The status of coral reefs of Surin Islands, Thailand based on surveys in December 2003

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1. Introduction

Surin Islands, a relatively unspoiled group of islands located in the Andaman Sea, approximately 60 km off the coast of Phang-Nga Province, Thailand (Fig. 1.1). They comprise five main islands: Koh Surin Nua, Koh Surin Tai, Koh Ree, Koh Klang and Koh Torinla. The location is a few kilometers from the border with Myanmar and about 100 km from Thailand's Mu Koh Similan National Park.

The islands are recognized for their diverse and rich marine life as well as research and tourism potential. In 1981, Surin Islands were gazetted as the 29th National Park of Thailand and placed under the jurisdiction of the Marine National Park Division, Royal Forestry Department. The park covers approximately 135 km^2 (09^{o}21'50''N – 09^{o}3'30''N; 97^{o}48'00''E – 97^{o}54'25''E) of which 76% is sea. The islands are indented with wide sandy bays protected by rocky headlands, with fringing reefs dominating. The islands are located far from mainland and away from pollution. The pollution-free waters as well as adjacent deep water and strong ocean currents provide an ideal environment for the growth of corals. Apart from the pristine coral reefs, the islands are covered by relatively undisturbed forests extending several hundred metres above sea level. These tropical forests are dominated by dipterocarps. Besides coral reefs and tropical rainforests, Surin Islands are also dotted with beach forests and patches of mangroves.

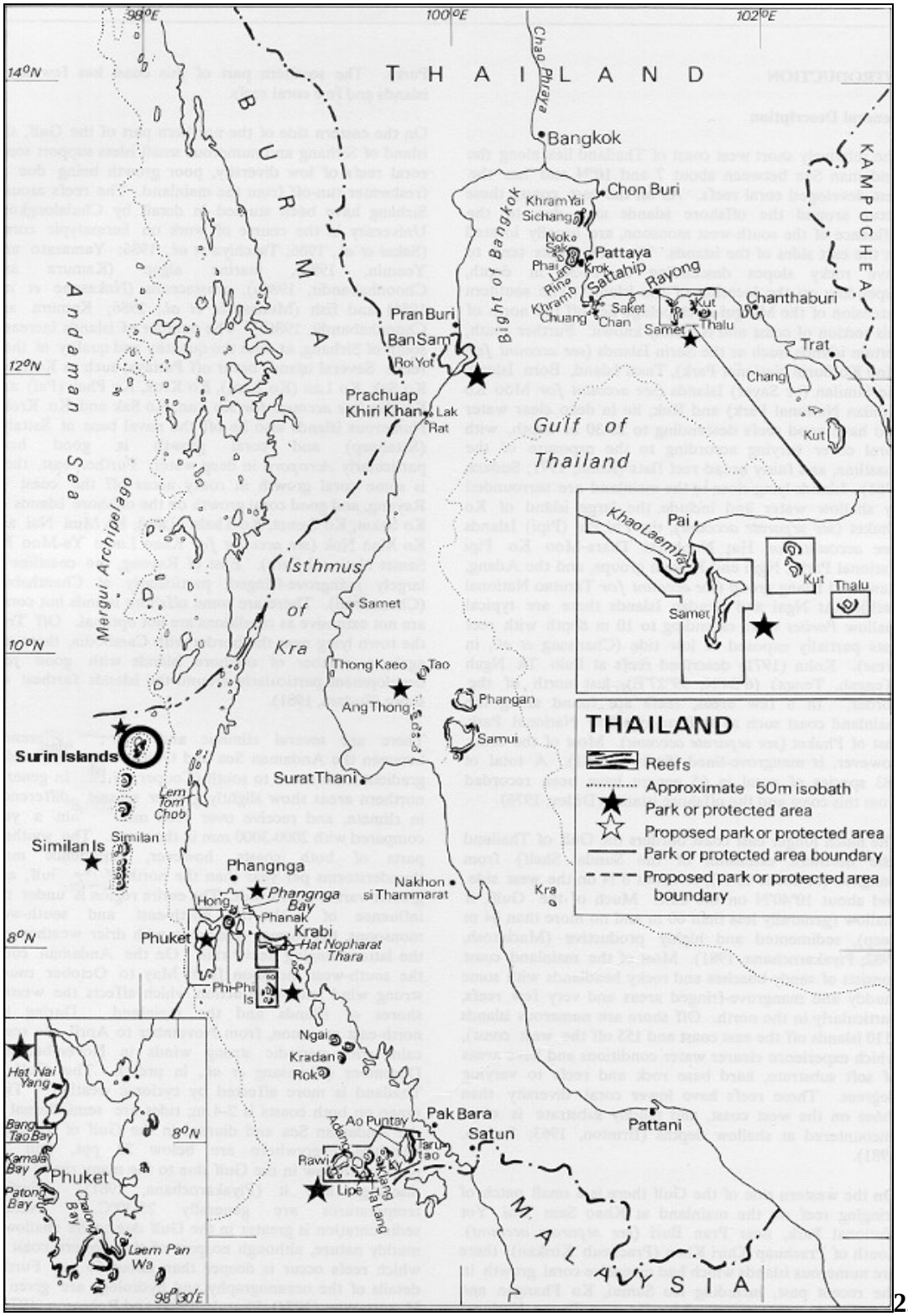
Surin Islands are affected by monsoons six months a year. They are closed to tourists from May to November. During the accessible months, many tourists, mainly Thais visit the islands. There are no resorts on the islands. Tourists stay in simple bungalows or tents

at the marine park's headquarters. Tourists visit Surin Islands mainly to snorkel as well as to enjoy the white sandy beaches. There are no dive operators on the islands. The only divers are those who arrive on live-aboard boats. Despite the increasing number of tourists visiting the islands each year, Mu Koh Surin Marine National Park has been very successful in managing the park. The park is recognized as the best marine park in Thailand (Sudara and Yeemin, 2001). This was achieved through strict enforcement of fisheries regulations by park rangers. Mooring buoys were established at snorkeling and diving sites all around the islands to discourage boats from dropping anchors. Active research and monitoring are also carried out by the marine park in collaboration with Kasetsart University and the Phuket Marine Biological Center.

Surin Islands are also home to a group of 170 sea gypsies or Mokens. They are nomadic and spend a lot of time traveling on their boats. They collect shellfish and spear fish for sustenance. They also harvest resources such as *Pandanus* leaves, wood from trees and medicinal plants from the forests. With the declaration of Surin Islands as a marine park, the foraging and fishing activities of the Mokens were restricted. However, they continued to gather shellfish and sea urchins for food and collect sea shells to exchange for rice and other necessities (UNESCO, 2001). During the monsoon months, they stay on the islands for shelter. In recent years, they have adopted a more sedentary lifestyle. It is feared that their collecting patches may be overexploited. It is thus a challenge for the authorities to ensure that the Mokens' unique way of life is preserved and at the same time the environment remains protected.

The objectives of this expedition, YEP Surin 2003 were: 1) to assist in the documentation of the diversity of the marine environment around Surin Islands, with emphasis on the conditions of coral reefs and the status of commercially important reef fishes and invertebrate populations, and 2) to interact with the Mokens and better understand their way of life in order to involve them in the Park's management. This expedition was organized by the Department of Biological Sciences, National University of Singapore, hosted by Mu Koh Surin Marine National Park, Thailand. It was partially funded by the Singapore International Foundation and sponsored by the Lee Foundation. The other partners of this expedition are Ramkhamhaeng University, Kasetsart University, Chulalongkorn University, Burapa University, Department of Coastal Resources, Thailand and United Nations Environment Programme (UNEP). This expedition took place from 7 December 2003 to 24 December 2003. The 22 volunteers who participated were Singapore youths aged 19-30 from various disciplines. They were trained by researchers from the National University of Singapore for a month to carry out reef surveys before embarking on the 18-day expedition.

Figure 1.1: Location of Surin Islands in the Andaman Sea



2.

Source: Coral Reefs of the World Volume 2: Indian Ocean, Red Sea and Gulf.

Materials and Methods

2.1 General Methodology

A total of 10 reef sites around Surin Islands were surveyed (Figure 2.1). Table 2.1 lists the sites and their GPS location. These sites were selected to cover as wide an area as possible. All surveys were conducted using Reef Check methodology with some modifications in the methodology of benthic surveys. Full details of the methodology are available at www.reefcheck.org.

At each site, four transects (each 20 m long) were used for the fish visual census, invertebrate census and benthic census. Fibreglass measuring tapes each 20 m long, were laid with a 3 to 5 m gap in between transects. Where there is a distinct reef profile (distinct reef crest and reef slope), the tapes were laid at two depths: reef crest (0 m) and reef slope (3 to 6 m below reef crest). Four pairs of divers were assigned to complete each set of transects. A pair of divers laid the tapes, the second pair conducted the fish visual census, the third pair performed the invertebrate transect survey and the last pair completed the benthic transect survey before the tapes were reeled in. The deeper transects of each site were completed first before proceeding on to the shallow transects.

Of the 10 survey sites, Mai Ngam Noi 1 and 2, Mai Ngam 1 and 2, Ko Klang and Hin Kong had no distinct reef profile, hence only one depth was surveyed. Ao Tao 2 had a distinct reef profile but due to constraints of time and resources, only one depth could be surveyed. For ease of data analysis, transects lying within 0 m to 7 m depth are regarded

as shallow transects. Those within 7.1 m to 12 m of the reefs are regarded as deep transects.

Figure 2.1: Map of Surin Islands showing survey sites.

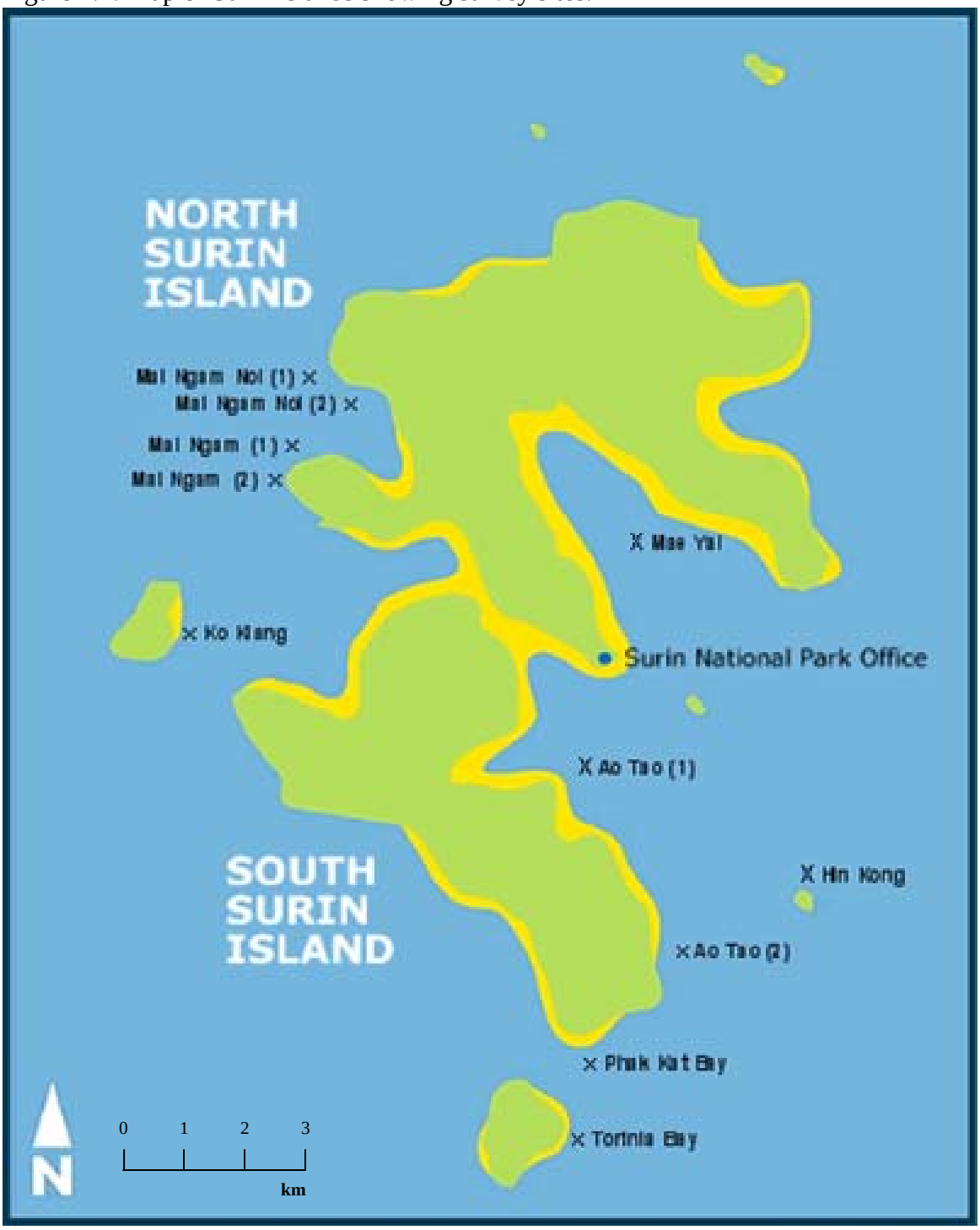


Table 2.1: GPS coordinates of sites surveyed between 11 December 2003 and 19 December 2003.

Sites	GPS Readings	Depths surveyed	Date
Mai Ngam Noi 1	97°51'27E 09°26'38N	Shallow (6 m)	11 December 2003
Mai Ngam Noi 2	97°51'27E 09°26'38N	Deep (9 m)	11 December 2003
Mai Ngam 1	97°51'16"E 09°26'13"N	Deep (8 m)	12 December 2003
Mai Ngam 2	97°51'16"E 09°26'13"N	Shallow (5 m)	12 December 2003
Torinla Bay	097°52'16N 09°22'10E	Shallow (7 m) Deep (10 m)	15 December 2003
Phak Kat Bay	097°52'48E 09°22'50N	Shallow (6 m) Deep (9m)	16 December 2003
Mae Yai	097°52'47E 09°22'50N	Shallow (3.6m) Deep (9.8 m)	17 December 2003
Ko Klang	097°50'05E 09°25'15N	Shallow (6 m)	18 December 2003
Ao Tao 1	097°52'53E 09°26'33N	Shallow (7 m) Deep (12 m)	18 December 2003
Hin Kong	97°52'53E 09°23'33E	Shallow (5.2 m)	19 December 2003
Ao Tao 2	97°52'58E 09°23'14N	Deep (7.1 m)	19 December 2003

2.2. Fish Visual Census

The Reef Check target fish groups were included in the surveys (Table 2.2). They were either commercially important or indicators of anthropogenic pressures influencing the reef site. Groupers counted were those larger than 30 cm length. Parrotfishes counted were those larger than 20 cm.

For all fish visual censuses, a lag period of 15 minutes was given after tape laying to allow the fishes to settle. Fishes within 2.5 m of either side of the tape and 5 m vertically above the tape were noted. The surveyor stopped at every 5 m along each transect tape for 3 minutes to allow the fishes to adapt to the presence of the divers. After the 3 min wait, the surveyors swam slowly to the next survey point while counting fishes encountered along the way. There were eight recording points along each transect and a total of 32 recording points for a set of four transects. The absolute number of fishes was recorded unless they were too numerous for which abundance categories (eg. 1-50, 50-100, 100-150 etc) were used (see Appendix A for a sample of a Fish Visual Census form). Fishes such as the Napoleon Wrasse (*Chelinius undulates)* or Bumphead Parrotfish ((*Bolbometapon muricatum)* were counted even if they were sighted more than 2.5 m away from either side of the tapes. This is because they are not strictly reef fishes and do not always swim close to reefs. Rare fishes such as sharks and rays, if any, were also recorded.

2.3 Invertebrate Belt Transect

Reef Check target invertebrate groups were included in the surveys (Table 2.3). Presence or absence of these target groups indicate the degree of harvesting pressures on the reef as well as the general health of the reef. Surveyors documented and calculated target invertebrates within 2.5 m on either side of the transect tapes. The area surveyed along each transect tape is 100 m^2. A total area of 400 m^2 was surveyed for each set of four transects (see Appendix B for a sample of an Invertebrate Belt Transect form).

2.4 Benthic surveys

The benthic survey methodology was a modification of the Reef Check method and GCRMN Line Intercept Transect method. Point sampling was used in the benthic surveys. Substratum type was recorded at each 0.25 m point along the transect tape instead of at each 0.5 m point as specified in the Reef Check method. There were 80 points on each transect tape and a total of 320 points for each set of four transects. A total of 30 benthic codes representing biotic and abiotic components of the reef were used (Table 2.4). The 30 codes are adopted from the GCRMN method (see Appendix C for a sample for a Benthic Survey form).

2.5 Environmental Parameters

For every site surveyed, a Site Description Datasheet (Appendix D) was completed. Important information such as the GPS readings of the survey site, temperature, underwater visibility under water, proximity to population centres and anthropogenic effects on the site were recorded. An assessment of the general reef condition was

completed for every site. Assessment parameters included coral damage by anchors and dynamite fishing. Trash such as abandoned fish nets on the reefs was also noted.

Table 2.2: List of target fish for the Reef Check Methodology.

1. Groupers (Size > 30 cm) (Family Serranidae)
2. Barramundi Cod (*Cromileptes altivelis;* Family Serranidae*)*
3. Sweetlips (Family Haemulidae)
4. Humphead Wrasse (*Chelinius undulatus*; Family Labridae)
5. Bumphead Parrotfish (*Bolbometapon muricatum*; Family Scaridae)
6. Other parrotfish (Family Scaridae)
7. Butterflyfish (Family Chaetodontidae)
8. Snapper (Family Lutjanidae)
9. Moray Eel (Family Muraenidae)

Table 2.3: List of target invertebrate groups for the Reef Check Methodology

Giant Clam - *Tridacna*
Pencil Urchin – *Heterocentrotus mammilatus*
Common urchins – *Diadema* spp.
Edible sea cucumbers – *Stichopus chloronotus* and *Thelenota ananas*
Crown-of-Thorns starfish – *Acanthaster planci*
Banded Coral Shrimp – *Srenopus hispidus*
Lobster
Triton shell – *Charonia tritonis*

Table 2.4: Lifeform codes used in the benthic surveys

Codes	Lifeforms	Remarks
Acropora corals		
ACB	Acropora – branching	
ACT	Acropora – tabular	
ACD	Acropora – digitate	
ACE	Acropora – encrusting	
ACS	Acropora –submassive	
Non-Acropora corals		
CB	Coral – branching	
CF	Coral – foliose	
CE	Coral – encrusting	
CM	Coral – massive	
CS	Coral - submassive	
CMR	Mushroom coral	
CME	*Millepora* (Fire Coral)	
CHL	*Heliopora* (Blue Coral)	
Dead corals		
DCA	Dead coral covered with algae	Corals that have been dead for sometime and covered with algae.
DC	Dead coral	Recently dead coral with white skeleton.
Algae		
AA	Algal assemblage	
TA	Turf algae	
MA	Macroalgae	Algae larger than 5 cm.
HA	*Halimeda*	
CA	Coralline algae	
Other Biotics		
SC	Soft coral	
ZO	Zoanthids	
SP	Sponge	
OT	Others	
Abiotics		
WA	Water	
S	Sand	
SI	Silt	
R	Rubble	
RCK	Rock	

3. Results

3.1 Fish Visual Census

On the reefs around Surin Islands, the most abundant fishes were butterflyfishes with a mean of 57 per 400m^2 at the shallow transects and 41.29 per 400m^2 (Table 3.1). Next were parrotfishes with a mean of 25.25 per 400m^2 at the shallow transects and 21.57 per 400m^2. Snappers were the third most abundant fish with a mean of 15.75 per 400m^2 at the shallow transects and 6.29 per 400m^2 at the deep transects. Groupers and sweetlips, the two families of commercially valuable fishes were few in numbers with a mean of 4.57-5.63 per 400m^2 and 1.71-2.63 per 400m^2 respectively. Only two Humphead wrasses and one Moray Eel were sighted throughout all the surveys (Table 3.2). Barramundi Cod and Bumphead Parrotfish were never sighted in any of the transects. There were no sightings of large predators such as sharks. Rays were uncommon. A few blue-spotted stingrays were spotted, but not within the transects.

The shallow transects of Torinla Bay had the highest total fish count (243) among all the sites (Table 3.2). The large fish count was contributed by high numbers of butterflyfish, snappers and parrotfish. This is followed by the shallow transects of Phak Kat Bay (154). Mai Ngam Noi 1 and Mai Ngam 1 both had a total fish count of 105 each. There is no observable trend in fish abundance between the shallow and deep transects although the shallow transects appeared to have higher fish counts than their corresponding deep transects with the exception of Ao Tao 1. Mai Ngam Noi 2 had the lowest fish count of 29 among all the sites. This was followed by Hin Kong (53) and the deep transects of Mae Yai (57).

Table 3.1: Abundance of target fishes for all survey sites (mean and SD per 400m^2)

	Shallow (n=8)		Deep (n=7)	
Target Fishes	**Mean**	**SD**	**Mean**	**SD**
Groupers (>30cm)	5.63	5.07	4.57	6.21
Barramundi Cod	0.00	0.00	0.00	0.00
Sweetlips	2.63	2.20	1.71	1.25
Snapper	15.75	29.23	6.29	5.47
Bumphead Parrotfish	0.00	0.00	0.00	0.00
Humphead Wrasse	0.13	0.35	0.14	0.38
Other parrotfish	25.25	15.30	21.57	14.43
Butterflyfish	57.00	22.17	41.29	14.85
Moray Eel	0.00	0.00	0.14	0.38

Table 3.2: Total number of fishes at all survey sites.

i) Shallow transects

Target Fishes	Torinla Bay	Phak Kat Bay	Mae Yai	Ao Tao (1)	Mai Ngam Noi (1)	Mai Ngam (2)	Ko Klang	Hin Kong
Groupers (>30cm)	7	16	1	8	7	3	2	1
Barramundi Cod	0	0	0	0	0	0	0	0
Sweetlips	6	3	5	3	1	0	3	0
Snapper	84	29	2	4	0	0	7	0
Bumphead Parrotfish	0	0	0	0	0	0	0	0
Humphead Wrasse	1	0	0	0	0	0	0	0
Other parrotfish	59	20	10	13	31	22	28	19
Butterflyfish	86	86	67	33	66	44	41	33
Moray Eel	0	0	0	0	0	0	0	0
Total	**243**	**154**	**85**	**61**	**105**	**69**	**81**	**53**

ii) Deep transects

Target Fishes	Torinla Bay	Phak Kat Bay	Mae Yai	Ao Tao (1)	Mai Ngam Noi (2)	Mai Ngam (1)	Ao Tao (2)
Groupers (>30cm)	12	15	2	2	1	0	0
Barramundi Cod	0	0	0	0	0	0	0
Sweetlips	2	4	1	0	2	1	2
Snapper	5	0	4	14	1	7	13
Bumphead Parrotfish	0	0	0	0	0	0	0
Humphead Wrasse	0	0	0	0	0	0	1
Other parrotfish	19	24	12	14	14	53	15
Butterflyfish	51	40	38	48	11	44	57
Moray Eel	0	0	0	1	0	0	0
Total	**89**	**83**	**57**	**79**	**29**	**105**	**88**

3.2 Invertebrate Belt Transects

The most abundant invertebrates in the surveys were the Giant Clams, *Tridacna* spp.with a mean of 9 per 400m^2 at the shallow transects and 19.71 per 400m^2 at the deep transects (Table 3.3). The highest count of 94 *Tridacna* occurred at Mai Ngam 1 (Table 3.4). The species of Giant Clams found on the reefs around Surin Islands were mostly *Tridacna crocea* (embedded in coral and rock). *Tridacna maxima* and *T. squamosa* were scarce.

The next most abundant invertebrate were the Long-spined urchins, *Diadema* spp. with a mean of 11.75 per 400m^2 at the shallow transects and 3.29 per 400m^2 at the deep transects (Table 3.3). The highest count of *Diadema* is 68 at Mai Ngam Noi 1 (Table 3.4). Most sites had no *Diadema*. Crown-of-thorns were present in low numbers with a total count of 22 in all the survey sites. Mai Ngam 2 had the highest number of Crown-of-thorns (8). Tritons and lobsters were seen only at two sites with a total count of three for each. Edible sea cucumbers were also low in numbers with only six recorded from two sites. Banded Coral Shrimps and Pencil Urchins were not seen at any of the survey sites.

Table 3.3 Mean number of target invertebrates at all survey sites (per 400m^2).

	Shallow (n=8)		Deep (n=7)	
Target invertebrates	**Mean**	**SD**	**Mean**	**SD**
Diadema	11.75	23.72	3.29	5.96
Pencil urchin	0.00	0.00	0.00	0.00
Edible sea cucumber	0.50	1.41	0.29	0.76
Crown-of-thorns	1.75	2.87	1.14	1.07
Giant clam	9.00	12.92	19.71	33.91
Triton	0.25	0.71	0.14	0.38
Lobster	0.00	0.00	0.43	0.79
Banded coral shrimp	0.00	0.00	0.00	0.00

Table 3.4: Total number of invertebrates at all survey sites.

Shallow transects

Target invertebrates	Mai Ngam Noi 1	Mai Ngam 2	Torinla Bay	Phak Kat Bay	Mae Yai	Ao Tao 1	Ko Klang	Hin Kong
Diadema	68	3	0	0	20	0	0	3
Pencil urchin	0	0	0	0	0	0	0	0
Edible sea cucumber	0	0	0	0	4	0	0	0
Crown-of-thorns	0	8	3	0	0	0	3	0
Giant clam	1	1	0	6	39	14	5	6
Triton	0	0	0	0	0	0	2	0
Lobster	0	0	0	0	0	0	0	0
Banded coral shrimp	0	0	0	0	0	0	0	0

Deep transects

Target invertebrates	Mai Ngam Noi 2	Mai Ngam 1	Torinla Bay	Phak Kat Bay	Mae Yai	Ao Tao 1	Ao Tao 2
Diadema	15	0	0	0	8	0	0
Pencil urchin	0	0	0	0	0	0	0
Edible sea cucumber	2	0	0	0	0	0	0
Crown-of-thorns	3	2	1	0	1	0	1
Giant clam	9	94	2	1	2	4	26
Triton	0	0	0	0	0	0	1
Lobster	1	0	0	0	0	2	0
Banded coral shrimp	0	0	0	0	0	0	0

3.3 Benthic surveys

Benthic composition of all sites is shown in Figure 3.5. Coral cover ranges from 39.16% to 85% (Figure 3.1). Ao Tao 2 had the highest coral cover of 85%. Its algae cover is correspondingly low (4.06%). Both the shallow and deep transects of Mae Yai also had high coral cover of 83.44% and 83.12% respectively. Mai Ngam (1) had the lowest coral cover of 39.16%. This site also had the highest percentage of algae (17.5%) and DCA (30.83%) while percentage composition of rubble is low (8.75%). The category 'DCA' denotes 'Dead Coral Algae' and represents corals that had been dead for sometime and overgrown by a film of algae. Ko Klang also had relatively low coral cover of 48.44%. This site had the highest percentage cover of rubble (27.5%). The category 'DC', recently dead corals ranged from 0% to 0.95%.

Corals were categorized into *Acropora* and non-*Acropora* corals in the surveys. *Acropora* corals are fast-growing and usually dominate any healthy and high-energy reef. *Acropora* on these reefs were mainly of the branching type (ACB). These corals are usually found at the shallower parts of the reefs. However, there is no trend in the survey results to support this (Figure 3.1). Percentage of *Acropora* coral ranged from 6.25% (Mae Yai– shallow) to 70.63% (Torinla Bay-shallow). Percentage of non-*Acropora* corals ranged from 2.5% (Hin Kong) to 77.19% (Mae Yai – shallow transects). There was no significant trend in the distribution of *Acropora* and non-*Acropora* corals between the shallow and deep transects.

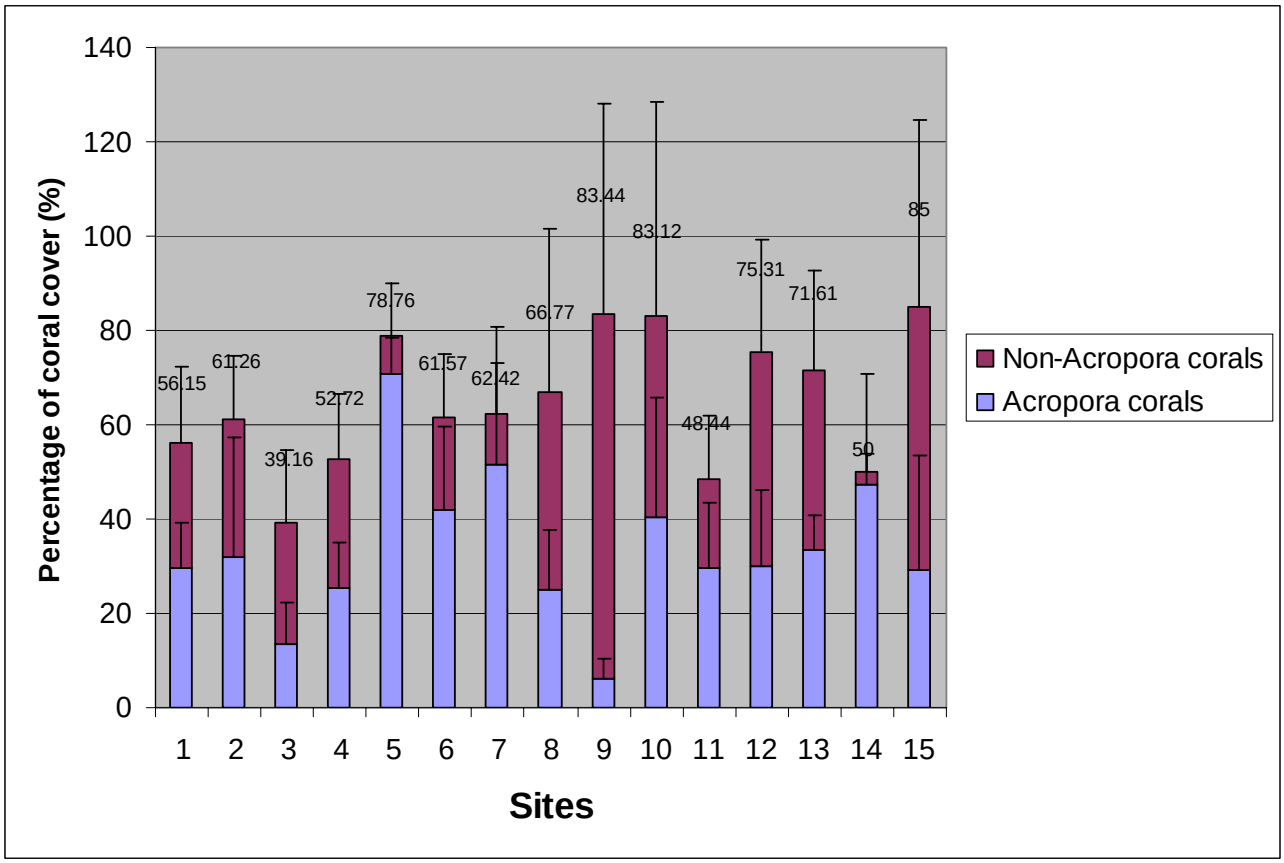
Algal cover on the survey sites was low, ranging from 0% to 0.94%, except for Mai Ngam 1 (17.5%). However, none of this was macroalgae. Percentage cover of sponges at all sites ranged from 0% to 0.63%. Both algae and sponge are indicative of nutrient levels in the water.

Table 3.5: Percentage composition of substratum from the benthic surveys.

Lifeform Category	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Acropora corals	29.65	31.88	13.33	25.56	70.63	41.88	51.59	25.08	6.25	40.31	29.69	30	33.44	47.5	29.06
Non-Acropora corals	26.5	29.38	25.83	27.16	8.13	19.69	10.83	41.69	77.19	42.81	18.75	45.31	38.17	2.5	55.94
Algae	0.32	0.31	17.5	1.6	0	0.94	0.64	0	0.9	0	0.31	0	0.63	0	0
Sand	1.58	7.83	0	7.03	0.63	2.19	0.64	0.63	0.94	0.94	2.5	0	2.2	16.88	0.31
Silt	0	0	0	0	0	0.31	0.64	0	0	0	0	0	0	0	0
Rock	2.21	1.88	3.75	3.51	0	9.69	9.55	0.94	0	0	1.88	4.38	8.52	2.81	8.13
Rubble	10.41	13.12	8.75	8.63	1.25	11.56	5.1	12.85	5.63	4.38	27.5	2.81	6.94	18.44	2.5
Water	7.26	0	0	8.31	0.63	1.56	0	0	0	1.56	0	5	2.52	0.31	0
Dead coral algae	22.08	14.69	30.83	16.93	18.75	8.75	19.43	16.61	9.06	8.44	15.94	12.5	4.42	8.44	4.06
Dead coral	0	0.63	0	0.32	0	0.63	0	0	0	0	0.94	0	0.95	0	0
Sponge	0	0	0	0	0	0.63	0	0	0	0	0	0	0.63	0	0
Zoanthid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soft coral	0	0	0	0.96	0	0	1.59	0	0.63	0.94	0.31	0	0.95	0	0
Others	0	0.31	0	0	0	2.19	0	2.19	0.31	0.63	2.19	0	0.63	3.13	0

Key: 1: Mai Ngam Noi (1); 2: Mai Ngam Noi (2); 3: Mai Ngam (1); 4: Mai Ngam (2); 5: Torinla Bay (shallow); 6: Torinla Bay (deep); 7: Phak Kat Bay (shallow); 8: Phak Kat Bay (deep); 9: Mae Yai (shallow); 10: Mae Yai (deep); 11: Ko Klang; 12: Ao Tao (1) (shallow); 13: Ao Tao (1) (deep); 14: Hin Kong; 15: Ao Tao (2).

Figure 3.1: Percentage of *Acropora* and non-*Acropora* cover for all survey sites.



Key: 1: Mai Ngam Noi 1; 2: Mai Ngam Noi 2; 3: Mai Ngam 1; 4: Mai Ngam 2; 5: Torinla Bay (shallow); 6: Torinla Bay (deep); 7: Phak Kat Bay (shallow); 8: Phak Kat Bay (deep); 9: Mae Yai (shallow); 10: Mae Yai (deep); 11: Ko Klang; 12: Ao Tao 1 (shallow); 13: Ao Tao 1 (deep); 14: Hin Kong; 15: Ao Tao 2.

3.4 Environmental parameters

The sites were pristine. No coral damage by anchors was observed at any of the reefs. Mooring buoys were present at all sites surveyed. Long-tail boats and tour boats were seen to comply with the Park's prohibition on dropping of anchors. No discarded fish nets were seen on the reefs. There were also no signs of blast fishing. The reefs were generally clean with no trash except for Ao Tao 2 where plastic bags, food packaging, empty cans and soft drink bottles were observed (Table 3.6).

Table 3.6: Assessment of reef conditions of all the survey sites

Scale of impact: None = 0; Low = 1; Medium = 2; High = 3

Survey Sites	**Coral damage by anchor**	**Coral damage by dynamite**	**Coral damage - others**	**Trash-Fish nets**	**Trash-Others**
Mai Ngam 1	0	0	0	0	0
Mai Ngam 2	0	0	0	0	0
Mai Ngam Noi 1	0	0	0	0	0
Mai Ngam Noi 2	0	0	0	0	0
Torinla Bay (shallow)	0	0	0	0	0
Torinla Bay (deep)	0	0	0	0	0
Phak Kat Bay (shallow)	0	0	0	0	0
Phak Kat Bat (deep)	0	0	0	0	0
Mae Yai (shallow)	0	0	0	0	0
Mae Yai (deep)	0	0	0	0	0
Ko Klang	0	0	0	0	0
Ao Tao 1 (shallow)	1	0	0	0	0
Ao Tao 1 (deep)	0	0	0	0	0
Hin Kong	0	0	0	0	0
Ao Tao 2	1	1	1	1	1

4. Discussion

4.1 Fish Visual Census

The reefs around Surin Islands support a diverse fish fauna. However, the abundances of these fishes are not high. This is especially noted for species which are greatly valued for the live fish trade, such as Barramundi Cod, Humphead Parrotfish and Napoleon Wrasse. These fishes were not sighted throughout the surveys except for the Napoleon Wrasse which was sighted twice. The numbers of other commercially valuable food fish such as groupers, sweetlips and snappers were low. Fishes not included in the surveys such as carangids and fusiliers were seen in small groups instead of the usual large schools. These may be indicators of harvesting pressure.

Butterflyfishes which are commonly used as bioindicators of reef health were present in high numbers. It is believed that the number of corallivorous butterflyfish on the reef correlate with coral cover (Bell and Galzin, 1984). The percentage coral cover at all the survey sites was generally high, ranging from 39.16% to 85%. This fits the postulation that high coral cover supports large numbers of butterflyfish. However, sites with very high coral cover, for example Ao Tao 2 with 85% coral cover did not have an exceptionally high number of butterflyfish compared to the other sites. Similarly, Mai Ngam 1 with the lowest coral cover of 39.16% did not have a very low number of butterflyfish. This can possibly be explained by the fact that not all the species of butterflyfishes sighted were obligate corallivores. Butterflyfishes sighted frequently included *Chaetodon meyeri, C. trifasciatus, C. andamanensis, C. trifascialis, C. collare, C. lunula, C. melannotus, C. falcula, C. lineolatus, C. rafflesii, C. auriga, C. trifascialis*

and *C. triangulum.* A few of the above-mentioned species feed exclusively on coral polyps while others are generalist feeders and can feed on invertebrates, algae and coral polyps (Table 4.1). The abundance and diversity of obligate corallivorous butterflyfishes alone will give a more accurate correlation with coral cover.

The next most abundant fish were parrotfishes. They are herbivorous and graze on algae. Scrape marks on massive corals were frequently observed. Parrotfishes play an important role on reefs by keeping algae growth in check. The presence of high numbers of parrotfish may explain the low algal cover apart from the low nutrient levels in the waters.

Table 4.1: Butterflyfishes recorded in Surin Islands and their diet.

Butterflyfish	**Diet**
Chaetodon meyeri	Feeds exclusively on coral polyps.
C. trifasciatus	Feeds exclusively in *Pocillopora* polyps.
C. collare	Feeds mainly on coral polyps.
C. andamanensis	Feeds mainly in coral polyps.
C. lunula	Feeds on invertebrates, algae and coral polyps.
C. melannotus	Feeds mainly on coral polyps.
C. falcula	Feed on invertebrates.
C. lineolatus	Feeds mainly on coral polyps.
C. rafflesii	Feeds on invertebrates, algae and coral polyps.
C. auriga	Feeds on invertebrates, algae and coral polyps.
C. trifascialis	Feeds exclusively on Acropora corals.
C. triangulum	Feeds mainly on coral polyps.

Information of the butterflyfish diet is obtained from www.fishbase.org and R. H. Kuiter, 2002.

4.2 Invertebrate Belt Transect

The most abundant invertebrate were Giant Clams. These are highly valued for their adductor muscles and mantle which are considered delicacies. Their shells are also popular with collectors. Most of the Giant Clams encountered on the reefs were *Tridacna crocea* which grow embedded in rocks or corals. This makes harvesting them difficult. The number of Giant Clams at the deeper transects (19.71 per $400m^2$) was significantly higher than the shallow transects (9 per $400m^2$). This may be due to greater harvesting difficulty at greater depth. The scarcity of *T. squamosa* and *T. maxima* which lie free on the bottom may be a result of over-harvesting.

Most survey sites had low or no *Diadema* urchins except for Mai Ngam Noi 1 where a relatively high count was noted. *Diadema* is often associated with the presence of algae. Low numbers of *Diadema* suggest that the reefs are relatively free of algae. This can also suggest that the reefs had healthy populations of herbivorous fishes such as parrotfish which help to keep the algae population in check. Edible sea cucumbers and tritons are very low in numbers indicating that they may have been over-harvested. Sea cucumbers are usually harvested for food while tritons are collected for their shells.

4.3 Benthic survey

Lifeform codes of the GCRMN method were used for these surveys as they provided more information than the 10 codes from Reef Check. With this modification, Reef Check data can still be easily extracted from the collected data. GCRMN method categorizes hard corals into *Acropora* and non-*Acropora* corals. This separation is useful.

For example, the presence of many massive *Porites* colonies, 2-3 m across shows that they have developed for several hundred years and implies that the reef is stable and free of disturbances for long periods. However, the presence of a high percentage of *Acropora* suggests that the reef is a high-energy one and frequently subjected to wave action (Sorokin,1993). *Acropora* being very opportunistic and fast-growing (15-20cm per year) will dominate a reef by number and area if environmental conditions are suitable.

Hard coral cover at the survey sites was relatively good. Three of the 11 survey sites (27.3%) fall under the 'fair' category where hard coral cover ranged from 25 to 50%, based on the criteria developed by ASEAN-Australia Living Coastal Resources Project (Chou *et al.*, 1994). Another three of the 11 survey sites (27.3%) fall under the 'good' category with hard coral cover ranging from 51 to 75%. Five sites (45.5%) fall under the 'excellent' category where hard coral cover was above 75%. The reefs around Surin Islands had high coral cover compared to the values given for Andaman Sea (Chou *et al.*, 2002). In that report, only 4.6% of the reefs in Andaman Sea were categorized as excellent, 12% good, 33% fair and 49.8% poor.

Mai Ngam Noi 1 and 2, Torinla Bay (both depths), shallow transects of Phak Kat Bay, Ko Klang and Hin Kong had more than 50% of the total coral cover consisting of *Acropora*. These reefs are probably more exposed and frequently subjected to strong wind and wave action.

Mai Ngam 1 had the lowest coral cover of all survey sites. 30.83% of the reefs was 'Dead Coral Algae' (DCA) and 17.5% was algae. The presence of high DCA showed that corals at this site were damaged previously either by storms or anthropogenic effects. This site had been dynamited in the past (www.talaythai.com). 9.1% of the algae was coralline algae suggesting that this site was not impacted by high nutrient level. Coralline algae are especially important to damaged reefs as they provide calcareous material to the reef structure and help to cement the reef together into a sturdy structure for future coral recruitment.

Ko Klang had the next lowest percentage of live coral cover (48.44%). It also had the highest percentage of rubble (27.5%) compared with the rest of the survey sites. There were no signs of blast fishing and the corals may have been storm damaged several years ago. The low percentages of algae and sponges showed that the sites were relatively free of high nutrient loads.

5. Conclusion

Thailand is estimated to have 153km^2 of coral reefs, half of which is found in the Andaman Sea (Chou *et al.,* 2003). Threats facing reefs in the Andaman Sea include destructive fishing practices such as trawling in the 1960s. However, these activities have declined, giving way to the increased level of tourism, Tourism brought about a different set of problems such as sedimentation, wastewater pollution, damage by boat anchors and divers, garbage, erosion, sewage and wastewater discharge (Burke *et al.,* 2002). The reefs of Andaman Sea also suffered from natural impacts such as coral bleaching. Reefs

suffered from extensive coral bleaching and mortality in 1991, 1995 and 1998 (Burke *et al.,* 2002).

Surin Islands were gazetted as a marine national park in 1981 and all fishing practices and harvesting were stopped. Commercial fishing within 3 km offshore was prohibited. Boats are not allowed to use anchors within the park but required to use the mooring buoys provided. The marine park is regularly patrolled by park rangers to ensure user compliance with rules and regulations. A park fee is also imposed on tourists visiting the islands. Tour boats require permits to enter the park. Long term monitoring was implemented by Phuket Marine Biological Station and Kasetsart University. Staff of Mu Koh Surin Marine Park were also trained in Reef Check and conduct their monitoring. With these successful practices in place, Mu Koh Surin Marine Park is recognized as the best marine park in Thailand. This is apparent from the reefs' high coral cover. Closure to the public for six months a year due to monsoons, gives the reefs a chance to recover from any anthropogenic effects. However, fishing by commercial operators immediately beyond the boundaries of the park may affect fish stocks within the park. Harvesting of invertebrates such as sea cucumbers, urchins and giant clams for subsistence by Mokens may have environmental impacts as well.

A long term and regular monitoring program should be established by the staff of the marine park. With consistent monitoring, any deterioration of the reef can be detected and the problem rectified as early as possible. The Mokens will benefit from education on

sustainable harvesting so that they do not deplete the reefs and at the same time still preserve their way of life.

More detailed information panel boards in Thai and English could be placed at the marine park's visitor centre to educate tourists of marine conservation. Educational talks can also be given to the tourists to increase their awareness of the marine environment.

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Appendix A: Fish Visual Census datasheet.

Coral Fish Visual Census

Site name:_____ Data recorded by:_____

Date:_____ Approximate depth of reef:_____

Transect No : _____

Target fish	Abundance	Total
Groupers (>30cm)		
Barramundi Cod		
Sweetlips		
Parrotfish (>20cm)		
Bumphead Parrotfish		
Humphead Wrasse		
Butterflyfish		
Snappers		
Moray Eel		
Rays		
Sharks		

Transect No: _____

Target fish	Abundance	Total
Groupers (>30cm)		
Barramundi Cod		
Sweetlips		
Parrotfish (>20cm)		
Bumphead Parrotfish		
Humphead Wrasse		
Butterflyfish		
Snappers		
Moray Eel		
Rays		
Sharks		

Appendix B: Invertebrate Belt Transect datasheet.

Reef Check 2003: Invertebrate Transect

Site Name:

Depth:_____ Team Leader:_____

Date:_____ Time:_____

Data recorded by:_____

Transect No: _____		**Total**
Banded coral shrimp		
Diadema urchins		
Pencil urchins		
Edible Sea cucumbers		
Crown-of-thorns		
Giant clam		
Triton shell		
Lobster		

Transect No: _____		**Total**
Banded coral shrimp		
Diadema urchins		
Pencil urchins		
Edible Sea cucumbers		
Crown-of-thorns		
Giant clam		
Triton shell		
Lobster		

Appendix C: Benthic survey datasheet.

Reef Check 2003: Benthic Transect

Site name
Depth:

Data recorded by:
Date:

Transect no.	
Transition (cm)	**Lifeform**
25	
50	
75	
100	
125	
150	
175	
200	
225	
250	
275	
300	
325	
350	
375	
400	
425	
450	
475	
500	
525	
550	
575	
600	
625	
650	
675	
700	
725	
750	
775	
800	
825	
850	
875	
900	
925	
950	
975	
1000	

Transition (cm)	**Lifeform**
1025	
1050	
1075	
1100	
1125	
1150	
1175	
1200	
1225	
1250	
1275	
1300	
1325	
1350	
1375	
1400	
1425	
1450	
1475	
1500	
1525	
1550	
1575	
1600	
1625	
1650	
1675	
1700	
1725	
1750	
1775	
1800	
1825	
1850	
1875	
1900	
1925	
1950	
1975	
2000	

Appendix D: Site Description datasheet

Site name:_____

BASIC INFORMATION

Country:_____ State/Province:_____ City/town:_____

Date: _____ Time: Start of survey: _____ End of survey: _____

Latitude (deg. min. sec): _____ Longitude (deg. min. sec) : _____

Distance from shore: _____m from nearest river: _____km

River mouth width: _____ <10m _____ 11-50m _____ 51-100m _____101-500m

Dist. to nearest population center: _____ km Population size: _____x1000

Weather: _____ sunny _____ cloudy _____raining

Visibility: _____m

Why is this site selected: _____ Is this best site in the area? _____Yes _____No

IMPACTS:

Is this site:	Always sheltered:_____	Sometimes sheltered: _____	Exposed:_____	
Major coral damaging storms	Yes:_____	No:_____	When was last storm:	_____
Overall Anthropogenic impact	None: _____	Low: _____	Med: _____	High: _____
Is siltation a problem	Never	Occasionally: _____	Often: _____	Always: _____
Dynamite fishing	None: _____	Low: _____	Med: _____	Heavy: ____
Poison Fishing	None: _____	Low: _____	Med: _____	High: _____
Aquarium Fishing	None: _____	Low: _____	Med: _____	High: _____
Harvest Inverts for Food	None: _____	Low: _____	Med: _____	High: _____
Harvest Inverts for curio sales	None: _____	Low: _____	Med: _____	High: _____
Tourist Diving/snorkeling:	None: _____	Low: _____	Med: _____	High: _____
Sewage Pollution	None: _____	Low: _____	Med: _____	High: _____
Industrial pollution	None: _____	Low: _____	Med: _____	High: _____
Commercial fishing	None: _____	Low: _____	Med: _____	High: _____
Fish for the live food fish restaurant trade	None: _____	Low: _____	Med: _____	High: _____
Artisinal/recreational	None: _____	Low: _____	Med: _____	High: _____
How many yachts are typically present within 1km of this site :	None: _____	Few (1-2): _____	Med (3-5): ____	Many (>5): _____

Other impacts: _____

PROTECTION:

Any Protection (legal or other) at this site?	Yes:_____	No: _____	if yes, answer questions below
Is protection enforced	Yes (full enforcement):_____	No:_____	
What is the level of poaching in protected area?	None: _____	Low: _____	Med: _____ High: _____

Check which activities below are banned:

Spearfishing _____
Commercial fishing _____
Recreational fishing _____
Invertebrate or shell collecting _____
Anchoring _____
Diving _____
Other (please specify) _____