<sup>2</sup>. No coral fragment was found at station 38 during the exploration. On the average, the ratios of corals were: plating type 70.11%, branching type 24.14% and branching *Acropora* spp. type 5.75%.

In the overall of coral reef around Mao Bay, submerged rocks were mostly found. At station 37, the coral reef was deteriorated. It was fertile at station 38 because the area was deeper groove of bedrock. The corals at station 39 and station 40 were moderately fertile.

#### 4.1.11 Hin Wong Bay

Coral reef of Hin Wong Bay is located at the east of Koh Tao. The collection was conducted at 4 stations at the depth between 1.5–8.0 meters. From the exploration, it was found that coral conditions at station 41 and station 42 were *good*. On the average, the ratio of coral living form was 30.60%. (There were corals in massive and encrusting type 12.90%, plating type 11.37%, branching type 3.89%, sub-massive type 1.95%, mushroom type 0.43% and *Acropora* spp. type 0.06%). The rest were sand 20.44%, dead corals 20.07%, old rubbles 20.07% and bedrock 8.82%.

Coral conditions at station 43 and station 44 were *very good*. On the average, the ratio of coral living form was 40.72%. (There were corals in plating type 15.75%, massive and encrusting type 13.65%, mushroom type 6.17%, *Acropora* spp. type 4.07%, sub-massive type 0.66% and branching type 0.42%). The others were sand 19.16%, old rubbles 16.41%, dead corals 15.63% and bedrock 8.08%.

Diversity indexes of corals at Hin Wong Bay from station 41–44 were 1.51, 2.30, 1.63 and 1.76 respectively. Coral fragments found at station 41–44 were 1.00, 0.31, 1.36 and 0.69 pieces/m<sup>2</sup> respectively. On the average, the ratio of corals were: plating type 72.85%, branching type 20.53%, branching *Acropora* spp. type 3.97% and tabulate *Acropora* spp. type 2.65%.

In the overall of coral reefs around Hin Wong Bay at station 41 and station 42 were highly fertile. There were dense corals at shallow area. The deeper area was covered by sand and old rubbles.

#### 4.1.12 Mango Bay

Coral reef of Mango Bay is located at the north of Koh Tao. The collection was conducted at 4 stations at the depth between 3.0–6.0 meters. From the exploration, it was found that coral condition at station 45 was *fair*. The ratio of coral living form was 31.45%. (There were corals in plating type 13.86%, massive and encrusting type 11.57%, *Acropora* spp. type 3.01%, branching type 2.41% and sub-massive 0.60%). The rest were dead corals 30.72%, sand 29.40% and old rubbles 8.43%.

Coral condition at station 46 was *very poor*. The ratio of coral living form was 20.37%. (There were corals in plating type 7.41%, massive and encrusting type

6.79%, *Acropora* spp. type 4.32%, branching type 1.24% and sub-massive type 0.61%). The others were dead corals 46.30%, sand 20.99% and old rubbles 12.35%.

Coral conditions at station 47 and station 48 were *very good*. On the average, the ratio of coral living form was 48.02%. (There were corals in massive and encrusting type 41.54%, plating type 4.94%, sub-massive 1.11%, *Acropora* spp. type 0.31%, and branching type 0.12%). The others were dead corals 17.28%, old rubbles 14.51%, sand 10.49% and bedrock 9.70%.

Diversity indexes of corals at Mango Bay from station 45–48 were 2.07, 2.06, 1.32 and 1.57 respectively. No coral fragment was found at these 4 stations during exploration.

In the overall of coral reef around Mango Bay at station 45 was moderately fertile. However, coral reef at station 46 was highly deteriorated. Most were dead corals and sandy area. At station 47 and station 48, highly fertile coral reefs developed on bedrocks.

#### **4.1.13 Eastern Koh Nang Yuan**

About coral reefs around eastern coast of Koh Nang Yan, the collection was conducted at 4 stations at the depth between 1.8–3.2 meters. From the exploration, it was found that coral conditions at station 49 and station 50 were *very good*. On the average, the ratio of coral living form was 55.54%. (There were corals in plating type 41.05%, massive and encrusting type 9.15%, mushroom type 3.19%, sub-massive type 1.27% and branching type 0.88%). The others were dead corals 23.69% and old rubbles 20.11%.

Coral conditions at station 51 and station 52 were *very poor*. On the average, the ratio of coral living form was 5.00%. (There were corals in plating type 1.44%, *Acropora* spp. type 1.39%, sub-massive type 1.33%, mushroom type 0.56%, and massive and encrusting type 0.28%). The rest were old rubbles 82.82% and dead corals 12.17%.

Diversity indexes of corals at Eastern Koh Nang Yuan from station 49–52 were 1.44, 2.19, 1.33 and 1.47 respectively. No coral fragment was found at 4 stations of eastern Nang Yuan Island.

In the overall of coral reefs around Eastern Koh Nang Yuan at station 49 and station 50 were highly fertile. At station 51 and station 52 around Koh Nang Yuan pier, the coral reefs were highly deteriorated. Most were old rubbles covered by macro algae.

#### 4.1.14 Western Koh Nang Yuan

About coral reef around western cost of Koh Nang Yuan, the collection was conducted at 4 stations at the depth between 2.5–3.8 meters. From the exploration, it was found that coral conditions at station 53, 54 and 55 were *fair*. On the average, the ratio of coral living form was 20.62%. (There were corals in plating type 10.29%, mushroom type 4.17%, massive and encrusting type 3.60%, branching type 2.23%, sub-massive type 0.25% and *Acropora* spp. type 0.08%). The others were old rubbles 48.47%, dead corals 18.06%, sand 10.58% and bedrock 2.27%.

Coral condition at station 56 was *very good*. The ratio of coral living form was 32.93%. (There were corals in mushroom type 14.27%, plating type 12.44%, massive and encrusting type 4.27%, branching type 1.34%, sub-massive type 0.49% and *Acropora* spp. type 0.12%). The others were old rubbles 42.32%, dead corals 13.78% and sand 10.98%.

Diversity indexes of corals at Western Koh Nang Yuan from station 53–56 were 1.17, 1.21, 1.49 and 1.67. The amount of coral fragments found at station 53–56 were 1.87, 2.24, 1.04 and 3.36 pieces/m<sup>2</sup> respectively. Coral fragments were mostly found at station 56. The ratios of corals were: plating type 73.51%, branching *Acropora* spp. type 22.52%, tabulate *Acropora* spp. type 2.65% and branching type 1.32%.

In the overall of coral reefs around Western Koh Nang Yuan at station 53, 54 and 55 were moderately fertile. Coral reefs were mostly found at shallow areas. *Pavona* corals and *Fungia* corals were mostly found.

**Table 4-1** Condition of coral reefs at each station in Koh Tao

Area	Station	Depth. (m.)	Coral Condition	Shannon diversity index	Fragment (fragment/m <sup>2</sup> )
Sai Ree Bay	1	4.0-6.0	5	2.27	1.42
	2		5	2.01	9.87
	3		5	2.11	1.73
	4		5	1.33	2.76
	5		5	1.99	0.98
	6		5	2.42	0.82
Mae Haad Bay	7	1.5-4.5	1	1.64	3.02
	8		1	1.42	2.27
	9		1	1.64	2.82
	10		3	1.75	3.44
Chalok Baan Kao Bay	11	3.5-5.0	1	0.96	1.98
	12		5	2.14	4.56
	13		1	1.35	3.11
	14		1	2.10	2.24
	15		2	1.08	4.98
	16		5	1.46	3.13
Taa Cha Bay	17	3.0-4.5	1	0.70	1.78
	18		1	0.95	1.33
Thian Og Bay	19	2.0-3.5	1	0.81	0.24
	20		1	1.07	0.44
	21		1	0.52	0.89
	22		1	0.98	0.20
Had Sai Daeng Bay	23	1.7-4.0	1	0.00	0.22
	24		3	1.18	0.04
Hin Ngam Bay	25	1.5-4.0	5	2.62	0.60
	26		5	2.15	1.09
Leuk Bay	27	1.5-3.5	4	2.22	1.33
	28		4	2.32	0.64
	29		5	2.36	0.00
	30		5	2.21	0.00
Tanote Bay	31	1.5-6.0	5	2.35	0.00
	32		5	1.26	0.00
	33		2	1.80	0.76
	34		3	2.38	0.73
	35		5	1.60	1.16
	36		5	1.48	0.93
Mao Bay	37	2.5-6.0	2	2.09	0.87
	38		5	1.88	0.00
	39		3	1.66	0.64
	40		3	1.48	0.42
Hin Wong Bay	41	1.5-8.0	4	1.51	1.00
	42		4	2.30	0.31
	43		5	1.63	1.36
	44		5	1.76	0.69

**Table 4-1** Condition of coral reefs at each station in Koh Tao (Cont.)

Area	Station	Depth. (m.)	Coral Condition	Shannon diversity index	Fragment (fragment/m <sup>2</sup> )
Mango Bay	45	3.0-6.0	3	2.07	0.00
	46		1	2.06	0.00
	47		5	1.32	0.00
	48		5	1.57	0.00
Eastern Nang Yuan	49	1.8-3.2	5	1.44	0.00
	50		5	2.19	0.00
	51		1	1.33	0.00
	52		1	1.47	0.00
Western Nang Yuan	53	2.5-3.8	3	1.17	1.87
	54		3	1.21	2.24
	55		3	1.49	1.04
	56		5	1.67	3.36

## 4.2 Coral reef zoning and utilization activities

### 4.2.1 Coral Reef Zoning

From the analysis on condition of coral reefs in Koh Tao by using fertility criterion of Department of Fisheries, coral reef zoning can be divided as follows.

(1) Conservation Zone: The coral conditions in this zone are *fair-very good*. The objective of conservation is to maintain and decrease the rate of biological diversity loss. The measure is in place to control and limit utilization activities to reduce the impact on coral reefs (Day, 2002).

(2) Rehabilitation Zone: The coral conditions in this area are *poor-very poor* due to natural factors and human. The objective is to restore its condition to be aquatic animals' habitat and maintain it for long term. The measure is in place for different levels. For example, decrease the utilization in deteriorated areas and allow it to restore naturally. Transplant living things and manage properly. (MNRE, 2005; Fernandes *et.al*, 2010)

**Table 4-2** Criterion of coral reef condition for zoning

Area	St	D (m.)	CC ( $\bar{X}$ )	H'	C Zone	R Zone	DC (St.)
Sai Ree Bay	1-6	4.0-6.0	5	1.33-2.42	✓		
Mae Haad Bay	7-10	1.5-4.5	2	1.42-1.75		✓	
Chalok Baan Kao Bay	11-16	3.5-5.0	3	0.96-2.14	✓		11, 13, 14, 15
Taa Cha Bay	17-18	3.0-4.5	1	0.70-0.95		✓	
Thian Og Bay	19-22	2.0-3.5	1	0.52-0.98		✓	
Had Sai Daeng Bay	23-24	1.7-4.0	2	0-1.18		✓	
Hin Ngam Bay	25-26	1.5-4.0	5	2.15-2.62	✓		
Leuk Bay	27-30	1.5-3.5	5	2.21-2.36	✓		
Tanote Bay	31-36	1.5-6.0	4	1.26-2.38	✓		33
Mao Bay	37-40	2.5-6.0	3	1.48-2.09	✓		37
Hin Wong Bay	41-44	1.5-8.0	5	1.51-2.30	✓		
Mango Bay	45-48	3.0-6.0	4	1.32-2.07	✓		46
Eastern Nang Yuan	49-52	1.8-3.2	3	1.33-2.19	✓		49, 50
Western Nang Yuan	53-56	2.5-3.8	4	1.21-1.67	✓		
<b>Note</b>	St: Station.		D: Depth of seabed. (meters)				
	CC: Average coral condition		H': Shannon diversity index				
	<b>C Zone:</b> Conservation zone, coral condition was fair to very good. (3-5)						
	<b>R Zone:</b> Rehabilitation zone, coral condition was poor to very poor. (1-2)						
	<b>DC:</b> Damaged coral partially area.						

From table 4-2, it can be concluded that unaffected coral reefs were Sai Ree Bay, Hin Ngam Bay, Luek Bay, Hin Wong Bay, and Western Koh Nang Yuan. Coral reefs' conditions were *fair-very good*. Some areas that were affected include Chalok Baan Kao Bay (station 11, 13, 14, 15), Tanote Bay (station 33), Mao Bay (station 46), Mango Bay (station 37), and Eastern Koh Nang Yuan (station 51, 52). The areas almost totally affected include Mae Haad Bay, Tacha Bay, Thian Og Bay, and Sai Daeng Bay. The coral conditions were *poor-very poor* deteriorated.

From the criterion of coral reef condition, the researcher will divide the zoning of fertile coral reefs (coral conditions were *fair-very good*) as Conservation Zone (Green Zone), including Sai Ree Bay, Chalok Baan Kao Bay, Hin Ngam Bay,

Luek Bay, Tanote Bay, Mao Bay, Hin Wong Bay and West Koh Nang Yuan. The areas of deteriorated coral reefs (coral conditions were *poor-very poor*) as Rehabilitation Zone (Yellow Zone), including on coral reef some area of Mae Haad Bay, Chalok Baan Kao Bay (station 11, 13, 14, 15), Tanote Bay (station 33), Mao Bay (station 46), Mango Bay (station 37) and Eastern Koh Nang Yuan specific on station 51 and station 52 as shown in (figure 4-2).

#### **4.2.2 Marine Tourism activities**

From the survey and interview with relevant persons (Appendix B), marine and coastal tourism activities around Koh Tao and Koh Nang Yuan can be classified. It was found that diving, including SCUBA and snorkeling were main activities favored by tourists. The next activities were other recreations on the beach. The detail of utilization activities in each area is as follows.

**4.2.2.1 SCUBA:** The coast around Koh Tao is approximately 14-18 meters depth and offshore area is approximately 30 meters. Therefore, one can dive around the island depending on the skill of diver. There are many diving points that guides usually take tourists to (Koh Tao Eco-Travel Mini Magazine & Map, 2012), such as coral reefs area or coastal submerged rocks to offshore area and diving point around Shark Island, which is the habitat of black tip shark looking for food in the morning at Thian Og Bay, Sai Daeng Bay, Hin Ngam Bay and Luek Bay. In addition, during July–August, we can watch whale shark that comes to look for food. It can be found at the southeast and northwest of Koh Tao.

**4.2.2.2 Snorkeling:** At near shore, coral reefs can be easily accessed. Tourists like to do snorkeling or swimming at that area. In some areas, group tour organizers take tourists on board to watch corals at each diving spot inside and outside of the area marked by buoy line. Each spot is averagely 1.5-5.0 meters depth. There are 6 popular areas in Koh Tao, namely Sai Daeng Bay, Luek Bay, Tanote Bay, Hin Wong Bay, Mango Bay and Eastern Koh Nang Yuan. These are included in group tour program. Every spot is marked by pontoons as snorkeling area to serve tourists around Mae Haad Bay, Tacha Bay, SaiDaeng Bay, HinNgam Bay, Luek Bay, Tanote

Bay, Hin Wong Bay, Mango Bay, Eastern and Western Koh Nang Yuan. Mooring buoys can be found at every area except Mao Bay.

**4.2.2.3 Recreation:** Marine and coastal recreations for study or relaxation include kayaking, sailing, windsurfing, and wake & ski. Each activity is found all over Island's coast. Moreover, tourists like to swim and sun bath on the beach. The potential areas suitable as tourist attractions occupy 553.74 rai (Bennui, 2006), scattered around the beaches. The beaches that can be easily accessed include Mae Haad Bay, Chalok Baan Kao Bay, and Sai Ree Bay. About Koh Nang Yuan, tourists have to rent the boat to travel. The roads that are inconvenient to access due to narrow and dangerous parts include Luek Bay, Sai Daeng Bay, Hin Wong Bay, and Mango Bay. (OMCRC, 2012)

From the survey on marine tourism activities of Koh Tao (Table 4-3), utilization area can be separated into 2 main types as follows. (1) Dive Zone: There will be snorkeling area for service. Protected coral reef areas are arranged for tourists to dive. There are diving sites at coral reefs, bedrock and artificial reef inside and outside of the bay. The guides bring tourists here. (2) Development Zone: This is construction zone to serve tourists. It is also public service for recreations (Figure 4-3).

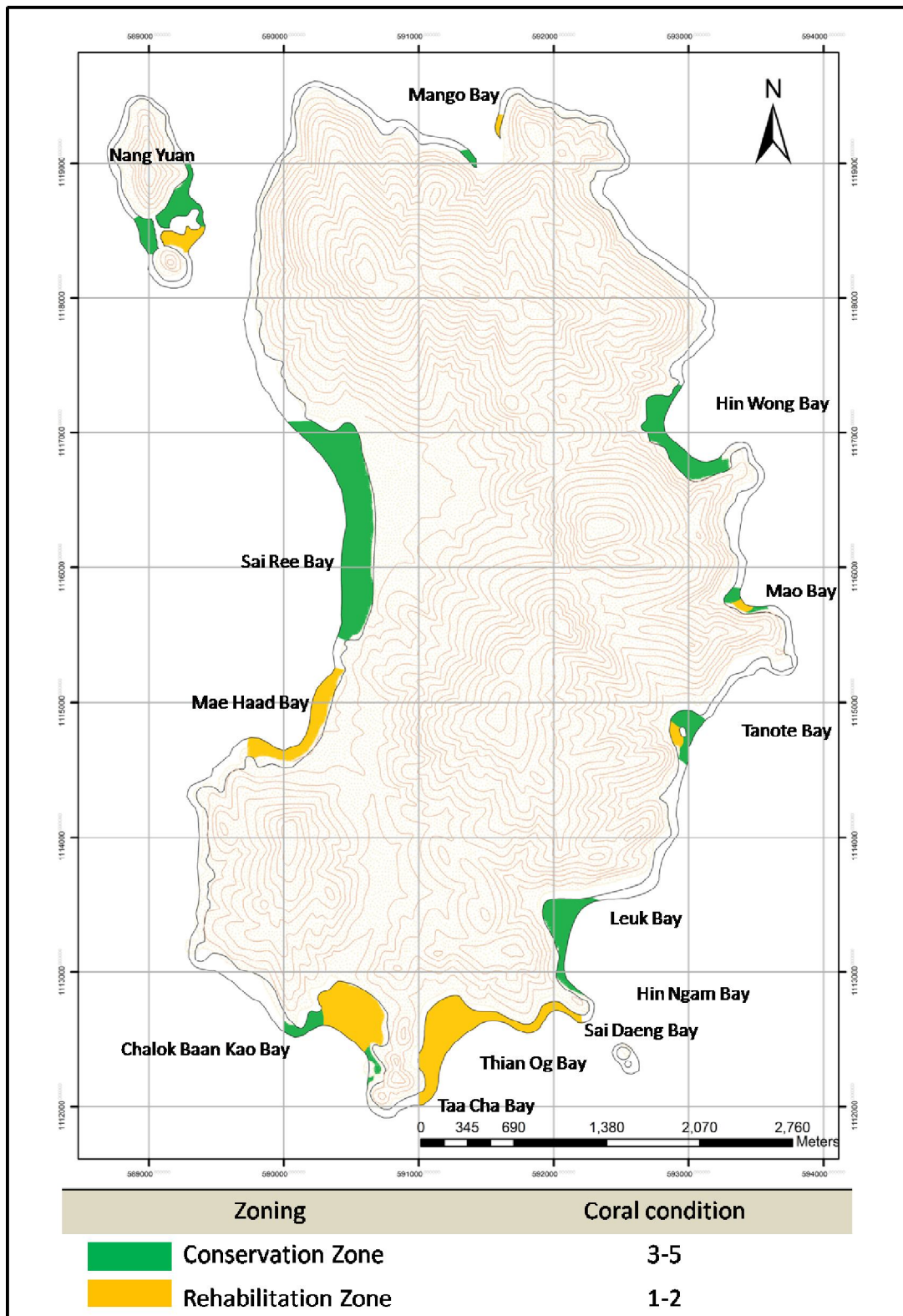


Figure 4-2 Map showing coral reefs zoning of Koh Tao

**Table 4-3** Marine tourism activities from the survey and in-depth interview

Area	Dive Zone						Development Zone	
	Snorkeling area			Dive site			Beach	Pier
	Group tour	Buoy area	Mooring buoy	Coral reef & rock	Artificial coral reef	Marine animals		
Sai Ree Bay	x	x	✓	x	x	x	✓	x
Mae Haad Bay	x	✓	✓	x	x	x	✓	✓
Chalok Baan Kao Bay	x	x	✓	x	x	x	✓	x
Taa Cha Bay	x	✓	✓	x	x	x	✓	x
Thian Og Bay	x	x	✓	x	x	✓	✓	x
Had Sai Daeng Bay	✓	✓	✓	x	x	✓	✓	x
Hin Ngaam Bay	x	✓	✓	✓	✓	✓	x	x
Leuk Bay	✓	✓	✓	✓	x	✓	✓	x
Tanote Bay	✓	✓	✓	✓	✓	x	✓	x
Mao Bay	x	x	x	✓	x	x	x	x
Hin Wong Bay	✓	✓	✓	✓	x	x	✓	x
Mango Bay	✓	✓	✓	✓	x	x	✓	x
Eastern Nang Yuan	✓	✓	✓	✓	x	x	✓	✓
Western Nang Yuan	x	✓	✓	✓	✓	x	✓	x
<b>Note</b>	✓ found      x Not found <b>Snorkeling area:</b> Provision for Snorkeling and swimming. <b>Dive site:</b> Provision for SCUBA diving. <b>Development Zone:</b> Intensive use and easy accessed area include multiple activities.							

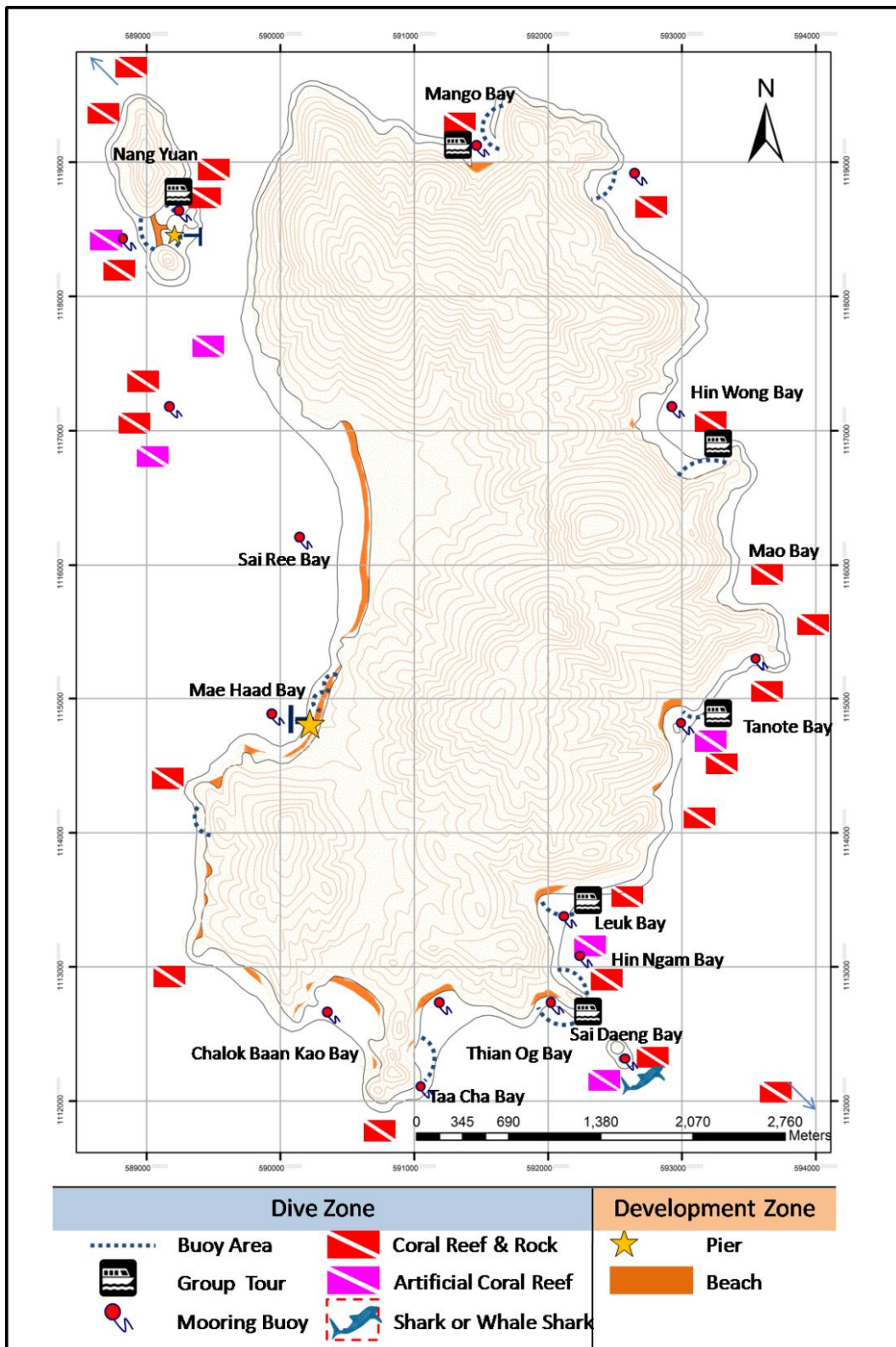


Figure 4-3 Map showing marine tourism activities of Koh Tao

When considering on ecological information of coral with marine tourism activities information, the researcher is able to classify the impact from degradation of coral reefs in divided zones by: (1) Natural factor: In 1989, Gay typhoon and the first coral bleaching phenomena in the Gulf of Thailand caused high death rate of *Acropora* spp. (Yeemin *et al.*, 2006) (2) Human factor: In the areas of coral reefs that can be accessed easily, tourists are able to walk from the beach to dive and watch corals. At some points, where mooring buoys are not enough, they will drop the anchor. Developing public service and invading the rainforest cause the sediment impact on coral reefs (Table 4-4).

**Table 4-4** Classification of degradation condition of corals

Area	Conservation Zone	Rehabilitation Zone		
	Not effect	Natural hazards	Human factors	
			Dives and anchoring	land development
Sai Ree Bay	✓			
Mae Haad Bay				✓
Chalok baan kao Bay	✓	✓		
Taa Cha Bay		✓		
Thian Og Bay		✓		
Had Sai Daeng Bay		✓		
Hin Ngaam Bay	✓			
Leuk Bay	✓			
Tanote Bay	✓		✓	
Mao Bay	✓	✓		
Hin Wong Bay	✓			
Mango Bay	✓		✓	
Eastern Nang Yuan	✓			✓
Western Nang Yuan	✓			