ASSESSMENT OF THE CURRENT STATUS OF THREE SELECTED CORAL REEFS IN THE ANDAMAN SEA, THAILAND

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PREFACE

This report describes the results of a survey of the status of selected coral reefs in the Tarutao Marine National Park, Phi Phi Marine National Park and Phuket Island, Thailand. The survey was carried out during April-May 1997 on a voluntary basis as a contribution to the global snapshot survey called by the Global Coral Reef Monitoring Network (GCRMN), which is coordinated by AIMS in Australia and ICLARM in the Philippines. The network was established in association with the International Coral Reef Initiative (ICRI) to provide research and monitoring information on coral reefs and related ecosystems for more efficient management and long-term conservation. In response to the growing threats to coral reefs around the world, 1997 was declared the International Year of the reef (IYOR '97). The IYOR '97 campaign is intended as the public awareness and communications vehicle for the Coral Reef Initiative (ICRI) during 1997. The field team involved staff from Phuket Marine Biological Centre and Wetlands International - Thailand Programme and two additional volunteers. Advice was provided by members of the Underwater Research Group at the Prince of Songkla University, Hat Yai. The project was supported financially by the Royal Netherlands Embassy, Bangkok (Local Environmental Project ENV/TH002). The survey followed simple but standardized survey and monitoring methods described in English *et al.* (1994). The data from the survey were pooled in the ARMDES database, hosted at ICLARM, for comparison with data from other regions and joint publication under IYOR '97. It is the sincere hope of the authors that this report will contribute to the efforts made by the responsible management authorities to develop sustainable coral reef management in Thailand.

Hat Yai, September 1997.

ACKNOWLEDGMENTS

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CONTENTS

FIGURES

TABLES

SUMMARY

This report presents the findings of a rapid assessment survey of the status of a number of selected coral reef sites in three areas in the Andaman Sea, Thailand, carried out during April-May 1997 by a joint team of volunteers and staff from Wetlands International and Phuket Marine Biological Centre. The assessment was made as a contribution to the Global Coral Reef Monitoring Network and related activities for the International Year of the Reef (IYOR '97). The project was supported financially by the Royal Netherlands Embassy in Bangkok. The survey followed relatively simple, standardized and internationally accepted methodologies. A total of 10 reefs sites were surveyed in the Tarutao Marine National Park, Phi Phi Marine National Park and Phuket Island. These surveys included a total of 182 manta tows of two minutes each (163 at Tarutao, 10 at Phi Phi and 9 at Phuket) and 34 line intercept transects of 20 m each (2 at Tarutao, 26 at Phi Phi and 6 at Phuket). The manta tows and line intercept transects provided a wealth of information on the current status of these reefs. The surveyed reefs had between 14 and 85 % dead coral (usually covered in a thin layer of algae). Living coral cover ranged from 14 to 67 % of the substrate. On average the ratio of live to dead coral cover was 1.2 : 1. The survey revealed significant indications of reef damage as a result of fishing activities, including incidental damage caused by highly destructive blast fishing techniques. The occurrence of such damage (even) within a marine protected area (Tarutao) is of concern, and stresses the need for involvement of the local fishing community in the management and conservation of these coral reef resources.

Recovery of reefs damaged years ago by severe storms, Crown-of-Thorns Starfish, *Acanthaster planci* infestations or pressure from destructive fishing appeared slow (assessed through comparison with earlier assessment and monitoring data). The best stretches of coral reef (i.e. with a high cover of structurally intact and diverse coral and other reef organisms) were found along the west coast of Adang Island and around Phi Phi Don Island (esp. transects at 5 m depth). A total of 76 Crown-of-Thorns Starfish were counted in the Tarutao area, with the highest number (42 animals) encountered along the east coast of Adang Island in the Tarutao Marine National Park. However, these numbers of the *Acanthaster* starfish are no reason for concern. Densities of *Diadema* sea urchins were generally high in the Tarutao archipelago and fairly low in the other reefs surveyed. Particularly high densities of these sea urchins are related to high fishing pressure and may hamper recovery of degraded reefs. The results obtained using the two methodologies compared well with one another and with data obtained several years ago using the same methods (Tarutao area). Despite the occurrence of a localized oil spill from a ferry accident at Phi Phi island during May, no evidence at the time of the survey could be found of any damage to the corals in this area due to the alleged oil pollution. Some minor occurrences of coral bleaching were recorded at some sites around the Adang and Lipe islands in Tarutao National Park, but the extent of this was negligible.

The report concludes with a summarized review of current management and monitoring activities of the coral reefs in Thailand, and some suggestions for future monitoring and management of the surveyed reefs. It is felt that there is a need to enhance the integration between the research and monitoring activities with the management authorities of the coral reef areas, to further increase dissemination and accessibility of the monitoring information, and to combine management and research with a strong conservation awareness campaign for the general public. Involvement of local communities in the management of the marine protected areas may prove successful in reducing damage from destructive fishing activities.

1.0 INTRODUCTION

1.1 General background

Coral reefs, often referred to as "rainforests of the sea", are among the most complex, diverse and economically valuable ecosystems in the world. They have high biological diversity and occur in shallow waters throughout the tropics. Coral reefs are found in over 100 countries of the tropical seas. Up to 3,000 animal and plant species may co-exist on a single reef, while reef structures can form tens of metres high and thousands of kilometres long, taking generations to form. They are of vital importance to many large islands and continental margins for the protection of land against storms and rough seas, and for the subsistence livelihood of coastal people. Their support to productive fisheries and recreational fisheries cannot be overemphasized. It has been estimated that one square kilometre of healthy coral reef can produce between 12 and 50 tonnes of seafood each year (World Bank, 1996).

A full cover of living coral on a reef slope

Although coral reef ecosystems are complex and of high biological diversity, they are not stable and as such are highly variable and sensitive to disturbance. A conservative estimate is that 10% of the earth's reefs are seriously degraded and a much larger percentage is threatened, particularly in areas adjacent to human populations. The proximity of many coral reefs to the coast exposes them, not only to subsistence pressures but also, to human-induced stresses such as land-based pollution (industrial, agro-chemical and sewage) and sedimentation (from land clearing, reclamation and mining). Declines in species richness in the marine environment due to habitat damage and loss have been attributed to human resource exploitation and pollution (Guzman, 1991; Salvat, 1987). The ongoing degradation of the world's reefs represents a significant loss of marine biodiversity and of valuable resources that would have otherwise been available for sustainable utilization by present and future generations.

Natural catastrophic events such as storms, warming events (often followed by secondary disturbances such as algal blooms and strong upwelling), periods of elevated seawater temperature, exposure to air during extreme low tides and Crown-of-Thorns starfish, *Acanthaster planci* outbreaks have also been reported to contribute to mass coral mortality in the last few decades. The available but scattered information about the status of the world's coral reefs indicates an alarming rate and level of degradation in line with the general deterioration of the condition of the world's coastal marine environment (Rogers, 1985; Brown, 1987; Birkeland, 1988; Sindermann, 1988; UNEP/IUCN, 1988; Williams and Bunkley-Williams, 1990). In combination with elevated SST and UV radiation levels and the anticipated sea level rise, the general coastal environmental degradation caused by man is likely to further aggravate the condition of the world's coral reefs. The alarming reports on the deterioration of the world's coral reefs, however, have led to increased interest in the management of these valuable, complex and beautiful ecosystems. In response to this a Global Coral Reef Monitoring Network was formed as part of a Global Coral Reef Initiative, and (most recently) 1997 was declared the "International Year of the Reef" (IYOR '97).

The coastline of Thailand extends for 2,614 km, comprising coastal areas within the Gulf of Thailand and bordering the Andaman Sea. A majority of Thailand's population (reportedly almost 70 %) live adjacent to the coast. Whereas most coral reefs in the Gulf of Thailand are generally less abundant and diverse (60 spp.), the Andaman Sea Coast harbours richer and more spectacular coral reefs with approximately 200 spp. (UNESCO, 1986). There are 268 species of hard coral in the reference collection at PMBC (Phongsuwan, pers. com.). The major reefs are found in 12 of the 23 coastal provinces. As anywhere else in the world, development of coastal areas has imposed a high pressure on Thailand's coral reefs. Besides land-based pollution and sedimentation, a high demand is put on Thailand's coral reefs and other coastal ecosystems from fisheries, tourism and research. These threats continue to increase in the wake of the country's rapid economic development. As a result, conflicts over the use of reef resources have intensified, calling for keen, urgent and purposeful implementation of strategies already laid down to manage and protect the coral reefs.

result, conflicts over the use of reef resources have intensified, calling for keen, urgent and purposeful implementation of strategies already laid down to manage and protect the coral reefs.

To support the 1997 International Year of the Reef, the Global Coral Reef Monitoring Network launched a one-off pilot programme to assess the status of coral reefs around the world. Data from different reefs around the world collected using standardized methodology will be pooled and presented as a snapshot overview of the status of the world's coral reefs during 1997. The present study aimed to contribute to this initiative with a rapid assessment of selected coral reefs in Thailand.

1.2 Objectives

The objectives of this survey were:

(1) To assess the current status of three selected coral reef areas in the Andaman Sea, Southern Thailand, using simple standardized methodology; and

(2) To provide a contribution from Thailand to the Global Coral Reef Monitoring Network for the publication of a special study for the International Year of the Reef (IYOR'97) on the status of the world's reefs.

Where possible, the study results were compared with existing information from literature and reports on earlier assessments and surveys. It is hoped that by making the information obtained during this study available to a wider audience, including scientists and managers, this report will make a valuable contribution to the research and management of coral reefs in Thailand.

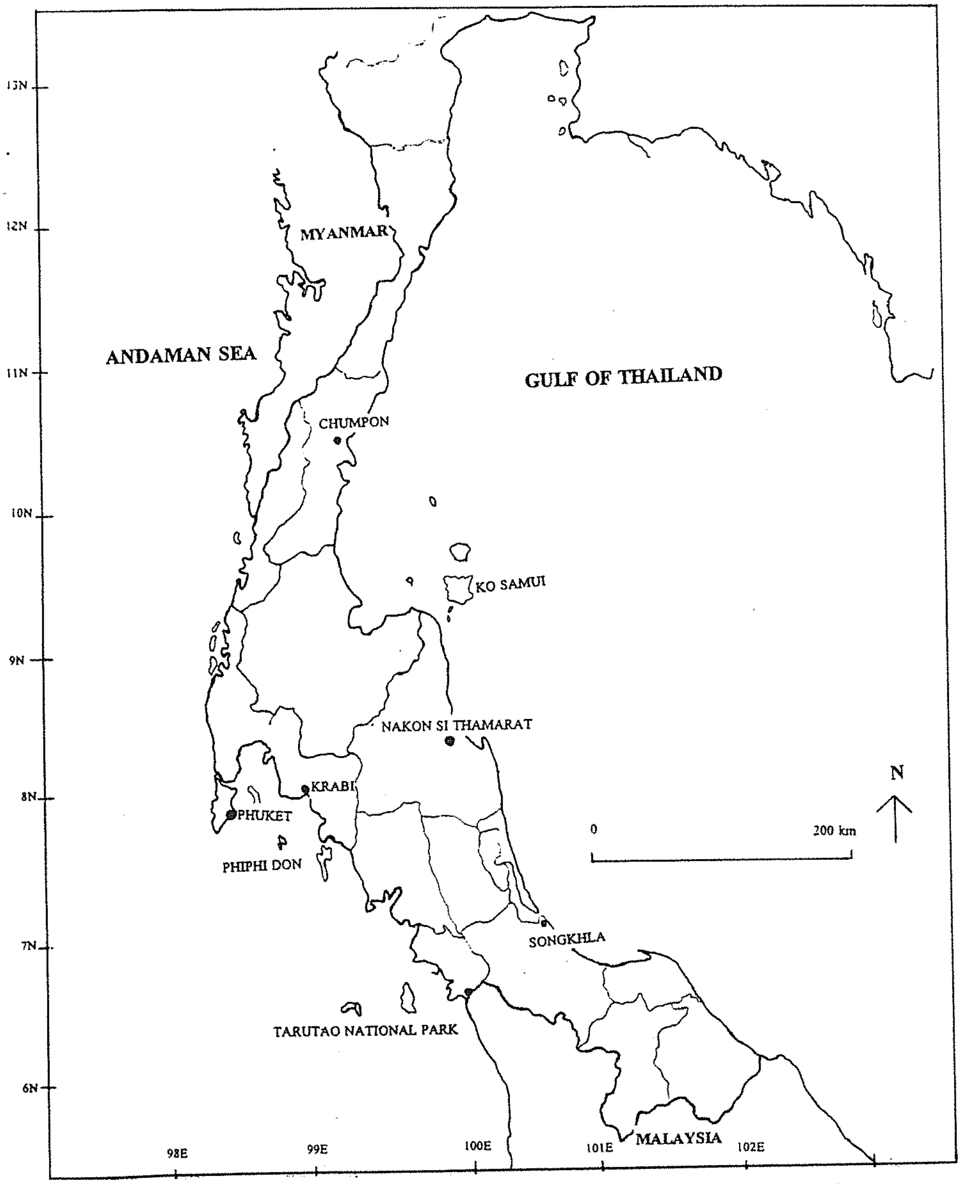


Figure 1. Map of Southern Thailand showing study areas, Ko Phi Phi, Ko Phuket and Tarutao Marine National Park

2.0 STUDY AREA

Three areas in the Andaman Sea along the west coast of peninsular Thailand were selected for this survey. It is almost impossible to have an ideal site selection for this kind of survey that allows for the assumption of reasonable representativeness for the Andaman Sea at large. The criteria used for site selection took into consideration practical aspects, such as accessibility, accommodation facilities and other logistics, availability of information from previous surveys, existing monitoring activities, and suggestions from cooperating institutions. The three areas that were chosen, namely the Tarutao Archipelago, the Phi Phi Island group in the Krabi region, and Phuket (see Figure 1), all have vast areas of reefs that are believed to encompass most of the situations and threats typical of Thai coral reefs.

Adang Island in Tarutao Marine National Park

Tarutao archipelago:

The Adang Rawi island group, approximately 6°30'N 99°15'E, situated in the Tarutao Marine National Park in the Andaman Sea (Fig. 2), was a good representative site. The area had been intensively surveyed during 1983 - 84 when it showed an

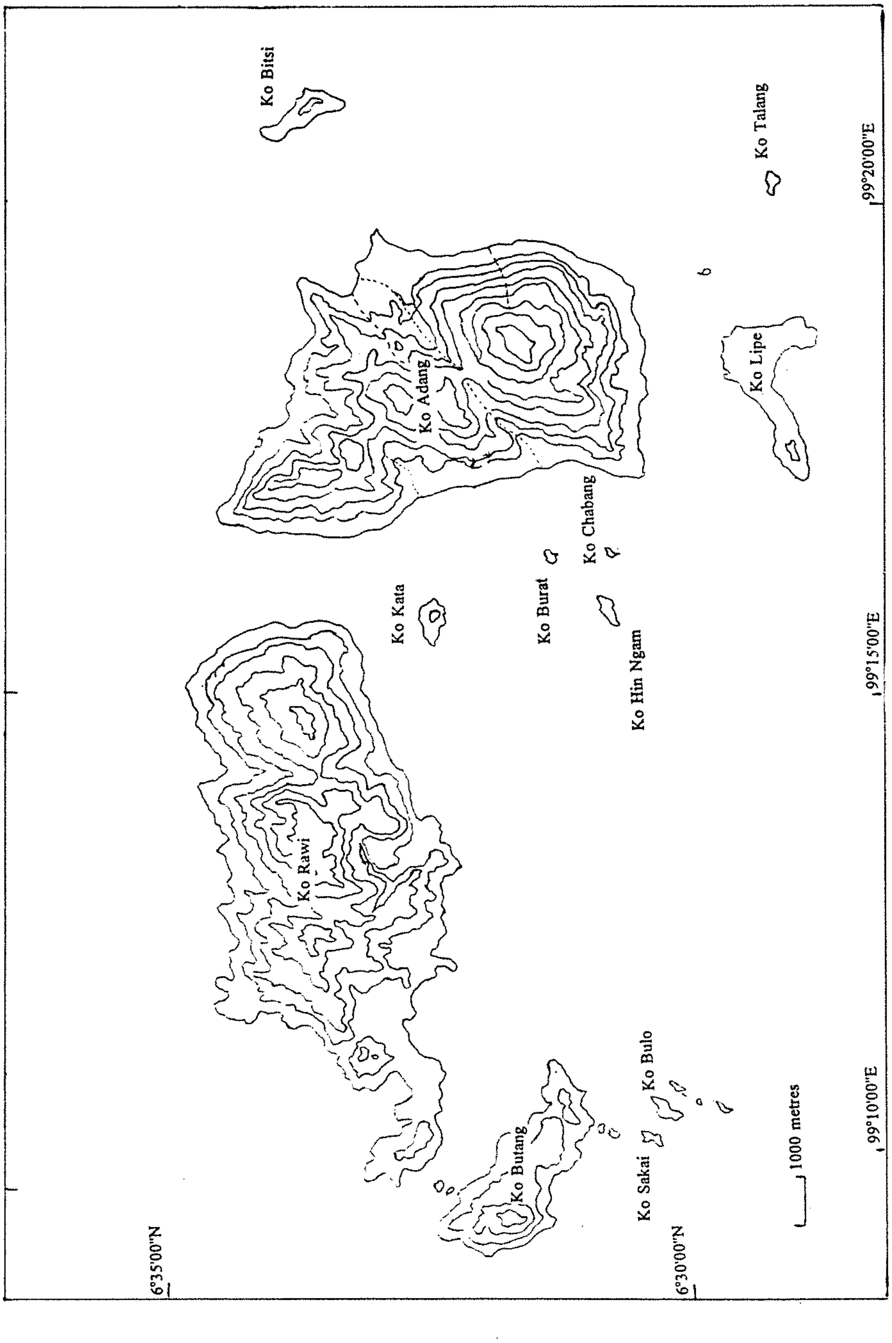
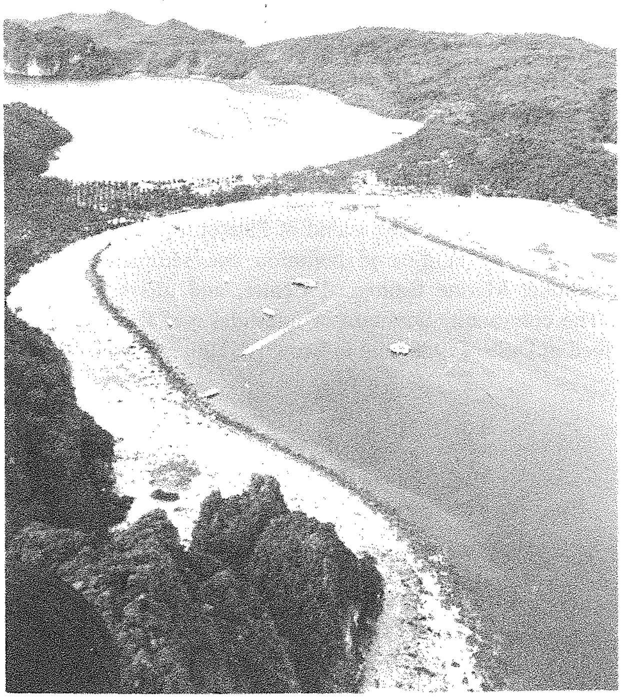


Figure 2. Map of Adang-Rawi island group in the Tarutao National Park

unspoiled, diverse and well-developed coral reef community. Consecutive surveys of the same area in the framework of the ASEAN - Australian Living Coastal Resources Project indicated gradual degradation of these reefs. It was deemed worth surveying, exactly ten years later, in order to update the existing information. Sites surveyed in this area were Adang Island (about 8 km across), Lipe Island (3 - 4 km across) and Talang Island (only a few hundred metres across). A full description of this area is given in Geater *et al.* (1989).



Phi Phi Don Island

Phi Phi island group:

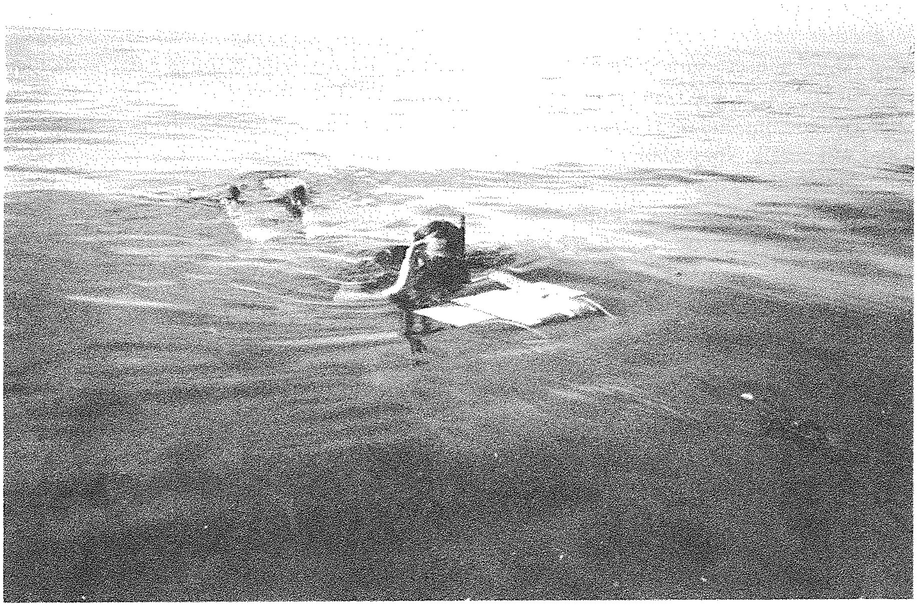
The Phi Phi island group, approximately 7° N, 98°45' E, is situated about 40 km from Krabi coast and is protected as a marine national park. The islands constitute the major reefs in the Krabi region. These limestone islands, which have steep underwater slopes covered in rich coral growths, were proposed for the survey, being among the best known and probably most frequer islands. The reefs in this area are probably more threatened by a high concentration (activities as a result of which they may be exposed to physical damage from SCUE snorkelling, and swimming, nutrient influx from sewage from the hotels, oil leaks severely, by boat grounding, anchoring and shoreline development. Two sites at Phi Phi Sai Bay and Yongkasem Bay, were surveyed. A ferry boat which sank recently off Phu and led to an oil spill of about 11,000 litres in the area near Phi Phi further prompted the this area for the survey.

Phuket island:

Reefs around Phuket island are found at approximately 5 - 15 m depth. The only site at that could be surveyed before the onset of the southwestern monsoon made further impossible was the pier reef at Cape Panwa, situated at approximately 7°48' N, 98°25' I is characterized by a mean annual temperature of approximately 28 °C and a seawater approximately 33 ppt. Phuket and the surrounding islands harbour more than 20% of coral reefs, including some of its most diverse reefs (Lemay and Chansang, 1989). More reefs on this island are found on the western coast (leeward side), which is not expo influence of the SW monsoon winds (Phongsuwan and Chansang, 1992) between November. Most of the reefs around the island of Phuket itself have been degraded by and dredging, as well as by land-based pollution and sedimentation. The reefs are monitored by the Phuket Marine Biological Centre, and this survey added to the i already gathered. The community structure of intertidal reef flats around the southeast Phuket was described in Ditlev (1978) and in Brown & Holley (1982, 1984).

3.0 MATERIALS AND METHODS

In order to obtain an assessment of reef status that would allow for checking of changes in future, this survey followed general survey and monitoring methods as described in English *et al*., (1994). These methods have been chosen as "standards" by the UNEP-IOC-WMO-IUCN meeting on a long-term global monitoring system of coastal and nearshore phenomena related to climate change, and confirmed by the UNEP-IOC-IUCN-ASPEO Global Task Team on the implications of climate change on coral reefs in 1992. These procedures allow for long-term monitoring, were designed to reduce observer bias, and can easily be repeated (being well-documented). Practical modifications of these methods were sometimes made to increase their effectiveness, depending on available time and expertise. Basic data (time, date, location, study site, water depth, sea state, cloud cover, wind strength, water transparency by secchi measurements, and personnel), were recorded to enable comparison in future monitoring.



The Manta Tow method

3.1 Manta Tow technique

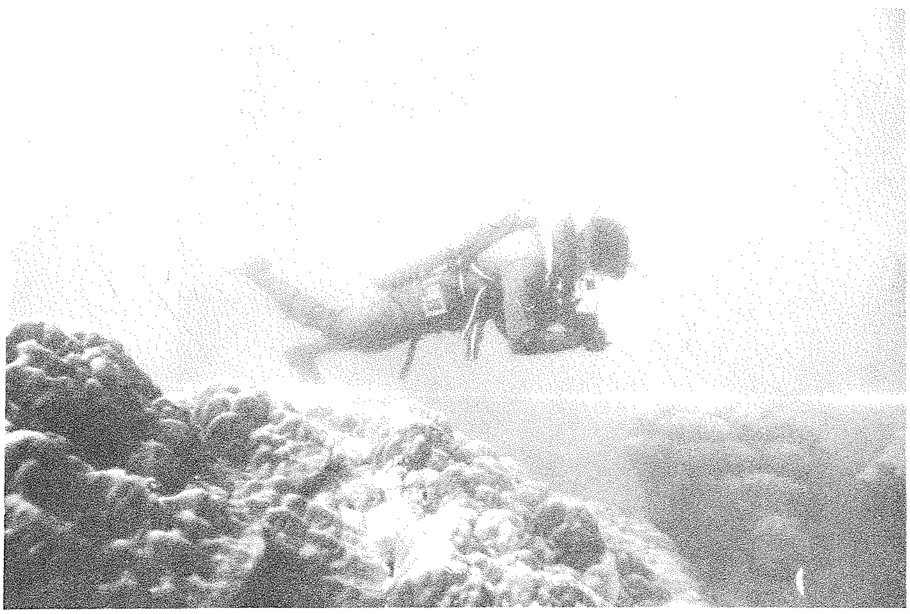
This technique was used to develop a broad picture of the selected reefs, and enabled us to see the "representativeness" of separate study sites in the context of the wider variability of the reef environment. At least nine tows were conducted at each reef. Before making any records, all participants were trained in a reconnaissance of the reef area. Tasks were practised until there was reasonable agreement on boat speed, timing, perception of percentage cover and communication signals. Usually, two snorkellers were towed over the reef by a small boat, starting from an easily identifiable point. The observers held on to a diving plane (mantaboard) made from wood fitted with handle grips. Attached to the board was a data sheet (prepared on a white underwater writing slate), a pencil and reference sheets containing schematic representations of percent cover used for the estimation of live and dead coral, soft coral and sand/rubble.

The boat driver and crew, equipped with a map of the reef and a compass (for recording the location), directed the boat over the reef, parallel to the reef crest, at a speed of 3 - 5 km per hour), while another person timed the tows and signalled to the observers every two minutes. The observers divided tasks among themselves, one looking out for other features such as incidence of damage and/or bleaching, counting Crown-of-Thorns Starfish *Acanthaster planci*, giant clams, *Diadema* sea urchins and other specific organisms, while the other recorded the percentages of live, dead and soft corals. They scanned a strip of about 10 - 12 m depending on their position relative to the reef, and recorded data on live, dead and soft coral cover as absolute percentages, as well as an estimate of the underwater visibility, each time after they were signalled to. A 2-minute tow generally covered an average distance of 200 m. After every 15 to 20 tows, observers changed roles with another set of observers. In case of islands, the tow numbers of all surveyed sections of the reef were combined after completion of the survey, and adjusted to correspond to a single clockwise data set around the island's reef.

The estimated percentage cover data were later transformed into categories on a scale 0 - 5 according to the Survey Manual for Tropical Marine Resources. Data were then entered in a database, ARMDES version 1.2. A summary of the median values of biological variables for all data was presented to give an indication of the reef composition for the island. For each reef section surveyed, data were also presented as pie charts showing absolute percent cover of live, dead and soft coral, against an outline of the island, for quick reference. Data were compared with those collected during manta tow surveys in 1987 (Geater *et al.*, 1989). It is noted that only data from sections surveyed during both periods were compared. The accurate documentation of tow numbers and positions from the 1987 surveys facilitated the comparison of data between the surveys. A small modification was made on the manta board to allow easier manoeuvrability and allow two observers to hold onto the board with ease. On the board, two strong loops were fixed on each end to act as extra hand-holds for the observers. Two ventral stabilizing fins of about 3" depth each were added, following the suggestions by Geater *et al.* (1989).

3.2 Line Intercept Transect method

This method assesses the benthic community of coral reefs using lifeforms categories which provide a morphological description of the community: live coral, with an estimate of coral types, dead coral, sand and algae. Training on benthos of the area under investigation by the Phuket Marine Biological Centre before this method was implemented helped to reduce possibilities of incorrect identification. Group discussion of lifeforms encountered rapidly improved and standardized identification of the categories. This problem was further reduced by use of photographs during orientation and try-outs and sometimes even later as reference under water. To achieve maximum use of underwater time, a set of tasks was provided to each team member, the number of sites per reef was also reduced and the number of personnel increased. In addition to reducing diving time, for safety's sake, an extra precaution was taken by subscribing to a temporary insurance scheme on Phuket Island.



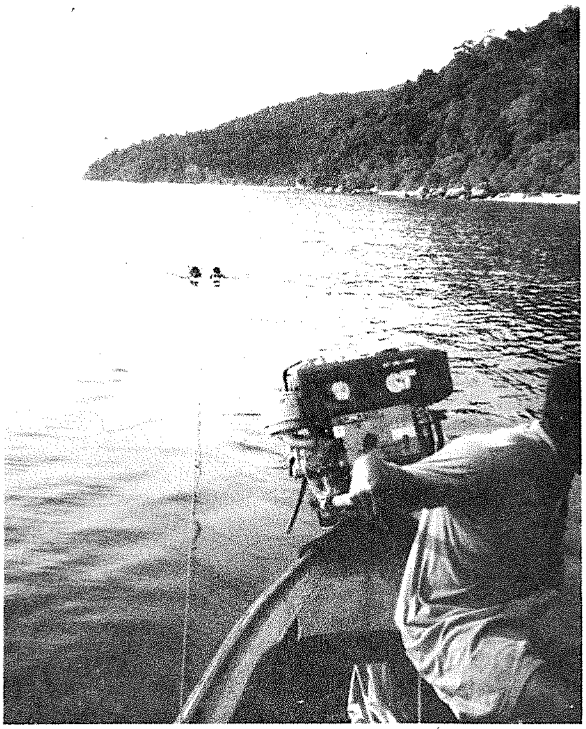
The Line Intercept Transect method

Three typical sites were selected (at Phi Phi Don island and Phuket site selection largely followed areas where Phuket Marine Biological Centre has its long-term monitoring project). At each site six lines of 20 m long, made from fibreglass and graduated in centimetres, were placed randomly by a diver at depths of 2.5-3 m for the shallow transect and 4.5-8 m for the deeper transect. Observers swam along the lines recording lifeforms under the tape along the transect, each line completed by a single observer. Intercepts of benthic lifeforms or substrate were defined as the points on the tape met by the edges of each lifeform or substrate.

After calculating the intercept (length) the percent cover of each lifeform category was calculated according to the formula:

Percent cover = Total length of category/length of transect * 100

Calculations of percent cover and number of occurrences were made to provide quantitative information on the community structure of the sample sites. Taxonomic data, of genera and species, were recorded inconsistently, and are therefore provided as an Appendix.



Observers apply the Manta Tow technique

4.0 RESULTS

Reef assessment surveys were carried out at seven reef sites in Tarutao Marine National Park (Adang, Lipe and Talang island), two sites at Phi Phi Marine National Park (Phi Phi Don island) and one site at Phuket Island (Cape Panwa). The surveys included a total of 182 manta tows (163 at Tarutao, 10 at Phi Phi, and nine at Phuket), and 34 line intercept transects (two at Tarutao, 26 at Phi Phi, and six at Phuket). These manta tows (Table 1) and line intercept transects provided a wealth of information on the current status of these reefs. The surveyed reefs had between 14 and 85% dead coral (usually covered in a thin layer of algae). Living coral cover ranged from 14 to 67% of the substrate. The average ratio of live to dead coral cover was 1.2:1. The survey revealed significant indications of recent reef damage as a result of fishing activities (including blast fishing at Adang-Rawi island group). Water transparency measurements showed average secchi depths of 15-19 m in Tarutao, 14 m at Phi Phi and 3 m at Phuket. Salinity ranged between 33-34 ppt in Tarutao, 36-37 ppt at Phi Phi and 30 ppt at Phuket. Assessment results are summarized below for each of the reef sites that were surveyed. The average percent cover of coral per reef section are presented as pies adjacent to individual tow numbers depicted on the map outline. Additional details are provided in an appendix.

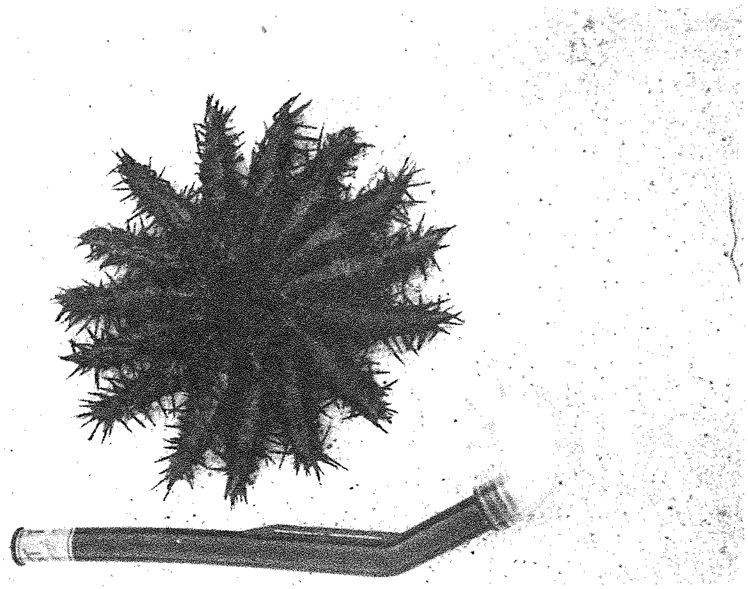
Adang South (equivalent to tow numbers 40 - 53 in 1987; see Geater *et al.*, 1989)
The reef in Adang south was well developed on the western side, but got less structural with a lot of sand and broken *Acropora* towards the east. The latter section, which was comprised entirely of broken coral in 1987, now showed some signs of recovery by the apparent recolonization by young *Acropora* and abundant Fungid corals. Some sponges, anemones and whip coral were present. Comparison of dead coral cover estimated during manta tow surveys (Figure 3) suggested that dead coral cover had reduced (from a former median of 4.5 in 1987 to 3 in 1997) whereas live coal cover had increased only insignificantly (median of 2 still 2 i.e. since these cover scores are ranges, percentage cover is likely to have increased). A total of seven fish traps/cages, two incidences of blast damage and 11 occurrences of "medium" *Diadema* were noted within a distance of approximately 3 km (Table 1). However, no *Acanthaster* starfish were encountered during this survey compared to 18 counted in 1987. This reef appeared to be slowly recovering from the storm damage that occurred in 1986.

Data from line intercept transects (Figure 4) at the western side of the southern sector, where the reef was structurally well-developed, also showed a reduction in dead coral cover from 21.63% in 1987 to 5% in 1997, which compares well with the manta tow data. Dead hard coral seemed to have been overgrown with other sessile fauna whose percent cover had increased from 3.33% to 21%. Whereas the percent cover of algae had dropped significantly (from 21.63% to 10%), the cover of living hard coral had remained almost the same, if not slightly reduced. These results suggest change in reef community structure, but the method for the survey did not allow any further

Table 1.
General observations made during the Manta Tow surveys
(data represent total number of occurrences recorded during the tows)

Location	Tows	COT*	*Diadema*** low	*Diadema*** med.	*Diadema*** high	Fish traps	Damage***	Bleaching
Adang-W	20	1	6	5	0	2	1	1
Adang-S	17	0	4	11	0	7	2	0
Adang-E	31	42	5	19	1	14	3	4
Adang-NE	14	2	1	1	0	2	4	1
Adang-N	16	1	1	3	0	3	2	0
Lipe Island	57	18	5	24	12	14	4	6
Talang Island	8	11	2	4	2	9	0	0
Ton Sai Bay	7	0	1	6	0	3	0	0
Yongkasem Bay	3	0	21	1	0	0	0	0
Cape Panwa Pier	9	-	-	-	-	-	-	-

* COT = Crown-of-Thorns Starfish (*Acanthaster planci*)
** *Diadema* (sea urchins): figures represent estimated abundance
***Damage by blast fishing or other fishing practices (not storm damage)



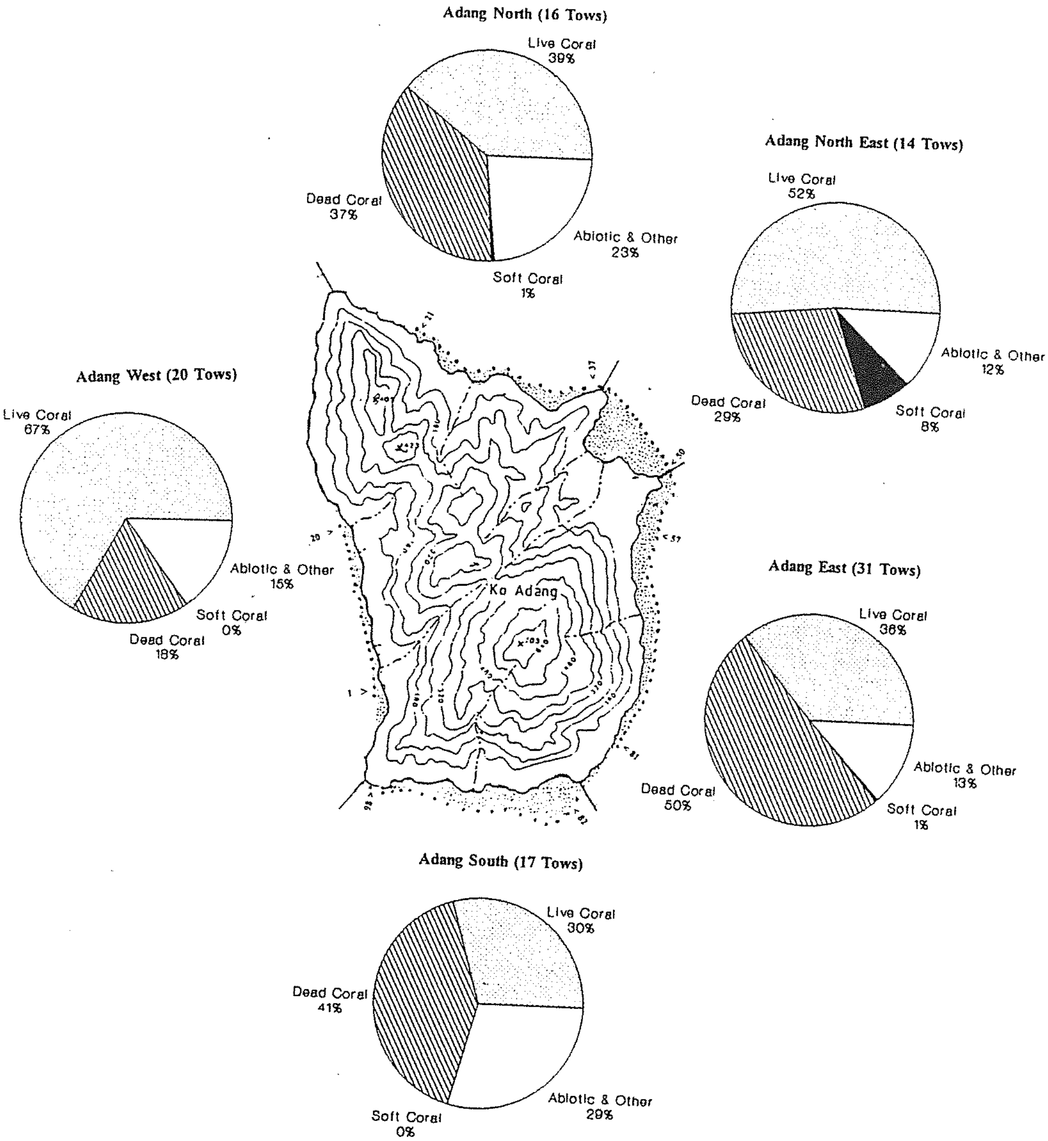
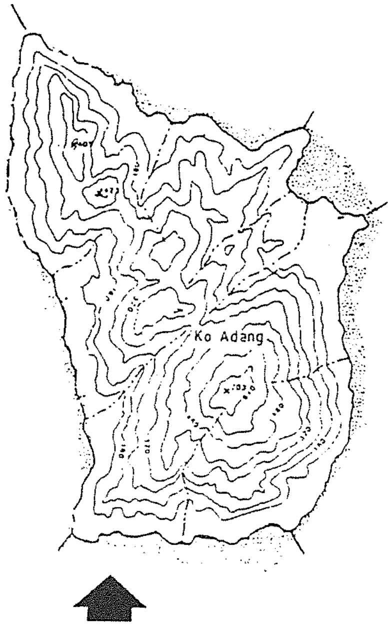


Figure 3.
Summary of manta tow survey results fron Adang Island (Tarutao National Park), showing average percent cover of coral for different sectors of the island.
(Division of the reef around the island into 5 sectors follows earlier surveys by Geater *et al.*, 1989; the actual sections that were towed are indicated with dots and tow numbers on the map.)



Adang South (THLIT0001)
date: 29 April 1997
average of 2 transects (20m) at 8 m depth

Life Form Category	% cover
Algal Assemblage	0
Branching Acropora	0.94
Digitate Acropora	5.48
Encrusting Acropora	0
Submassive Acropora	8.50
Tabulate Acropora	2.73
Coralline Algae	1.37
Branching Non-Acropora	1.60
Encrusting Non-Acropora	0
Foliaceous Non-Acropora	0.83
Heliopora	0
Massive Non-Acropora	25.98
Millepora	0
Mushroom Coral	0
Submassive Non-Acropora	0.61
Dead Coral	3.53
Dead Coral with Algae	1.29
Halimeda	0
Macroalgae	0
Other	12.72
Rubble	10.76
Rock	0
Sand	5.75
Soft Coral	0.08
Silt	0.55
Sponge	0.40
Turf Algae	8.78
Water	1.18
Zoanthid	6.92

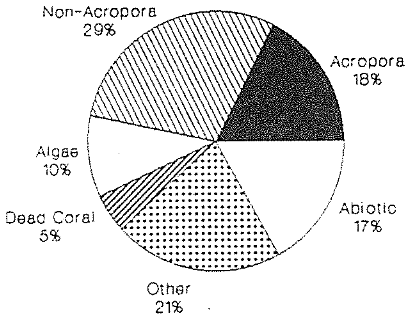


Figure 4.
Percent cover of benthic life form categories measured by Line Intercept Transe (n=2) at 8 m depth, South Adang Island in Tarutao National Park.
[Detailed data presented in the table are summarized in the pie chart, in which hard corals a grouped into "Acropora" and "Non-Acropora"; "Algae" = coralline algae, Halimeda, macroalg and turf algae; "Dead Coral" = dead coral and dead coral with algae; "Other" = soft-coral sponges, anemones, zoanthids and other fauna; "Abiotic" = sand, silt, rubble and rock]

interpretation of the information. This section of the reef is protected from severe wave action during the SW monsoon, by Lipe island, but under disturbance from human activities.

Adang East (equivalent to tow numbers 58 - 71 in 1987)
This section had the highest percentage of dead coral cover (50%). The ratio of live to dead coral in this section had remained almost unchanged compared to ten years ago. The Crown-of-Thorns Starfish abundance was higher (42 counted compared to 4 counted in 1987). A higher number of fish traps, relative to other sections around the island of Adang, were counted here. Densities of *Diadema* were relatively high. The incidence of some bleaching of *Acropora* and of a few *Porites* heads, and blasted as well as newly smashed or overturned coral colonies was evident. There seemed to be a garbage dumping site nearby. Floating and partly sunken garbage material was observed during the survey. Large colonies of *Porites* and *Lobophyllia* dominated the coral cover.

Adang North East (equivalent to tow numbers 72 - 78 in 1987)
The reef in this section had low *Acanthaster* and *Diadema* abundance. A fair percentage cover of live coral (52%), mainly massive forms with a relatively high incidence of smashing and blast was evident. Relative to 1987, the percent cover of dead coral had remained the same, while live coral cover had slightly reduced. This site had a relatively high cover of soft corals, esp. at promontories.

Adang North (equivalent to tow numbers 79 - 94 in 1987)
Cover of live and dead coral was almost equal in this section (39% and 37% respectively). There were almost no detectable changes in percent cover since ten years ago. *Acanthaster* and *Diadema* abundance was low. No bleaching was observed on the tow path, and there were relatively low numbers of fish traps. Some coral damage by blast fishing was evident.

Adang West (equivalent to tow numbers 16 - 33 in 1987)
The surveyed section had the highest percentage (67%) of live hard coral of all the sections of Adang island. The reef was diverse, with very low *Acanthaster* and moderate *Diadema*. Only one incidence of blast damage and bleaching was noted. Massive forms of benthic cover were more abundant and there was almost no branching coral. Sponges and anemones were abundant.

Lipe Island (equivalent to tow numbers 1 - 41 in 1987)
The status of the reef around Lipe Island varied depending on the side of the island. Quite some part of the area around the island has no real reef, but rock and sand. Many activities go on around and on Lipe Island, and part of the reef, especially in the northeastern corner with considerable boat traffic, was subject to physical damage from these activities. There was only a moderate incidence of *Acanthaster* infestation. A large number of damaged, overturned coral heads, bleaching of mainly *Acropora* spp., a large number of functional and abandoned fishing traps and nets, and a relatively high abundance of *Diadema* were observed.

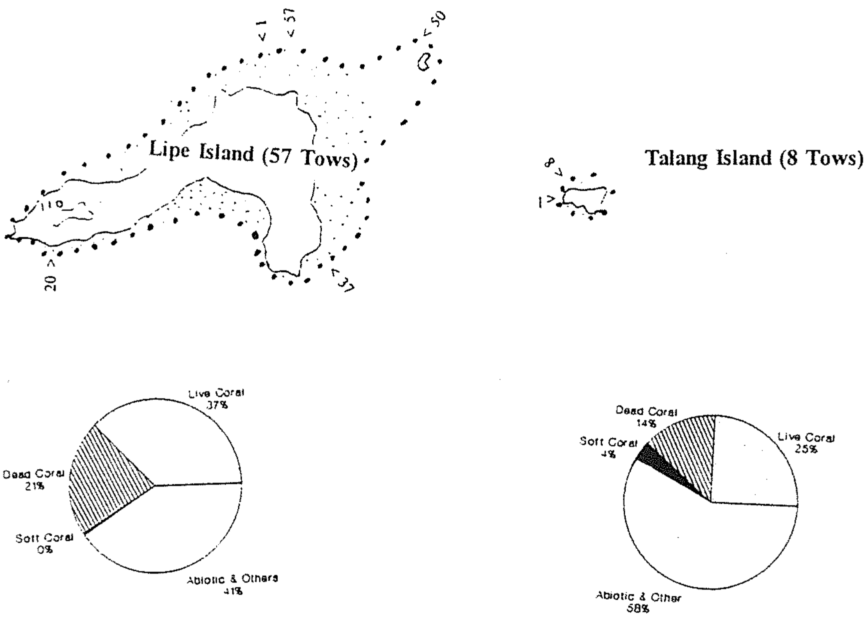
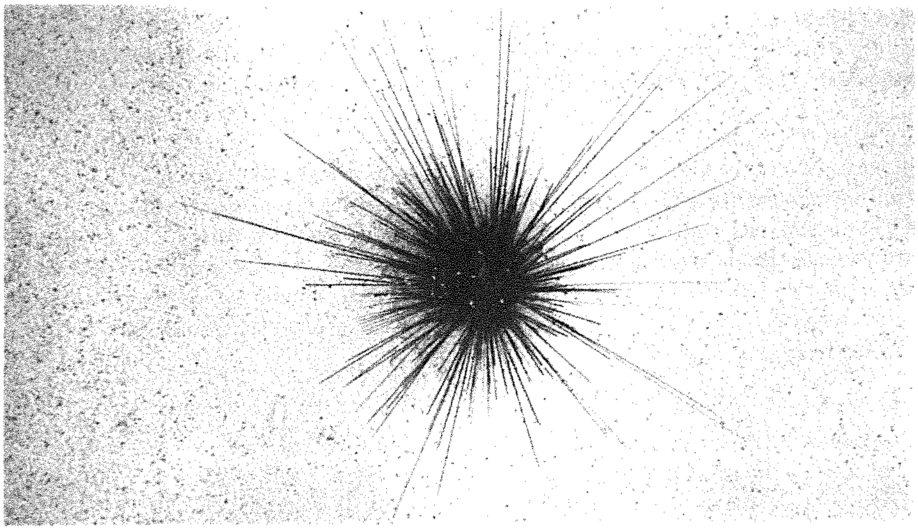


Figure 5.
Summary of manta tow survey results showing average percent cover of coral from Lipe and Talang Islands (Tarutao National Park).
(Locations of tows are indicated with dots and tow numbers on the map.)



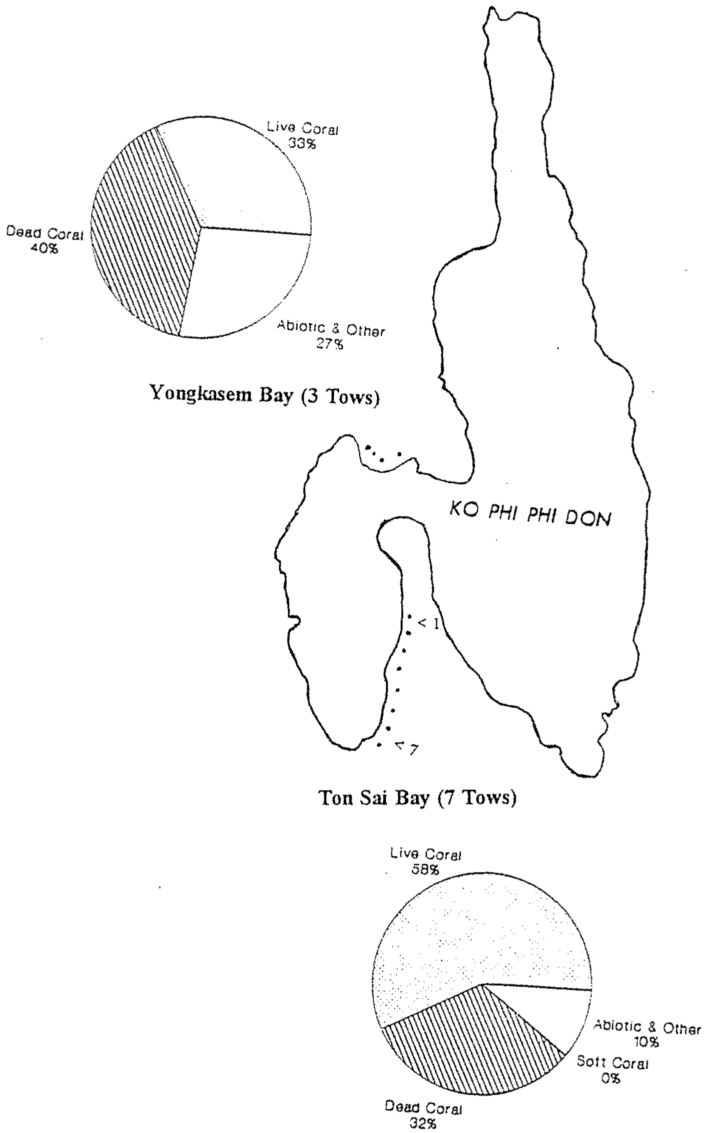
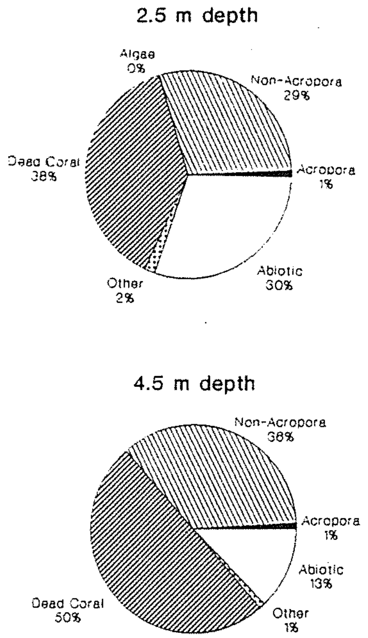
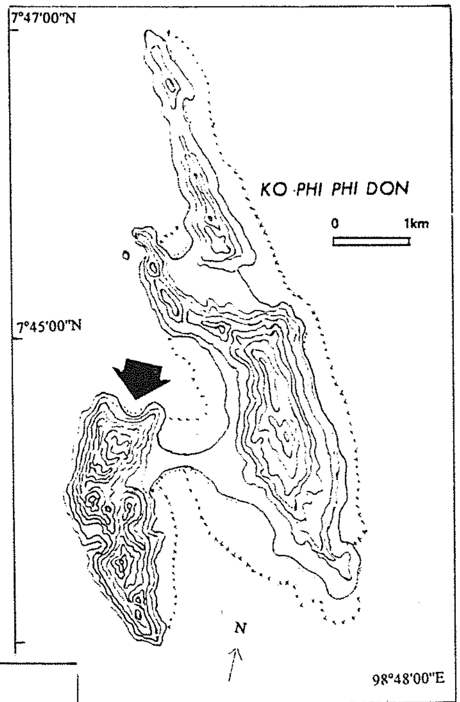


Figure 6.
Summary of manta tow survey results showing average percent cover data from Yongkasem Bay and Ton Sai Bay (Phi Phi national Park).
(Locations of tows are indicated with dots and numbers on the map.)





Yongkasem Bay (THLIT0003 & THLIT0004)
date: 13 May 1997
average of 7 transects (20m) at 2.5 m depth and 7 transects at 4.5 m depth

Life Form Category	% cover 2.5 m depth	% cover 4.5 m depth
Algal Assemblage	0	0
Branching Acropora	0.57	0.87
Digitate Acropora	0.26	0
Encrusting Acropora	0.14	0
Submassive Acropora	0	0
Tabulate Acropora	0	0
Coralline Algae	0.13	0
Branching Non-Acropora	2.29	3.61
Encrusting Non-Acropora	1.62	0.81
Foliaceous Non-Acropora	5.03.	1.53
Heliopora	0	0
Massive Non-Acropora	10.78	19.34
Millepora	0.32	1.13
Mushroom Coral	1.41	8.94
Submassive Non-Acropora	7.54	0.36
Dead Coral	0	0
Dead Coral with Algae	38.34	49.76
Halimeda	0	0
Macroalgae	0	0
Other	0.06	0.78
Rubble	22.19	0
Rock	0	0
Sand	6.18	12.71
Soft Coral	0.07	0
Silt	1.59	0
Sponge	0	0.10
Turf Algae	0	0
Water	1.46	0.06
Zoanthid	0	0

Figure 7
Percent cover of benthic life form categories measured by Line Intercept Transect (n=7) at different depths on the reef in Yongkasem Bay, Phi Phi Don Island

Talang Island (equivalent to tow numbers 1 - 4 in 1987)
Results (Figure 5) showed a slightly higher percentage (25%) of live hard coral than dead coral (14%). This island also had large numbers of fishing gear, but no blast damage or coral bleaching was observed. Many *Diadema* were present. However, the number of *Acanthaster* was relatively larger (11) than at any other sites surveyed, except for the Adang East section. Some sponges, gorgonians and soft coral but no obvious branching coral were noted. The presence of dead but largely intact branching coral in some parts of the reef, as recorded in 1987, was not observed.

Yongkasem Bay (Phi Phi Don)
Manta tow data are presented in Figure 6. General observations suggested many incidences of *Diadema* and other sea urchins, though in low abundance. Many Fungid corals were noted. No *Acanthaster* starfish were recorded. Weathering of limestone rock resulted in milky water full of silt particles, reducing visibility and causing discontinuity of manta tow survey in this area.

Line intercept transects, however, revealed that half of the existing reef consisted of dead coral, the deeper transects in the lower slope having a higher percentage of dead coral compared to the shallower transects on the upper slope (Figure 7). This reef was dominated by massive Non-Acropora forms relative to the feebly represented branching coral. A very high percentage of rubble (22 %) on the upper slope is evidence of physical damage by human activities or could be partly an aftermath of a bleaching event that occurred in 1991.

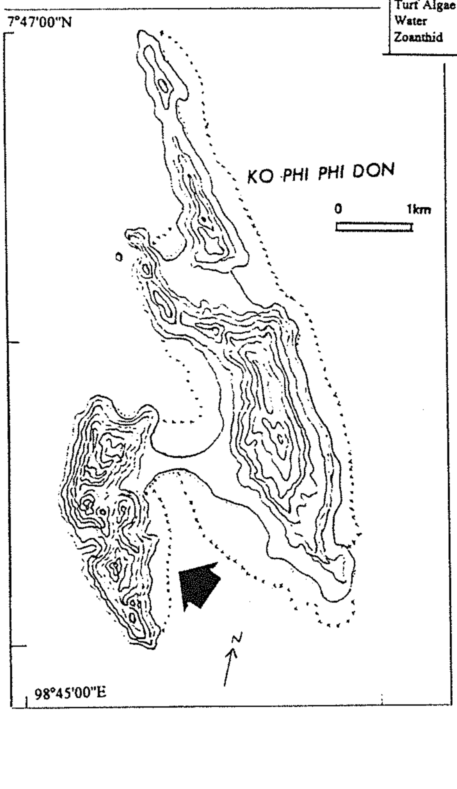
Ton Sai Bay (Phi Phi Don)
This reef was fairly diverse and no *Acanthaster* was observed. The reef flat extended to a rocky coast without a beach. Adjacent was a popular tourist area with frequent boat traffic. The reef was likely to have physical disturbance from water sports and boat anchoring. A moderate density of *Diadema* and other sea urchins was noted.

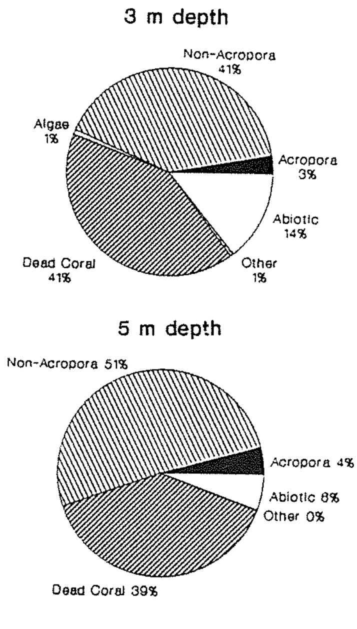
Percentage cover of dead coral was approximately 40% at both the upper and the lower slopes (depths 3 and 5-6 respectively) while live coral constituted about 50% at both depths, suggesting that of the existing reef, nearly half of the coral cover was dead (Figures 6 and 8). The percent cover of benthic life forms, apart from dead coral, was dominated by branching Non-*Acropora* in the transects of the lower slope (5 - 6 m deep) in sharp contrast to the upper slope which was dominated by massive Non-*Acropora*. The upper slope (3 m) also had a considerable percentage cover of rubble, mainly from broken branching coral, which was likely to be a result of recreation activities in this area.

Figure 8
Percent cover of benthic life form categories measured by Line Intercept Transect (n=6) at different depths on the reef in Ton Sai Bay, Phi Phi Don Island

Ton Sai Bay (THLIT0005 & THLIT0006)
date: 13 May 1997
average of 6 transects (20m) at 3 m depth and 6 transects at 5 m depth

Life Form Category	% cover 3 m depth	% cover 5 m depth
Algal Assemblage	0	0
Branching Acropora	1.49	4.27
Digitate Acropora	0.08	0
Encrusting Acropora	0	0
Submassive Acropora	0	0
Tabulate Acropora	1.26	0.07
Coralline Algae	0.64	0
Branching Non-Acropora	2.84	35.19
Encrusting Non-Acropora	3.06	0.03
Foliaceous Non-Acropora	0.26	1.56
Heliopora	0	0
Massive Non-Acropora	16.69	5.58
Millepora	0	0
Mushroom Coral	0.45	1.82
Submassive Non-Acropora	17.41	6.89
Dead Coral	0.14	0
Dead Coral with Algae	40.86	38.87
Halimeda	0	0
Macroalgae	0	0
Other	0.51	0
Rubble	5.25	1.15
Rock	0	0
Sand	8.80	4.48
Soft Coral	0	0.05
Silt	0	0
Sponge	0	0.05
Turf Algae	0.18	0
Water	0.07	0
Zoanthid	0	0





Cape Panwa Pier (Phuket)

In 1995, a manta tow reconnaissance showed 90% dead coral cover (Figure 9). Our results from line intercept transects showed that only 14% was constituted of live hard coral, and the remaining 84 % was still dead coral covered with algae (Figure 10). This reef was damaged by a bleaching event in 1991. The slow recovery is attributed to high sedimentation rates from run-off due to clearing and construction in the surrounding area, which has become a famous tourist resort. Other factors, beyond the scope of this survey, are likely to have contributed.

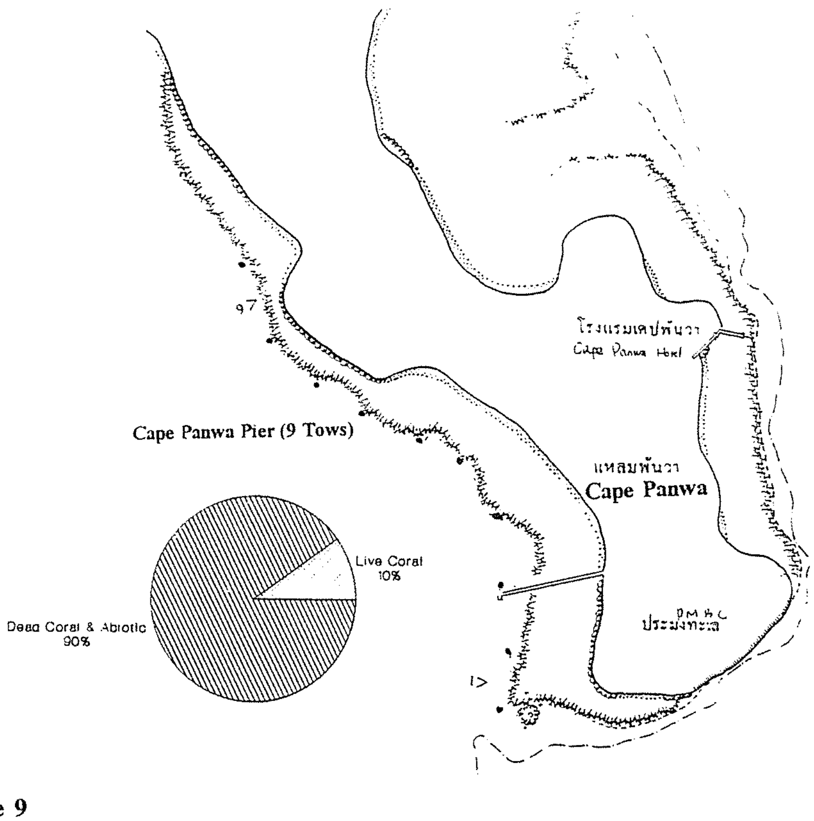


Figure 9
Summary of manta tow survey results from Cape Panwa pier reef (Phuket Island) showing average percent cover data.
(Locations of tows are indicated with dots and numbers on the map.)

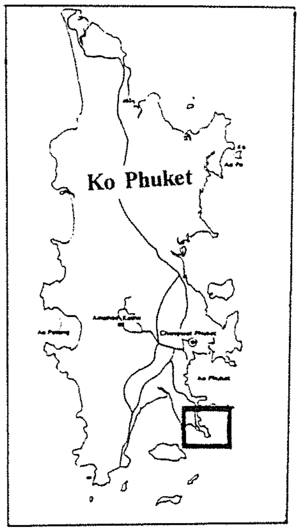
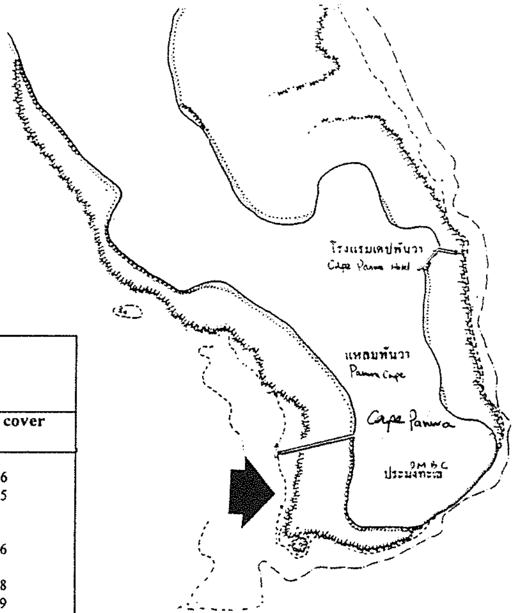
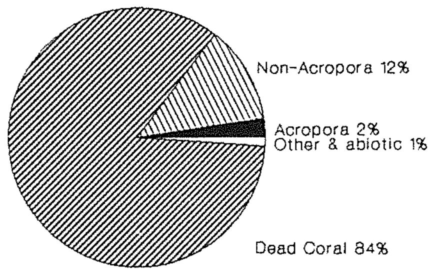


Figure 10
Percent cover of benthic life form categories measured by Line Intercept Transect (n=6) at 2.5 m depth on Cape Panwa reef, South East of Phuket Island



Cape Panwa Pier (THLIT0002)
date: 12 May 1997
average of 6 transects (20m) at 2.5 m depth

Life Form Category	% cover
Algal Assemblage	0
Branching Acropora	1.06
Digitate Acropora	0.75
Encrusting Acropora	0
Submassive Acropora	0
Tabulate Acropora	0.46
Coralline Algae	0
Branching Non-Acropora	0.58
Encrusting Non-Acropora	0.69
Foliaceous Non-Acropora	0.55
Heliopora	0
Massive Non-Acropora	7.05
Millepora	0
Mushroom Coral	1.62
Submassive Non-Acropora	1.73
Dead Coral	0.55
Dead Coral with Algae	83.86
Halimeda	0
Macroalgae	0
Other	0
Rubble	0
Rock	0
Sand	0.46
Soft Coral	0.08
Silt	0
Sponge	0
Turf Algae	0
Water	0.56
Zoanthid	0



5.0 DISCUSSION

5.1 General discussion of results

The surveyed reefs were variable in percent cover of live, dead and soft coral. The percentage of the substrate that was covered by dead coral (usually overgrown with a thin layer of algae) ranged from 14 to 85%, while live coral covered between 10 and 67%. Cover by soft corals and gorgonians was generally very low (average < 2%), and most prominent at areas of high water movement, such as at promontory rocky protrusions (e.g. 8% at Adang North-East). On average, the ratio of live to dead coral cover was 1.2:1 (i.e. there was 20% more live coral than there was dead coral). This ratio, however, varied between sites, from an average low of 0.2:1 at Cape Panwa (Phuket), and 1.1:1 at Phi Phi Don, to 1.6:1 at the sites in Tarutao Marine National Park. The occurrence of relatively high percentages of dead coral in the study areas (an undisturbed healthy reef classified as "good" should generally have at least twice as much live coral than dead coral) might be attributed to damage and disturbances due to fishing practices, storms, bleaching events, Crown-of-Thorns Starfish infestations and intensive marine tourism, all of which are reported in the literature to have occurred in the Andaman Sea reefs in Thailand over the past 20 years of studies. Recovery of damage may in some places be slowed down by high densities of *Diadema* sea urchins, ongoing sedimentation and land-based eutrophication, or simply the re-occurrence or continuation of the causal factors for the damage.

Although it was reported that incidences of blast fishing in Thai waters had declined significantly between 1981-1987, our survey results showed damage from destructive fishing activities on at least 16 occasions (incl. four cases of damage from blast fishing), which indicates that these activities still occur. Other reported damage to reefs such as fractured and dislodged colonies reported earlier are still apparent. The observation of broken ropes and fish lines, and the occurrence of remains of damaged fishing gear such as traps, cages and nets, as well as dead and broken *Acropora* corals within marine protected areas, where fishing is illegal, show that the activities which lead to these damages are not adequately controlled.

There was no apparent evidence of reef damage from activities by tourists and other recreational park visitors at Adang, Lipe and Talang islands. The reefs around Kata Island, in the Adang Rawi island group, which of late have become a popular attraction for snorkellers, are still in fairly good condition, but may soon face impacts from the activities of increasing numbers of recreational park visitors who take small trips by long-tail boats to these sites. We observed a small localized oil spill at one of the sites on the reef at this island, which originated from reckless discharges by local long-tail boats. It was nearly impossible to enter the water or the beach at one point, because the whole embayment here was covered in oil at the time of our visit.

The Crown-of-Thorns Starfish was observed only at reefs in the Tarutao Marine National Park. The highest numbers (per unit of distance) were recorded at Talang Island (11 COT in 8 tows) and the Eastern part of Adang Island (42 COT in 31 tows). Even here, however, their density was considered to be fairly low and of no real concern. Currently, they appear to be causing little or no damage to the reefs. Only at Kata Island, a short snorkel around the reef gave the impression that Crown-of-Thorns Starfish population was on the increase. At this site their size appeared larger than elsewhere, and the starfish were observed to be actively feeding on live Acroporid corals. Feeding scars which had hardly been observed at any of the other islands surveyed were very clear on this island.

Relatively large numbers of the sea urchin *Diadema* were observed on many reef sections, especially around Lipe Island and the eastern section of Adang Island. These organisms are generally part of the reef community, and indeed should not be seen as invaders. However, as in all ecosystems, the understanding of predator-prey interactions and community structure will always indicate any imbalances within the ecosystem. Excessive fishing may result in an increase in numerous sea urchin species due to the removal of their triggerfish and wrass predators (Muthiga and McClanahan, 1987; McClanahan and Muthiga, 1988; McClanahan and Shafir, 1990).

Previous comparative studies from exploited and unexploited reefs have shown that the removal of finfish from unprotected reefs has caused sea urchin populations, and sometimes the co-occurring populations of sea urchins and gastropods, to increase. Sea urchins were found to be the most abundant grazers on heavily fished reefs with herbivorous fishes, while herbivorous fishes were the most abundant grazers on less fished reefs (McClanahan *et al.*, 1994). These studies suggest that sea urchin populations are most likely to be controlled by predators rather than by competition with competitors such as parrot fishes. The urchins also increase in biomass when their predators are reduced (often attributed to overfishing). In the Caribbean, increased sea urchin populations were thought to (i) reduce algal food and reef space resource outcompeting some fish species and thereby reducing the diversity of the coral reef fish assemblage (Robertson, 1991; Sammarco, 1980) (ii) increase erosion rates of reef substrate leading to loss in reef topographic complexity (McClanahan, 1994). A biomass-based energetic model (McClanahan, 1992) supported this, suggesting that sea urchin biomass increases due to low algal consumption rates and outcompetes herbivorous fishes by reducing algal biomass.

Therefore large numbers of sea urchins is an indication of an imbalance of reef fish assemblage (and perhaps gastropods), in the Adang - Rawi island group, suggesting removal of urchin predators (carnivorous fishes such as the balistrids) and outcompetition of their competitors (herbivorous fishes). Excessive fishing may also lead to coral assemblages largely composed of massive and submassive *Porites* (McClanahan and Mutere, 1994), conditions in which the coral-eating snails become more abundant.

5.2 Review of the general status of the reefs of Thailand

In view of the status of coral reefs in Thailand, surveyed reefs under this study may have lacked in their representativeness, but provided at least an update for the status of the individual reefs. It may, however, be assumed (and previous studies and ongoing monitoring programmes confirm this) that most of the threats encountered during this survey, as well as the average proportions of live to dead coral cover are typical of most reefs in Thailand, notably those of the Andaman Sea coast. Over 60 % of all major reef groups in Thailand were either in poor or moderate-to-fair condition and only less than 36 % in good or very good condition by 1991 (Thailand CRMP, 1991).

Despite the realization and awareness of the declining status of the reefs in Thailand by those responsible for their management, most reefs are still being degraded at a high rate. This degradation is caused by the increased activities of man, which include land-clearing and deforestation industrial and coastal development, land-based and marine pollution, eutrophication, excessive sedimentation and increased turbidity (caused by run-off, soil erosion, and by the discharge and suspension of sediment by mining and dredging activities), pesticide use, hot water discharge (from industrial plant cooling - mainly in the Gulf), domestic waste and sewage effluent from tourist complexes, agricultural and landscape fertilization, destructive fisheries exploitation (using explosives and poison, pushnets and trawling too close to the reefs), accidental spills of oil and other chemicals, activities related to tourism, and collection of coral for commercial purposes (UNESCO, 1986; Piyakarnchana, 1988; Brown *et al.*, 1990; OEPP, 1995) All these activities are known to affect coral reefs worldwide and have been reported to contribute to the degradation of Thailand's reefs.

The general condition of reefs according to past and on-going studies in the Andaman Sea coast of Thailand varies widely and may change with time. The reefs vary considerably with regard to their degree of exposure to southwest monsoon winds, as well as their location, whether offshore or nearshore. Monitoring reports show that Crown-of-Thorns Starfish plagues, tourism activities, storm damage, bleaching events, sewage effluent and fisheries are some of the most evident contributors to changes in reef status. While in some sites reefs that were previously damaged are recovering, other sites are deteriorating due to the emergence or increase of human-induced and environmental stresses

Phuket and its vicinity:

Seven years of monitoring of eleven islands in the vicinity of Phuket (between 1988-1994) showed that the reefs here experienced a significant reduction in live coral cover as a result of a major bleaching event in 1991 (Phongsuwan and Chansang, 1994). At least [illegible]0 out of 25 monitored reef sites around Phuket Island itself showed remarkable deterioration, some with conditions as poor as having a ratio of 1:7 of live to dead coral cover. Another reef, off Patong Bay, was reported to have deteriorated significantly between 1988-1992 due to municipal sewage run-off. Some reefs on the west coast of Phuket Island, degraded from the effects of tin-mining and tin-dredging, were reported to have recovered after the mining and dredging stopped.

Reports from a reef monitoring programme by PMBC include examples in which the reef at the southern tip of Cape Panwa recovered from severe storm damage with up to 52% increase in live coral cover within five years after the storm in 1986 (Phongsuwan, 1991). Before that, this reef was dominated by *Acropora* sp. and *Montipora* sp. and only when live coral began to increase in 1991, a coral bleaching event reduced this from 52 to 20%. Recovery of this reef after bleaching is rapid, with live coral cover of 72% in 1994 (Phongsuwan and Chansang, 1994). In contrast to the adjacent site which is sheltered from storm waves, the reef on the west of Cape Panwa (Pier reef in this study) highly reduced in live coral after bleaching and recovery to date has been slow. These studies suggest that high accumulation of sediment disturb this sheltered reef. Full recovery vary with location and depends on other factors. In areas where nearby coral survivors are present, recovery may be fast. At sites where coral communities are experiencing unusually frequent disturbances, recovery is low (Glynn, 1993). Today, seven years after the bleaching event, the pier reef at Cape Panwa has barely improved due to continuous (land-derived) sedimentation from runoff. Evidence from major natural disturbances such as storms, volcanic activity, extremely low temperature stress and *Acanthaster* outbreaks suggest that the rate of coral recovery is often related to the severity and scale of the disturbance, but varies greatly with location.

Pollution caused by tin smelting discharges has been shown in past studies to influence the community structure of reefs. Branching corals, which are more sensitive to stress, were reported to have significantly lower coverage (Brown and Holley, 1984). A 3-year study on temporal changes in macrobenthos on the west coast of Phuket Island (Hylleberg et al., 1985) found off-shore tin mining to have caused significant impoverishment of benthic fauna of shallow depths. Although tin mining has recently collapsed, after-effects of the operation remain to affect coastal areas indirectly by runoff from former mining areas which were not covered up after the termination.

Sedimentation: The effects of sedimentation on coral reefs have been widely discussed in literature (Pastorak and Bilyard, 1985; Grigg and Dollar, 1990). According to Brown *et al.* (1990), dredging of 1.3 million m^3 of sediment for channel construction and land fill at a port facility in Phuket Island in 1986-87 showed a measurable decrease in coral diversity and coral cover on intertidal reef flats at Phuket Island (in their study sites communities were dominated by *Porites lutea*, which apparently may remain alive beneath sediment for several weeks). Dredging activities lower the amounts of living coral and cause the death of living tissues relative to control reefs (Dodge and Vaisnys, 1977), and may lead to slower extension in colonies of some species due to sedimentation. Sedimentation also reduces calcification of coral (Bak, 1978); Dodge and Brass (1984). Other studies (Sudara *et al.*, 1991a) have also shown that the amount of suspended solid particles correlates positively with coral growth.

Sea walking, which has recently become a popular activity particularly among Taiwanese, Japanese and Korean tourists in Phuket, may also contribute to the deterioration of Phuket's reef environments, but no detailed studies have been done on this.

Phi Phi Islands:

Some reefs around the Phi Phi Islands showed a reduction in live coral cover over seven years, with the evidence of death from physical damage from boat grounding and anchorage and a bleaching event, which wiped out almost all of the *Acropora* species (Phongsuwan and Chansang, 1994). The tremendous increase in tourism on all the popular islands has prompted large-scale construction works and coastal development, and accelerated urbanization pressures, which lead to sedimentation and continual suspension of particles in the water column of nearshore coral reef areas.

In Thailand tourism has exceeded rice as a foreign exchange earner. In the wake of tourism, many economic activities related to it are coral reef-associated, earning the country an estimated 8.7 million Baht a year together with its extended arm gains such as hotels car and motorbike rentals etc. (Sudara *et al.*, 1991b). Much damage to corals is caused directly by boat operations in the tourism industry, especially in the high season when there are not enough buoys to anchor the boats. Physical damage by anchoring of boats has been estimated to cause even more harm to the reef environment than actual snorkelling. With the increase in popularity of diving and snorkelling, activities which collectively damage coral reefs in many ways including physical breaking, touching either accidentally or intentionally, and churning of sediments with fins in attempts to stabilize oneself, have increased.

Direct sewage disposal threatens reefs locally, mainly such tourist areas as Phuket and Phi Phi. Reefs found in all popular tourist attractions risk disturbances from related activities. In these sites, little but persistent oil leaking from boats also threatens to alter reef conditions.

Adang-Rawi Island group (Tarutao National Park):

In the waters of the Adang - Rawi island group, the earlier mentioned human activities, which include commercial fishing, trawling, trapping, reef fish round up, netting and blasting, seem to continue even within the protected areas. Although blasting and cyanide fishing methods have reportedly lessened because of the shift to trawling, tourism, and the decline in the fisheries resource, they still threaten important coral reef areas in this region. A major elaboration on the status of the reefs in this area has been provided in the report by the Underwater Research group of PSU (Geater *et al.*, 1989) and the present report.

The Gulf of Thailand:

Fisheries activities constitute the predominant use of coral reef resources in Thailand. Reef fisheries and the collection of associated fauna and related products are an important source of food and income for many coastal and island communities. Fishing activities, however, also rate highest in their contribution to reef destruction. The explosive growth of the Thai demersal fisheries resulted in a situation whereby Thai waters, especially the Gulf, are full of boats and "empty" of fish (Pauly and Thia-Eng, 1988). Consequently, the coral reefs in the Gulf are in a serious state of degradation, which will continue to worsen unless effective measures are imposed.

Recently, the increasing cry from small-scale fishermen about the increase in the number of trawlers destroying their nets and coming too close to the reefs reflects the worrying state of degradation and threats to the coral reef ecosystem in the Thai Gulf. Today, the widespread use of pushnets, bottom gill nets to catch shrimp and other fish and trawling too close to the shore remain among the major issues affecting the coastal resources in Thailand. Pushnets involve pushing by boats with powerful engines, while dragging nets along the bottom collecting everything. This activity has become predominant and a source of conflict between fishing villages, especially in Southern Thailand.

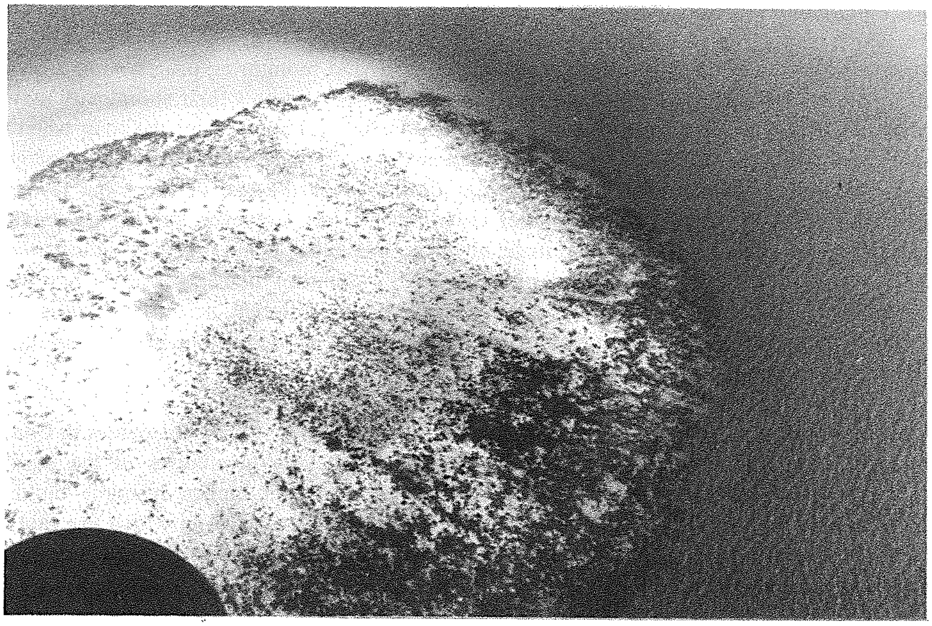
Trawling on coral reef areas has been reported as a cause of damage at 79% of Thailand's coral reefs. Despite significant reductions in catch statistics, fisheries activities are still on the increase. Sudara and Patimanukasaem (1991) recently reported a large-scale increase in anchovy fisheries in the Gulf of Thailand. Intensive shell collection from littoral and sublittoral zones from coral reefs and other substrates was reported as early as 1976, which - at intensive levels - is capable of reducing population sizes by 57% within a single year. Such over-harvesting of shellfish can have significant impacts on stability in the coral reef ecosystem, where nearly all organisms show strong inter-relationships and dependencies.

5.3 Coral reef management and monitoring in Thailand

The need for effective management of coral reefs is urgent and has been recognized as a priority in the "world conservation strategy". Unfortunately, research findings and management experiences from coral reef areas elsewhere are often not readily accessible to planners, managers, advisors and policy/decision makers whose responsibilities include coral reef areas (Kenchington, 1988). In a sense, the lack of enforcement of regulations in many coral reef areas is the major reason for some of the degradation which could have otherwise been avoided.

Scientists, conservation organizations, hotels, dive operators, the tourism industry, local communities, holiday makers and governments all have a major role to play in the protection and wise use of the coral reef resource. One of the major challenges today is to see that the knowledge of scientists and even local village communities is brought to the attention of the general public and decision-makers to ensure that people are fully aware of the implications of human impacts on dwindling coastal resources.

There have been various efforts in Thailand by the academic sector, marine park authorities and other government departments to draw coral reef management plans for the long-term conservation and wise use of coral reef resources. Among these plans are: (i) Coral Reef Protection Strategy for Phuket and surrounding islands (Lemay and Chansang, 1989); (ii) National Coral Reef Strategy for Thailand (Thailand Coastal Resources Management Project, 1991); (iii) Management Plan for the Coral Reefs of Thailand (OEPP, 1992); and the management recommendations in several other publications such as Geater *et al.* (1989), Piyakarnchana (1988), Sudara *et al.* (1991). The establishment of a system of marine protected areas in Thailand is a fairly recent development. Until the recent establishment of a special Marine Parks Division in 1993, Marine Parks were managed in the same way as the terrestrial National Parks. Many of Thailand's most important coral reef areas are now protected within Marine National Parks. Skills and data on environment and assessment exist from earlier and ongoing projects, but communication and coordination between the management authorities and scientific institutions appears to be insufficient. No clear legal framework exists to facilitate integrated management, further hampered by overlaps and gaps in roles and responsibilities in the management of marine parks between the Royal Forest Department, Fisheries Department and other governmental agencies.



A patch reef near Phi Phi Don Island

Wise management planning for reasonable and sustainable use of coral reef resources calls for the ability to balance the short, medium and long-term needs of the human community. Reasonable, sustainable use as a concept will vary from place to place depending on different local political, social and environmental situations. Because of different cultural, social and economic factors, the perceived value of a coral reef may be seen differently by many countries and communities. Many countries which are in rapid economic transition, such as Thailand, are likely to be faced with difficult management situations, which require consideration of a wide scope of factors. Similarly, differences in perception of the values of reef resources may widely differ within a country. In a country like Thailand, there may be isolated local communities living within a coral reef system and depending on it for most of their material requirements and food, in which case the coral reef is central to their social, economic and cultural life. On the other hand, to another part of the community in the same country, developed and only distantly related and at most indirectly dependent on coral reefs for their livelihood, the reef is seen mainly as a resource that can be exploited, valued largely in economic terms, with preservation valued only in support of sustaining recreation and tourism. The gap between the two perceptions of the same resource continues to widen and contributes to a further decline of the resource as well as of the socio-economic status of the local communities directly dependent on it.

Attempts to support reef management by scientific research and monitoring programmes aimed at increasing the understanding of how coral reef systems function and how their complexity may be related to other marine and terrestrial systems are well-intended, but often hit the snag when the manager's key problems appear not be related to reef ecology but rather to the inability to integrate different interests of various user groups having conflicts over the use of the same resource. Detailed documentation on the status of reef environments has, however, proven its value to managers in many other cases. It is unfortunate, however, that existing and practical information in literature on coral reef conservation and management in countries like Thailand is not easily accessible to the reef managers, but is usually scattered in different scientific libraries and universities, distributed in literature of many different disciplines, or included in internal reports and unpublished material that may be difficult to acquire.

The "ASEAN-Australian Cooperative Programme on Marine Science: Living Resources in Coastal Areas" (1988-1994) has undertaken the important task of making inventories of the existing resources in the ASEAN region. This ambitious project aimed at human resource building, standardization of methods and data handling to allow interchange of data, in which the value of data sets were expected to increase with time as they provided a basis for measurement of change in the coastal ecosystems of the ASEAN region. At the same time countries involved in the project were encouraged/expected to work together at the same level. Under this project, reefs in Thailand were monitored in two phases (Phase I: 1988-1989; Phase II: 1990-1994). As part of the initiative, a detailed survey was undertaken of the reefs of the Adang-Rawi Island group situated in the Tarutao National Park by the Underwater Research Group (URG) of the Prince of Songkla University. The Phuket Marine Biological Centre (PMBC), meanwhile, is (still) undertaking a coral reef monitoring programme sponsored by the Thai Fisheries Department, under which as many as 65 reef sites are being monitored. Other national institutions, engaged in coral reef research in Thailand, include the Chulalongkorn University (Bangkok), Kasetsart University (Bangkok), and Burapa University (Chonburi).

For future surveys and monitoring, it is recommended that the assessment of biological and ecological aspects, identification of critical habitats and fish stock assessments should go hand in hand with the examination of socio-economic aspects and management implications.

As coral reef management is generally more concerned with reducing the human-induced impacts, it is considered important to implement a feasible routine monitoring by the managers themselves, through which major changes in reef conditions can be detected at an early stage and both immediate and long-term effects of management decisions can be assessed. The manta tow method is particularly good for this kind of monitoring as it is relatively simple and capable of covering large areas, and yet its results correlate well with the more complicated line intercept method (which cannot be performed without SCUBA skills and equipment, and which can only cover small areas).

The National Coral Reef Management Strategy outlines the Statement of Need in volume one and Policies and Actions in volume two. The strategy calls for inter-agency cooperation and encourages all levels of the government to solve problems in partnership with local communities and the private sector. Action steps to solve the key problems such as impacts related to fisheries, pollution and tourism and objectives for reef management were identified in the strategy, with the help of the ASEAN - Australian study. However, implementation of these suggestions appears to lack strength and is limited to a few small but successful examples. Despite the ongoing degradation of Thailand's coastal and marine resources, however, there have been several initiatives by local communities and environmental NGOs, as well as some initiatives by government authorities, especially working hand in hand with local communities in conservation and management of coral reefs, that show potential for becoming great success, which is extremely encouraging.

6.0 SOME SUGGESTIONS FOR MONITORING & MANAGEMENT

From the present study it has become evident that the manta tow technique is a useful tool for both manager and scientist to acquire a wealth of information from a large area in a relatively simple manner within a short time. Not only can the observer adapt his search pattern and level of detail depending on his own needs or interest, but the general data on percentages of live/dead coral and other broader impressions of the status of the reef collected by this method prove to be as accurate as those collected with more complicated methods with the use of SCUBA equipment, such as the Line Intercept Transect (both showing a nearly perfect match in many cases).

It is highly recommended that local marine park management staff be fully involved in future assessment and monitoring programmes. Training in simple but effective field assessment techniques (such as manta tow) will be extremely helpful and provide park staff with an easy tool for follow-up assessment of the general status of the reefs under their responsibility. Such tools may also enable them to detect unusual phenomena (such as bleaching, starfish infestations, localized storm damage) at an early stage, and monitor the impact of management decisions.

It would be advisable to further strengthen links between research and management institutions, to adjust (or fine-tune) research and monitoring programmes to the needs and queries of marine park management staff and authorities, notably where support to management is among the objectives of the research. Enhanced sharing of information and mechanisms to improve the accessibility and availability of monitoring and research findings for management staff of marine protected areas are also highly recommended.

The widespread occurrence of reef damage due to fishing activities, even within marine protected areas, stresses the need for involvement and participation of local fishing communities in the management of these areas and resources. Some examples from Thailand and abroad have demonstrated that community involvement in demarcation, planning, management and patrolling of protected areas can work and lead to more successful and sustainable management of coastal and marine resources.

International networking of reef monitoring can be instrumental in detecting global trends, facilitating exchange of information and experiences, providing assistance in technical problems and fund-raising, and mobilization of international pressure to voice concern in cases of major threats to coral reef areas from large-scale developments. It would therefore be advisable for key Thai coral reef scientists and their institutions to join in further initiatives of the Global Coral Reef Monitoring Network and similar international fora.

Needless to say, the firm enforcement of existing regulations, and follow-up/effective implementation of existing strategies for coral reef management would contribute to a better preserved and useful coral reef ecosystem.

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APPENDICES

Sample Table

Sample Id	Location	Reef Name	Date	Cloud	Wind	Sea	Tide	Latitude	Longitude	Reef Zone	Data Type	Depth	Collectors
THWET0001	Tarutao National Park	Ko Adang West (A)	28/04/1997	2	1	C	F	63230N	991730E		M		Caroline Oc
THWET0002	Tarutao National Park	Ko Adang South (B)	29/04/1997	5	1	C	R	63100N	991800E		M		Paul Erftem
THWET0003	Tarutao National Park	Ko Adang East (C)	28/04/1997	2	1	C	R	63300N	991900E		M		C.Ochieng,
THWET0004	Tarutao National Park	Ko Adang N.East (D)	28/04/1997	4	1	C	H	63400N	991900E		M		Caroline Oc
THWET0005	Tarutao National Park	Ko Adang North (E)	28/04/1997	4	1	C	F	63430N	991800E		M		Paul Erftem
THWET0006	Tarutao National Park	Ko Lipe	27/04/1997	8	3	S	F	63000N	991800E		M		P Erftemeij
THWET0007	Tarutao National Park	Ko Talang	28/04/1997	2	1	C	F	63000N	992000E		M		Paul Erftem
THWET0008	Ko PhiPhi Don	Ton Sai Bay	13/05/1997	5	1	C	H	74400N	984700E		M		Paul Erftem
THWET0009	Ko Phi Phi Don	Yongkasem Bay	13/05/1997	5	1	C	H	74500N	984600E		M		Paul Erftem
THWET0010	Ko Phuket	Cape Panwa pier	18/01/1995	5	2	S	R	74800N	982500E		M		Niphon Pho

APPENDIX 1. **Sample table showing the location of reefs and some ambient parameters during manta tow surveys.**

Manta Tow Summary

Sample Id	Location	Reef Name	Date	Live Coral Median	DeadCoral Median	Soft Coral Median	No. Tows	No. COTS	COTS/Tow
THWET0001	Tarutao National Park	Ko Adang West (A)	28/04/1997	4	2	0	20	1	0.05
THWET0002	Tarutao National Park	Ko Adang South (B)	29/04/1997	3	2	0	17	0	0
THWET0003	Tarutao National Park	Ko Adang East (C)	28/04/1997	3	3	0	31	42	1.355
THWET0004	Tarutao National Park	Ko Adang N.East (D)	28/04/1997	3.5	2	1	14	2	0.143
THWET0005	Tarutao National Park	Ko Adang North (E)	28/04/1997	3	3	0	16	1	0.063
THWET0006	Tarutao National Park	Ko Lipe	27/04/1997	3	2	0	57	18	0.316
THWET0007	Tarutao National Park	Ko Talang	28/04/1997	2	1	1	8	11	1.375
THWET0008	Ko PhiPhi Don	Ton Sai Bay	13/05/1997	4	2.5	0	7	0	0
THWET0009	Ko Phi Phi Don	Yongkasem Bay	13/05/1997	3	3	0	3	0	0
THWET0010	Ko Phuket	Cape Panwa pier	18/01/1998	1	5	0	9	0	0

APPENDIX 2. **Manta tow summary showing medians and numbers of Crown-of-Thorns Starfish (COT) encountered.**

APPENDIX 3. Manta Tow raw data including some general observations. For actual reef names refer to the sample table.

Sample Id	Tow No	Live Coral	Dead Coral	Soft Coral	Vis.	No. COTS	COT Size	COT Scar	Comments
THWET0001	1	5	1	0	2	0		A	anemones, sponges, clams
THWET0001	2	4	2	0	2	0		A	clam, Diadema, fish trap
THWET0001	3	4	1	0	2	0		A	clam, low Diadema
THWET0001	4	5	1	0	2	0		A	medium Diadema
THWET0001	5	5	2	0	2	0		A	fish trap, medium Diadema
THWET0001	6	3	3	1	2	0		A	low Diadema
THWET0001	7	3	3	1	2	0		A	clam, some anemones
THWET0001	8	3	3	0	2	0		A	clam, some anemones, low Di
THWET0001	9	4	2	0	2	0		A	many clams, bleached Acropor
THWET0001	10	5	1	0	2	0		A	many clams, mainly Porites
THWET0001	11	4	2	0	2	0		A	huge Porites
THWET0001	12	4	1	0	2	0		A	sponge, some anemones
THWET0001	13	4	2	0	3	1	L	A	whip coral, anemone, medium
THWET0001	14	5	2	0	3	0		A	huge overtumed Porites, medi
THWET0001	15	4	2	1	3	0		A	medium Diadema
THWET0001	16	4	2	0	3	0		A	bleached Acropora, sand, main
THWET0001	17	4	1	0	3	0		A	low Diadema, sponge
THWET0001	18	5	1	0	3	0		A	low Diadema
THWET0001	19	0	0	0	3	0		A	sand only, no coral
THWET0001	20	4	2	0	2	0		A	some anemones
THWET0002	1	1	5	0	3	0		A	Sand/rubble (broken Acrop) R
THWET0002	2	2	4	0	3	0		A	Recolon Acrop rubble/sand lo
THWET0002	3	1	4	1	3	0		A	Rubble/sand, med diadema
THWET0002	4	1	5	0	3	0		A	med Diad, fungid
THWET0002	5	2	4	0	3	0		A	rubble/sand, med diadema
THWET0002	6	2	3	0	3	0		A	much rubble, med. Diadema
THWET0002	7	3	2	0	3	0		A	much rubble fish net whip cora
THWET0002	8	2	2	0	3	0		A	rubble/sand med diad fish rop
THWET0002	9	3	2	0	3	0		A	med diad spoges fish cage Por
THWET0002	10	3	3	0	3	0		A	med Diad fish cage, sand fung
THWET0002	11	3	2	0	3	0		A	sand, sponges med diad fish o
THWET0002	12	3	2	0	3	0		A	sand mainly Porites low Diad
THWET0002	13	3	2	0	3	0		A	Med Diad localize damage san
THWET0002	14	3	2	0	3	0		A	Med Diad sand recol by Acrop
THWET0002	15	3	2	0	3	0		A	signs of dynamite med Diad, f
THWET0002	16	3	2	0	3	0		A	fish cage, CM, fungids
THWET0002	17	2	2	1	3	0		A	Rocks fungids
THWET0003	1	2	3	1	3	1	L	A	Alot of damage, Low Diad
THWET0003	2	3	2	0	3	1	L	A	Med Diad mainly Porites

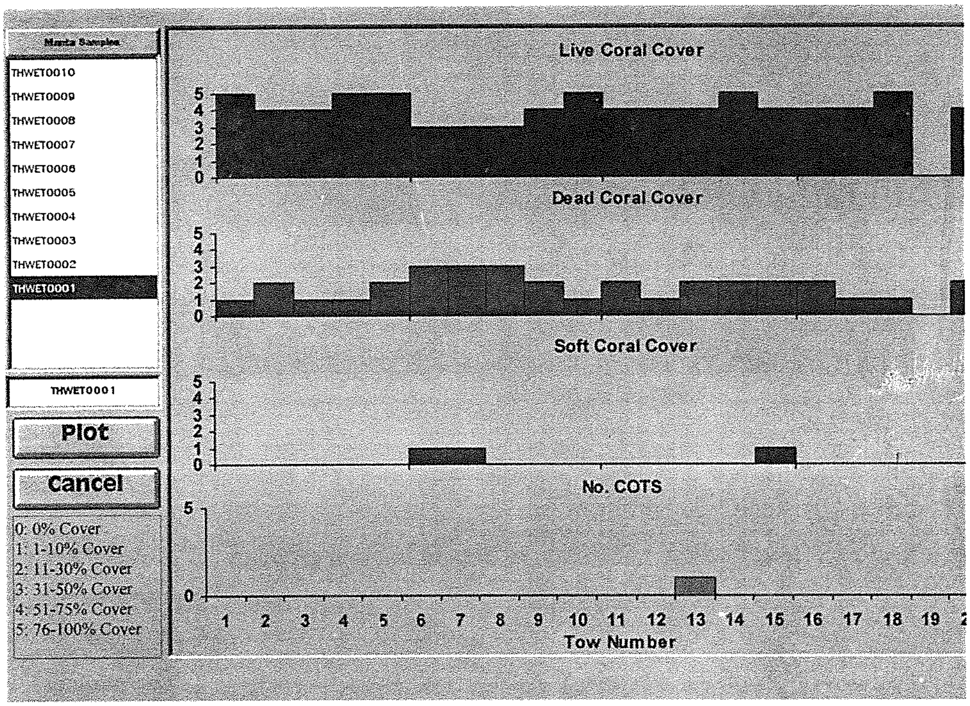
Sample Id	Tow No	Live Coral	Dead Coral	Soft Coral	Vis.	No. COTS	COT Size	COT Scar	Comments
THWET0003	3	4	2	0	3	1	L	A	Low Diad Fish cage, diverse re
THWET0003	4	3	2	0	2	1	L	A	low Diad fish cage
THWET0003	5	3	2	1	3	1	L	A	Mid Diad, fish net
THWET0003	6	3	3	0	3	0		A	med Diad Fish nets and cages
THWET0003	7	3	3	0	2	1	L	A	med Diad fish cage
THWET0003	8	3	3	0	2	0		A	med Diad fish net
THWET0003	9	3	3	0	2	1	L	A	Gorgonians, med Diadema
THWET0003	10	3	3	1	3	1	L	A	rubble, med Diad, fish cage
THWET0003	11	3	3	0	3	0		A	Mainly Porites, med Diad
THWET0003	12	3	2	0	2	7	L	A	Dynamite damage, med Diad
THWET0003	13	3	2	0	2	1	L	A	rubble, med Diadema, fish net
THWET0003	14	2	3	0	2	3	L	A	med Diad, fish net, mainly Pori
THWET0003	15	3	2	0	2	6	L	A	fish nets,sand,med Diad
THWET0003	16	3	3	0	2	3	L	A	fish traps,med Diad, clams
THWET0003	17	3	3	0	2	0		A	giant clams
THWET0003	18	2	3	0	2	1	L	A	low Diad
THWET0003	19	2	3	0	2	0		A	Gorgonians, CM, clams, bleac
THWET0003	20	2	3	0	2	0		A	med Diad
THWET0003	21	2	3	0	2	1	L	A	sponges,, med Diad
THWET0003	22	2	3	0	2	1	L	A	
THWET0003	23	2	4	0	3	1	L	A	giant clams med Diad
THWET0003	24	2	3	0	3	1	L	A	bleached Porites heads
THWET0003	25	2	3	0	3	2	L	A	
THWET0003	26	3	3	0	3	1	L	A	bleached Porites heads, med
THWET0003	27	3	3	0	2	2	L	A	
THWET0003	28	2	3	0	2	2	L	A	bleached Porites heads, large
THWET0003	29	1	3	2	2	1	L	A	signs of blasting, bleached Acr
THWET0003	30	1	3	0	2	0		A	clams
THWET0003	31	2	3	0	2	1	L	A	sand, high Diad, clams
THWET0004	1	3	3	0	2	0		A	low Diadema
THWET0004	2	2	3	0	2	0		A	Fire coral med Diadema
THWET0004	3	3	2	1	2	1	L	A	sand whip coral
THWET0004	4	5	1	1	2	0		A	smashed Cm, CF recolonizing
THWET0004	5	5	1	1	2	0		A	2 signs of blasting, M.fish
THWET0004	6	5	1	1	2	0		A	whip corals, Many CS
THWET0004	7	3	1	3	2	0		A	CS, soft coral
THWET0004	8	3	1	3	1	0		A	CS, soft coral
THWET0004	9	4	2	1	1	0		A	whip coral, giant clams, L.fish
THWET0004	10	5	1	1	1	0		A	mainly CS,, whip coral, M.fish

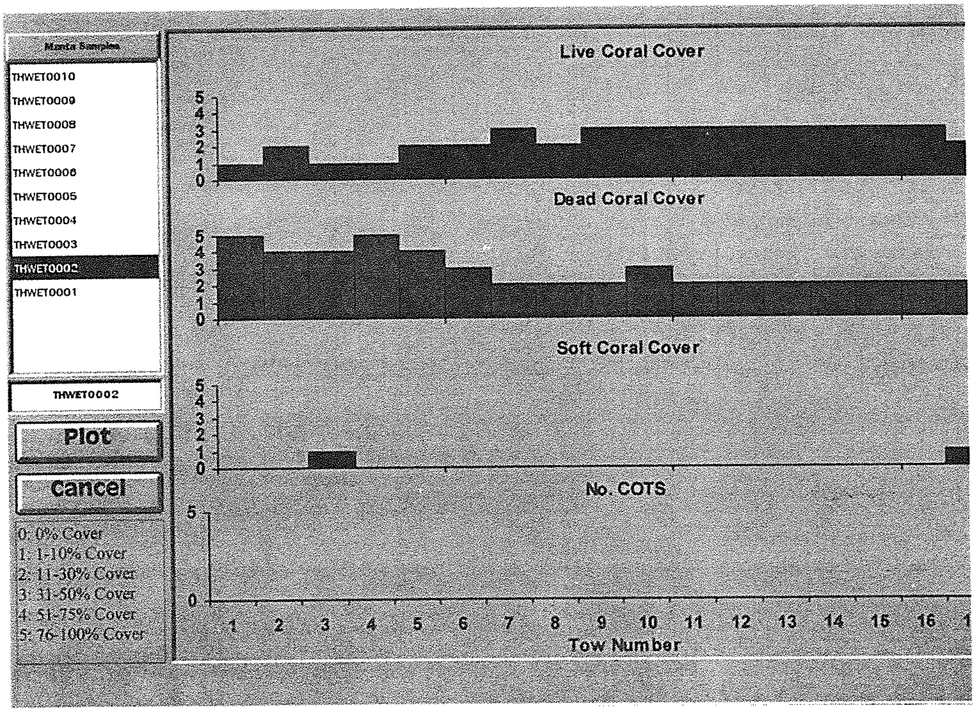
Sample Id	Tow No	Live Coral	Dead Coral	Soft Coral	Vis.	No. COTS	COT Size	COT Scar	Comments
THWET0004	11	2	4	1	2	0		A	mainly CS, fish nets
THWET0004	12	4	2	0	2	1	L	A	CS, CM
THWET0004	13	4	2	1	1	0		A	bleached CM heads
THWET0004	14	1	4	0	2	0		A	smashed CS
THWET0005	1	2	4	0	2	0		A	rubble, med Diad, fungids, fish
THWET0005	2	2	3	0	2	1	L	A	med Diad, rubble, fungids
THWET0005	3	2	4	0	2	0		A	many fungids, rubble, few Diad
THWET0005	4	3	2	0	2	0		A	fundgids, rubble, med Diad
THWET0005	5	4	2	0	2	0		A	rubble/sand, fungids, blast da
THWET0005	6	3	2	0	2	0		A	sand
THWET0005	7	3	3	0	2	0		A	sand/rubble
THWET0005	8	3	2	0	2	0		A	clear dynamite damage
THWET0005	9	3	3	0	2	0		A	sand/rubble, fishnet, fish trap
THWET0005	10	3	2	0	1	0		A	(turbid)
THWET0005	11	3	3	0	1	0		A	sand/rubble
THWET0005	12	3	3	0	2	0		A	sand/rubble, Echinometra
THWET0005	13	3	3	1	2	0		A	sand/rubble, gorgonians
THWET0005	14	3	3	1	3	0		A	rock, whip corals
THWET0005	15	2	1	1	3	0		A	rock, gorgonians, soft corals, r
THWET0005	16	2	2	1	2	0		A	rock
THWET0006	1	2	1	0	2	0		A	med Diad
THWET0006	2	4	2	0	2	0		A	Acropora, fire coral, rubble, me
THWET0006	3	4	2	0	2	0		A	med Diad
THWET0006	4	4	2	0	2	0		A	med Diad
THWET0006	5	5	1	0	2	0		A	med Diad, fish rope, bleaching
THWET0006	6	4	2	0	2	0		A	fish net, med Diad, localized d
THWET0006	7	5	1	0	2	0		A	med Diad, highly diverse reef
THWET0006	8	5	1	0	2	0		A	fish trap, med Diad
THWET0006	9	5	1	0	2	0		A	fish trap, fish net, med Diad, g
THWET0006	10	3	3	0	2	1	L	A	fish net, fish trap, med Diad
THWET0006	11	3	2	0	2	0		A	rock, low Diad
THWET0006	12	3	3	0	2	0		A	sand, med Diad
THWET0006	13	2	3	0	2	0		A	bleached Acrop tips, med Diad
THWET0006	14	2	3	0	2	0		A	med Diad, bleached Acrop tips
THWET0006	15	2	3	0	2	2	L	A	med Diad, fish trap
THWET0006	16	3	2	0	2	0		A	sediment on coral, many Diad,
THWET0006	17	2	2	1	2	1	L	A	whip coral, rock
THWET0006	18	2	2	1	2	3	L	A	whip coral
THWET0006	19	2	2	0	3	4	L	A	rock, many Diad

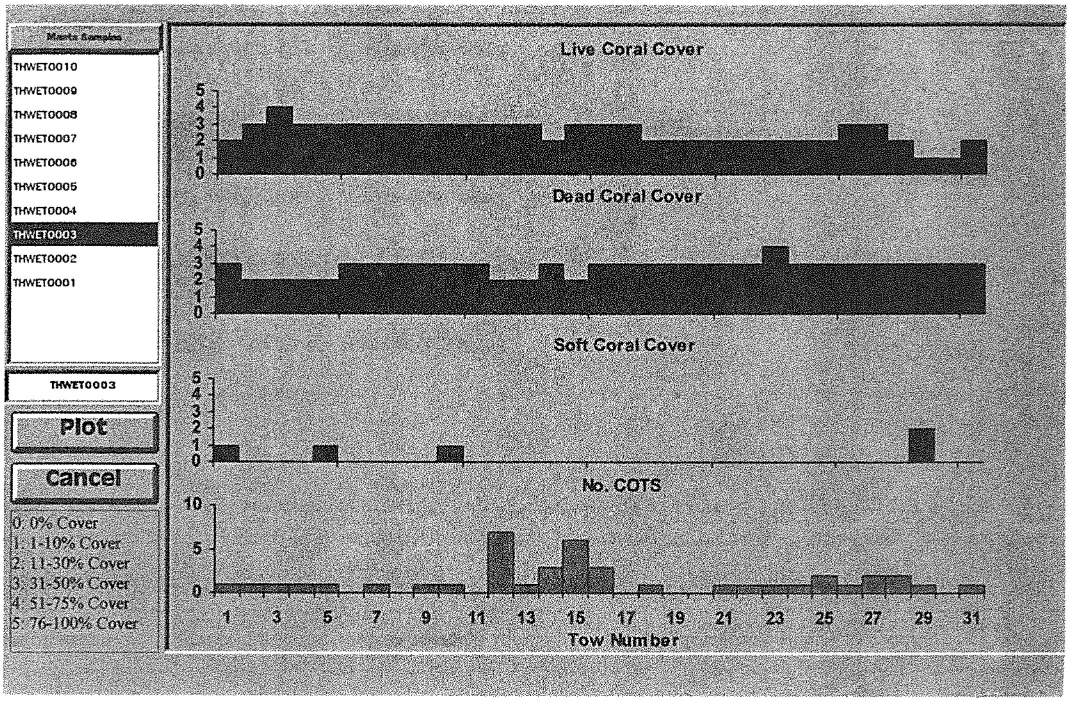
Sample Id	Tow No	Live Coral	Dead Coral	Soft Coral	Vis.	No. COTS	COT Size	COT Scar	Comments
THWET0006	20	4	1	1	2	4	L	A	mainly Porites/Lobophil
THWET0006	21	4	2	1	2	0		A	wreck remains, ropes, fish line
THWET0006	22	3	2	1	2	0		A	mainly Porites
THWET0006	23	3	2	1	2	0		A	mainly Porites
THWET0006	24	3	2	0	2	0		A	mainly Porites
THWET0006	25	2	3	0	2	0		A	sand/rubble, many Diad
THWET0006	26	2	3	0	2	0		A	sand, many small Porites (rec
THWET0006	27	1	1	0	2	0		A	sand/rubble
THWET0006	28	2	2	0	2	0		A	sand
THWET0006	29	2	2	0	2	0		A	sand, low Diad
THWET0006	30	2	2	0	2	0		A	sand, med Diad
THWET0006	31	2	2	0	2	0		A	sand
THWET0006	32	2	2	0	3	0		A	sand, med Diad
THWET0006	33	3	3	0	3	0		A	rock/sand, med Diad
THWET0006	34	2	3	0	3	0		A	mainly Porites, clam
THWET0006	35	1	2	0	3	0		A	rubble, rock/sand
THWET0006	36	1	1	0	3	1	L	A	rock, many Diad
THWET0006	37	1	1	0	3	2	L	A	rock, many Diad
THWET0006	38	1	1	0	2	0		A	rock, med Diad
THWET0006	39	1	1	0	2	0		A	med Diad, rock
THWET0006	40	1	1	0	2	0		A	rock, many Diad
THWET0006	41	0	0	0	2	0		A	deep, no reef
THWET0006	42	1	1	0	2	0		A	rock, many Diad
THWET0006	43	1	2	0	2	0		A	rock, deep, many Diad
THWET0006	44	2	3	0	2	0		A	low Diad
THWET0006	45	3	2	0	2	0		A	med Diad
THWET0006	46	4	1	0	2	0		A	med Diad, bleach plate Acrop t
THWET0006	47	4	2	0	2	0		A	fishnet, med Diad
THWET0006	48	4	2	0	2	0		A	bleached Acrop tips, fishnet,
THWET0006	49	4	2	0	2	0		A	bleaching, fish trap, diverse re
THWET0006	50	3	2	0	2	0		A	med Diad
THWET0006	51	4	2	0	2	0		A	low Diad, fish net
THWET0006	52	4	1	0	2	0		A	med Diad, mainly dead Porites
THWET0006	53	4	1	0	2	0		A	overturned Porites, low Diad
THWET0006	54	1	3	0	2	0		A	rubble/sand, many Diad
THWET0006	55	3	2	0	2	0		A	rubble, overturned Porites, ma
THWET0006	56	3	2	0	2	0		A	rubble/sand, many Diad
THWET0006	57	1	2	0	2	0		A	mainly rubble
THWET0007	1	2	1	0	4	5	L	A	many Diad, rock

Sample Id	Tow No	Live Coral	Dead Coral	Soft Coral	Vis.	No. COTS	COT Size	COT Scar	Comments
THWET0007	2	1	2	2	4	1	L	A	many Diad, sand, rock
THWET0007	3	2	2	0	4	1	L	A	2 fish traps, low Diad, sponge
THWET0007	4	3	1	1	4	1	L	A	med Diad, Acropora
THWET0007	5	3	1	1	4	0		A	med Diad, fish trap
THWET0007	6	2	1	1	3	1	L	A	med Diad, 3 fish traps, sand,
THWET0007	7	2	2	1	3	0		A	whip corals,fishtrap,sand/rubb
THWET0007	8	2	2	2	3	2	L	A	gorgonians, med Diad, 2 fishtr
THWET0008	1	4	1	0	3	0		A	sand/rubble, low Diadema
THWET0008	2	4	2	0	3	0		A	fishing nets
THWET0008	3	4	2	0	3	0		A	Acropora rubble, med Diad
THWET0008	4	3	4	0	2	0		A	much rubble, med Diad,fungid
THWET0008	5	4	2	0	3	0		A	rubble, med Diad
THWET0008	6	3	4	0	3	0		A	Many Diad, rubble
THWET0008	7	3	3	1	2	0		A	fish net, rubble, fungids, med
THWET0009	1	3	2	0	3	0		A	fungids, med Diad
THWET0009	2	3	3	0	2	0		A	low Diad, fungids, some V. lar
THWET0009	3	2	3	0	1	0		A	poor visibility
THWET0010	1	1	5	0	1	0		A	
THWET0010	2	1	4	0	1	0		A	
THWET0010	3	1	4	0	1	0		A	
THWET0010	4	1	5	0	1	0		A	
THWET0010	5	1	4	0	1	0		A	
THWET0010	6	1	5	0	1	0		A	
THWET0010	7	1	5	0	1	0		A	
THWET0010	8	1	5	0	1	0		A	
THWET0010	9	2	4	0	1	0		A	

APPENDIX 4. **Graphs presenting cover scores of live, dead and soft live coral along the reefs surveyed by manta tow. For full names and map references of the actual reef sites refer to the sample table.**







Manta Samples
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THWET0009
THWET0008
THWET0007
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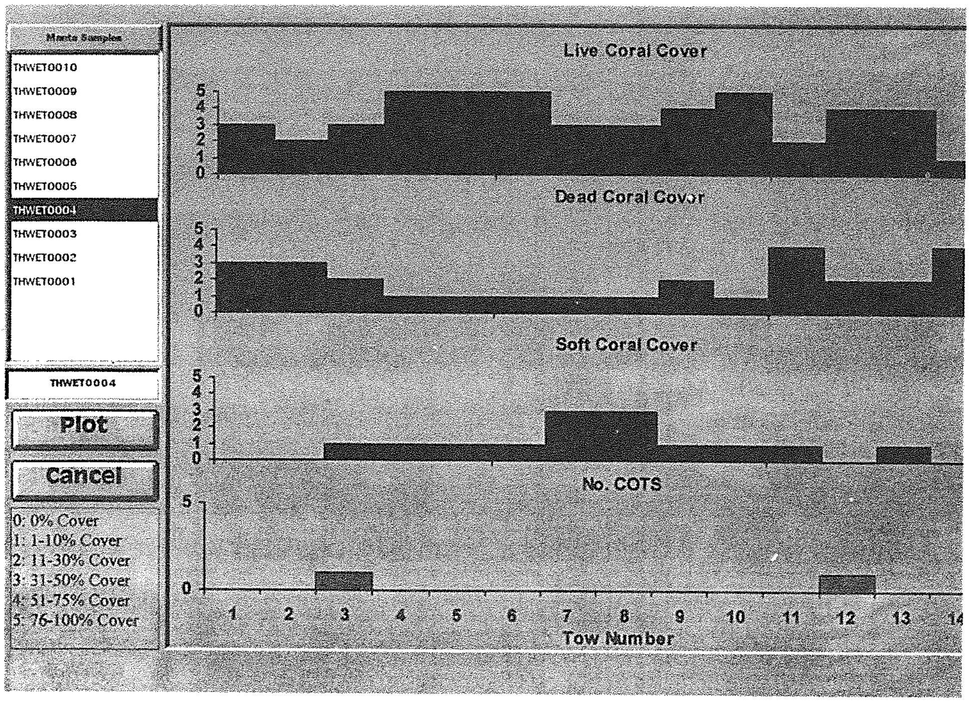
THWET0005
THWET0004
THWET0003
THWET0002
THWET0001
THWET0003
Plot
Cancel
0: 0% Cover
1: 1-10% Cover
2: 11-30% Cover
3: 31-50% Cover
4: 51-75% Cover
5: 76-100% Cover
Live Coral Cover
Dead Coral Cover
Soft Coral Cover
No. COTS
Tow Number



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Plot
Cancel
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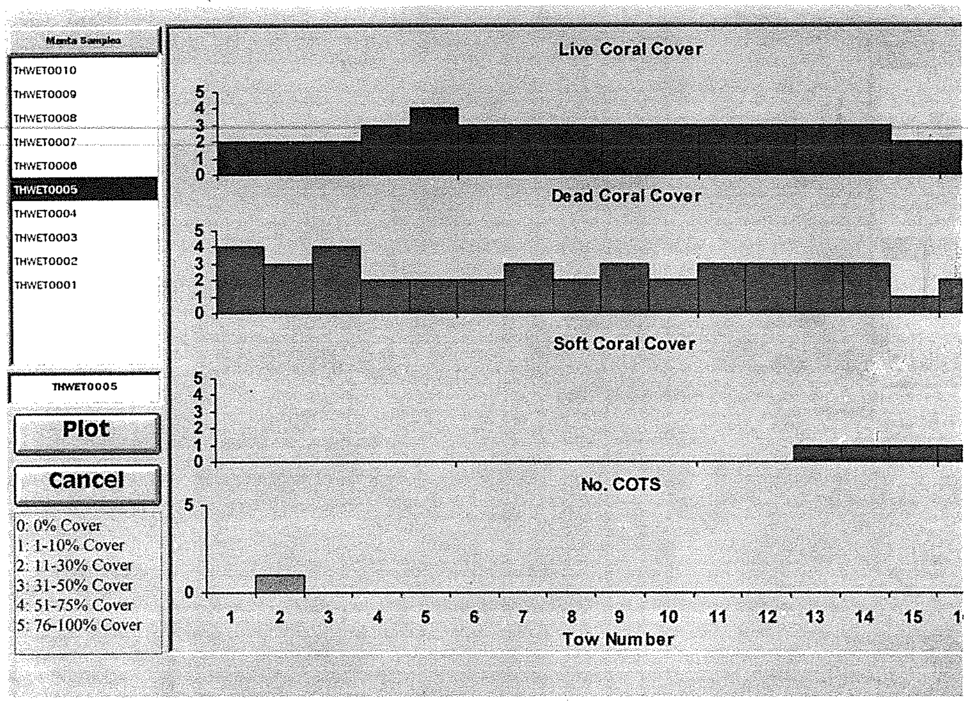
1: 1-10% Cover
2: 11-30% Cover
3: 31-50% Cover
4: 51-75% Cover
5: 76-100% Cover
Live Coral Cover
Dead Coral Cover
Soft Coral Cover
No. COTS
Tow Number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Plot
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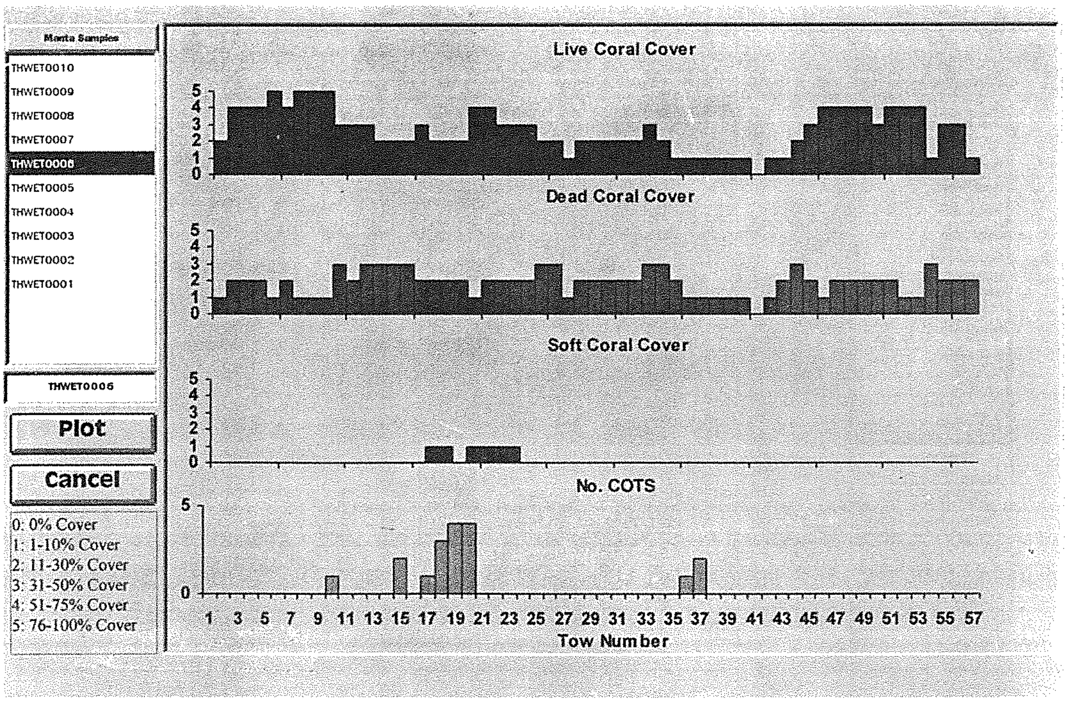
3: 31-50% Cover
4: 51-75% Cover
5: 76-100% Cover
Live Coral Cover
Dead Coral Cover
Soft Coral Cover
No. COTS
Tow Number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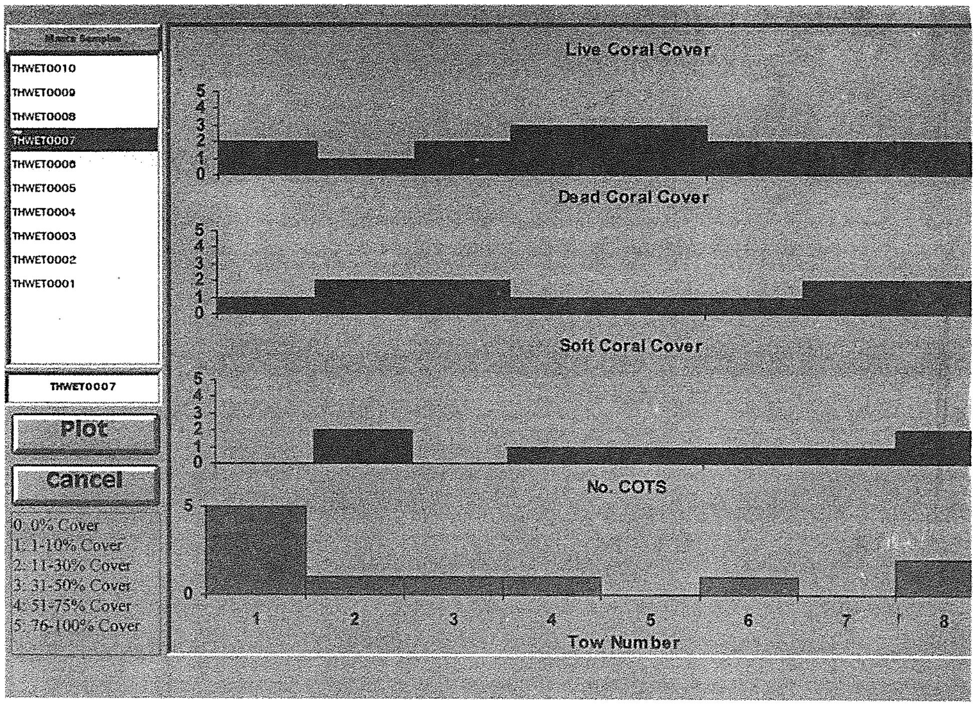
Live Coral Cover
Dead Coral Cover
Soft Coral Cover
No. COTS
Tow Number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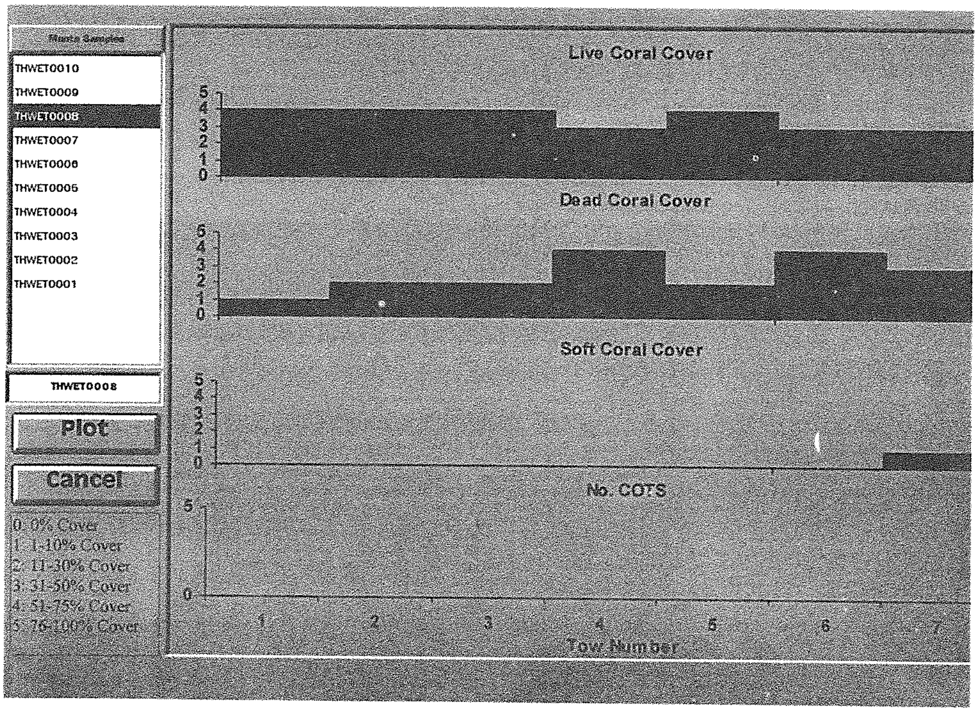
5: 76-100% Cover
Live Coral Cover
Dead Coral Cover
Soft Coral Cover
No. COTS
Tow Number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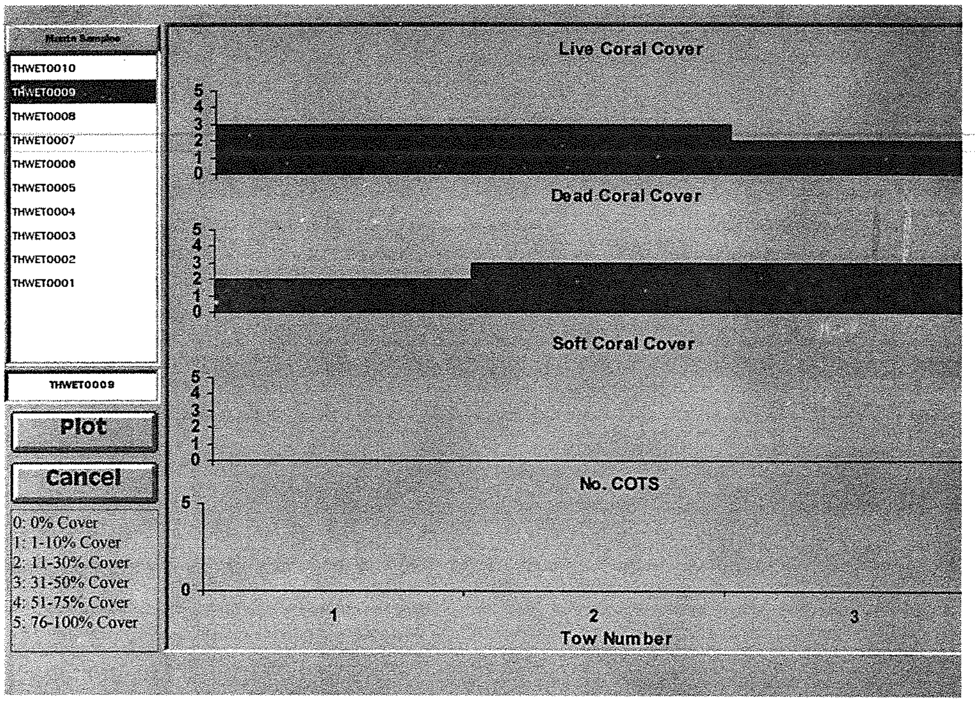
Live Coral Cover
Dead Coral Cover
Soft Coral Cover
No. COTS
Tow Number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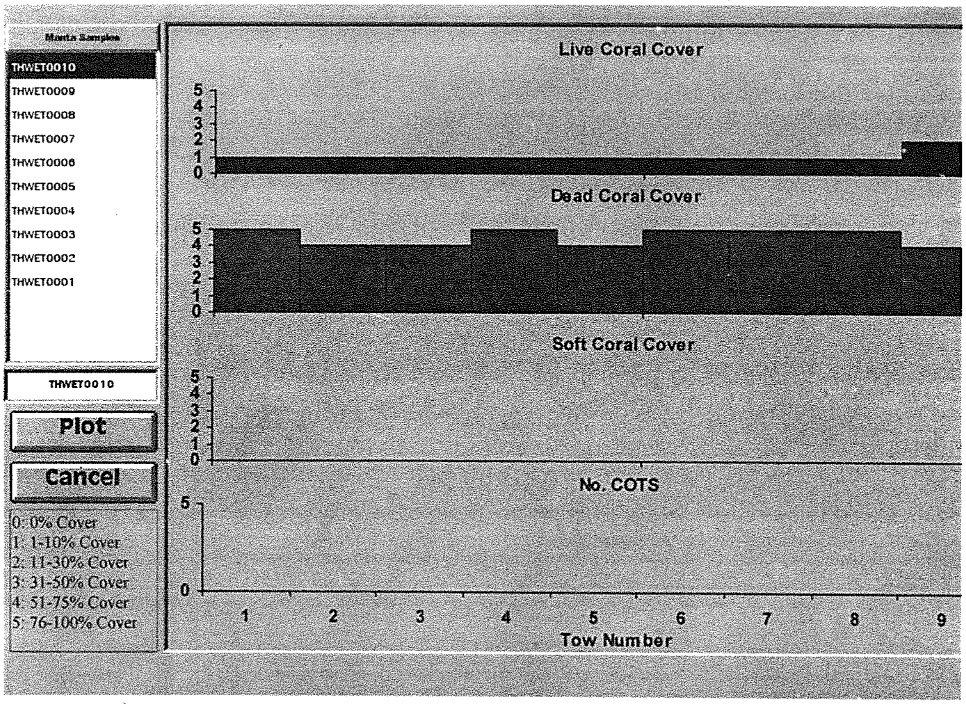
Live Coral Cover
Dead Coral Cover
Soft Coral Cover
No. COTS
Tow Number


Manta Samples
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THWET0009
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THWET0003
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THWET0001
THWET0010
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3: 31-50% Cover
4: 51-75% Cover
5: 76-100% Cover
Live Coral Cover
Dead Coral Cover
Soft Coral Cover
No. COTS
Tow Number

Sample Table

Sample Id	Location	Reef Name	Date	Cloud	Wind	Sea	Tide	Latitude	Longitude	Reef Zone	Data Type	Depth	Collectors
THLIT0001	Tarutao National Park	Ko Adang South (B)	29/04/1997	5	1	C	R	63100N	991800E	SLOPE	T	8	Guillermo
THLIT0002	Ko Phuket	Cape Panwa Pier	12/05/1997	6	2	S	F	74800N	982500E	SLOPE	T	2.5	Paul, Nipho
THLIT0003	Ko Phi Phi Don	Yongkasem Bay	13/05/1997	3	2	S	R	74500N	984600E	SLOPE	T	5	Niphon Pho
THLIT0004	Ko Phi Phi Don	Yongkasem Bay	13/05/1997	3	1	C	R	74500N	984600E	CREST	T	3	Paul Erftem
THLIT0005	Ko Phi Phi Don	Ton Sai Bay	13/05/1997	5	1	C	R	74400N	984700E	SLOPE	T	5	Niphon Pho
THLIT0006	Ko Phi Phi Don	Ton Sai Bay	13/05/1997	5	1	C	R	74400N	984700E	FLAT	T	3	Caroline, P

APPENDIX 5. **Sample table showing the reef zone and depths of the Line Intercept Transects.**

APPENDIX 6. A list of coral reef species encountered during the survey.

	Cape Panwa Pier	Yongkasem Bay	Ton Sai Bay
Acropora divaricata	x	x	-
Acropora sp.	x	x	x
Acropora formosa	x	-	x
Acropora humilis	-	x	x
Acropora nobilis	x	x	-
Astreopora sp.	-	x	-
Coeloseris mayeri	-	x	-
Cyphastrea sp.	x	x	-
Diploastrea heliopora	-	x	-
Echinopora horrida	-	x	-
Echinopora lamellosa	-	-	x
Echinopora sp.	-	x	-
Echinophyllia sp.	x	x	-
Favites sp.	x	x	-
Favites abdita	x	x	-
Fungia sp.	x	x	x
Fungia echinata	x	x	x
Favia sp.	x	x	x
Goniastrea pectinata	x	x	-
Goniastrea retiformis	x	-	-
Galaxea fascicularis	-	x	-
Galaxea sp.	-	x	-
Goniopora fruticosa	-	x	-
Goniopora sp.	-	x	x
Herpolitha limax	-	x	x
Herpolitha sp.	-	-	x
Hydnophora exesa	-	x	-
Hydnophora rigida	-	x	x
Leptastrea sp.	-	x	-
Lithophyllon edwardsi	x	-	-
Montipora aequituberculata	-	x	-
Montipora hispida	-	x	-
Montipora sp.	x	x	-

Merulina ampliata	x	x	x
Millepora sp.	-	x	-
Montastrea sp.	-	x	-
Mycedium elephantotus	-	x	-
Porites lutea	x	x	x
Porites sp.	-	x	-
Porites nigrescens	x	-	x
Porites (Synaraea) rus	x	x	x
Porites vaughni	-	x	-
Pachyseris rugosa	-	x	-
Pectinia sp.	x	x	x
Platygyra sp.	x	x	-
Plerogyra sinuosa	-	-	x
Plerogyra sp.	-	-	x
Physogyra lichtensteini	-	-	x
Pocillopora damicornis	x	x	x
Pocillopora verrucosa	-	x	-
Podabacia crustacea	x	x	x
Polyphyllia talpina	-	x	-
Pavona explanulata	x	x	x
Pavona sp.	-	x	x
Pavona varians	x	x	x
Sinularia sp.	-	-	x
Symphylia sp.	x	x	-
Tridacna squamosa	-	x	-
corallimorph	-	x	-
Cladiella sp.	x	-	-

APPENDIX 7. Percent cover data of benthic lifeform categories

	Ko Adang South (8 m)		Cape Panwa Pier (3 m)		Yongkasem bay (5 m)		Yongkasem bay (3 m)		Ton sai bay (5 m)		Ton Sai Bay (3 m)	
Life form	Avg %cover	SD (n=2)	Avg % Cover	SD (n=6)	Avg % Cover	SD (n=7)	Avg % Cover	SD (n=7)	Avg %cover	SD (n=6)	Avg %cover	SD (n=6)
AA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ACB	0.94	0.94	1.06	0.98	0.87	0.76	0.57	1.13	4.27	1.86	1.49	5.86
ACD	5.48	2.43	0.75	0.90	0.00	0.46	0.26	0.00	0.00	0.12	0.08	0.00
ACE	0.00	0.00	0.00	0.00	0.00	0.35	0.14	0.00	0.00	0.00	0.00	0.00
ACS	8.50	8.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ACT	2.73	1.08	0.46	1.10	0.00	0.00	0.00	0.00	0.07	2.34	1.26	0.15
CA	1.37	0.03	0.00	0.00	0.00	0.31	0.13	0.00	0.00	1.29	0.64	0.00
CB	1.60	1.60	0.58	0.60	3.61	2.45	2.29	5.21	35.19	3.92	2.84	16.19
CE	0.00	0.00	0.69	0.81	0.81	1.32	1.62	0.79	0.03	1.78	3.06	0.07
CF	0.83	0.83	0.55	0.86	1.53	5.53	5.03	2.16	1.56	0.45	0.26	2.48
CHL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CM	25.98	1.33	7.05	7.85	19.34	4.87	10.78	6.74	5.58	9.05	16.69	5.73
CME	0.00	0.00	0.00	0.00	1.13	0.55	0.32	0.72	0.00	0.00	0.00	0.00
CMR	0.00	0.00	1.62	1.16	8.94	1.94	1.41	2.73	1.82	0.55	0.45	1.82
CS	0.61	0.36	1.73	1.91	0.36	8.11	7.54	0.59	6.89	6.73	17.41	9.16
DC	3.53	1.48	0.55	1.32	0.00	0.00	0.00	0.00	0.00	0.35	0.14	0.00
DCA	1.29	0.16	83.86	9.07	49.76	14.15	38.34	5.86	38.87	12.29	40.86	14.51
HA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OT	12.72	0.82	0.00	0.00	0.78	0.16	0.06	0.79	0.00	1.16	0.51	0.00
R	10.76	6.14	0.00	0.00	0.00	11.30	22.19	0.00	1.15	3.58	5.25	2.57
RCK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	5.75	2.90	0.46	0.48	12.71	8.19	6.18	7.70	4.48	7.39	8.80	6.46
SC	0.08	0.08	0.08	0.00	0.00	0.17	0.07	0.00	0.05	0.00	0.00	0.11
SI	0.55	0.55	0.00	0.00	0.00	3.51	1.59	0.00	0.00	0.00	0.00	0.00
SP	0.40	0.40	0.00	0.00	0.10	0.00	0.00	0.16	0.05	0.00	0.00	0.11
TA	8.78	5.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.18	0.00
WA	1.18	1.18	0.56	1.34	0.06	3.59	1.46	0.14	0.00	0.17	0.07	0.00
ZO	6.92	1.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

GLOSSARY

AIMS	Australian Institute of Marine Science
ARMDES	Aims Reef Monitoring Data Entry System
ASEAN	Association of South East Asian Nations
ASPEO	Association of South Pacific Environment Organizations
COT	Crown-of-Thorns Starfish
GCRMN	Global Coral Monitoring Network
ICLARM	International Centre for Living Aquatic Resources Management
ICRI	International Coral Reef Initiative
IOC	Intergovernmental Oceanographic Commission
IUCN	World Conservation Union (formerly, "International Union for the Conservation of Nature and Natural Resources")
IYOR'97	International Year of the Reefs, 1997
Ko	Thai word for "island"
OEPP	Office of Environmental Policy and Planning
PMBC	Phuket Marine Biological Centre
PSU	Prince of Songkla University
RFD	Royal Forest Department
SCUBA	Self Contained Underwater Breathing Apparatus
SST	Sea Surface Temperature
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
URG	Underwater Research Group
UV	Ultraviolet Rays
Vis	Visibility
WMO	World Meteorological Organization

Thailand's coastline is blessed with exquisite coral reefs. These "rainforests of the sea" are among nature's most spectacular and productive ecosystems. They provide a habitat for more than a million marine species. It is estimated that one square kilometre of healthy coral reef can produce between 12 and 50 tonnes of seafood each year. Besides their support for fisheries, coral reefs act as "wave-breaks", protecting the shoreline against erosion.

Coral reefs take thousands of years to develop, but are currently being degraded at an alarming rate. Unlike the easily observed rainforest destruction, damage to reefs is largely hidden beneath the sea and is more difficult to monitor. Natural events such as storms and Crown-of-Thorns Starfish infestations have some impacts, but human activities, even those carried out far away from reefs, may have serious consequences. Overfishing, reef blasting, shell collection, dynamite fishing, bleach and pesticide poisoning, siltation, mining, agricultural chemical run-off, sewage contamination, trawling, push-net fisheries and tourist-related activities are all contributors to the deterioration of the reefs.

In this report, results of an assessment of the current status of some spectacular reef sites in the Andaman Sea, Thailand are presented, including a summarized review of the current coral reef management and monitoring activities in Thailand.

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