

SOUTHERN LEYTE CORAL REEF CONSERVATION PROJECT

1st Bi-Annual Report



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CONTENTS

ACKNOWLEDGEMENTS	IV
EXECUTIVE SUMMARY	V
LIST OF TABLES AND FIGURES	VII
LIST OF ABBREVIATIONS	X
1. INTRODUCTION	1
1.1 Project Background	2
1.2 Previous studies in the area	4
1.3 Threats to the coral reefs of Sogod Bay	6
1.3.1 Sedimentation	6
1.3.2 Pollution and nitrification	7
1.3.3 Fishing Pressure	7
1.3.4 Crown of thorns outbreaks	9
1.3.5 Coral bleaching	10
1.4 Marine Protected Areas	10
2. METHODS	12
2.1 Survey Strategy	12
2.2 Volunteer Training	14
2.3 CCC Baseline survey technique	15
2.3.1 Generation of habitat information	20
2.4 Rapid Reef Assessment	20
2.5 Reef Check	21
2.6 Crown of thorns surveys	23
2.7 Sedimentation monitoring programme	23
3. RESULTS	26
3.1 Rapid Reef Assessments	26
3.2 Baseline Surveys	35
3.3 Reef Check Surveys	42
3.3.1 Timba Sanctuary	42
3.3.2 Secret Garden	46
3.3.3 Liloan Sanctuary	50
3.4 Crown of thorns Survey	54
3.4.1 Crown of thorns density and substrata	54
3.4.2 Extent of Coral Damage	56
4. DISCUSSION	58
4.1 Rapid Reef Assessments	58

4.2 Baseline Surveys	59
4.3 Reef Check Surveys	61
4.4 Crown of Thorns surveys	63
4.5 Community Projects and Capacity Building	64
4.6 Conclusion	67
5. REFERENCES	69
6. APPENDICES	72
Appendix A	72
Appendix B	74
Appendix C	82
Appendix D	86

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EXECUTIVE SUMMARY

- The coastal and marine resources of Sogod Bay (Eastern Visayas, Philippines) are considerably diverse and provide livelihoods for multiple stakeholders including fishers, recreational divers and miners
- Various significant anthropogenic impacts threaten the intricate diversity of the coral reefs of this area including overfishing, eutrophication, sedimentation and destructive fishing methods such as the use of cyanide.
- The Southern Leyte Coral Reef Conservation Project (SLCRCP) was initiated in September 2002 after an agreement was signed between Coral Cay Conservation (CCC), a UK-based not-for-profit organisation, the Philippines Reef and Rainforest Conservation Foundation Inc. (PRRCFI) and the Provincial Government of Southern Leyte.
- The primary aims of the SLCRCP are to survey the coral reefs of the Sogod Bay region and also providing both training and conservation education for project counterparts and local communities.
- Since September 2002, teams of international CCC volunteers carried out survey dives including rapid reef assessments, CCC baseline reef surveys, Reef Check surveys, crown of thorns monitoring and the initialising of a sedimentation monitoring programme.
- Initial rapid assessment surveys indicated that the region is extremely rich in coral reef flora and fauna with abundant reef fish communities and very high hard coral cover in some areas.
- The results of the rapid reef assessments suggest that the east coast of the bay has a richer coral reef environment, which may be attributable to the more sheltered location or less anthropogenic impacts. Observation and results also suggest that coral reefs are more extensive closer to the mouth of the bay.
- Sedimentation is a growing concern within the bay, with many reefs, particularly at the vertex of the bay, and close to population concentrations suffering from high sediment loads in the water column. The majority of sediment appears to stem from the extensive river systems entering at the head of the bay near Sogod town.
- Results of baseline surveys carried out during 91 dives over 21 transects in Sector 10 show an area which is biologically and aesthetically poor. Scleractinian coral abundance was low and the dominant fish family was damselfish (Pomacentridae). There was a notable absence of commercially important fish species.

- Reef Check surveys of two fish sanctuaries and one unprotected reef site revealed that the unprotected site had the highest abundance and diversity of fish, with commercially important species present but small in size.
- Crown of thorns sea stars, which feed on live coral have been observed in several areas within the bay and although not at outbreak levels, widespread damage is evident. Monitoring of these echinoderms is continuing and control measures may have to be implemented in the future if the integrity of economically important reef areas is threatened.
- Alongside the marine surveys CCC is initiating environmental education programmes in Sogod Bay. The CCC project site has held a number of very successful ‘open days’ where local schools are invited to participate in a series of education and awareness events. Local counterpart dive and survey training is also underway for provincial government employees.
- Given the high biodiversity of coral populations of some areas within Sogod Bay, serious consideration should be made to increasing the number and range of marine protected areas. Recommendations for such areas will form part of subsequent SLCRCP reports.

LIST OF TABLES AND FIGURES

Table 1.1	Established fish sanctuaries in Sogod Bay.
Table 2.1	Ordinal scale assigned to life forms and target species during CCC Reef Survey Technique surveys.
Table 2.2	Crown of thorns size classes used to assess the diameter of crown of thorns during surveying.
Table 2.3	Damage categories used to assess the extent of crown of thorns damage to scleractinian coral.
Table 3.1	Number of sites surveyed using Rapid Reef Assessments within each sector and the municipalities covered by that sector.
Table 3.2	Codes used as abbreviations for hard coral lifeforms (Adapted from English <i>et al.</i> , 1997).
Table 3.3	Mean numbers ($\pm$ standard deviations) of invertebrates recorded during four 20m transects set at two depths (8m and 12m) at Timba fish sanctuary (Sector 9). Each transect represents a replicate.
Table 3.4	Mean numbers ($\pm$ standard deviations) of invertebrates recorded during four 20m transects set at two depths (6m and 12m) at Secret Garden (Sector 8). Each transect represents a replicate.
Table 3.5	Mean numbers ($\pm$ standard deviations) of invertebrates recorded during four 20m transects set at two depths (6m and 12m) at Secret Liloan fish sanctuary (Sector 19). Each transect represents a replicate.
Table 3.6	Size distribution of COTs recorded along six 20m transects at four depth contours. Values are percentages of total COTs observed per depth contour.
Figure 1.1	Location Map of Eastern Visayas Region.
Figure 2.1	Topographic map of Sogod Bay showing the 26 survey sectors.
Figure 2.2	Schematic diagram of a CCC Reef Survey Technique.
Figure 2.3	Schematic diagram (aerial aspect) of an example of a reef area mapped by divers during a sub-transect survey.
Figure 2.4	The use of a secchi disc to assesses vertical water clarity.
Figure 2.5	Schematic diagram showing the position of the transect lines during a Reef Check survey.
Figure 2.6	Model of a sediment trap.
Figure 3.1	Map of Sogod Bay showing the location of Rapid Reef Assessments
Figure 3.2	Mean abundance (DAFOR Scale) of fish recorded at three depths in sectors 3, 7, 8, 9, 10, 19 and 22.
Figure 3.3	Mean abundance (DAFOR Scale) of main benthic faunal groups recorded at Sector 3.

- Figure 3.4 Mean abundance (DAFOR Scale) of main benthic faunal groups recorded at Sector 7.
- Figure 3.5 Mean abundance (DAFOR Scale) of main benthic faunal groups recorded at Sector 8.
- Figure 3.6 Mean abundance (DAFOR Scale) of main benthic faunal groups recorded at Sector 9.
- Figure 3.7 Mean abundance (DAFOR Scale) of main benthic faunal groups recorded at Sector 10.
- Figure 3.8 Mean abundance (DAFOR Scale) of main benthic faunal groups recorded at Sector 19.
- Figure 3.9 Mean abundance (DAFOR Scale) of main benthic faunal groups recorded Sector 21.
- Figure 3.10 Relationship between mean hard coral abundance and mean fish abundance at all sectors.
- Figure 3.11 Mean abundance (DAFOR Scale) of the most common fish families recorded during baseline surveys in Sector 10.
- Figure 3.12 Abundance (DAFOR scale) of hard coral life forms observed in Sector 10.
- Figure 3.13 Abundance (DAFOR scale) of the most frequently recorded hard coral target species in Sector 10.
- Figure 3.14 Abundance (DAFOR scale) of the infrequently recorded hard coral target species in Sector 10.
- Figure 3.15 Abundance (DAFOR scale) of the most common invertebrate target species/ life forms recorded in Sector 10.
- Figure 3.16 Abundance (DAFOR scale) of the less commonly observed invertebrate target species/ life forms recorded in Sector 10.
- Figure 3.17 Abundance (DAFOR scale) of green algae (*Chlorophyta*) target species recorded in Sector 10.
- Figure 3.18 Abundance (DAFOR scale) of brown algae (*Phaeophyta*) target species recorded in Sector 10.
- Figure 3.19 Abundance (DAFOR scale) of red algae (*Rhodophyta*) target species recorded in Sector 10.
- Figure 3.20 Abundance (DAFOR scale) of marine plants (*Angiospermatophyta*) target species recorded in Sector 10.
- Figure 3.21: Percent cover of substrata recorded during Reef Check surveys at Timba fish sanctuary (Sector 9).
- Figure 3.22 Mean percent cover of hard coral life forms recorded during Reef Check surveys at Timba fish sanctuary (Sector 9).
- Figure 3.23 Mean percent cover of hard coral target species recorded during Reef Check surveys at Timba fish sanctuary (Sector 9).

- Figure 3.24 Mean numbers ($\pm$ standard deviations) of target fish recorded during Reef Check surveys at Timba fish sanctuary (Sector 9).
- Figure 3.25 Percent cover of substrata recorded during Reef Check surveys at Secret Garden (Sector 8).
- Figure 3.26 Mean percent cover of hard coral life forms recorded during Reef Check surveys at Secret Garden (Sector 8).
- Figure 3.27 Mean percent cover of hard coral target species recorded during Reef Check surveys at Secret Garden (Sector 8).
- Figure 3.27 Mean numbers ($\pm$ standard deviations) of target fish recorded during Reef Check surveys at Secret Garden (Sector 8).
- Figure 3.28 Percent cover of substrata recorded during Reef Check surveys at Liloan fish sanctuary (Sector 19).
- Figure 3.29 Mean percent cover of hard coral life forms recorded during Reef Check surveys at Liloan fish sanctuary (Sector 19).
- Figure 3.30 Mean percent cover of hard coral target species recorded during Reef Check surveys at Liloan fish sanctuary (Sector 19).
- Figure 3.31 Mean numbers ($\pm$ standard deviations) of target fish recorded during Reef Check surveys at Liloan fish sanctuary (Sector 19).
- Figure 3.32 Density of Crown-of-thorns at “Logger’s Eden”.
- Figure 3.33 Percentage of COTs recorded on various substrates.
- Figure 3.34 The percentage of COTs recorded on non-*Acropora* hard coral species.
- Figure 3.35 Percentage of coral colonies damaged.
- Figure 3.36 Percentage of hard coral forms visibly damaged by COTs averaged over 6 depth contours.

LIST OF ABBREVIATIONS

ANOSIM	Analysis of Similarity
BC	Benthic Class
CCC	Coral Cay Conservation
COT	Crown of Thorns (Sea star)
DENR	Department of the Environment and Natural Resources
DIMRS	Danjugan Island Marine Reserve and Sanctuaries
GIS	Geographic Information System
GPS	Global Positioning System
ha	Hectares
ICZM	Integrated Coastal Zone Management
ID	Identification
MPA	Marine Protected Area
MOA	Memorandum of Agreement
MTMBCP	Mabini-Tingloy Marine Biodiversity Conservation Project
NGO	Non-Governmental Organisation
p	Percent (significance value in statistics)
PADI	Professional Association of Diving Instructors
PGSL	Provincial Government of Southern Leyte
PRIMER	Plymouth Routines in Multivariate Ecological Research
PRRCFI	Philippines Reef and Rainforest Conservation Foundation Inc.
PS	Project Scientist (CCC staff position)
RRA	Rapid Reef Assessment
SCUBA	Self Contained Underwater Breathing Apparatus
SIMPER	Similarity Percentage
SLCRCP	Southern Leyte Coral Reef Conservation Project
SLSCST	Southern Leyte College of Science and Technology
SMB	Surface Marker Buoy
SO	Science Officer (CCC staff position)
WWF	World Wide Fund for Nature

1. Introduction

The Philippine archipelago of approximately 7100 islands forms part of the Wallacea triangle, an area renowned for its high terrestrial and marine biodiversity. Some 499 hard coral species (Chou, 1998) and more than 2500 fish species (Collins, 2001) have been recorded to date. The coastline is fringed with approximately 25,000 km² of coral reefs, about 10% of the land area of the whole archipelago (Spalding *et al.*, 2001).

Coral reefs provide livelihoods for coastal communities through fishing, aquaculture and tourism. Reef fish are the primary source of protein for most Filipinos, whilst many invertebrates such as giant clams (*Tridacna* spp.) and sea cucumbers (Holothurians) are also commercially harvested and fetch high prices on the market. Coastal tourism and diving tourism in particular can provide alternative means of income for coastal communities as long as the industry is managed sustainably in terms of the environmental effects of development. The majority of the population (approximately 70 million) of the Philippines is concentrated along the coastline putting intense pressure on the marine resources through a range of impacts. The greatest anthropogenic impacts are caused by solid and liquid pollution, overfishing, habitat degradation and increased sedimentation. Coral reefs act as important physical barriers, which, along with mangroves, protect coastal communities from storm damage and coastal erosion. Coastal habitat loss can therefore have a dramatic influence on the success and future livelihoods of coastal populations. Hard corals require environmental stability in order to thrive and have a narrow band of tolerance for physical parameters such as temperature and salinity and sediment loads. Small changes in these properties can have dramatic impacts on the reef ecosystem.

Effective coastal zone management, including conservation of coral reefs, requires a holistic and multi-sectoral approach, which is often a highly technical and costly process and one that many developing countries cannot adequately afford. With appropriate training, non-scientifically trained, self-financing volunteer divers have been shown to be able to provide useful data for coastal zone management at little or no cost to the host country (Hunter and Maragos, 1992; Mumby *et al.*, 1995; Wells, 1995; Darwall and Dulvy, 1996; Erdmann *et al.*, 1997; Harding *et al.*, 2000; Harborne *et al.*, In press). This technique has been pioneered and successfully applied by Coral Cay Conservation (CCC), a British not-for-profit organisation.

Founded in 1986, CCC is dedicated to '*providing resources to protect livelihoods and alleviate poverty through the protection, restoration and sustainable use of coral reefs and tropical forests*' in collaboration with government and non-governmental organisations within a host country. CCC does not charge the host country for the services it provides and is primarily self-financed through a pioneering volunteer participatory scheme whereby international volunteers are given the opportunity to join a phase of each project in return for a financial contribution towards the project costs. Upon arrival at a project site, volunteers undergo a training programme in marine life identification and underwater survey techniques, under the guidance of qualified project scientists, prior to assisting in the acquisition of data. Finances generated from the volunteer programme allow CCC to provide a range of services, including data acquisition, assimilation and synthesis, conservation education, technical skills training

and other capacity building programmes. CCC is associated with the Coral Cay Conservation Trust (the only British-based charity dedicated to protecting coral reefs) and the USA-based Coral Cay Conservation Foundation.

1.1 PROJECT BACKGROUND

The Southern Leyte Coral Reef Conservation Project (SLCRCP) was initiated in September 2002 after an agreement was signed between Coral Cay Conservation (CCC), a UK-based not-for-profit organization, the Philippines Reef and Rainforest Conservation Foundation Inc. (PRRCFI) and the Provincial Government of Southern Leyte (PGSL). The project is initially planned to run for three years and is based near Malitbog in Sogod Bay, Southern Leyte Province in the Eastern Visayas.

The objectives of the project are to:

- Undertake a comprehensive assessment of coastal marine resources in Sogod Bay.
- Collect quantitative information on ecologically and commercially important marine species.
- Produce detailed coastal habitat maps for use as an educational and planning tool for Marine Protected Area (MPA) designation.
- Undertake community education and capacity building programmes in order to:
 - Increase local awareness of marine environmental issues.
 - Highlight the importance and economic benefits of MPAs.
 - Train PGSL employees in SCUBA and marine surveying techniques.
- Initiate the planning of an ICZM scheme for Southern Leyte with full stakeholder involvement.

Southern Leyte, one of the six provinces of Eastern Visayas (Figure 1.a,b) is bounded in the north by Leyte province, in the south by Mindanao Sea, in the east by the Pacific Ocean and in the west by the Canigao Channel. Sogod Bay (10° 12' N, 125° 12' E) is surrounded by 131.67 km of coastline and is bordered by 11 municipalities: Padre Burgos, Malitbog, Bontoc, Sogod, Libagon, Liloan, San Francisco, Limasawa, Pintuyan, San Ricardo and Tomas Oppus (Calumpong *et al.* 1994). The islands of Panaon and Limasawa also form part of Sogod Bay. Within the bay, Sogod town is the centre for trade, commerce and industry.

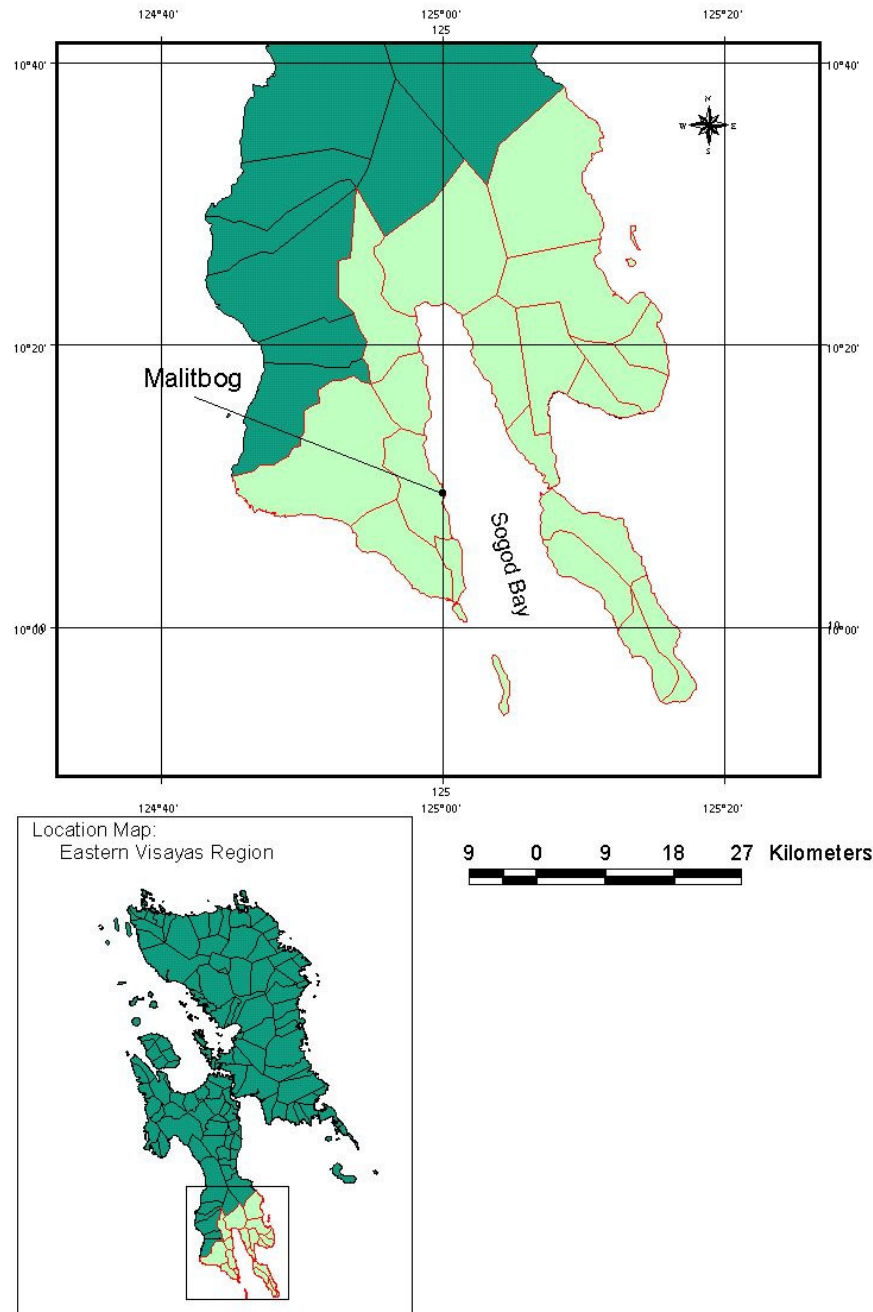


Figure 1: 1a. Map of Eastern Visayas Region showing the location of Southern Leyte Province in light green. Sogod Bay and the location of Malitbog where CCC is based are also marked (1b.). Source: DENR, Leyte and SLSCST, Southern Leyte.

The coral reefs of Southern Leyte remain some of the least disturbed and least researched habitats in the Philippines. Sogod Bay is an important fishing ground and the area is rich in tuna, flying fish, herrings, anchovies, shell-fish, lobsters and spanish mackerel. The Bay has been targeted by the Fisheries Sector Program of the

Department of Agriculture as one of the country's ten largest bays in need of assessment and management (Calumpong *et al.*, 1994). Sogod Bay is also a feeding ground for attractive mega-fauna such as pilot whales, melon-headed whales, dolphins, manta rays and whale sharks.

The bay is characterised by naturally limited mangrove areas, narrow coral reefs, limited seagrass beds and narrow intertidal areas and beaches (Calumpong *et al.*, 1994). Depths in the bay reach a maximum of approximately 800 metres in the central channel. Aquaculture is limited in the province and mainly consists of a clam-culturing programme in Bontoc, mud-crab farming and also fin-fish operations in Liloan, Libagon and Tomas Oppus where groupers (Serranidae) are cultured. However, some of these ventures have been unsuccessful, possibly due to poor placement and management. The bay is ideal for nearshore fish farms and aquaculture procedures as the seabed is often steeply sloping and current patterns carry water away from the coast to the centre of the bay where they are flushed out during ebb tides.

The topography of the coast surrounding Sogod Bay is characterised by steeply sloping hills. The western side of the bay has a flatter topography than the eastern coast, where steep hills often slope straight into the sea. The seabed is steeply sloping providing the bay with a minimal coastal shelf and a deep, narrow central channel. There are two major rivers entering the north of Sogod Bay; the Divisoria River in Bontoc and the Subang Daku River in Sogod. This area has been subjected to high sediment loadings and subsequent marine life mortality (Calumpong *et al.*, 1994). There are also numerous smaller rivers entering the bay, which do not seem to be transporting excessive amounts of terrigenous sediments into the coastal waters.

The province does not have distinct dry and wet seasons. However, maximum rainfall occurs between October to January during the southwest monsoon and annual rainfall averages 2 metres per year (Calumpong *et al.*, 1994).

Population in the province has declined at a rate of 0.84% from 321, 940 in 1990 to 317, 565 in 1995 and resides at a density of 183 people km⁻². Low human population is a factor that has contributed to the protection of coral reefs locally to date. However, a rise in population and subsequent pressure on all marine resources could result in marine habitat degradation and consequently the loss of income or whole livelihoods. The ecosystem diversity in Sogod Bay is limited and the processes of degradation are prevailing (Calumpong *et al.*, 1994).

1.2 PREVIOUS STUDIES IN THE AREA

The first comprehensive survey of marine resources in the area was carried out between 1990 and 1993 (Koch, 1993). The study was aimed at determining the physical and biological condition of the near-shore marine environment of the Province of Southern Leyte as well as the state of the fisheries resource. Interviews carried out with local people revealed that the fish catches of coastal areas had decreased. Marine surveys confirmed extensive damage to coral reefs and other

critical habitats. The damage can be linked to anthropogenic activities both in the water and on land. Koch (1993) recommended the establishment of marine reserves to promote the recovery and protection of the area. The author also identified the need to carry out vigorous education campaigns in order to elucidate the benefits of good marine, land and waste-management practices. From the surveys, it was estimated that 50% of the coral reefs, which were extensive 15 years previously, had been almost totally destroyed. Another 30% had been heavily damaged with less than 25% of the corals remaining.

Silliman University undertook a thorough assessment of the natural resources and coastal ecology in Sogod Bay in 1993/1994 and again in 2001/2002. The more recent study was in press and unavailable at the time of writing. During the 1993/1994 surveys, water quality and fisheries were assessed and an ecological study of the bay was carried. A summary of the main findings and recommendations is presented below. The extent and condition of the coral reef resources was assessed using manta tow surveys and quadrat sampling methods. To date, no comprehensive work has been carried out on the deeper parts of the reefs in Sogod Bay.

➤ **Fisheries**

- No growth overfishing.
- Heavy fishing pressure indicated by commercially important fish maturing at a smaller size than elsewhere.
- Recommended a ban on commercial fishing within and at the mouth of the bay.

➤ **Water Quality**

- The bathymetry and current patterns of the bay enable a continual flushing out of silt delivered by the major rivers.
- Indications of severe damage to coastal areas in the vicinity to the large rivers near Sogod town at the vertex of the bay.

➤ **Ecology**

- 78% of manta tows had 1-10% live coral cover and only 2% have coral cover greater than 31%.
- Most of the reefs were observed to be heavily silted and waters were generally turbid throughout the bay.
- High degree of disturbance indicated by the predominance of soft corals and encrusting and massive hard coral morphologies.
- The marine sanctuary at Liloan harboured the most diverse mollusc population.
- Three sites were identified as good candidates for protection as they had high percentage of live hard coral cover (36-49%). These are Tabugon and Kalian in Liloan municipality and Ilijan Point in San Fransisco municipality.

1.3 THREATS TO THE CORAL REEFS OF SOGOD BAY

It has been predicted that 97% of the reefs across the Philippines are at risk (Spalding *et al.*, 2001). A variety of factors, exacerbated by an expanding population, have caused serious degradation of the coral reefs. The main anthropogenic impacts are described below.

1.3.1 Sedimentation

Over much of South East Asia, extensive deforestation has resulted from the harvesting of tropical hardwoods (Hodgson, 1997) and land clearance for agriculture. Sedimentation is expected to be considerable in Sogod Bay, particularly on reefs in proximity to river mouths. Runoff from the land is substantial due to the elevation of the surrounding land, where mountains are in close proximity to the sea and reach a maximum of 2650m. The extensive mountain range encompassing Sogod Bay is covered with both primary forests dominated by the Philippine mahogany tree as well as planted coconut palms, harvested every three months. Logging in the area has been banned but illegal logging does occur, particularly in times of bad weather (Pretentio, pers. comm.). During the wet season (between November and February) and during periods of extreme rainfall, runoff is expected to be greater and hence have a considerable impact on the narrow band of fringing reefs.

Following particularly heavy rainfall during December 2002 sedimentation from runoff was evident around the reef in front of our base in Malitbog (Doyle, pers. obs.). The seabed was coated in a thick layer of brown, terrigenous sediment.

Five main rivers flow into Sogod Bay; the Pandan with 5 tributaries entering the bay to the east of Sogod town. Two rivers enter at Bontoc, two at Libagon and another in the north of the Bay at Concalacion. Anecdotal evidence suggests that the St. Antonio fish sanctuary at Tomas Oppus is prone to high levels of sedimentation (Roy Cahambing, pers. comm.). The area surrounding Sogod town in the apex of the bay is also served by a large river. It has been documented that the coastal resources of this area have already suffered extreme degradation as a result of high sedimentation (Calumpong *et al.*, 1994).

Resuspension of sediments near the coasts is also caused by both wind and wave action. The west coast of Sogod Bay may be more affected by wind driven resuspension as the shallow reefs in east of the bay are protected by mountains from the predominant north-easterly winds. The resuspended sediments may be siliclastic or marine based. That is, the sediments that well up and settle during each tidal cycle, are likely to arise from the movement of natural marine-derived limestone deposits.

Siltation, as a result of natural processes or anthropogenic interference, is thought to be the most important factor influencing the condition of coral reefs (Jacinto *et al.*, 2000). Sedimentation may cause coral mortality and lower recruitment rates leading to decreased rates of accretion of coral reefs and overall habitat degradation. Corals rely on a high amount of light irradiance to survive. Increased sediment loading in the water column reduces the light available to the symbiotic algae (zooxanthellae) living

in the corals tissues for photosynthesis. Sedimentation also physically smothers coral polyps and removal of sediment requires the production of large amounts of mucous, which is an energetically demanding activity. Excess mucous production over long time periods stresses the coral host, further reducing growth and reproductive capacities. Subsequent coral mortality and decreased coral reef growth rates can have knock-on effects by reducing the diversity of invertebrate and fish life.

1.3.2 Pollution and nutrification

Tropical waters are generally nutrient poor environments (oligotrophic) and anthropogenically-induced nutrient inputs can upset the water chemistry of coral reefs (McCook, 1999). Excess nutrients (nutrification) in the coastal waters can arise from discharge of untreated effluent and from agricultural run-off containing fertiliser. Pollution may be a particular problem in bay areas where flushing rates are slow and nutrients are not quickly dispersed. Furthermore eddies within coral reef areas can create water circulation patterns, which prevent removal of nutrients to the open ocean and result in localised concentrations.

Nutrification stimulates the growth of marine algae because nutrients such as nitrogen and phosphorous which, under normal conditions limit the growth of marine algae, are in excess. Faster-growing algae begin to compete with and overgrow corals, resulting in a phase shift from a coral-dominated to an algal-dominated community. Certain macroalgae (such as *Lobophora* spp. and *Dictyota* spp.) respond to high levels of nutrients by increasing the growth of their rigid tissue which can contain toxic secondary metabolites. These compounds cannot easily be digested by herbivores, and can therefore result in an almost complete lack of herbivory on the coral reefs (Hay *et al.*, 1996).

Mangrove removal has exacerbated the problems of sedimentation and pollution. Mangroves are important nursery grounds for juvenile fish and invertebrates and their roots help retain and filter nutrients from sediments. The loss of considerable areas of these coastal forests has resulted in the removal of sediments and nutrients to the adjacent coral reefs.

The main sources of pollution in Sogod Bay identified by Calumpong *et al.*, (1994) are: domestic garbage, faecal matter and waste water from population centres. One particular mangrove area in Liloan was being used as a dump for garbage. In the majority of municipalities in Sogod Bay people are responsible for handling their own waste. This is usually burnt, composted or thrown directly into the sea. Some municipalities have landfill sites and rubbish is collected on a twice-weekly basis. However municipalities such as Padre Burgos are having difficulties locating suitable areas as landfill sites that can also meet the requirements of the Provincial ordinance.

1.3.3 Fishing Pressure

The Philippines is one of the largest island groups in the world with 60% of the population residing in coastal areas (Jacinto *et al.*, 2000). The majority of these people are highly dependent on coastal resources for their livelihood and have sustainably

harvested reef resources without causing significant impacts. The current population growth rate will cause the population to double by the year 2035 and this will put significant pressure on resources, including fisheries. It has been suggested that the present levels of fishing can no longer be sustained (Courtney *et al.*, 1999).

Increased fishing pressure poses a major threat to the integrity of coral reefs as well as to the future of these coastal communities. In particular the use of destructive fishing techniques (cyanide, blast-fishing, hookah and muro-ami), reduce the long-term survival of coral reef communities as they inadvertently cause damage to non-target fish, invertebrate and coral species. The use of explosives and poisonous substances and the exploitation of coral have been banned in the Philippines according to the New Fisheries Code (Republic Act 8550) and are declining threats facing the reefs of Sogod Bay.

In Sogod Bay 16 official fish sanctuaries have been established (Table 1.1). There are also eight un-official sanctuaries at present which are proposed for incorporation into legislation in the near future. The sanctuaries are managed by Sanctuary Management Council of the Barangay, which in turn is controlled by the Bureau of Fisheries and Aquatic Resources (BFAR). These sanctuaries were established by initial visual assessments made by government officials who have been SCUBA diving in the bay for many years (Rio Cahambing, Roy Cahambing and Dag Navarette). The sanctuaries were placed in areas which possessed the most abundant and diverse coral reefs. Following their development visual assessments were carried out by the same group every 1-3 years but have not been recently assessed. Initially the sanctuaries were actively guarded by the local Bantay-dagat which each had their own boat for patrol purposes. However in the last four years the Bantay-dagat have not been needed to patrol the areas as vigorously and no longer have local boats to do so. A problem facing the sanctuaries is that the white buoys marking the boundaries tend to disappear during stormy weather and are apparently replaced by the BFAR only every 6 months. Although fishing does not often occur within the sanctuary, boats do pass through the sanctuaries using them as shortcuts. Spearfishing within the sanctuary boundaries at Liloan has occasionally been observed (Doyle, pers. obs.).

Table 1.1 Established fish sanctuaries in Sogod Bay.

Sanctuary name	Approx. area (ha)	Municipality
Son-ok	10	Pintuyan
Napantau	5	San Francisco
Tabugon	20	Liloan
Biasong	Not known	Libagon
Otikon	5	Libagon
San Jose	Not known	Sogod
Tampoong	Not known	Sogod
San Antonio	Not known	Sogod
San Augustin	6	Tomas Oppus
Juargon	2	Malitbog
Timba	2	Malitbog
Lugsongan	Not known	Limasawa
Benit	5	Sn. Ricardo

Residents of the local municipalities predominantly carry out fishing in Sogod Bay. Of the approximately 3000 fishing boats in use 99% are less than 3 tons in weight (Calumpong *et al.*, 1994). The majority of the boats are non-motorized but bangkas with inboard engines are becoming more frequent. Approximately 2000 fishers depend on the bay's marine resources and the majority of these are part time fishers (Calumpong *et al.*, 1994).

The fishery in the bay is multispecific and multigear. Total catch composition is diverse consisting of a total of 347 finfish, 26 molluscan, 8 crustacean, 4 echinoderm and 3 marine mammal species (Calumpong *et al.*, 1994). Multiple hook and line is the most common type of fishing gear used, followed by jigger, trolline, single hook and drift gill net (Calumpong *et al.*, 1994). Studies carried out by Silliman University indicated that the total recorded catch for Sogod Bay was 400.5 metric tonnes. Thirty percent was contributed by drift gill netting. Finfishes comprised 88% of the catch and molluscs 11.5% (Calumpong *et al.*, 1994). Most fishermen still use traditional fishing methods and commercial gears have been banned within the bay. There was evidence of high fishing pressure however it was concluded that no growth overfishing was occurring (Calumpong *et al.*, 1994).

Although the use of destructive fishing methods is illegal, there have been unconfirmed reports of the use of cyanide in both Limasawa and Padre Burgos. Furthermore hookah diving, a dangerous means to an end is still being carried out in both aforementioned municipalities.

The diving industry is in its infancy in the surrounding areas but is showing prospects for growth. There are two active dive operators on the west coast of Sogod Bay, both receiving an increasing number of tourists in early 2003. The dive operations are all small scale and cater for backpacker-type tourists. The establishment of small-scale dive resorts in the future will bring new livelihood options to the people of Sogod Bay and hopefully will provide a greater incentive to preserve the local coral reefs.

1.3.4 Crown-of-thorns outbreaks

Crown-of-thorns starfish (*Acanthaster planci*) is a corralivore, feeding on the lipid palmatate reserves of hard corals. Under normal conditions, it is thought to be a rare echinoderm inhabiting deeper parts of sheltered reefs throughout the Indo-Pacific region. The most distinguishing feature of the adult starfish is its protective armoury of sharp spines up to 50 mm in length, which contain a neurotoxin.

The crown of thorns starfish (COT) was first recognized in an outbreak on the Ryukyu Islands in the 1957 and then around Green Island on the Great Barrier Reef in 1962, (Moran, 1986). The actual numbers of individuals that constitute an outbreak varies spatially and temporally but when a population is consuming coral at a rate faster than the rate corals can grow, an outbreak has been established, (Lourey *et al.*, 2000). *A. planci* prefers to feed on commonly occurring and fast-growing corals such as *Acropora* and *Pocillopora* species. However slow-growing (1cm diameter yr⁻¹), massive corals such as *Porites* spp. are also targeted during outbreaks and can suffer

significant damage. Local extinction of these long-lived, architectural reef colonies could gradually extend the reefs recovery time, (Seymour & Bradbury, 1999). Lourey, (2000), found evidence that up to 25% of the reefs surveyed on the Great Barrier Reef may not recover, as outbreaks over the last thirty years have been occurring more frequently and preventing full regeneration of coral cover.

Whether the outbreaks are a natural phenomenon or are human-induced remains undecided. Given that all major starfish aggregations have occurred near populated areas it seems likely that anthropogenic activities would be linked to the outbreaks (Moran, 1986).

In Sogod Bay crown-of-thorns are abundant in certain areas, and unusually, often in shallow waters (<12m depth). In particular the reefs outside the CCC base at 'Loggers Eden' and 'Secret Garden' have suffered considerable damage by large numbers of COT's since November 2002. From underwater observation the numbers have increased considerably since January 2003 and large areas of dead branching *Acropora* are visible.

1.3.5 Coral Bleaching

A further impact affecting coral reefs globally is coral bleaching, which occurs across all tropical seas as a result of increases in surface water temperature (Hoegh-Guldberg, 1999). Corals either temporarily or permanently disassociate from the symbiotic algae (zooxanthellae) on which they depend, leaving only the white coral skeletons remaining. It is believed that bleaching could become more frequent and more severe as sea surface temperatures rise in response to global warming.

Large-scale bleaching has not been observed within Sogod Bay, which may be a consequence of the movement of the cooler water from the deep parts of the bay to the shallow areas as a result of upwelling currents. The sea surface temperature has been recorded to be less than 28°C to date.

1.4 MARINE PROTECTED AREAS

The establishment of Marine Protected Areas (MPAs) has proved to be an effective method for preserving reefs which have suffered reduction in both coral cover and fish catch. Excellent case studies are Apo Island off the coast of Negros Oriental (Russ and Alcala, 1996) and Danjungan Island in Negros Occidental (Harborne *et al.*, 1996).

Apo Island in Negros Oriental was initially set up as a marine reserve with the full commitment and backing of the local community. It was planned that a small section of the reef (<250 x 50m) would be used as a fish sanctuary (no-take zone). Monitoring surveys showed that large reef associated predator fish such as Jacks (Carangidae) and Grouper (Serranidae) populations increased in biomass and number within 5 years of establishment, both within, and outside the fish sanctuary (Russ and

Alcala, 1996). A local education programme was combined with the surveys to promote understanding of the value of reserves and resulted in the reserve regulations being respected by the fishing community of the island. The reserve continues to provide considerable spill-over of fish to areas surrounding the no-take zone whilst maintaining fish populations within the sanctuary (see Roberts 2000 and Roberts and Hawkins, 2000).

Tubbataha reef protection is on a larger (financial, logistical and spatial) scale, and is managed by the global NGO, the World Wide Fund for Nature (WWF). WWF and other researchers from the Philippines gained the interest of the international scientific and national political world to establish this area as a United Nations World Heritage Site in 1993.

The Danjungan Island Marine Reserve and Wildlife Sanctuaries (DIMRS) in Negros Occidental is another good example of effective marine reserve management. The Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI) has been managing Danjungan Island since 1994, with assistance from the UK-based Non Governmental Organisation (NGO), Coral Cay Conservation (CCC) (Solandt *et al.*, 2000; Harborne *et al.*, 1996). CCC recruited volunteer divers in order to carry out biological surveys of both the marine and terrestrial resources of the island between 1996 and 2001. PRRCFI and CCC also provided training for local fishermen and other community members in marine identification and survey skills, such that the local community is now successfully monitoring the reefs themselves. Alternative livelihoods have also been initiated in the area of Bulata (the coastal village adjacent to the island) in order to take the pressure off the natural resources of the area. These include the development of a mud-crab fishery and mangrove replanting scheme; basket weaving and employment as terrestrial guides, dive guides and reef surveyors.

As a result of the success of the scientific and socio-economic management of the area, the DIMRS was officially sanctioned by Philippine provincial law in February 2000. In 2002 the reserve was voted the 'Best Managed Reef' in the Philippines (by a committee consisting of members of the Department of the Environment and Natural Resources; PhilReefs – the newsletter of the University of the Philippines; The Philippine Council for Aquatic and Marine Research and Development, and The Department of Agriculture).

These projects are beacons that stand out as the success stories of Marine Protected Areas in the Philippines. It has to be the aim of a sustainable development initiative within the Philippines that more success stories such as those from Apo Island, Danjungan Island and Tubbataha are born from other areas of the Philippines. This will help alleviate the poverty resulting from destruction of natural marine resources and help to accommodate large coastal populations and their dependence on the marine environment.

2. Methods

2.1 SURVEY STRATEGY OVERVIEW

The area of Sogod Bay is extensive, with approximately 131 km of coastline and a maximum distance of 15 km between the eastern and western landmasses. The coastline of the bay has been divided into 26 survey sectors each approximately 5 km in length (Figure 2.1) to enable the establishment of a methodical surveying programme.

Initially Rapid Reef Assessments (RRA) were carried out in order to gain an immediate snapshot of the status of the coral reef environment within Sogod Bay. The locations of initial RRA survey sites are shown in Figure 2.2.

Following the rapid evaluation each sector will be surveyed using the *CCC Reef Survey Technique* to create a baseline dataset for habitat designation. Firstly surveys transects were sited at 1 km intervals along the coastline to determine the extent and condition of the coral reef environment present in each sector. Following on from this further transects will be surveyed at intervals of either 500 or 250 metres depending on the results of the initial assessment. Areas with extensive reefs in good condition will be surveyed in more detail than those with degraded reefs.

An adapted form of the global reef survey technique ‘Reef Check’ is used to add quantitative data to the semi-quantitative information collected by the CCC Reef Survey Technique. Reef Check surveys will be conducted both inside and outside of the fish sanctuaries currently designated within the bay. The results will help to determine whether the level of protection in the sanctuaries is working to conserve and or enhance the marine biodiversity and resources within Sogod Bay.

Studies on Crown of Thorns starfish (COTs) were also conducted during December 2003 on the ‘house reef’ in close proximity to the CCC base, as it appeared to be suffering from a COTs outbreak.

Finally a sedimentation study is underway. This will attempt to discern the rates of sedimentation in key areas of the bay, such as within the fish sanctuaries as well as areas close to major rivers.

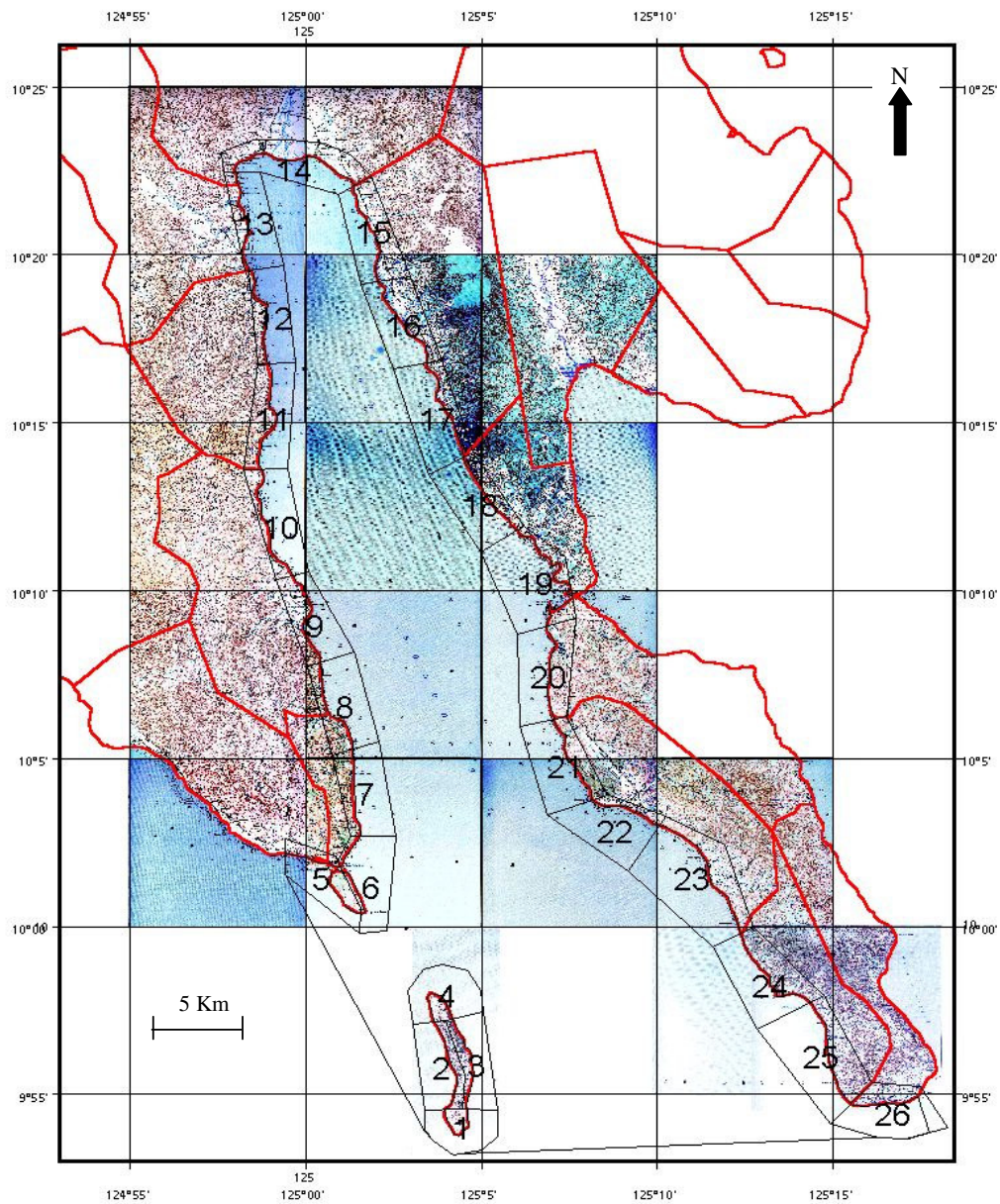


Figure 2.1 Topographic map of Sogod Bay showing the 26 survey sectors. Source: DENR, Leyte and SLSCST, Southern Leyte.

2.2 VOLUNTEER TRAINING

Efficient and effective training is a vital component of any volunteer programme in order that participants quickly gain the required identification and survey skills that allow them to collect accurate and useful data. CCC uses an intensive 12-day training programme, plus several in water and on land validation exercises. The programme has been designed to provide volunteers, who may have no prior biological knowledge, with the skills necessary to collect useful and reliable data. The primary aim of the lecture programme is to give volunteers the ability to discern the specific identification characteristics and relevant biological attributes of the species that they encounter during their diving surveys. The training programme is co-ordinated by the Project Scientist (PS) and Science Officer (SO) and involves two lectures and two dives each day along with de-briefings and evening audio-visual presentations. Volunteers are also encouraged to snorkel and utilise identification guides to ensure a thorough understanding of the information provided in the lectures.

An important component of the training schedule is a series of testing procedures to ensure that each volunteer has reached a minimum acceptable standard. Hence the training programme concludes with a series of tests, which ensures that the volunteers reach an acceptable standard of knowledge. These tests use both slides, 'flash-cards' and in-water identification exercises for corals, fish and invertebrates. Furthermore, to assess the quality of data collected by CCC volunteers during actual survey work, two validation exercises are undertaken. The coral validation exercise uses a 30m test transect survey set up and thoroughly surveyed by the PS and SO to collate a reference data set. Test transects are conducted in buddy pairs with both people recording hard coral species and abundances (as performed by Divers 3 during surveys; Section 2.3). Data are then transferred to recording forms and entered into a spreadsheet where the results from each pair are compared to the reference using the Bray-Curtis similarity coefficient (Equation 1; Bray and Curtis, 1957). Validations for soft corals, sponges and other benthic colonial invertebrates are also conducted along a 30m transect. Data collected by one of the science staff is used as the reference data-set against which all volunteer data is compared. Results are compared using the Bray-Curtis similarity coefficient.

Equation 1:

$$\text{Bray - Curtis Similarity, } S_{jk} = \left[1 - \frac{\sum_{i=1}^p |x_{ij} - x_{ik}|}{\sum_{i=1}^p (x_{ij} + x_{jk})} \right]$$

Where x_{ij} is the abundance of the i th species in the j th sample and where there are p species overall.

Since it is impossible to compare volunteer fish data to a reference, validation of fish surveys are conducted by measuring the consistency between pairs of surveyors. It is then assumed that if surveyors are consistent they are also accurate. Therefore, both divers within a buddy pair independently survey the target fish list and each surveyor fills out their own survey form and enters it onto a spreadsheet. As with the benthic validation, the pairs of results are compared using the Bray-Curtis similarity coefficient. These assessments are similar to the critical assessment conducted by CCC in 1993 to test the accuracy of volunteer divers conducting baseline transect surveys (Mumby *et al.*, 1995).

2.3 BASELINE SURVEY TECHNIQUE

The CCC Reef Survey Technique was developed by CCC for the rapid assessment of biological and physical characteristics of reef communities by trained volunteer divers. Following an intensive training programme, CCC's techniques have been shown to generate precise and consistent data appropriate for baseline mapping (Mumby *et al.*, 1995). All surveys were co-ordinated by the PS and SO to ensure accurate and efficient data collection.

CCC's baseline survey technique has been continuously refined and improved since 1990. The technique is designed to be appropriate for non-professional surveyors and to provide appropriate data for classifying remotely sensed imagery and hence producing marine habitat maps. The basic rationale is to use teams of divers to undertake a transect from 18m (or 28m where the reef extends below 18m) to the reef crest. Each survey provides one or more biological record forms which are effectively snapshots of the biological community (benthic and fish) found within any particular reef zone. These data are complimented by basic physical and oceanographic information. The technique has been favourably reviewed by Dr Andrew Price (University of Warwick – 1991) and Dr John Turner (University of Wales – 1996).

The major changes, which have occurred since 1990 are:

- 1991: Surveying fish at species level.
- 1991: Using Global Positioning Systems (GPS) for locating the start and end of each transect (GPS became commercially available in the early 1990's).
- 1994: The use of a 10m line to improve assessment of the distance travelled by survey teams.
- 1996: Use of quantitative limits within the 0-5 scale for fish and invertebrates.
- 1997: Change of maximum depth from 30 m to 28 m in accordance with new diving protocols.

The CCC Reef Survey Technique utilises a series of plot-less transects, perpendicular to the reef, starting from the 18m contour (28m if the reef extends beyond 18m) and terminating at the reef crest or in very shallow water (0.5m). Benthic and fish surveys are focused on life forms or families along with a pre-selected number of target species that are abundant, easily identifiable or ecologically or commercially important. Hard corals are recorded as life forms as described by English *et al.* (1997) and 36 target corals are identified to genus or species level. Fish are generally identified to family level (45 families) but in addition, 104 important target species are identified. Sponges and octocorals are recorded in various life form categories. Macroalgae are classified into three groups (green, red and brown algae) and identified to a range of taxonomic levels such as life form, genera or species.

Since most transects require two or more dives to complete, transect surveys are divided up into sections (or 'sub-transects') with surveys of each sub-transect carried out by a team of four trained divers diving into two buddy pairs (A and B) as shown in Figure 2.2. At the start point of each sub-transect, Buddy Pair B remains stationary with Diver 3 holding one end of a 10 m length of rope, whilst Buddy Pair A swims away from them, navigating up or along the reef slope on a pre-determined bearing until the 10 m line connecting Diver 1 and 3 becomes taught. Buddy Pair A then remains stationary whilst Buddy Pair B swims towards them. This process is repeated until the end of the planned dive profile, when a surface marker buoy (SMB) carried by Diver 2 is deployed to mark the end of that sub-transect. The SMB acts as the start point for the next survey team and this process is repeated until the entire transect is completed. The positions of the SMB at the start and end of each dive are fixed using a Global Positioning System (GPS).

Diver 1 is responsible for leading the dive, taking a depth reading at the end of each 10m interval and documenting signs of anthropogenic impact such as broken coral or fishing nets. Diver 1 also describes the substratum along the sub-transect by recording the presence of six substrate categories (dead coral, dead coral with algae, bedrock, rubble, sand and mud). Divers 2, 3 and 4 survey fish, hard corals and invertebrates (soft corals, sponges) and algae respectively. Diver 3 surveys an area of approximately 1 metre to each side of the transect line whilst Divers 1, 2 and 4 survey an area of approximately 2.5 metres to either side of the line.

During the course of each sub-transect survey, divers may traverse two or more apparently discrete habitat types, based upon obvious geo-morphological (e.g. fore reef, escarpment or lagoon) or biological differences (e.g. dense coral reef, sand or rubble; Figure 2.3). Data gathered from each habitat type are recorded separately for subsequent analysis.

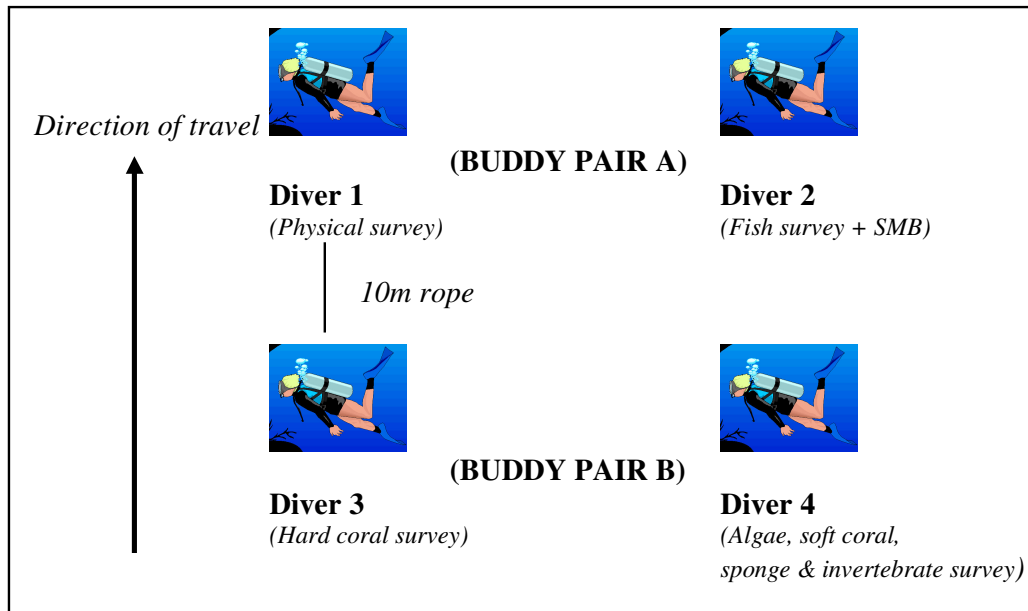


Figure 2.2 Schematic diagram of a CCC Reef Survey Technique dive team showing the positions and data gathering responsibilities of all four divers. Details of the role of each diver are given in the text.

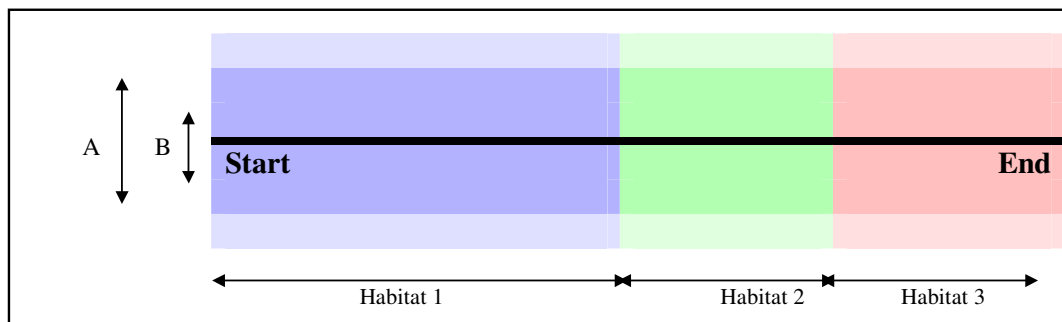


Figure 2.3 Schematic diagram (aerial aspect) of an example of a reef area mapped by divers during a sub-transect survey. Solid line represents imaginary sub-transect line. Dashed lines and shaded areas represent areas surveyed (A=5m wide band surveyed by Divers 1, 2 and 4; B=2m wide band surveyed by Diver 3). Benthic data from habitats 1, 2 and 3 (e.g. reef, sand and rubble) are recorded separately.

Each species, life form or substratum category within each habitat type encountered is assigned an abundance rating from the ordinal scale shown in Table 2.1.

Table 2.1 The ordinal scale assigned to life forms and target species during CCC Reef Survey Technique surveys.

Abundance rating	Corals, other colonial invertebrates and macroalgae	Fish and invertebrates (number of individuals)
0	None	0
1	Rare	1-5
2	Occasional	6-20
3	Frequent	21-50
4	Abundant	51-250
5	Dominant	250+

During the course of each survey, certain oceanographic data and observations on obvious anthropogenic impacts and activities are recorded at depth by the divers and from the surface support vessel. Water temperature readings ($\pm 0.5^{\circ}\text{C}$) are taken from the survey boat using a bulb thermometer at the sea surface. The survey team also takes the temperature at the maximum survey depth (i.e. at the start of the survey) and the air temperature.

Similarly, the salinity is recorded using a hydrometer and a water sample taken from both the surface and the maximum survey depth. Water visibility, a surrogate of turbidity (sediment load), is measured both vertically and horizontally. A secchi disc is used on the survey boat to measure vertical visibility through the water column (Figure 2.4). Secchi disc readings are not taken where the water is too shallow to obtain a true reading. Horizontal visibility through the water column is measured by divers' estimates while underwater. Survey divers qualitatively assess the strength and direction of the current at each survey site. Direction is recorded as one of eight compass points (direction current was flowing towards) and strength is assessed as being 'None', 'Weak', 'Medium' or 'Strong'. Similarly, volunteers on the survey boat qualitatively assess the strength and direction of the wind at each survey site. Direction is recorded as one of eight compass points (direction wind was blowing from) and strength is assessed using the Beaufort scale.

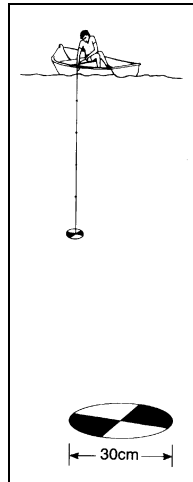


Figure 2.4 The use of a secchi disc to assess vertical water clarity. The secchi disc is lowered into the water until the black and white quarters are no longer distinguishable. The length of rope from the surveyor to the disc is then recorded (m). Source: English et al. (1997).

Natural and anthropogenic impacts are assessed both at the surface from the survey boat and by divers during each survey. Surface impacts are classified as 'litter', 'sewage', 'driftwood', 'algae', 'fish nets' and 'other'. Sub-surface impacts are categorised as 'litter', 'sewage', 'coral damage', 'lines and nets', 'sedimentation', 'coral disease', 'coral bleaching', 'fish traps', 'dynamite fishing', 'cyanide fishing' and 'other'. All information is assessed as presence/ absence and then converted to binary data for analysis. Any boats seen during a survey are recorded, along with information on the number of occupants and its activity. The activity of each boat is categorised as 'diving', 'fishing', 'pleasure' or 'commercial'. Finally the divers record a general impression of the site during each survey. These ratings are completed for biological (e.g. benthic and fish community diversity and abundance) and aesthetic (e.g. topography) parameters. Both parameters are ranked on a scale from 5 (excellent), 4 (very good), 3 (good), 2 (average) to 1 (poor).

Data collected from each sub-transect survey are transferred to recording forms prior to incorporation into CCC's database, which is compatible with a range of Geographic Information System (GIS) software used for spatial analysis. The recording forms consist of a 'Boat Form', 'Physical Form' and 'Biological Form'. Each form is completed for each individual dive, although there may be more than one biological form depending on the number of habitats observed. The Boat Form holds data on the GPS co-ordinates of the dive along with oceanographic and climate data such as winds, currents, temperatures and salinities. The Physical Form contains data on the maximum and minimum depths of the dive, the aesthetic and biological quality and also a reef profile drawn from the depths collected every 10m. Finally the Biological Form(s) contain data on the reef zone, the major biotic and substratum features of the habitat and the ordinal ratings of each life form and target species. Survey forms are presented in Appendix A.

2.3.1 Generation of habitat information

In order to describe the reefal habitats within the project area, benthic and substratum data are analysed using multivariate techniques within PRIMER (Plymouth Routines in Multivariate Ecological Research) software. Data from each Biological Form (which represents a 'snap-shot' of the benthic community from either part or all of a habitat type distinguished by the survey team) are referred to as a Site Record. Multivariate analysis can be used to cluster the Site Records into several groups, which represent distinct benthic classes. Firstly, the similarity between benthic assemblages at each Site Record is measured quantitatively using the Bray-Curtis Similarity coefficient without data transformation (Equation 1; Bray and Curtis, 1957). This coefficient has been shown to be a particularly robust measure of ecological distance (Faith *et al.*, 1987).

Agglomerative hierarchical cluster analysis with group-average sorting is then used to classify field data. Cluster analysis produces a dendrogram, grouping Site Records together based on biological and substratum similarities. Site Records that group together are assumed to constitute a distinct benthic class. Characteristic species or substrata of each class are determined using Similarity Percentage (SIMPER) analysis (Clarke 1993).

To identify characteristic features, SIMPER calculates the average Bray-Curtis similarity between all pairs of intra-group samples (e.g. between all Site Records of the first cluster). Since the Bray-Curtis similarity is the algebraic sum of contributions from each species, the average similarity between Site Records of the first cluster can be expressed in terms of the average contribution from each species. The standard deviation provides a measure of how consistently a given species contributes to the similarity between Site Records. A good characteristic species contributes heavily to intra-habitat similarity and has a small standard deviation. The univariate summary statistics of median abundance of each species, life form and substratum category are also used to aid labelling and description of benthic classes.

Finally, the benthic class of each Site Record is combined with the geo-morphological class assigned during the survey to complete the habitat label. The combination of a geo-morphological class and benthic class to produce a habitat label follows the format described by Mumby and Harborne (1999).

Data analysis to produce habitat information is not included in this report but will be presented in the 1st Annual report for the SLCRCP.

2.4 RAPID REEF ASSESSMENT

At the start of the project, spot dives were performed in seven survey sectors in order to assess the main habitats and common species present. Each site was investigated at three depths; 6, 12 and 18 metres. At each depth the abundance of hard corals, soft corals, sponges, other invertebrates and algae was estimated. The dominant species in each group were also recorded and a description of the substratum was noted. Furthermore any impacts were recorded. These could include fish traps, litter, and

evidence of pollution, sedimentation and algal blooms. Sites surveyed included areas renowned for their good hard coral cover such as Limasawa, Napantau and areas in Padre Burgos. Survey forms are shown in Appendix A.

2.5 REEF CHECK

Reef Check¹ was designed to be used by non-professional divers to assess reef health and hence generates relatively simple, but quantitative, information. During the SLCRCP the standard Reef Check protocol has been modified to collect more detailed data (e.g. via greater taxonomic resolution) and hence provide an enhanced assessment of reef health. Such modifications are possible because all CCC volunteers receive more intensive training in order to undertake baseline surveys than regular spot divers.

The standard Reef Check survey protocol utilises two transects at two depth bands (4-6m and 10-12m) or where the greatest coral reef diversity and cover occurs on these reefs. Along each depth contour a 100m transect was deployed, and along it four 20 m long replicate transects surveyed. The replicate transects follow the designated depth contour in sequence but the start and end points are separated by a 5m space (Figure 2.5) i.e. the distance between the start of the first transect and end of the last transect will be $20 + 5 + 20 + 5 + 20 + 5 + 20 = 95\text{m}$. Each transect represents a replicate and so By collecting data from each of the four 20m sections, four replicates will be collected per survey allowing the calculation of a mean per replicate and hence more powerful statistical analysis.

Five types of data will be recorded via three surveys along each transect line at each depth. Firstly, a site description sheet will be completed which includes anecdotal, observational, historical, location and other data. Secondly, four 5m wide by 20m long transects (centred on the transect line) will be sampled for commercially important fish, for example those typically targeted by fisher folk and aquarium collectors. Fish will only be counted if they are less than 5m above the transect line, giving a survey area for each transect replicate of $20 \times 5 \times 5 \text{ m} = 500 \text{ m}^3$. CCC volunteers in the Philippines record data on more fish species than specified by the standard Reef Check protocol. Divers assigned to count fish will swim slowly along the transect counting target fish and then stop every 5 metres and wait three minutes for target fish to resume normal behaviour before proceeding to the next stop point. Thirdly, four 5m wide by 20m long transects (centred on the transect line) will be sampled for invertebrate taxa typically targeted as food species or collected as curios. Quantitative counts will be made of each species. In addition, invertebrate surveyors will note the presence of coral bleaching or unusual conditions (e.g. diseases) along transects.

¹ Further details at <http://www.reefcheck.org>

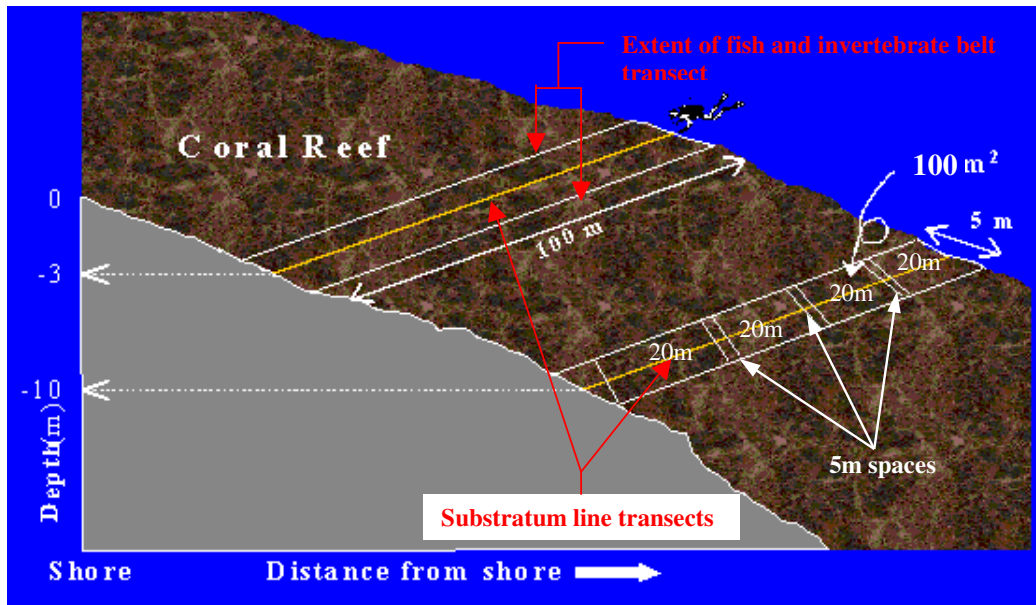


Figure 2.5 Schematic diagram showing the position of the transect lines during a Reef Check survey. 100 m transect is divided into four 20 m replicates so the area of each belt transect is $20 \times 5 \text{ m} = 100 \text{ m}^2$. Source: modified from figures on <http://www.reefcheck.org>

Finally, four 20m long transects will be point sampled at 0.5m intervals to determine the substratum types and benthic community of the reef. The diver looks at each point and will note down what lies under each of the points. The standard Reef Check protocol specifies that the categories recorded under each 50 cm point are: hard coral, soft coral, recently killed coral, dead coral, fleshy seaweed, sponge, rock, rubble, sand, silt / clay and 'other'. However, CCC volunteers will record hard corals to life form level (along with target species), soft corals to life form level and five categories of algal cover (mixed assemblage, coralline, *Halimeda*, 'macro' and 'turf'). The substratum surveyors also record coral damage from anchors, dynamite, or 'other' factors and trash from fishing nets or 'other'. Divers will rate the damage caused by each factor using a 0-3 scale (0 = none, 1 = low, 2 = medium, 3 = high).

Data from the Reef Check surveys will be made available to the global and national databases, hence increasing the impact of the project. Counterparts will also be trained in the modified more comprehensive Reef Check techniques which can then be used to continue monitoring in key areas of Sogod Bay such as within fish sanctuaries.

Reef Check surveys will be undertaken both inside and outside of all fish sanctuaries in the bay. Results are presented for the first three surveys; two in sanctuaries and one unprotected site close to the CCC base (Section 3.5).

2.6 CROWN OF THORNS SURVEYS

The crown of thorns (COT) surveys were designed to give an indication of the density of COTs within a given area as well as to assess the extent of damage caused to coral colonies. The area outside of CCC base known as 'Loggers Eden' was surveyed as large numbers of COTs had been observed. The number of COTs within a 5m band (2.5 m either side of the line) were recorded along 10m transects, running parallel to the shore. Twelve 20m transects were laid directly after each other at the following depth contours: 1-2m, 3-4m, 5-6m, 7-8m, 9-10m and 11-12m.

Each survey team consisted of two people holding a 10m rope between them. The first person swam ahead, holding one end of the rope and recorded the number of COTs along the transect and each COT was assigned to a size class (as shown in Table 2.2). Diver 1 also recorded what substrate the COT was found on and if hard corals, the form and species were recorded. The forms are the same as those used for both baseline surveys and Reef Check and are described in English *et al.* (1997).

Table 2.2 COTs size classes used to assess the diameter of crown of thorns (form tip of one arm to tip of opposite arm) during surveying.

Size class	Length (cm)
1	< 25
2	26-35
3	> 36

Table 2.3 Damage categories used to assess the extent of COTs damage to scleractinian corals.

Damage categories	Extent of damage
1	<30%
2	31-70%
3	> 71%

The second person followed behind while keeping hold of the other end of the rope and recorded the numbers of coral apparently damaged by COT feeding. For each damaged colony the form and species was noted and a value was assigned to it according to the extent of the damage (as shown in Table 2.3). Finally the presence of algal growth on the colony was also recorded.

2.7 SEDIMENTATION MONITORING PROGRAMME

The sedimentation study aims to assess the degree of sedimentation caused indirectly by runoff from deforestation or infrastructure development. The main objective is to investigate the rate at which the suspended solids are settling out of the water column and establishing whether these are cause for concern. Sediment traps will be placed in six sites in the bay. Two traps have been put in place at Liloan sanctuary and on the opposite side of the Bay at 'Secret Garden', Malitbog. The other four sites will be Napantau sanctuary, Padre Burgos, Biasong sanctuary and San Antonio sanctuary, Tomas Oppus. Sediment traps will be placed at sites opposite each other simultaneously, to allow a comparison of sedimentation rates between the two sides of the bay.

The sediment sampling technique used by CCC is modified from English *et al.*, (1997). Sediment traps are placed at either end of permanent transects or in relevant locations, the depth varying between 3m and 10m. Each sediment trap consists of three PVC tubes which are open at the top and closed at the bottom, attached to a central stake, which is permanently fixed to the substratum (Figure 2.6). The permanent survey locations are fixed with a Global Positioning System (GPS) in order to relocate the sites. Each sediment trap is also marked using a sub-surface marker buoy. Usually the traps will be located at the beginning of a marked Reef Check transect to increase the probability of retrieval.

In order to take a sample, a team of two divers swims down and places a sampling bag over the opening of the first tube and secures it with a rubber band. This is repeated for all three tubes. The wire is then unlashd and the tubes are taken off. New clean tubes are then secured to the stake. The tubes are taken back to the camp whilst being kept upright. The samples will then be analyzed for dry weight and if possible for particle grain size. From this information the rate of sedimentation can be calculated from the following equation:

$$\text{Sedimentation rate (gcm}^{-2}\text{day}^{-1}\text{)} = \frac{\text{Dry weight (g) / Area of aperture of trap (cm}^2\text{)}}{\text{Time (days)}}$$

Furthermore the percentage contribution of each particle size to the sediment sample can be established, which gives an indication of the extent of stress corals may be experiencing, as finer particles tend to smother coral polyps.

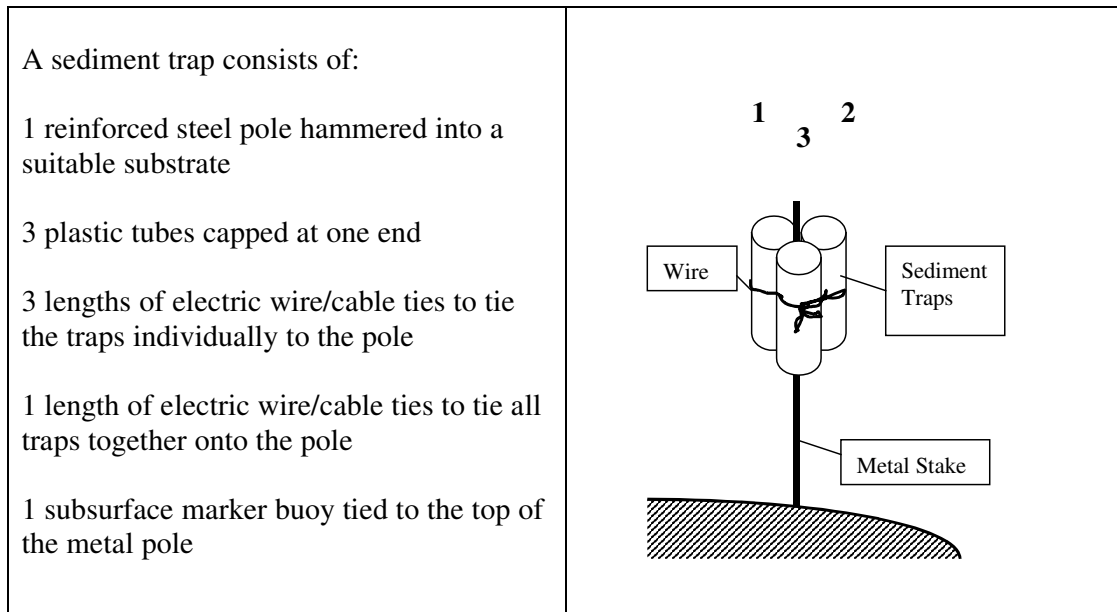


Figure 2.6 Model of a sediment trap, consisting of three replicate traps tied to a metal stake. Modified from English et al (1997).

3. Results

3.1 RAPID REEF ASSESSMENTS

Table 3.1 shows the survey sectors in which RRAs were undertaken and the number of sites surveyed. The locations of the RRAs in Sogod Bay are shown in Figure 3.1. Numbers in brackets throughout this section refer to the values of mean abundance using the DAFOR scale.

Table 3.1 Number of sites surveyed using Rapid Reef Assessments within each Sector and the municipalities covered by that Sector.

Sector No.	Municipality	No. of sites surveyed
3	Limasawa	1
7	Padre Burgos	3
8	Malitbog/ Padre Burgos	5
9	Malitbog	10
10	Malitbog	7
19	Liloan	8
22	San Fransisco (Napantau)	3

Benthic Fauna

Sector 3: Limasawa (Figure 3.2)

The RRAs at Limasawa Island were undertaken in Sector 3 on the west coast, which is more sheltered than the east. The substrate was predominantly bedrock (5.0) with low levels of dead coral (1.0) and sand increasing in dominance at 18m (3.0).

Hard coral cover was high overall with an average abundance of 4.3. Soft coral cover increased in the shallow parts of the reef but abundance was on average low (1.7). Macroalgae and other invertebrates were only recorded at 12m and were rare (1.0). Sponges remained constant over changes in depth and were also rare (1.0).

Sector 7: Padre Burgos (Figure 3.3)

The substrate at the three sites surveyed in Sector 7 was predominantly sand (2.8). Rubble increased in occurrence at depth whereas dead coral increased in abundance with proximity to the shore.

Soft coral and sponge abundance were low at all depths (1.0). Hard coral abundance increased with depth with the greatest abundance (2.7) at 18m. Macroalgal abundance was low (1.6) with a slight increase in frequency with depth. Other invertebrates were most abundant at 12m (1.7).

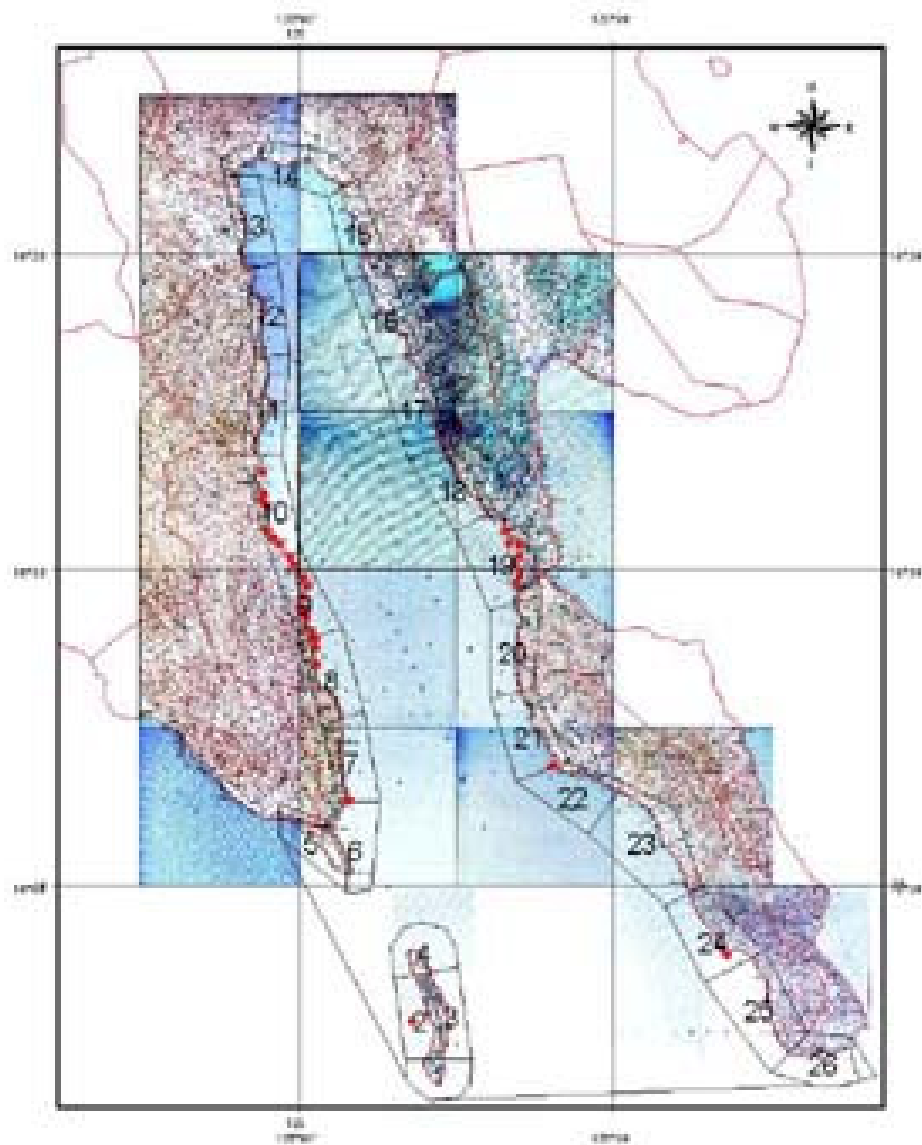


Figure 3.1 Map of Sogod Bay showing the location of Rapid Reef Assessments (indicated by red marks)

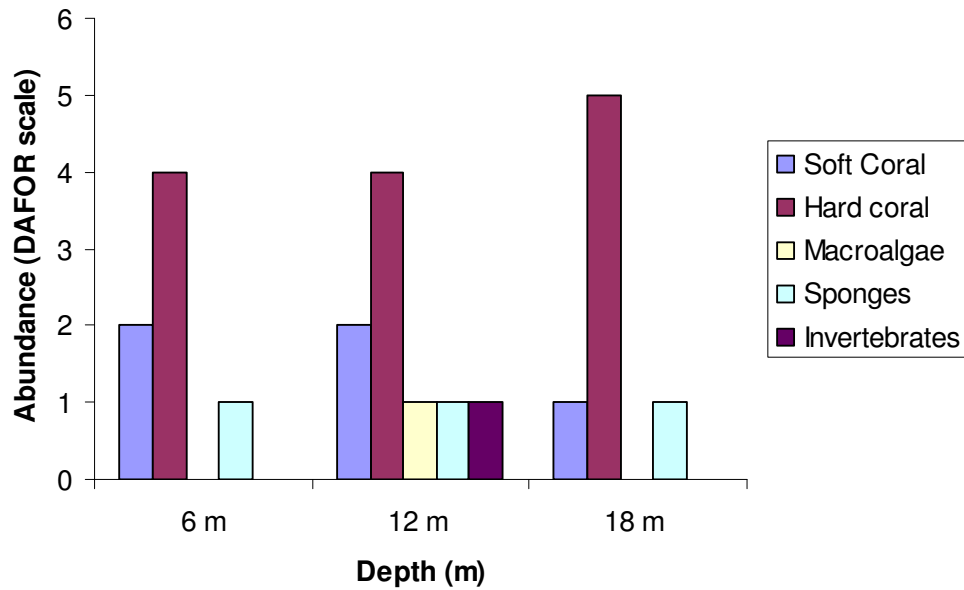


Figure 3.2 Mean abundance (DAFOR Scale) of main benthic faunal groups recorded at three depths in Sector 3 (Limasawa). Number of sites = 1.

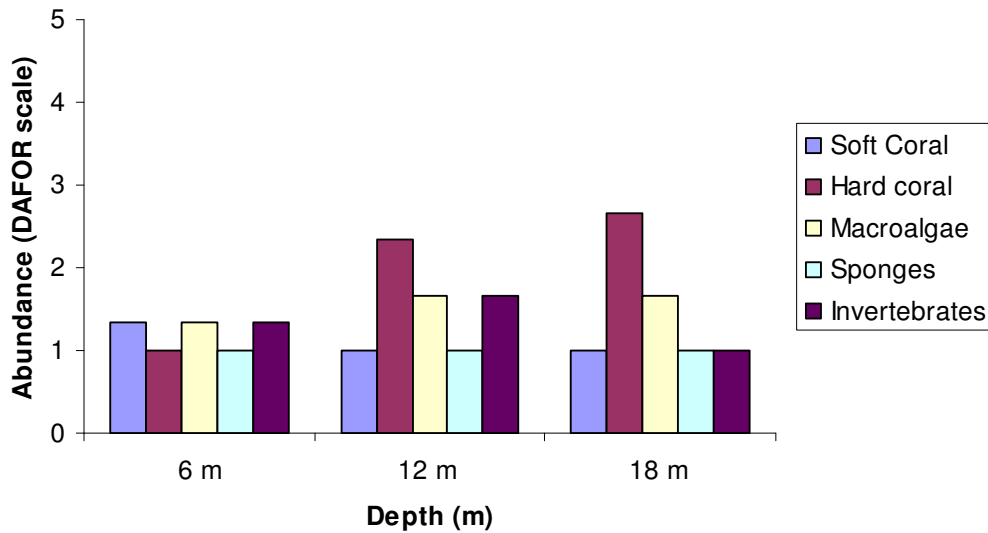


Figure 3.3 Mean abundance (DAFOR Scale) of main benthic faunal groups recorded at three depths in Sector 7 (Padre Burgos). Number of sites = 3.

Sector 8: Malitbog & Padre Burgos north. (Figure 3.4)

Five sites were surveyed within this Sector and the substrate was dominated by sand (4.8) with frequent outcrops of rubble (2.8). No bedrock, dead coral or mud was recorded during surveys.

All benthic biological communities were present at all depths surveyed but overall at low abundance. Soft coral cover was particularly low at 6m (0.4). Averaging over depths hard coral cover was low (1.9) and decreased slightly with depth (Figure 3.4). Macroalgal cover was greater than hard coral cover at all depths (Figure 3.4) and abundance averaged 2.1. Sponges were the target group in lowest abundance with an average value of 1.1. Invertebrate abundance was stable over depth with an average abundance rating of 1.7.

Sector 9: Malitbog (Figure 3.5)

Ten spot surveys were carried out in the Sector. Sand was the dominant substrate over all depths (3.8) with few recordings of bedrock (0.8), rubble (0.8), and dead coral (0.5).

Again all benthic faunal groups were in low abundance. Soft coral abundance was low averaging over all depths (0.9). Hard coral abundance was on average low (1.5) and consistent with depth. Macroalgae was more abundant than hard coral at all depths (1.8). Sponges were the group in the lowest abundance (0.7). Invertebrates were also in low abundance and constant over changes in depth (1.1).

Sector 10: North of Malitbog (Figure 3.6)

Seven surveys were undertaken throughout this Sector. Sand was the most abundant substrate (3.7). Rubble (1.0), dead coral (0.4), mud (0.9) and bedrock (0.4) were infrequently recorded over all depths.

Soft coral was most abundant at 18m (1.4) but generally low in abundance (1.0). Hard coral was similarly low in abundance over all depths (1.0). Macroalgae increased in abundance with proximity to the shore where it was rated with a greater abundance than hard coral (macroalgae=1.6, hard coral= 0.9). Sponges were infrequently recorded (0.5). Invertebrates were “rare” with an average abundance rating of 1.0 over all depths.

Sector 19: Liloan (Figure 3.7)

Eight surveys were conducted within this Sector. The seabed is characterized by a sandy bottom (3.7) with outcrops of bedrock at 12m (0.8) and 6m (1.0). Rubble and dead coral were infrequently recorded at all depths (rubble=0.6, dead coral 1.9).

Soft coral cover was “occasional” (2.0) and increased in abundance with depth. Hard coral cover was quite high when averaged over depths (2.4) and increased in abundance from 18m (1.8) to 6m (2.6). Algal cover was high at all depths (2.2) with the greatest abundance recorded at 18m (2.5), where hard coral cover was particularly low. The abundance of algae recorded here was the highest of all Sectors. Sponges and other invertebrates’ abundance remained stable over changes in depth. On average sponge abundance was 1.2 and other invertebrates were 1.7.

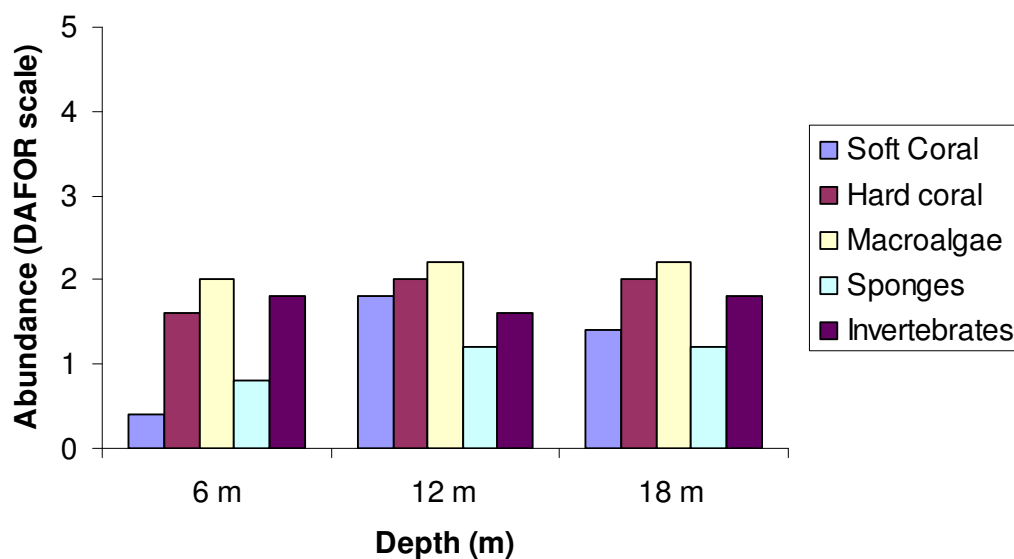


Figure 3.4 Mean abundance (DAFOR Scale) of main benthic faunal groups recorded at three depths in Sector 8 (Malitbog and Padre Burgos north). Number of sites = 5.

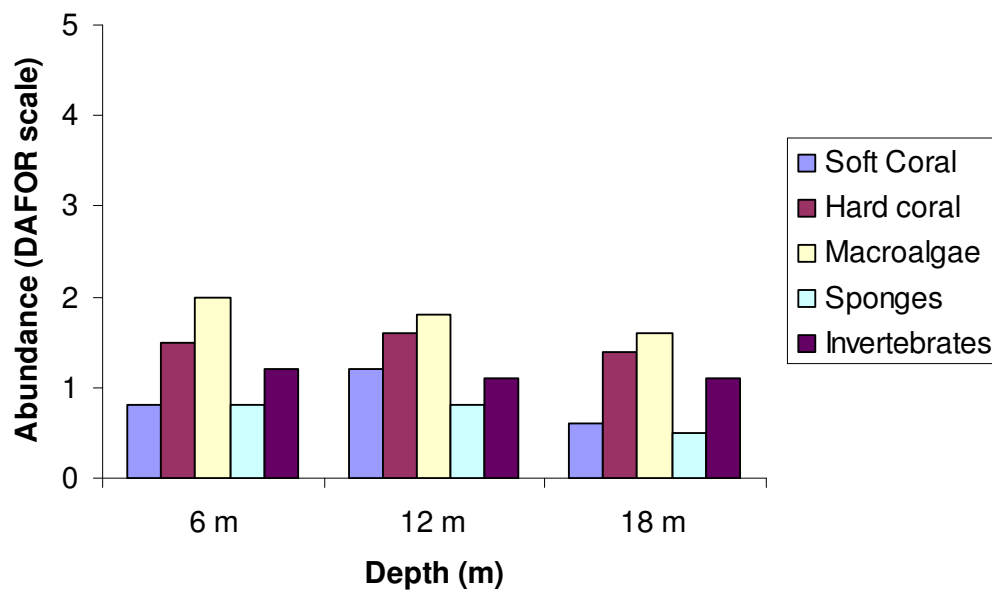


Figure 3.5 Mean abundance (DAFOR Scale) of main benthic faunal groups recorded at three depths in Sector 9 (Malitbog). Number of sites = 10.

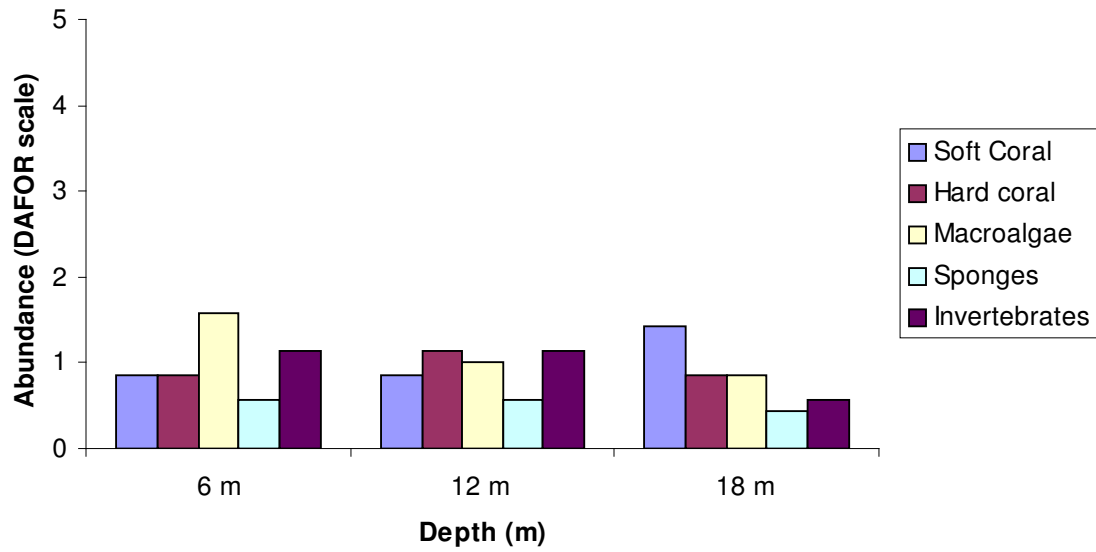


Figure 3.6 Mean abundance (DAFOR Scale) of main benthic faunal groups recorded at three depths in Sector 10 (Malitbog north). Number of sites = 7.

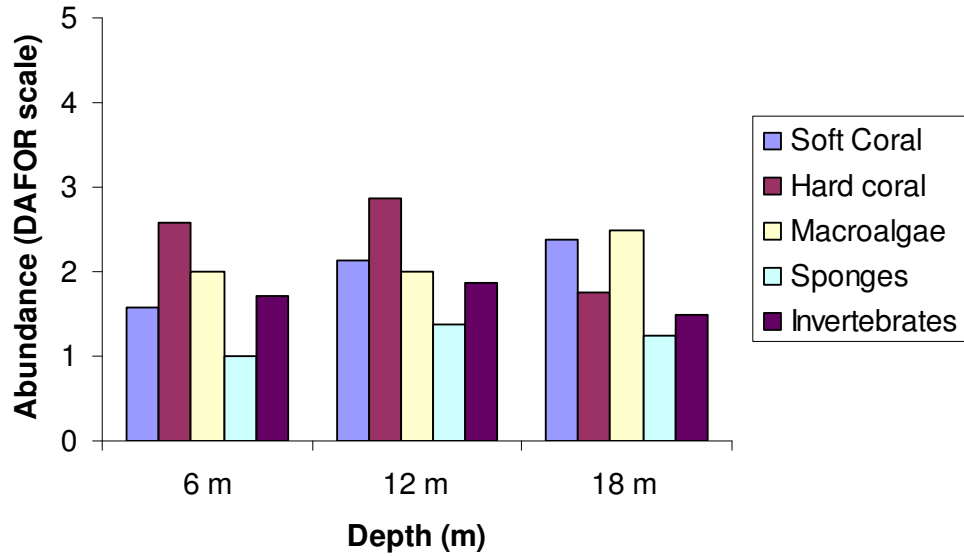


Figure 3.7 Mean abundance (DAFOR Scale) of main benthic faunal groups recorded at three depths in sector 19 (Lilo-an). Number of site = 8.

Sector 21 Napantau (Figure 3.9)

The topography of the three sites surveyed is a steep wall with bedrock the dominant substrate at all depths (4.6). Sand was only present and at 6m (2.3).

Soft corals were “rare” at 18m (1.3) but increased in abundance with proximity to the shore with a maximum abundance of 2.7 at 6m. Hard coral abundance was the greatest recorded out of all Sectors and averaged 4.0 over all depths. Hard coral was most abundant at 18m (4.7). Macroalgae were recorded in low abundance over all depths (0.6). Sponges and other invertebrates were in low abundance at all depths (sponges=1.0, invertebrates 1.2).

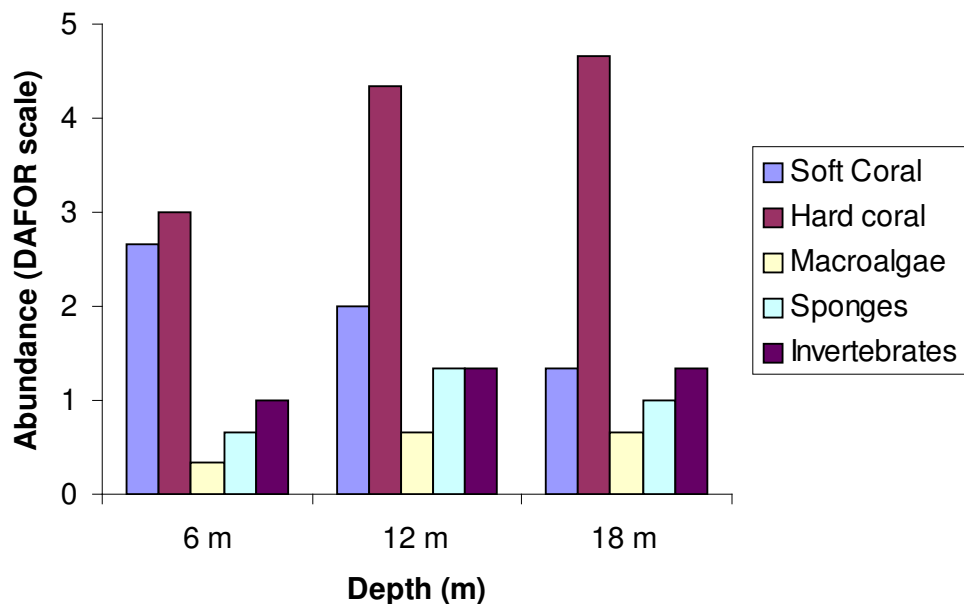


Figure 3.8 Mean abundance (DAFOR Scale) of benthic faunal groups recorded at three depths in Sector 21 (Napantau). Number of sites = 3.

Reef Fish

Reef fish abundance was greatest in sector 21 where fish were rated with a DAFOR abundance of 4.8. Sector 10 had the lowest fish abundance averaging over depths (1.9). Over all sectors and depths the average fish abundance was rated at 3.2, which is equivalent to 21-50 individuals recorded during the dive.

In Sectors 3 and 9 fish abundance was greatest at 12m. Fish abundance remained unchanged with depth in Sector 7. In Sectors 8, 10 and 19 fish abundance was greatest at 18m. In Sector 21 fish abundance was equally high at 12 and 18m. It can be seen from Figure 3.2 that throughout all Sectors, fish abundance tended to be higher at 12 and 18m than at 6m.

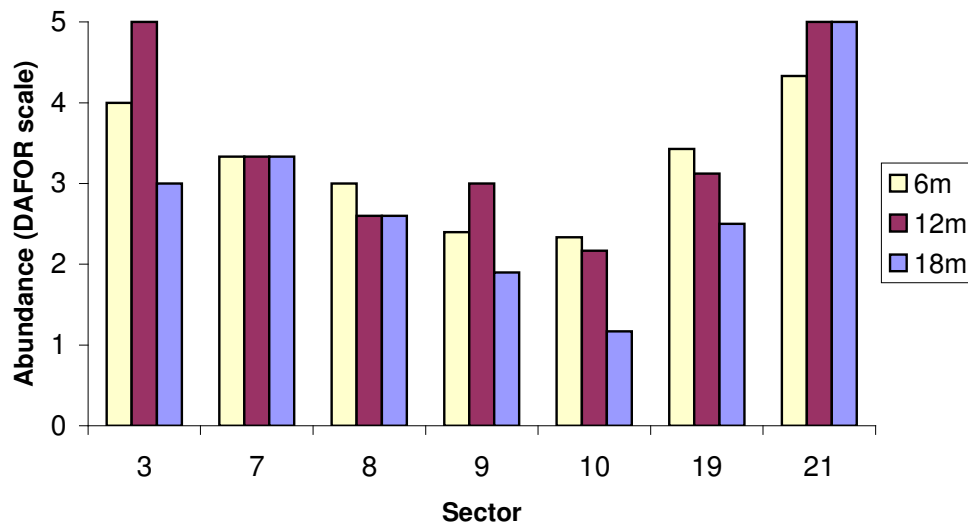


Figure 3.9 Mean abundance (DAFOR Scale) of reef fish recorded at three depths in seven survey sectors.

Summary of Results of Rapid Reef Assessments

The greatest abundance of hard coral and fish were recorded in Napantau fish sanctuary (Sector 21). The next highest abundance was recorded on the east coast of Limasawa Island (Sector 3). From the results presented there is a tendency for the sites on the west coast of the bay to have lower hard and soft coral abundances than those on the east coast of the bay. There is no such relationship evident for algae, sponges and other invertebrates. The highest abundance of algae was recorded at Sector 19 (2.2) and the lowest in Sector 3 (0.3). Similarly other invertebrates were in greatest abundance in Sectors 19 (1.7) and 8 (1.7) and lowest in Sector 3 (0.3). Sponges were recorded in low abundance throughout, particularly in Sector 10 (0.5).

Fish numbers appear to be greater in areas where hard coral is also abundant (see Figures 3.2-.3.9). The two areas (Sectors 3 and 21) with the greatest abundance of fish (4.0 and 4.8 respectively) also had the highest abundance of coral (4.3 and 4.0 respectively). There is a significant relationship between hard coral abundance and fish abundance ($R^2 = 0.86$) (see Figure 3.10); as hard coral abundance increases so does fish abundance.

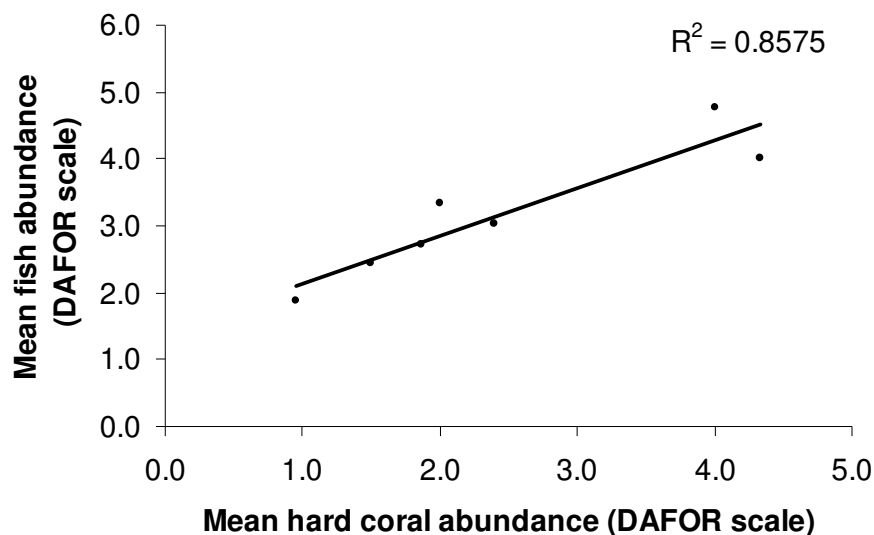


Figure 3.10 Relationship between mean hard coral abundance and mean fish abundance at all sectors.

3.2 BASELINE SURVEYS

Baseline surveys were started in Sectors 10 (North Malitbog) and 19 (Liloan) in November 2002. Sector 10 was completed in March 2003 and a qualitative description of the sector follows. Detailed analysis of the data will be undertaken at CCC Head Office and the results will be presented in an annual report due late 2003 / early 2004.

A total of 21 transects (1001-1021) were used to survey this sector, involving 92 dives and snorkels carried out between 25th November 2002 to 18th March 2003. This equates to over 49 hours of underwater research. Where possible some transects were only surveyed from 18m depth due to lack of biological cover below this depth. GPS locations were taken at the beginning and end of each survey dive.

Reef fish

The average abundance of fish was generally quite low in Sector 10. The most abundant family observed were Damselfish (Pomacentridae), with a mean abundance of 2.6 (Figure 3.11). Within this family the most abundant species observed was the Humbug dascyllus (*Dascyllus aruanus*) (1.1). This species along with Whitebelly damsel (*Amblyglyphidodon leucogaster*), Blackbar chromis (*Chromis retrofasciata*), Three-spot dascyllus (*Dascyllus trimaculatus*) and Reticulated dascyllus (*Dascyllus carneus*), increased in abundance from the lower reef slope to the reef flat.

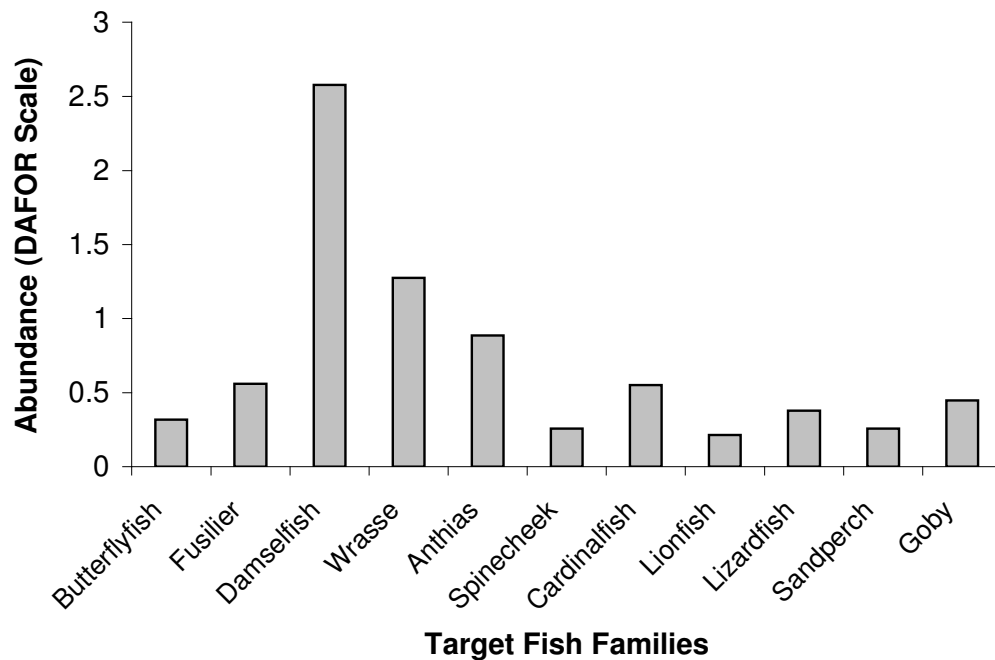


Figure 3.11 Mean abundance (DAFOR Scale) of the most common fish families recorded during baseline surveys in Sector 10 (North Malitbog).

The abundance of Wrasse (Labridae) and Anthias (Anthiinae- Serranidae) were also relatively high with a value of 1.3 and 0.89 respectively. The total number of fish species observed in the Sector was 98. Commercial fish families such as grouper (Epinephelinae- Serranidae), Snapper (Lutjanidae) and Emperor (Lethrinidae) are notable by their absence.

Hard corals

Coral abundance was on average low (2.1) with the substratum often dominated by sand. A relatively large amount of dead coral with algae was observed (1.1). The most abundant life forms recorded were *Acropora* branching (1.2) and Non-*Acropora* encrusting (1.2) (Figure 3.12).

The most abundant target hard corals observed were Massive *Porites* spp. (0.77), *Galaxea* spp. (0.88), *Seriatopora hystrix* (0.6), *Goniopora* and *Alveopora* spp. (0.65), *Favia* spp.(0.83) and *Favites* spp. (0.92) (Figure 3.13). The abundances of other target species, which were recorded less frequently, are shown in Figure 3.14. A total of 44 species of hard coral were observed in this sector.

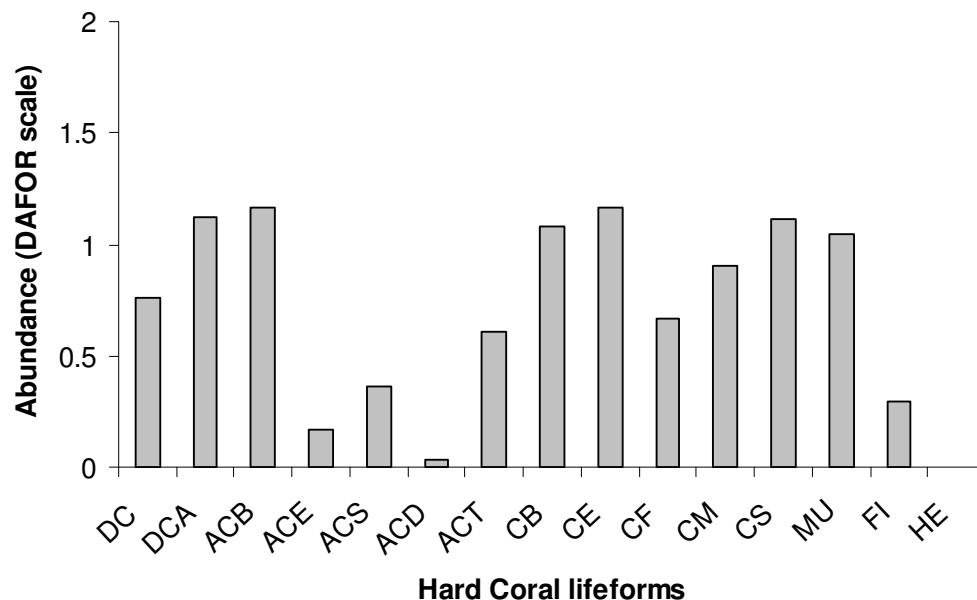


Figure 3.12 Abundance (DAFOR scale) of hard coral life forms observed in Sector 10. Codes used for hard coral life forms are adapted from English et al., 1997 and are shown in Table 3.2

Table 3.2 Codes used as abbreviations for hard coral life forms (Adapted from English *et al.*, 1997).

Code	Hard coral Life form
DC	Dead Coral
DCA	Dead coral with algae
ACB	<i>Acropora</i> branching
ACE	<i>Acropora</i> encrusting
ACS	<i>Acropora</i> sub-massive
ACD	<i>Acropora</i> digitate
ACT	<i>Acropora</i> tabulate
CB	Non- <i>Acropora</i> branching
CE	Non- <i>Acropora</i> encrusting
CF	Non- <i>Acropora</i> foliose
CM	Non- <i>Acropora</i> massive
CS	Non- <i>Acropora</i> sub-massive
MU	Mushroom
FI	Fire
HE	Blue

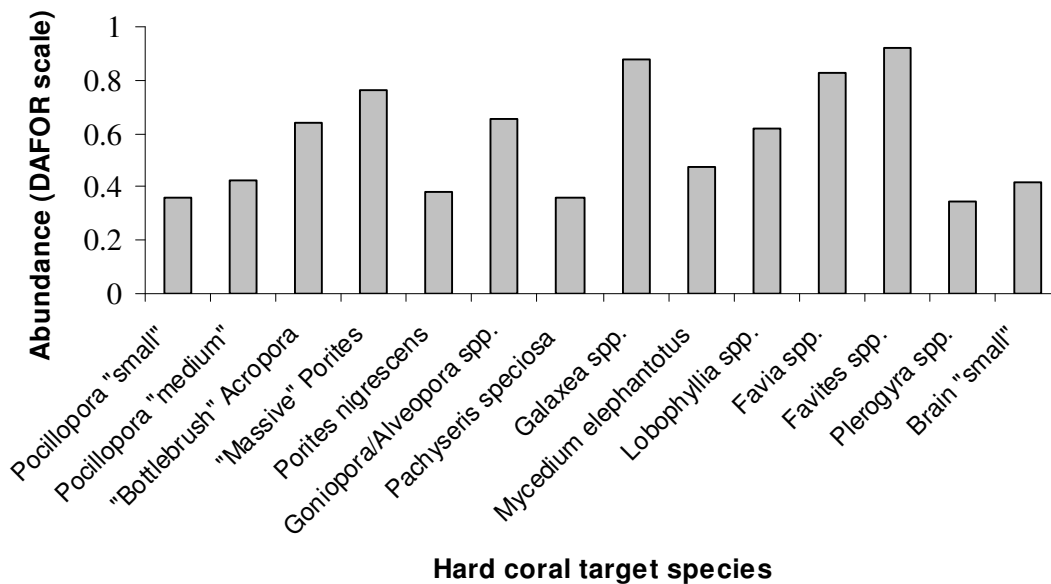


Figure 3.13 Abundance (DAFOR scale) of the most frequently recorded hard coral target species in Sector 10.

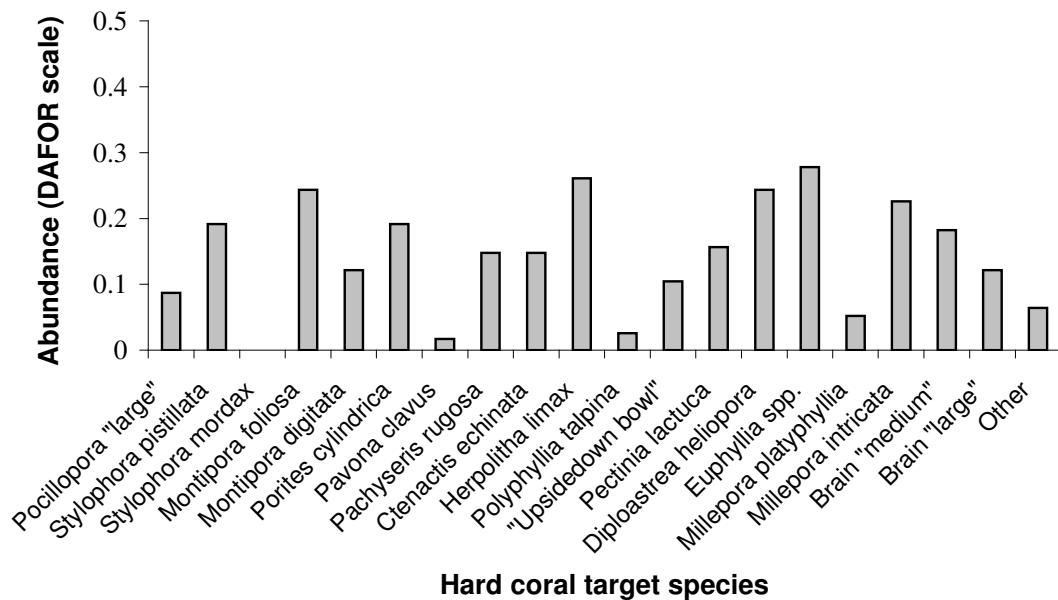


Figure 3.14 Abundance (DAFOR scale) of the infrequently recorded hard coral target species in Sector 10.

Invertebrates

Although a total of 60 invertebrate species were observed in this sector, invertebrates were not abundant (1.6). The most abundant invertebrates observed were tree soft coral *Dendronepthea* spp. (1.2), Sabellid worms (1.1), Feather stars or Crinoids (1.4) and Tunicates (Phylum Urochordata) (1.4), leather soft coral e.g. *Sarcophyton* spp. (0.9), encrusting sponges (0.9), flower soft coral (*Xeniidae*) (0.9) and Brittle stars (*Ophiidermatidae*) (0.9) (Figure 3.15). These were equally abundant at all depths of the reef except for brittle stars, which were generally more abundant on the reef flat. Target invertebrates recorded at lower abundances are shown in Figure 3.16.

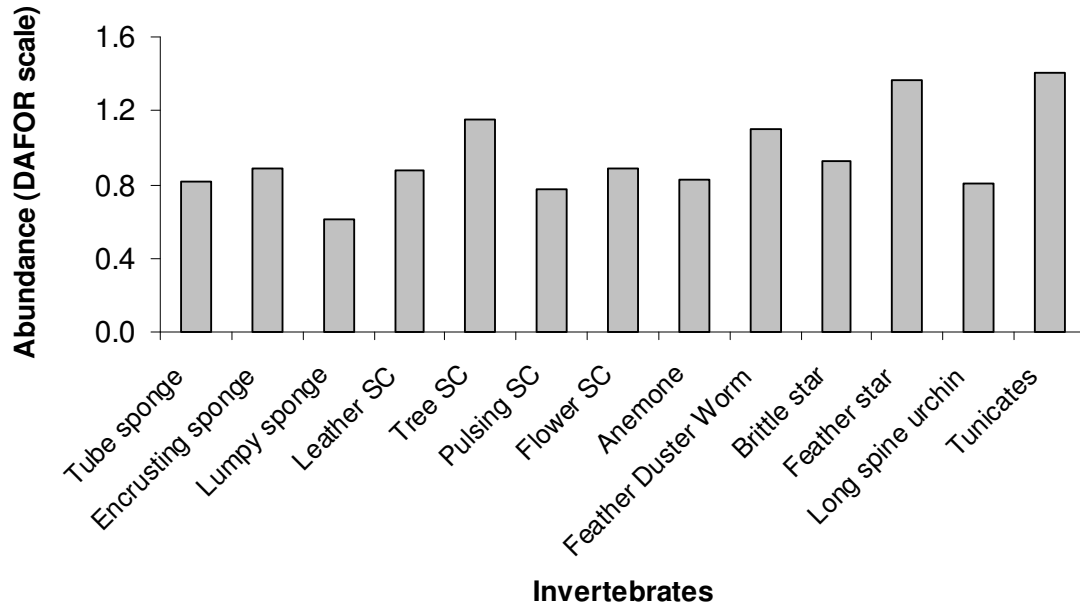


Figure 3.15 Abundance (DAFOR scale) of the most common invertebrate target species/ life forms recorded in Sector 10. (SC= Soft coral).

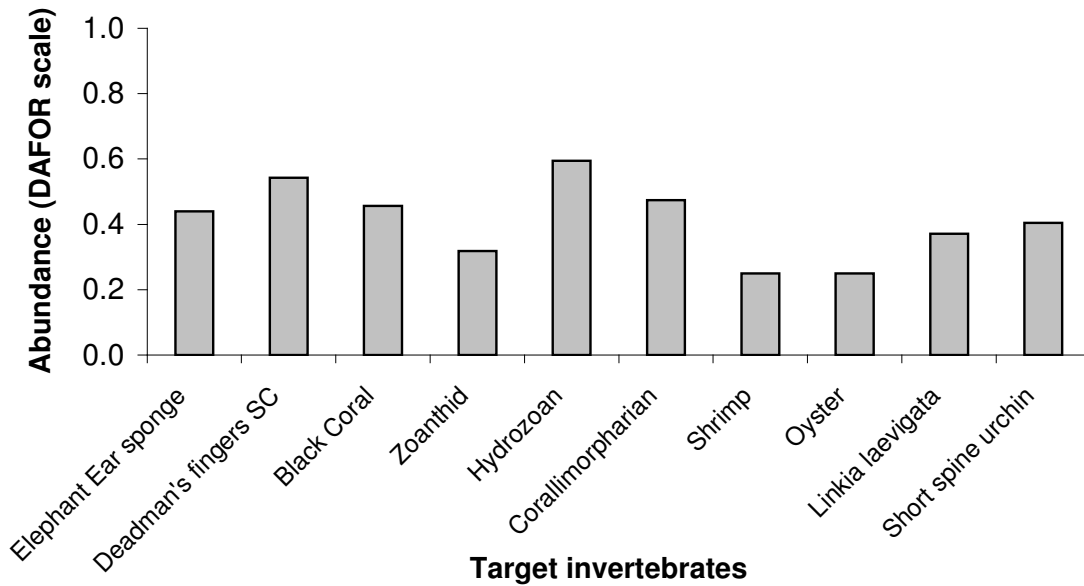


Figure 3.16 Abundance (DAFOR scale) of the less commonly observed invertebrate target species/ life forms recorded in Sector 10. (SC= Soft coral).

Macroalgae

Macroalgal abundance in this sector was rated as occasional (2.0) with green filamentous algae (*Chlorophyta*) the most common (1.2). This was recorded at all depths surveyed but increased in abundance from the lower reef slope (20-30m) up to the reef flat (<3m). Although at a reasonably low abundance there was a wide variety of other macroalgal species observed with a general increase in diversity from the lower reef slope towards the reef flat. The most abundant brown algae included *Padina* spp. (0.6) and Brown filamentous (*Phaeophyta*) (0.5). The red algae species that were relatively abundant were *Amphiroa* spp. (0.4), red filamentous (*Rhodophyta*) (0.4) and coralline encrusting algae (0.5). There was a distinct increase in the abundance of sea grasses with proximity to shore. The most abundant species observed was *Halophila* (0.7). A total of 38 species of marine plants and algae were observed in this sector.

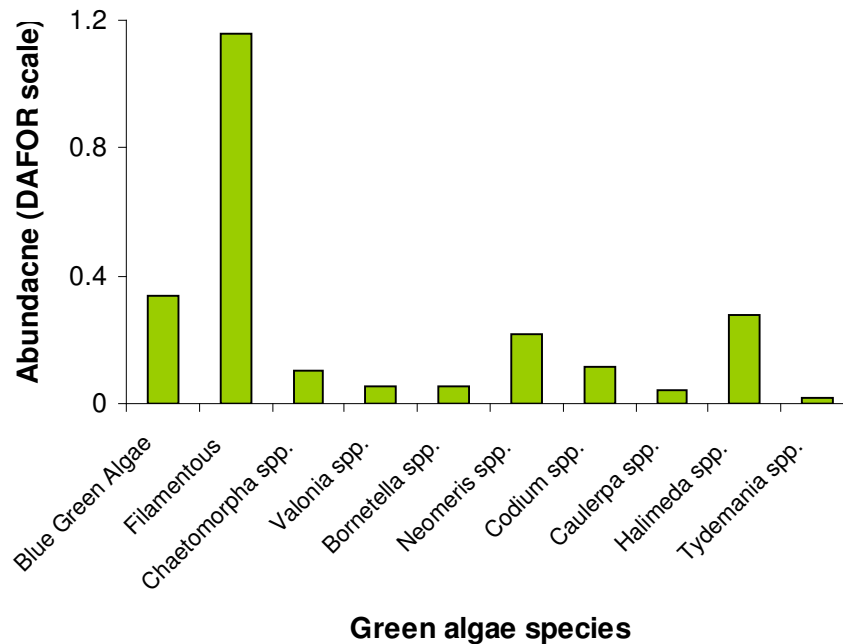


Figure 3.17 Abundance (DAFOR scale) of green algae (*Chlorophyta*) target species recorded in Sector 10.

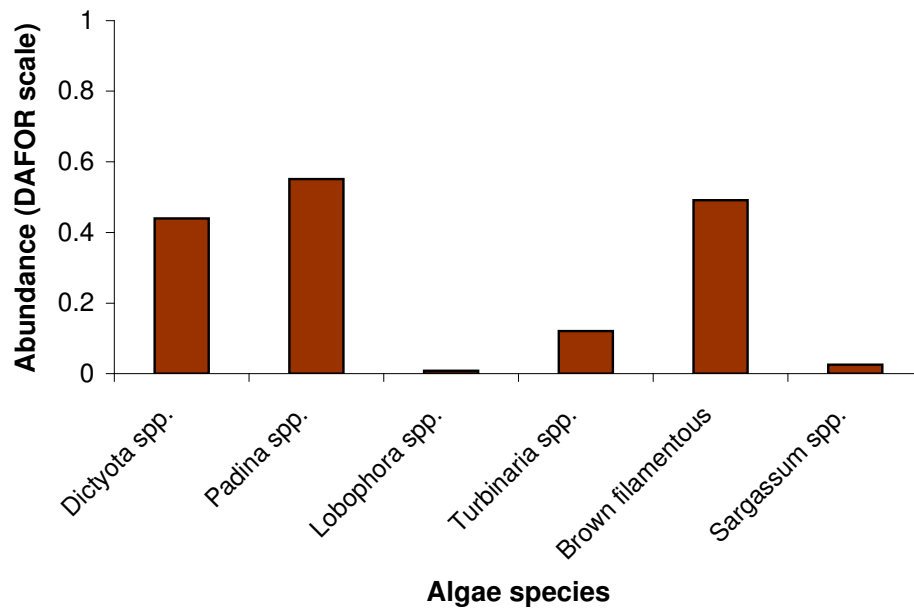


Figure 3.18 Abundance (DAFOR scale) of brown algae (*Phaeophyta*) target species recorded in Sector 10.

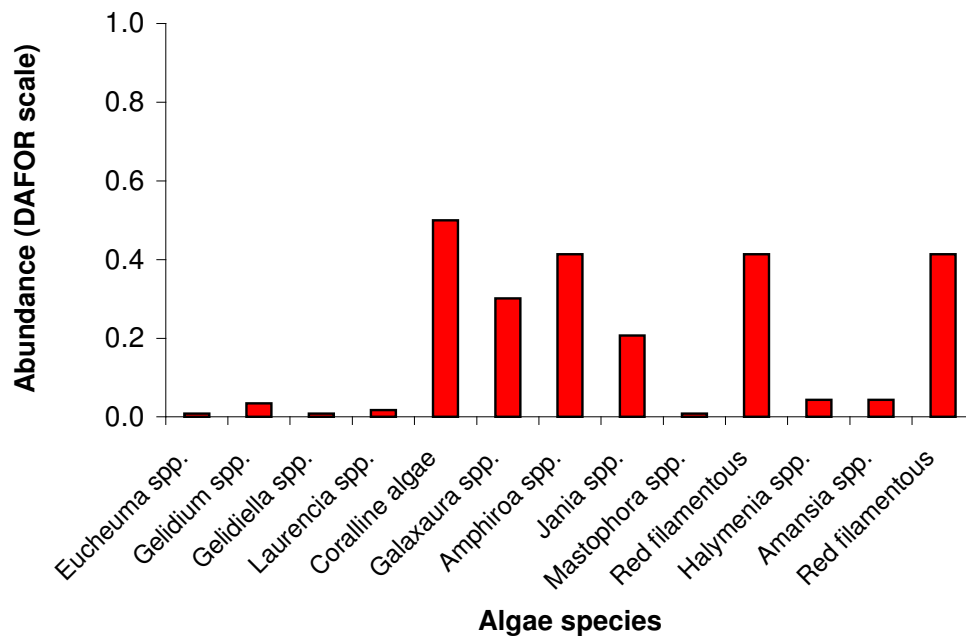


Figure 3.19 Abundance (DAFOR scale) of red algae (*Rhodophyta*) target species recorded in Sector 10.

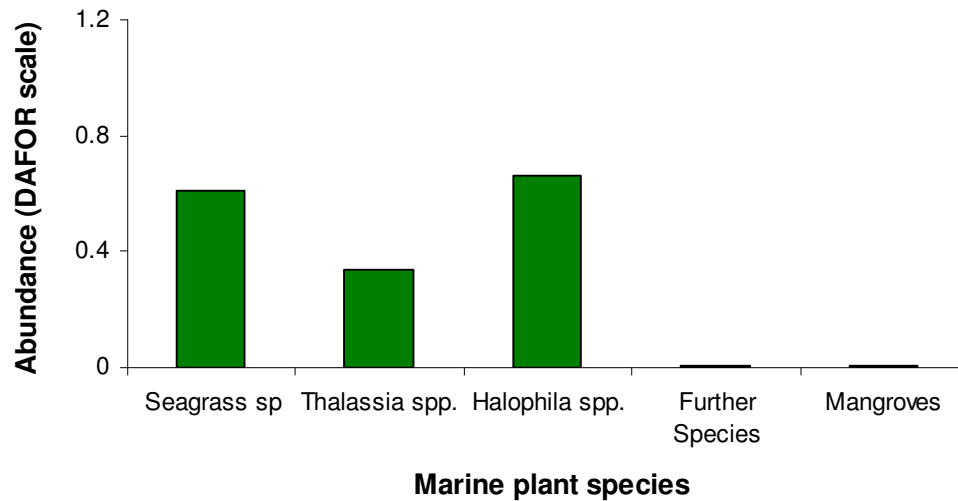


Figure 3.20 Abundance (DAFOR scale) of marine plants (*Angiospermatophyta*) target species recorded in Sector 10.

3.3 REEF CHECK SURVEYS

The results for the Reef Check surveys carried out at three sites within three different sectors are presented. The first site is Timba fish sanctuary located in the municipal waters of Malitbog, Sector 9, the second is ‘Secret Garden’ – an unprotected site in Malitbog within Sector 8. Both these sites are located on the west coast of Sogod Bay. Finally on the east coast surveys were carried out at Liloan fish sanctuary in Sector 19. Descriptions of the codes used for substrate and hard coral species identification are shown in Appendix B.

3.3.1 Timba Fish Sanctuary - Sector 9

This site was chosen as it falls within the boundaries of the fish sanctuary. The fish sanctuary is no longer marked by buoys and so it is unlikely that its status has been enforced. Above 15m depth the reef is gently sloping but develops below into a steep wall to a maximum depth of 28m. This wall is the best part of the sanctuary in terms of abundance of reef fish and hard coral. Large black corals and sea fans growing out of the wall are also common. In contrast, the shallow areas are poor in reef fish, hard coral and invertebrate abundance. Here the substratum is predominantly sand with coral outcrops. During the surveys there was evidence of coral damage, presumably caused by anchors.

Substratum

It can be seen from Figure 3.21 that sand was the dominant substratum at both 8 and 12m depth contours. Hard coral almost doubled in cover from 8m to 12m, whereas rubble decreased in abundance with depth. Furthermore soft corals and sponges were present in low abundances at both depth bands. No algae was recorded at 12m but occupied an average of 1.25 % of the transect at 8m.

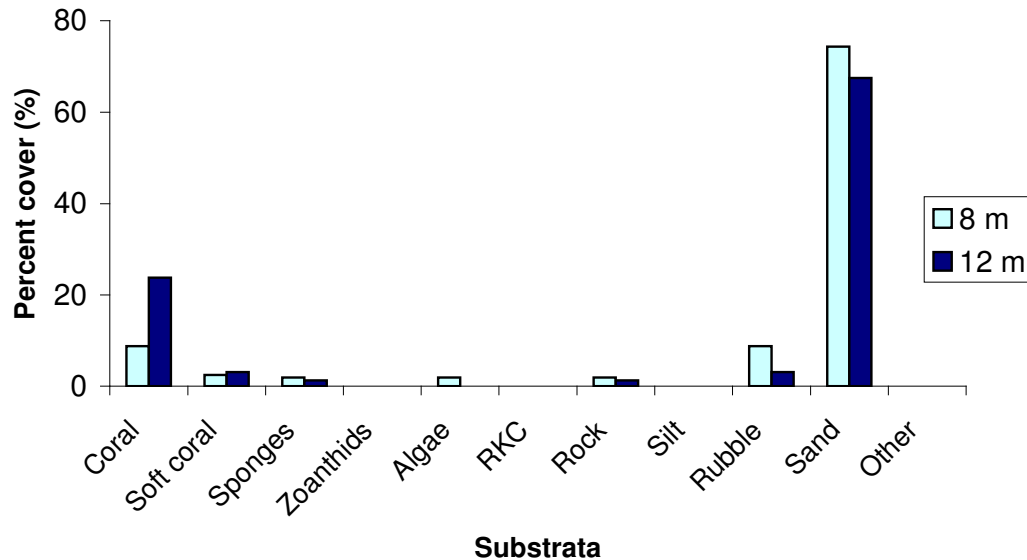


Figure 3.21: Mean Percent cover of substrata recorded during four 20m transects set at two depths (8m and 12m) at Timba fish sanctuary (Sector 9)..

The percent cover of coral life forms for both depth bands is shown in Figure 3.22. At depth band 12m the dominant coral life form recorded were non-*Acropora* massive (8.13%) and next non-*Acropora* branching and *Acropora* tabulate (3.75%). At 8m these abundances had decreased to 0.63% and 2.5% respectively. Other forms present included branching *Acropora* and non-*Acropora*, and encrusting and foliose non-*Acropora*.

The target species with the greatest cover was “massive” *Porites* (MP) recorded at 12m (5%). No massive *Porites* were recorded at 8m. The next most abundant scleractinian corals were *Seriatopora hystrix*, (SH), *Pocillopora* “large” (PL), *Pocillopora* “small” (PS) and *Favites* spp. (FTS), each with a cover of 1.25%. Other species recorded in low abundance included *Pocillopora* “medium”, *Montipora foliosa*, *Ctenactis echinata*, *Galaxea* spp., *Lobophyllia* spp., *Favia* spp., *Diploastrea heliopera*, *Plerogyra* spp., *Tubastrea micrantha*, brain coral “medium” and “large”. Percent cover of target hard coral species recorded are shown in Figure 3.23.

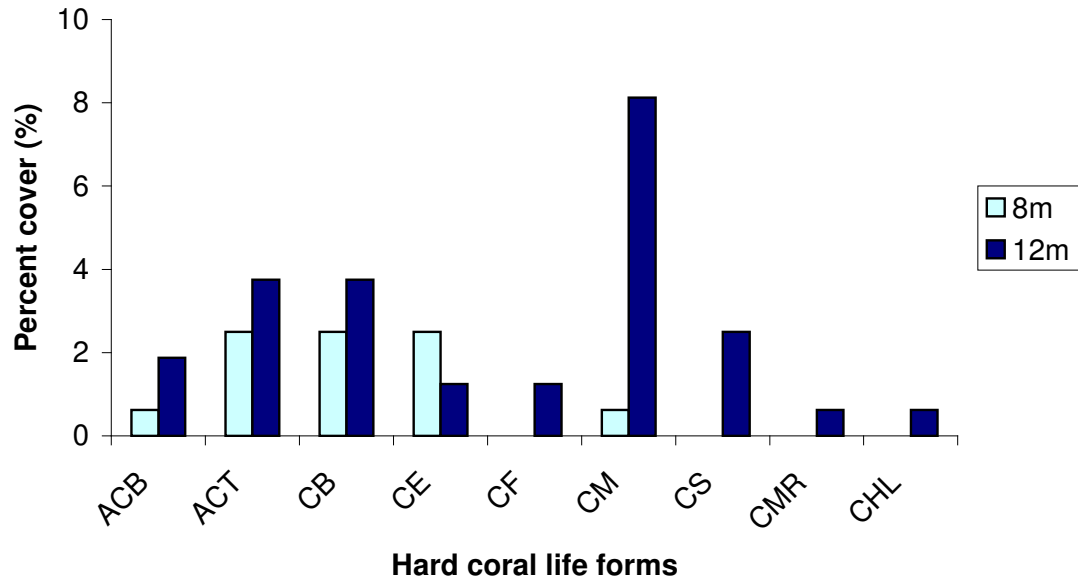


Figure 3.22 Mean percent cover of hard coral life forms recorded during four 20m transect set at two depths (8m and 12m) at Timba fish sanctuary (Sector 9). Each transect represents a replicate. Refer to Appendix B for codes.

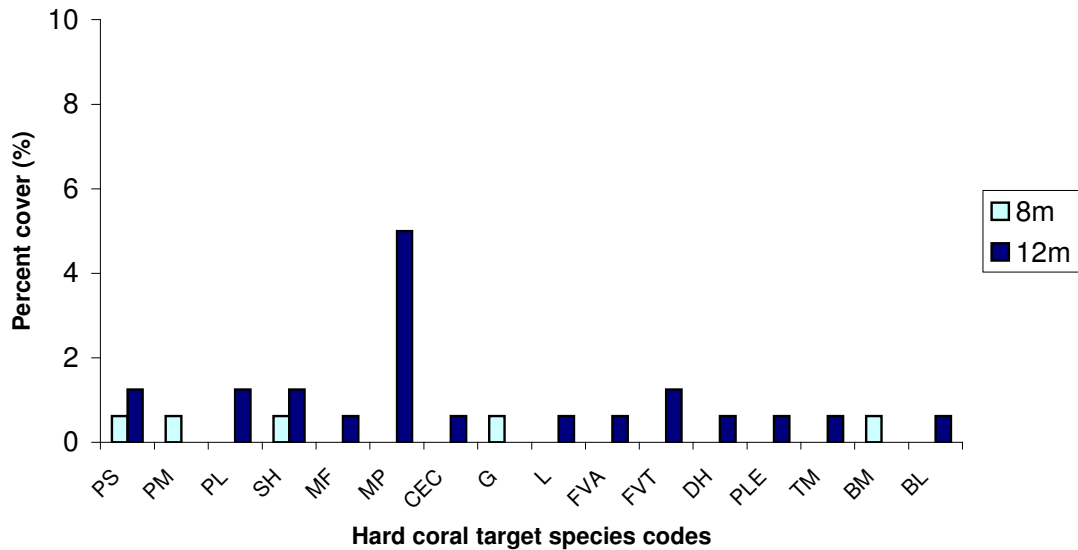


Figure 3.23 Mean percent cover of hard coral target species recorded during four 20m transects set at two depths (8m and 12m) at Timba fish sanctuary (Sector 9). Each transect represents a replicate. Refer to Appendix B for codes.

Invertebrates

Target invertebrates noted during the transects are shown in Table 3.3. There were considerably less *Diadema* urchins at 12m than 8m. Pencil urchins (*Heterocentrotus mammilatus*) and edible sea cucumbers were also recorded. It was estimated that 15% of the coral along the transect at 12m was damaged due to crown of thorns damage. The coral forms which appeared to have suffered from crown of thorns were *Acropora* branching and non-*Acropora* branching. No such damage was recorded at 8m. Only two COTs were recorded during surveying at 12m.

Table 3.3 Mean numbers ($\pm$ standard deviations) of invertebrates recorded during four 20m transects set at two depths (8m and 12m) at Timba fish sanctuary (Sector 9). Each transect represents a replicate.

Species	8m	12m
<i>Diadema</i> urchins	5.5 ± 3.5	1.0 ± 0.82
Pencil urchins	0.25 ± 0.5	0.3 ± 0.5
Sea Cucumber	0	0.3 ± 0.5
Crown-of-thorns	0	0.5 ± 1.0

Fish

No target fish species were recorded during the transects at 8m. At 12m Butterflyfish (*Chaetodontidae*), Two-spot snapper (*Lutjanus biguttatus*), other Snapper spp., Parrotfish (*Scaridae*), Fusiliers (*Caesionidae*) and Surgeonfish (*Acanthuridae*) were recorded. Mean numbers per 20m replicates are shown in Figure 3.24. Fusiliers were the fish family with the greatest recorded numbers ($X = 5.0 \pm 10.0$), however the standard deviation was high as all were recorded as a school within one transect.

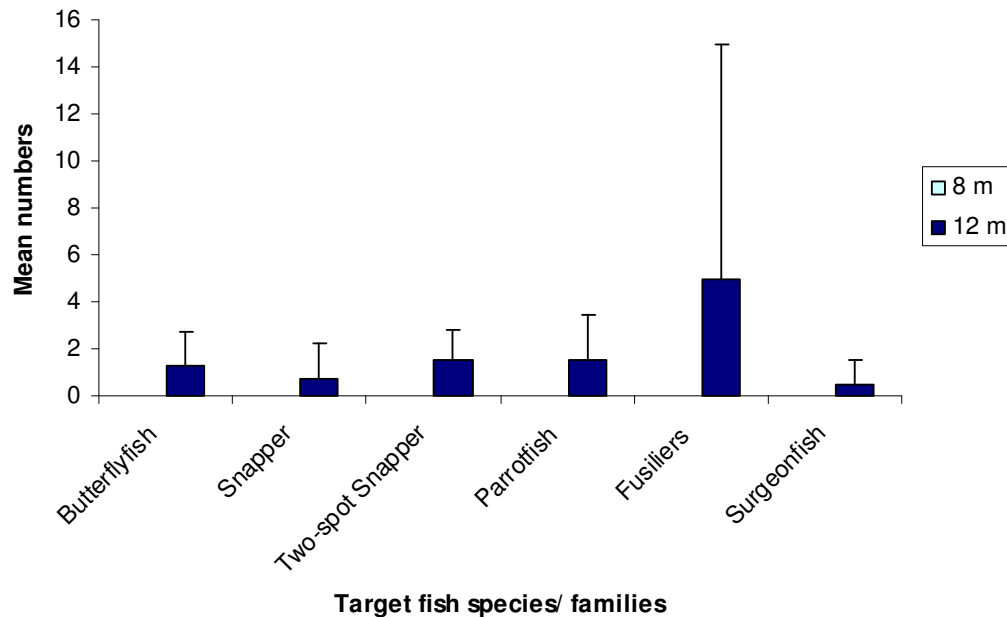


Figure 3.24 Mean numbers ($\pm$ standard deviations) of target fish recorded along four 20m transects set at two depths (8m and 12m) at Timba fish sanctuary (Sector 9). Each transect represents a replicate.

3.3.2 Secret Garden - Sector 8

Secret Garden was chosen as a Reef Check site as it is the ‘house reef’ outside the CCC base. It has the highest coral cover in the near vicinity and as has recently suffered from a large aggregation of crown of thorns.

Substrata

At 6m sand was the dominant substratum with a mean cover of 56.9%, whereas at 12m hard coral was the dominant substratum with a mean cover of 44.4%. At 12m sand occupied on average 8.8% of the transect. Hard coral cover at 6m (25.6%) was almost half that recorded at 12m (see Figure 3.25). Soft coral was also abundant at depth with an average cover of 27.5 %. Recently killed coral was more abundant at 12m where coral cover was also greater. Sponges, algae, rock and ‘other’ groups such as tunicates and anemones were present at both depths.

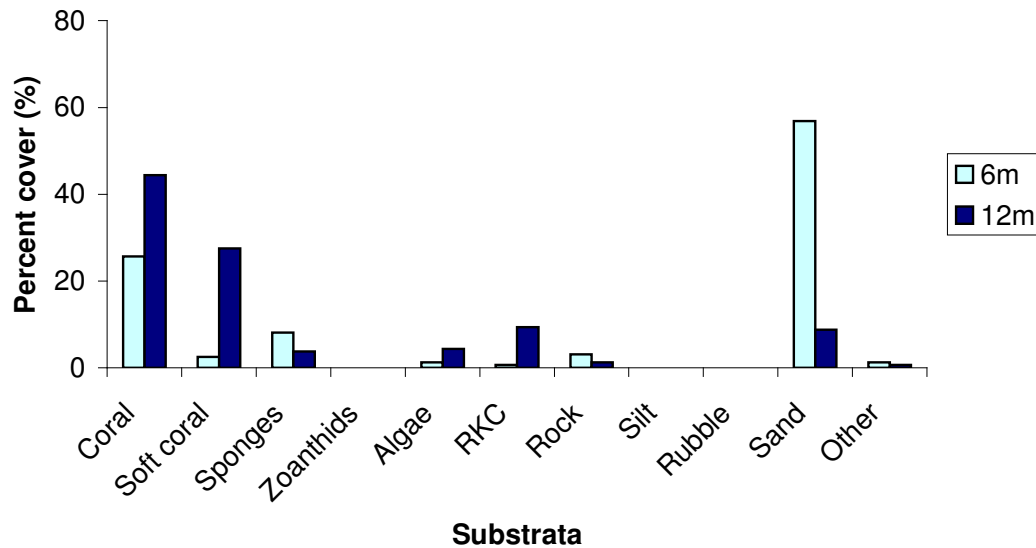


Figure 3.25 Mean percent cover of substrata recorded during four 20m transects set at two depths (6m and 12m) at Secret Garden (Sector 8)..

At 6m the most commonly recorded hard coral life forms were non-*Acropora* massive (10.6%) and non-*Acropora* branching (8.1%). Other represented life forms included *Acropora* submassive, encrusting, branching, non-*Acropora* foliose and mushroom corals. No non-*Acropora* submassive forms were recorded at 6m. At 12m the dominant life form was *Acropora* branching (30.6%), particularly ‘bottlebrush’ *Acropora* (20.6%). Life forms recorded less frequently were non-*Acropora* branching, foliose, massive, submassive and mushroom (see Figure 3.26).

The most abundant target species recorded was ‘bottlebrush’ *Acropora*, which was dominant at 12m (20.6% cover) (Figure 3.27). Other species only recorded at 12m were *Seriatopora hystrix*, *Favites* spp. and *Tubastrea micrantha*. At 6m coral cover was considerably low and the most abundant species was *Porites nigrescens* (5%). Species only recorded at 6m were *Pocillopora* ‘small’, *Pachyseris speciosa*, *Polyphyllia talpina*, *Galaxea* spp., *Lobophyllia* spp., *Favia* spp. and Brain coral ‘small’. Although hard coral cover was greater at 12m, diversity was greater at 6m, with no one species occurring as frequently as *Acropora* branching at 12m. Scleractinian corals recorded at both depths were *Millepora platyphila*, *Goniopora/Alveopora* spp., *Herpolitha limax*, Brain coral ‘small’ and ‘medium’. Figure 3.27 shows the percent cover of the target hard corals recorded during surveying.

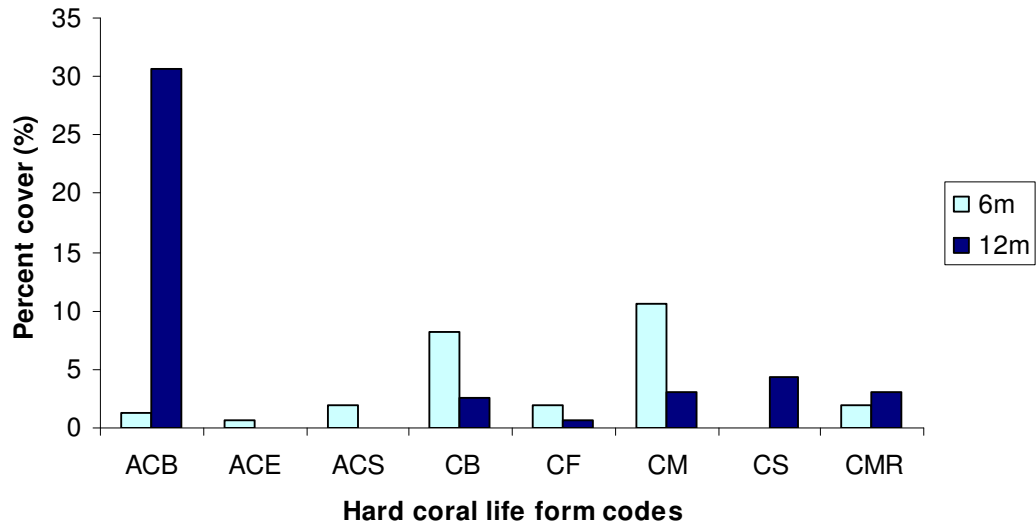


Figure 3.26 Mean percent cover of hard coral life forms recorded during four 20m transects set at two depths (6m and 12m) at Secret Garden (Sector 8). Refer to Appendix B for codes.

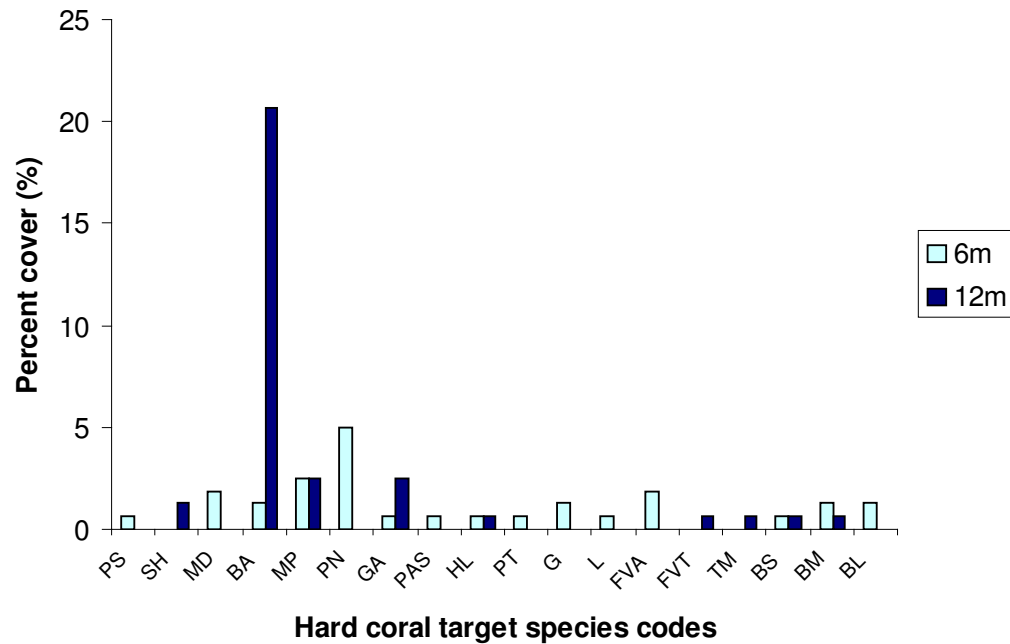


Figure 3.27 Mean percent cover of hard coral target species recorded in four 20m transects set at two depths (6m and 12m) at Secret Garden (Sector 8). Each transect represents a replicate. Refer to Appendix B for codes.

Invertebrates

Invertebrates were more diverse at Secret Garden than at Timba fish sanctuary. *Diadema* urchins were recorded in lower numbers than at Timba. Pencil urchins were only recorded at 6m. Sea cucumbers were recorded in equal frequency at both depths. Crown of thorns sea stars were present only at 12m and in low numbers (see Table 3.4). Giant clams (*Tridacna* spp.) were recorded during transects at both depths.

Table 3.4 Mean numbers ($\pm$ standard deviations) of invertebrates recorded during four 20m transects set at two depths (6m and 12m) at Secret Garden (Sector 8).

Species	6m	12m
<i>Diadema</i> urchins	0.5 $\pm$ 0.58	0.75 $\pm$ 1.50
Pencil urchins	0.25 $\pm$ 0.5	0
Sea Cucumber	0.75 $\pm$ 0.96	0.75 $\pm$ 0.96
Crown-of-thorns	0	0.25 $\pm$ 0.5
Giant clam (<i>Tridacna</i> spp.)	0.25 $\pm$ 0.5	0.25 $\pm$ 0.5

Reef Fish

Target fish species were more abundant at Secret Garden than Timba. Fish abundance was greater at 12m (Figure 3.28), where the dominant target species were Fusiliers (11.3 $\pm$ 14.4) and Butterflyfish (6.8 $\pm$ 2.5). Commercially important species such as Snapper, Checkered snapper (*Lutjanus decussates*) and Parrotfish were also recorded at 12m (Figure 3.28). At 6m Fusiliers were also in greatest abundance out of the target species (8.8 $\pm$ 11.8). Butterflyfish, Sweetlips (Haemulidae), Snapper including Black and white snapper (*Macolor macularis*), Groupers including Peacock groupers (*Cephalopholis argus*) and a Moray eel (Muraenidae) were all recorded at 6m.

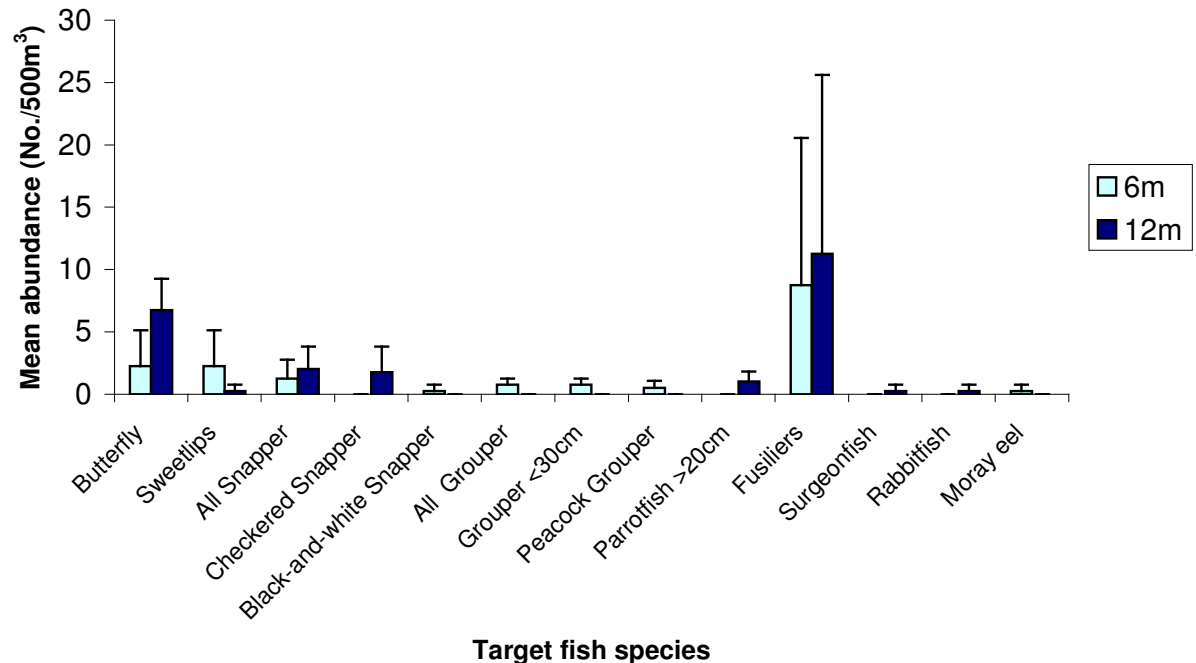


Figure 3.27 Mean abundance ($\pm$ standard deviations) of target fish recorded on four 20m transects set at two depths (6m and 12m) at Secret Garden (Sector 8).

3.3.3 Liloan fish sanctuary – Sector 19

Liloan fish sanctuary is located on the east coast of Sogod Bay within Sector 19 (Figure 1.1). The sanctuary has been operational for approximately 15 years and is guarded most of the time by a marine warden. However on occasion spear-fishermen have been observed fishing within the boundaries of the sanctuary. The area also seems to suffer from high turbidity resulting from a high sediment load. This may stem from the land as it is in close proximity to Liloan town, a large settlement with approximately 2,000 inhabitants.

Substratum

Hard coral cover was particularly high at 6m (56.3%) and slightly lower at 12m (35.0%) (Figure 3.28). The mean cover of sand was also greater at 6m (33.1%) than at 12m (26.39%). Rubble increased considerably with depth from 3.8% at 6m to 25.6% at 12m. Soft coral was not present at 6m and was low in abundance at 12m (0.6%). Sponges, algae, rock and silt were all recorded with low percent cover values at both depths (Figure 3.28). Silt was only recorded at 12m.

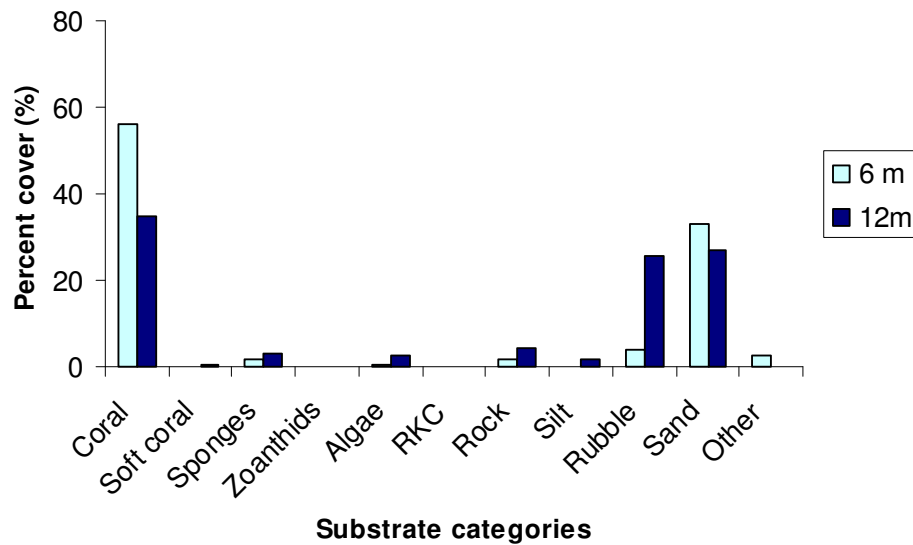


Figure 3.28 Percent cover of substrata recorded during four 20m transects set at two depths (6m and 12m) at Liloan fish sanctuary (Sector 19).

Hard coral life forms with the greatest percent cover recorded at 6m were non-*Acropora* submassive (14.4%), non-*Acropora* massive (11.9%), non-*Acropora* branching (11.3%) and *Acropora* tabulate (6.9%). At 12m the dominant life forms were non-*Acropora* branching (6.9%), non-*Acropora* encrusting (5.6%) and non-*Acropora* submassive (5.6%) (Figure 3.29). In total 11 different coral life forms were recorded at 6m and 10 and 12m.

At both 6 and 12m, *Porites cylindrica* was the most abundant target hard coral species recorded (Figure 3.30). At 6m *P. cylindrica* covered an average of 9.4 % of the transect and at 12m 4.4% of the transect. The next most commonly recorded species at 6m were *Millepora platyphyllia* (8.7%) and *Porites nigrescens* (6.9%). Hard coral diversity appeared to be greater at 6m than at 12m with 15 target hard coral species recorded compared to only 8 at 12m (Figure 3.30).

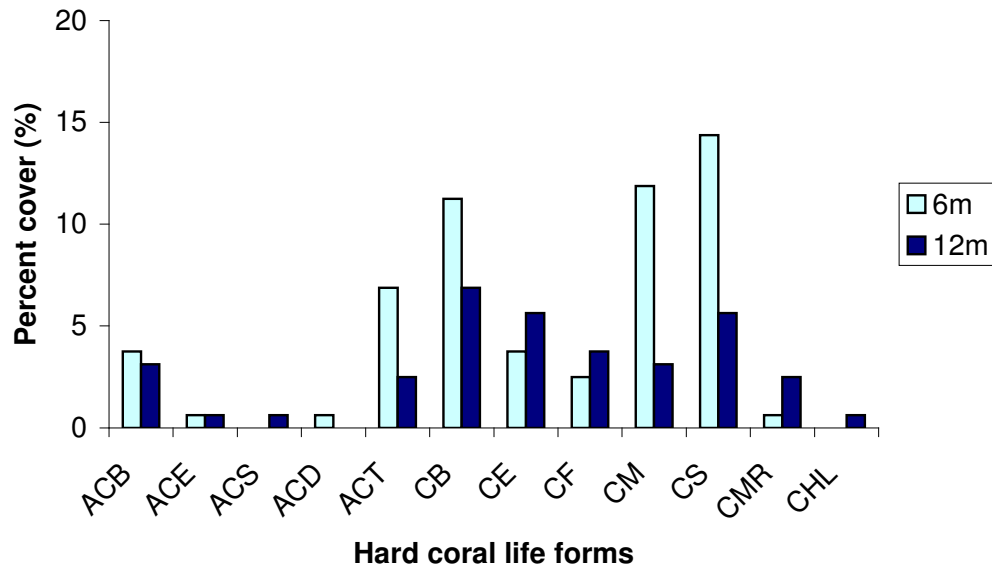


Figure 3.29 Mean percent cover of hard coral life forms recorded during four 20m transects set at two depths (6m and 12m) at Liloan fish sanctuary (Sector 19). Refer to Appendix B for codes.

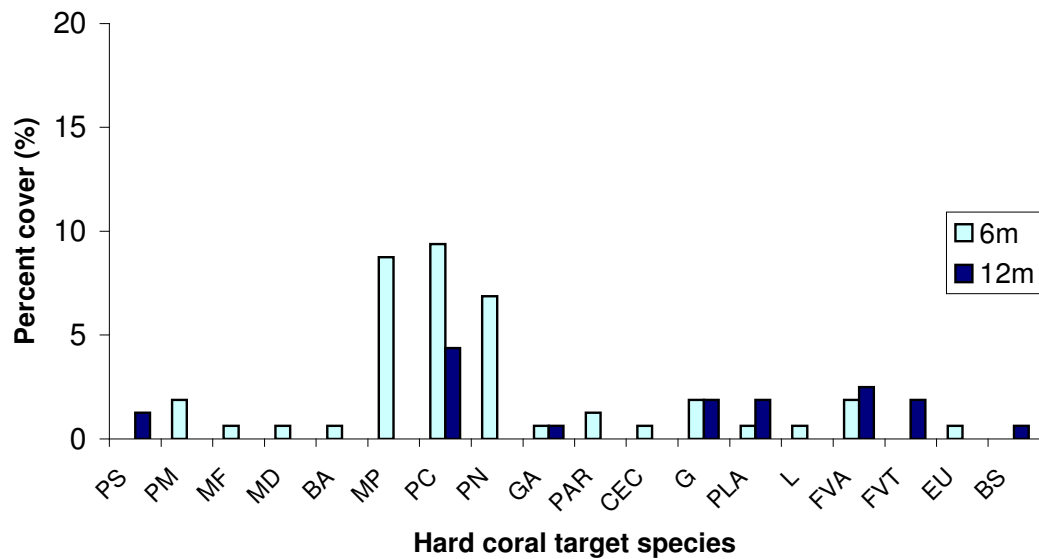


Figure 3.30 Mean percent cover of hard coral target species recorded during four 20m transects set at two depths (6m and 12m) at Liloan fish sanctuary (Sector 19). Refer to Appendix B for codes.

Invertebrates

Invertebrates were more abundant at 6m than at 12m. The only invertebrates recorded at 12m were *Diadema* urchins. Species present at 6m included the banded coral shrimp (*Stenopus hispidus*), pencil urchins (*Heterocentrotus mammilatus*), crown of thorns and in total 6 giant clam (*Tridacna* sp.) was recorded at 6m. *Diadema* urchins occurred with greater frequency at 6m than at 12m (Table 3.5).

Table 3.5 Mean numbers ($\pm$ standard deviations) of invertebrates recorded during four 20m transects set at two depths (6m and 12m) at Secret Liloan fish sanctuary (Sector 19).

Species	6m	12m
Banded coral shrimp	0.25 ± 0.5	0
<i>Diadema</i> urchins	10 ± 6.48	0.75 ± 1.5
Pencil urchins	0.25 ± 0.5	0
Crown-of-thorns	0.5 ± 0.58	0
Giant clam (<i>Tridacna</i> spp.)	1.5 ± 1.0	0

Reef Fish

Target fish species were more abundant at 6m than at 12m (Figure 3.31). Butterflyfish were on average the most abundant target species at 6m ($X = 15.8 \pm 12.7$), however their frequency decreased with depth ($X = 3.5 \pm 3.1$). Grouper and Rabbitfish were only recorded at 6m. Parrotfish and Fusiliers were present in low abundances at 12m ($X = 1.5 \pm 1.73$ and 2.0 ± 2.7 respectively). Commercially significant snapper and sweetlips were absent.

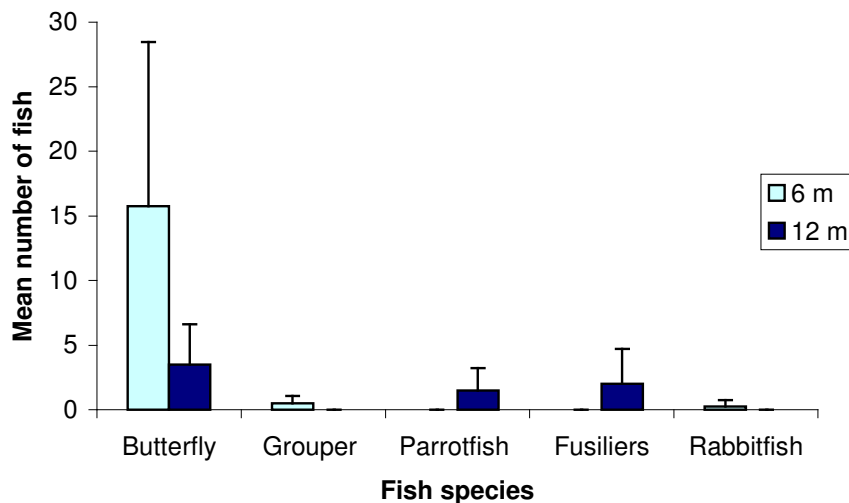


Figure 3.31 Mean numbers ($\pm$ standard deviations) of target fish recorded during four 20m transects set at two depths (6m and 12m) at Liloan fish sanctuary (Sector 19).

3.4 CROWN-OF-THORNS STUDY

The preliminary results are presented for the monitoring study set up in December 2003. Since the first surveys were undertaken the COTs have been observed to move south through a sites called “Secret Garden” and on towards another site known as “Bamboo Pier” (Doyle, pers. obs.).

3.4.1 Crown of thorns density and substrata

The mean number of COTs observed per transect was 9.2 ± 10.6 . This corresponds to a density of 0.02 ± 0.02 COTs m^{-2} (Figure 3.32). The maximum number of COTs recorded at one depth band across all 6 transects was 23 at the 3-4m depth contour. This gives a density of 0.04 COTs m^{-2} . No COTs were observed in transects laid at the 7-8 and 11-12m depth contours.

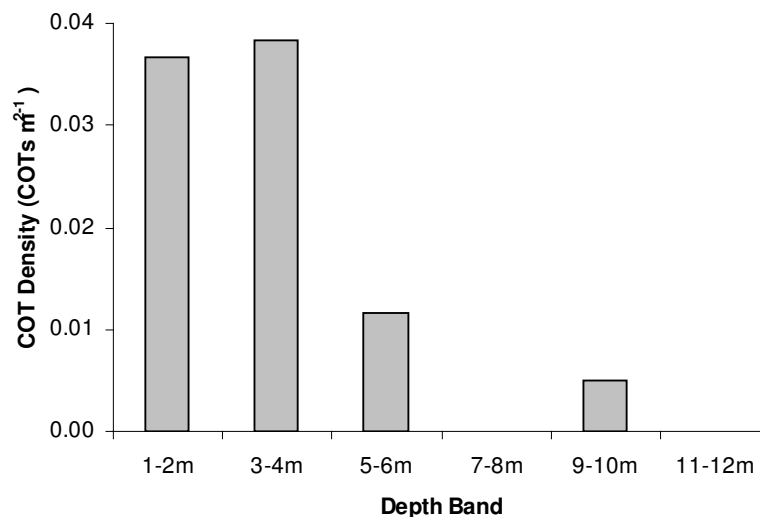


Figure 3. 32 Density of Crown-of-thorns seastars observed in a 5 m band along 6 x 20m transects laid at 6 depths contours at “Logger’s Eden”.

There is no clear relationship between the sizes of COTs and the depth contour they were recorded at (see Table 3.6). Overall the majority of COTs ($X=30.6\% \pm 36.15\%$) were in the size 3 category (i.e. $> 36\text{cm}$ diameter from arm to arm). The 5-6m depth contour had the most numerous COTs in the Size 3 category (85.7%)

Table 3.6 Size distribution of COTs recorded along six 20m transects at four depth contours. Values are percentages of total COTs observed per depth contour.

Depth contour	Size 1 (<25cm)	Size 2 (26-35cm)	Size 3 (>36cm)
1-2m	0	54.6	45.5
3-4m	13.1	34.8	52.2
5-6m	0	14.3	85.7
9-10m	33.3	66.7	0
Mean	7.7	28.4	30.6
SD	13.6	28.3	36.2

COTs were commonly recorded on *Acropora* spp., in particular branching and tabulate forms (Figures 3.33, 3.34). A considerable amount of COTs were found on sand at the shallower depth contours (1-2m, 3-4m) (41 and 30 % respectively) and predominantly on *Acropora* branching at 5-6m (71.4%). At 9-10m COTs were predominantly found on *Acropora* tabulate and foliose corals (67% and 33% respectively). Out of the non-*Acropora* species, the most common hard corals COTs were seen on were *Galaxea* spp and *Favia* spp (Figure 3.34).

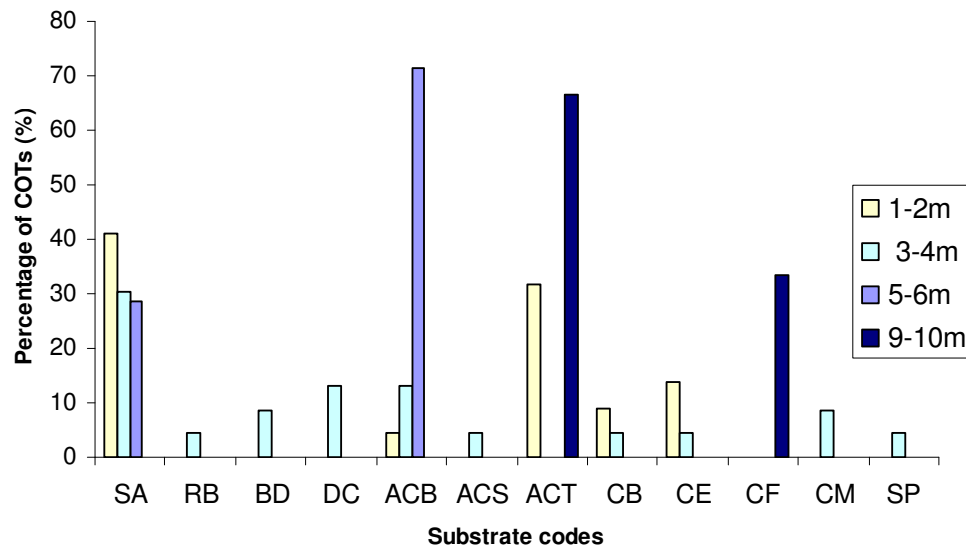


Figure 3.33 Percentage of COTs recorded on various substrata for all 6 x 20m transects at each depth band. There were no COTs recorded at depth contours 7-8m and 11-12m. Abbreviations for substratum categories are taken from English *et al.*, 1997.

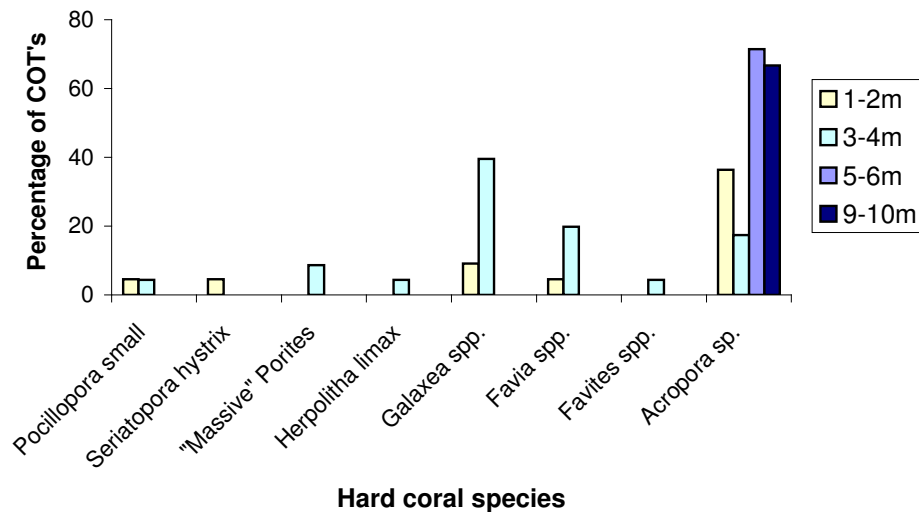


Figure 3.34 The percentage of COTs recorded on non-*Acropora* hard coral species during 6 x 20m transects at depth contours 1-2m and 3-4m.

3.4.2 Extent of Coral Damage

There was evidence of hard coral damage due to COTs feeding with an average of 5.4 ± 2.5 colonies damaged per transect (equivalent to $0.06 \text{ colonies m}^{-2}$). The density of damaged corals was greatest at depth contour 3-4m ($0.1 \text{ colonies m}^{-2}$), which corresponds to the depth at which COTs were most abundant.

Over all depth contours 63% ($\pm 14\%$) of these colonies displayed extensive damage (>70% of the colony damaged), 27% ($\pm 11\%$) displayed 30-70% of colony damage and 9% ($\pm 5\%$) showed >30% colony damage (Figure 3.35).

Over all depth contours, both *Acropora* and non-*Acropora* coral species were damaged due to COTs feeding. The majority of damaged colonies were *Acropora* tabulate ($31.5 \pm 18.8\%$) and *Acropora* branching ($22.6 \pm 6.2\%$) (Figure 3.36). Other coral forms which suffered visible damage included non-*Acropora* branching ($13.8 \pm 10.6\%$), encrusting ($10.6 \pm 6.8\%$), massive ($8.4 \pm 9.6\%$) and submassive ($7.0 \pm 7.6\%$). The majority of damaged colonies ($83 \pm 16\%$) were becoming colonised by algae.

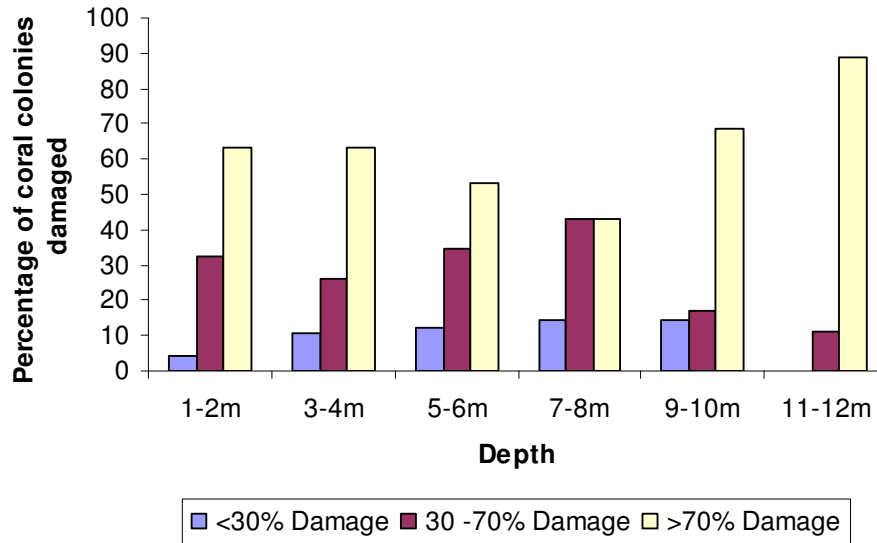


Figure 3.35 Percentage of coral colonies damaged in three categories representing the extent of damage (<30%, 30-70% and >70%). Percentages calculated for 6 x 20m transects at 6 depth contours.

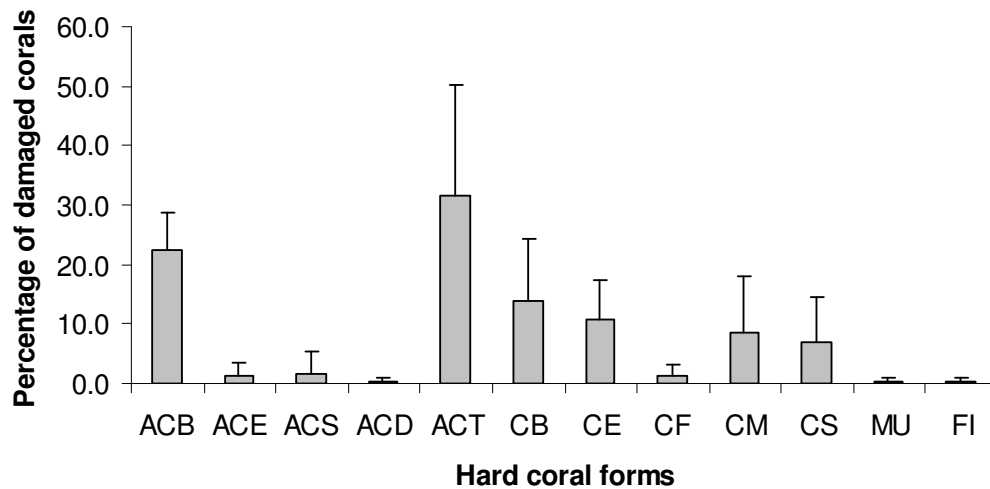


Figure 3.36 Percentage of hard coral forms visibly damaged by COTs averaged over 6 depth contours. Abbreviations for substratum categories are taken from English *et al.*, 1997.

4. Discussion

4.1 RAPID REEF ASSESSMENTS

The purpose of Rapid Reef Assessments (RRAs) was to give an indication of the relative abundance of the main reef fish and benthic communities at a particular site in a short period of time. Out of the 40 sites assessed during RRAs, two stand out as having the greatest abundance of hard corals and reef fish. These sites are the Napantau fish sanctuary in San Francisco (Sector 21) and Limasawa Island (Sector 3).

There is a trend for the more sheltered sites to have both the greater cover of hard coral as well as greater abundance of fish. Sites on the more sheltered eastern coast of Sogod Bay and the west coast of Limasawa follow this trend. Hard coral communities may be more established on the east coast of the bay as it is more sheltered than the west coast, which often receives strong winds during the north-easterly monsoon. Numerous studies have documented direct and indirect dependence of reef fish on the coral reef community (Hodgson, 1997). The results also indicate the degree of this relationship in that there is a high correlation ($R^2 = 0.86$) between the abundance of hard corals and reef fish. In this study the two areas with the greatest abundance of hard coral (Napantau and Limasawa) also had the greatest abundance of fish.

Over all sites and depths, average fish abundance was rated as 3.2 on the DAFOR scale, which equates to 21-50 individuals per survey. When the fish families were scrutinised it can be noticed that the most abundant families were Damselfish (*Pomacentridae*) and Wrasse (*Labridae*), which are both not commercially important. In fact commercially important species were rarely seen throughout the RRA's and this trend is also evident from the results of the baseline data presented for Sector 10. The lower abundance of fish at 6m than at other depths may be attributed to two factors: both anthropogenic impacts and natural physical disturbance due to wave action and storm damage.

Although soft coral cover was lower than that for hard corals at most sites and depths, soft corals were also most abundant in areas where hard coral cover was high. This is not surprising as both groups have similar requirements; clear water enabling high levels of light penetration, suitable substratum for settlement, food availability and reasonably low-energy hydrodynamic conditions. In some areas where hard coral abundance was particularly low, for example at 18m in Sector 10, soft coral was recorded as having a higher abundance. This may be an indication of disturbance and reef stress (Calumpong *et al.* 1994).

The highest abundance of macroalgae was recorded at Liloan in Sector 19, an area which is in close proximity to a large human population. Macroalgal levels may be higher here as a result of increased nutrient input from the nearby town as well as from the ferry terminal in close vicinity to the site. Dumping of waste and rubbish into the sea and into the mangroves from the town and the ferries has been documented (Calumpong *et al.*, 1994). In other sites macroalgal abundance was relatively low but the actual species composition can sometimes give a better indication of whether an area is suffering from nitrification. Certain species of algae such as some

cyanobacteria, *Sargassum* spp., *Padina* spp. and *Turbinaria* spp. have been associated with elevated nutrient levels in the water column. The species composition will be determined in the more detailed baseline survey analysis.

In most sites all target biological communities were present at all depths surveyed. However no macroalgae and invertebrates were recorded at two depths surveyed at Limasawa. The abundance of sponges and 'other' invertebrates did not appear to be considerably different between depths or between sites. However, 'other' invertebrates were most abundant at Liloan (Sector 19).

In general, all communities were more abundant at either 12m or 18m than at 6m. This is to be expected when the reef tends to be poorly developed in the shallow parts, partly due to increased wave exposure but also due to human impacts such as trampling, small-scale mollusc collecting and anchor damage. It is important to note that these surveys only give a very crude estimate of marine flora and fauna abundances as part of an initial rapid assessment. More comprehensive survey techniques such as the CCC baseline method are required to produce an accurate representation of biological abundance.

4.2 BASELINE SURVEYS

The generally poor abundance of fish in Sector 10 may be related to the large amount of sand substratum cover observed. Numerous studies have documented direct and indirect dependence of coral reef fish on the coral-reef community (Hodgson, 1997). Large reductions in both fish biodiversity and abundance have been documented as a result of coral reef degradation. Most coral reef fish depend on coral reefs as they feed on organisms that live in close association with the reef, e.g. algae, crustaceans (Sale, 1991). There was a notable absence of any large commercially important families such as Groupers (Epinephelinae- Serranidae) and Snappers (Lutjanidae) in this sector, which could be attributed to the levels of fishing pressure within Sogod Bay. Calumpong *et al.* (1994) noticed several indicators of overfishing during surveys. There was a lack of commercial species (such as Jack, Emperors, Grey mullets) and economically important finfish such as *Scolopsis cancellatus*, *Siganus canaliculatus* and *Euthynnus affinis* fish matured at a smaller size than in other areas. It was concluded that this could lead to an increasing dominance of smaller species in the future, due to a reduction in the genetic diversity by the removal of individuals with desirable features such as large size (Calumpong *et al.*, 1994). This tendency for smaller individuals to dominate has been observed during both CCC baseline surveys as well as other surveys, in particular for commercially targeted species.

During baseline surveys, Damselfish (Pomacentridae) were the most abundant fish family recorded followed by Wrasse (Labridae). These results are comparable to Calumpong *et al.*, (1994). Traditionally these families have not been considered commercially important however more recently they have become targets of the aquarium trade.

Coral cover was also low and there was a relatively large amount of dead coral with algae recorded. The most abundant life forms observed were *Acropora* branching and non-*Acropora* encrusting forms, the former fast growing and the latter often an

adaptation to high-energy environments. These results reflect those of Calumpong *et al.* (1994), where live coral cover was poor from the reef flat to the reef slope. Their results indicated that 78% of the 123 manta tows undertaken had 1-10% live coral cover and 2% had coral cover greater than 31% (Calumpong *et al.*, 1991). However, these manta tows only include shallow reef environments. Many reef slopes show an increasing coral cover with depth to about 5-10m and then a sustained high cover to at least 30m, after which coral cover declines (Sheppard, 1982). Furthermore scleractinian corals have been recorded at depths greater than 100m in areas with extremely clear waters (Lang *et al.*, 1975; Goraue and Wells, 1967). The low coral cover here may be a result of high turbidity and sedimentation as well as regular typhoon damage. It is possible that anthropogenic activities such as land clearing and re-channelling projects around the bay have resulted in high sediment loads which have then been transported via tides and currents to other localities within the Sogod Bay. Sedimentation and turbidity both have the overall effect of causing stress to corals which will reduce their ability to recover from natural destruction such as typhoon damage. Heavily silted reefs may have poor coral cover, particularly if sedimentation is chronic.

Sedimentation can result in direct smothering of corals and forces them to expend energy on sediment removal by producing vast amounts of mucus or by accelerated ciliary action in an attempt to slough off the sediment. Susceptibility to sedimentation is species specific but is also a function of morphology; where for example massive life forms are better adapted to high sediment conditions than flat platy corals as it easily rolls off their surface.

High turbidity reduces irradiance and hence the light available to corals for photosynthesis. Scleractinian corals live in a symbiotic relationship with algae known as zooxanthellae. The zooxanthellae photosynthesize and produce carbon, 90% of which leaks into the coral polyp tissue and is then used in metabolism. In return waste products produced by the coral polyp are taken up by the algae and are utilised during the photosynthetic cycle. Light is hence a limiting factor to scleractinian coral growth. A reduction in light levels can result in a greater susceptibility to disease and even coral mortality. Shifts in coral communities can result as species with adaptations to low light environments may be selected for.

The knock-on effect of low coral cover was a low abundance of other invertebrates throughout the sector. Many invertebrates live in close associations with coral reefs as the reef provides shelter and food.

Macroalgal cover was also low but increased in abundance close to the shore, which may be a result of localised nutrification. Domestic waste management is not yet well developed in most municipalities and households are required to manage their own wastewater, which usually ends up in the sea.

A second sector (8) south of Malitbog, also on the west coast of the bay is nearing completion. Preliminary results suggest a more extensive reef system with greater coral cover and associated reef organisms. From observation a general trend within Sogod Bay is that the more extensive fringing reefs are found closer to the mouth of the bay to the south. This is most likely related to the high sediment loads entering the bay via the large rivers in the north such as Fiong, Consolacion and Salog rivers.

Calumpong *et al.* (1994) identified that these rivers at the vertex of the bay were the main source of the siltation problem. It has been suggested by Koch (1993) that most of the shore of Sogod Bay once had extensive reefs covering hundreds of thousand of square metres. When logging removed a considerable amount of the forest cover in the area, large amounts of sediment were washed into the sea with heavy rains. This in turn may have severe impacts on the local coastal communities and the effects of fisheries may be considerable. Habitat destruction can result in decreased fish biomass and diversity (Hodgson, 1997). Siltation has been sited as being the single most important impact influencing coral reef health in the Philippines (Jacinto *et al.*, 2000).

4.3 REEF CHECK SURVEYS

Substrata

All sites were characterised by a gentle slope and sandy substrate. The percent cover of hard corals was lowest at Timba fish sanctuary, greatest at Liloan fish sanctuary and intermediate at Secret Garden. At both Timba fish sanctuary and Secret Garden coral cover almost doubled from 6m to 12m and this may be attributed to the high-energy environment in the shallow water. Conversely at Liloan coral cover was greatest at 6m. There are two possible explanations for this. Firstly as the site is more sheltered than both Timba and Secret Garden, corals can establish themselves in the shallow environment. All sites had a predominantly sandy slope so the availability of hard substrata for attachment of coral recruits is not limiting growth only at Liloan. It is also possible that the lower growth of coral at 12m at Liloan is the result of high levels of turbidity. As discussed in Section 4.2 high turbidity levels result in a decrease in illumination at depth, reducing the calcification rates of corals and hence growth (Sheppard, 1982). It has been noticed that visibility, both horizontal and vertical has been particularly poor during surveying at this site.

Acropora species which are known to be sensitive to sedimentation (Wesseling *et al.*, 1999) were in low abundance at Timba. In Secret Garden *Acropora* sp. were dominant at 12m, but in low abundance at 6m. This could be again due to the high-energy environment as a branching structure would be more susceptible to wave damage. Interestingly at Liloan, where coral cover was greatest and hydrodynamic energy was low, *Acropora* spp. were in very low abundance. If this area is suffering from siltation as is expected, then this would explain the lack of *Acropora* spp. as this genus is most susceptible to sedimentation stress (Sheppard, 1982). Non-*Acropora* foliose forms were also in low abundance at Liloan. Foliose forms are an adaptation to low light environments and would be expected to be present in deeper water or in areas where light penetration is low due to increased turbidity (Doyle, 2002). However if sedimentation rates are also high then foliose forms will be easily smothered, and other forms with greater abilities to remove sediments would be expected to prevail. Foliose forms were also rarely recorded at the other sites where turbidity appeared to be considerably less. Both sites on the west coast of the bay are often exposed to high wind levels and subsequent hydrodynamic action. Foliose forms are not expected to occur in high-energy environments, as they are rather fragile.

Invertebrates

Diadema urchins and pencil urchins (*Heterocentrotus mammilatus*) were recorded at all sites. *H. mammilatus* is dependant on the reef for shelter and tends to occur in wave-swept areas (Colin and Arneson, 1995). These sea urchins were more abundant at shallow depths (6m and 8m) at all sites.

Diadema urchins were considerably more abundant during the shallow transects at both Timba and Liloan. The greatest abundance of *Diadema* urchins was recorded at 6m at Liloan sanctuary. At Secret Garden *Diadema* urchins were recorded in lower numbers than at Timba. These echinoderms have been documented to aggregate in exposed or recently disturbed locations, and so would be expected to be greater in number in areas where corals are less abundant. Surprisingly the greatest abundance of these sea urchins coincided with the greatest coral cover of all sites. An increase in *Diadema* abundance may also be related to the level of predation on these urchins by certain fish families. Overfishing of urchin predators such as Triggerfish (Balistidae) can enable *Diadema* urchin populations to grow unchecked.

Crown of thorns sea stars were recorded in low abundances at all sites. Damage due to these corallivores was evident at Timba with the targeted hard coral life forms being *Acropora* branching and non-*Acropora* branching. It has been documented that fast growing coral species such as *Acropora* spp, are their preferred food source (Moran, 1986).

Giant clams (*Tridacna* spp.) were recorded at both Liloan and Secret Garden but were more numerous at Liloan. These bivalve molluscs have been illegally poached by shell collectors and their numbers in the wild are dwindling. The true Giant Clam (*Tridacna gigas*) has become very rare if not extinct and is listed on the CITES “threatened species list” (Colin and Arneson, 1995). The banded coral shrimp (*Stenopus hispidus*), an indicator of reef health, was only recorded at Liloan; the site with the greatest coral cover.

Fish

Secret Garden had the most diverse fish life with 13 of the target species present. Fish abundance was also greatest here with a mean of 40.5 fish recorded per transect (20m). Fish abundance was lowest at Timba with an average of 10.5 fish recorded per transect. The low abundance of target fish again may be attributed to the low hard coral cover at this survey site. There was also an absence of commercially important species such as Snapper and Parrotfish at Timba. Parrotfish were present at Liloan but the greatest abundance of both Snapper and Parrotfish was at Secret Garden. The most abundant fish family recorded at Liloan were Butterflyfish and commercially significant Snapper and Sweetlips were absent.

Groupers, which are prime target for the live fish trade were in low abundance at both Liloan and Secret Garden and totally absent from Timba. The groupers that were recorded during surveying were less than 30cm in length and all the groupers spotted during other surveys and dives have also been small (Doyle pers. obs).

Summary

Like many parts of Sogod Bay that have been visited to date the shallow reef at Timba was biologically and aesthetically poor. However the wall extending from 18m to 28m was rich in both hard and soft corals and target Reef Check invertebrates and fish species. The Reef Check surveys will be continued to the deeper parts of this reef. Purely from observation the reef at Liloan appeared to be suffering from high turbidity as well as sedimentation. This may be adversely affecting the growth of corals in the deeper waters as well as the composition of life forms and species present. Coral cover is still high at this stage, particularly at 6m. Overall fish abundance was quite low with commercially important species being absent or present in low numbers and small sizes. The site which currently has no designated protection, 'Secret Garden' had the highest abundance of target fish species.

4.4 CROWN-OF-THORNS SURVEYS

The density of COTs observed does not seem to represent outbreak levels. The actual numbers of individuals that make up an outbreak varies spatially and temporally but when a population is consuming coral at a rate faster than the rate corals can grow, an outbreak has been established, (Lourey *et al.*, 2000). However it is recommended that the numbers are continuously monitored. A cause for possible concern is the fact that they have also been observed in large numbers in other parts of the Bay. On the west coast of the bay within Liloan fish sanctuary over 100 individuals were counted during a 15 minute snorkel (Doyle, pers. obs.). Furthermore extensive Crown of Thorns damage was noticed during a dive at Santa Paz, San Francisco (Doyle, pers. obs.).

The predominance of the larger size class suggests that the majority are adults of at least 3 years of age and may stem from the same age class. Following Birkeland's terrestrial run-off hypothesis (1982) coupled with the knowledge that the surrounding areas of the bay have been heavily logged and denuded in the past, the large numbers of COTs may be the result of an event (drought followed by heavy rain) several years ago which caused a localised increase in larval survival.

As anticipated coral damage was greatest within the depth band where COT density was highest (3m). The most common hard coral life forms they were found on were *Acropora* tabulate and branching corals. Fast growing and commonly occurring hard coral species are their preferred food source (Moran, 1986).

As it has not yet been established whether aggregations of these sea stars are a natural phenomena or human-induced the use of control methods is controversial. In this case monitoring of the numbers should continue but control methods could be considered if aggregations appear in economically important diving locations.

4.5 COMMUNITY PROJECTS AND CAPACITY BUILDING

CCC is dedicated to aid in developing local capacity by undertaking training programmes in SCUBA diving and marine science as well as educating local people in environmental awareness.

Community Education

One of the aims of SLCRCP is to help educate people in environmental issues as well as create an awareness of the marine environment and its fragility. To start off this integral part of the project we began running “Marine Education Open Days” in December 2002. These Open Days are aimed at elementary school children between the ages of 10-12 and also cater for the accompanying teachers.

The typical day involves groups of 60 children and their teachers arriving at 8 am. The day starts with an introductory lecture about CCC and the work undertaken. Following this the children are divided into three groups of 20 and each group undertakes a different activity for one hour. Afterwards the groups are rotated so that everybody has a chance to join in on all the activities offered. The activities are:

- Learning how to snorkel and to identify marine organisms underwater.
- Beach walk whilst identifying coral skeletons, macroalgae and other animal remains washed onto the shore.
- Touring the interactive displays with a guide.
- Trying out breathing from a regulator in a dunk tank on the shore.
- Watching a video documentary on “Reefs at Risk” which is based in the Philippines.
- Drawing their favourite marine organism and creating a collage of an underwater seascape, which they can then take back to their school for display.
- A Marine Life Quiz for which the children have to find the correct answers (which are hidden around the area) to a number of marine and environment related questions.
- Marine life puppet show entitled “The Adventures of Fred the Fish” which reiterates the messages introduced during the day of environmental respect and awareness.

The interactive displays include the following:

Coral Biology and Reef Ecology

A display of coral skeletons collected from the local shoreline. The topics of coral biology and reef ecology are introduced. Specifically the polyp stage, symbiotic relationship with algae, requirements of corals for growth and the inter-connectivity of organisms within a reef system area described.

Macroalgae and Marine Plants display

In this display macroalgae samples from each major family (Chlorophyta, Rhodophyta and Phaeophyta) are collected and displayed. A poster is fixed above the display and shows photographs of the various algae for identification purposes. The ecological role of algae, the importance of mangroves and the dependence of animals

on algae for food are all explained. Finally the children are encouraged to pick up the samples to help identify them from the photographs.

Pollution Display

The main causes of pollution and their effects are shown via posters and are explained by the guide. The display consists of a large tub with sand at the bottom, seawater, some dead corals as well as all the major rubbish items we commonly find washed up on the beach or attached to corals under the water; plastic bags and bottles, glass bottles, stray fishing gear such as lines and nets.

Science Display

This display consists of all of the science equipment that we use to survey, including the Secchi disc, hydrometer and thermometer, survey forms, measuring tapes and sediment traps. The guide informs the students how surveys are carried out and what type of information is collected. There are also previous reports on display for the teachers to browse through along with a poster about CCC and the previous projects undertaken.

SCUBA Display

The SCUBA display consists of a fully kitted out diver model. The guide will show the group each piece of equipment used during diving and describe its functions. The children also have the opportunity to discover what it feels like to breathe underwater using a regulator in a dunk tank filled with fresh water on the shore.

During the day the teachers are encouraged to join each group in order to supervise as well as participate in the activities, including snorkelling. At the end of the day there are a series of lectures from the staff about coral reef conservation and a lecture by a guest speaker, which has been Neil Pretentio, the marine warden for Sogod Bay. He usually speaks to the children in Visayan about his speciality, whale sharks and turtles. Finally the school group are presented with the “Underwater seascape” collage they have constructed before they leave.

CCC also held an Open Day for members of the PGSL on May 3rd 2003. During this day the Governor Rosette Y. Lerias made a point of doing a Discover SCUBA course with one of our SCUBA instructors and successfully dived in the waters outside the CCC base. The day was geared towards educating the decision makers and members of the PGSL in marine conservation issues as well as allowing similar interactive activities, such as snorkelling and displays to those offered at the Open Days for schools.

Capacity Building

Information dissemination and the development of the local capacity is an essential element of the project. One of the problems facing marine environmental protection in developing countries is the lack of local knowledge, training and equipment to facilitate carrying out surveys and monitoring studies. We aim to assist the Provincial Government of Southern Leyte by training members of the PGSL in SCUBA diving, marine environmental education and surveying. The training takes place at two different levels.

Firstly government officials will be trained up to the PADI Open Water SCUBA diving standard in order to allow them to develop an appreciation of the marine environment and simultaneously give them the opportunity to spend time with CCC at the base and learn about the project. These people will then have the ability to create awareness and interest in the marine environment amongst others within the region.

At the next level candidates which the provincial government has selected, will be trained with the intention of giving them the capability of carrying out surveying and monitoring studies after CCC has completed the project. All municipal governments in Sogod Bay have been encouraged to put forward candidates for this training. Those chosen by the PGSL are then trained in SCUBA diving up to PADI Advanced Open Water level and receive full science training. The science training includes developing identification skills for the target species and families of fish, hard corals, invertebrates and macroalgae, learning the various survey methodologies adopted by CCC, being taught about reef ecology, threats facing the reefs and the need for conservation. This group will then have the capacity to survey alongside CCC and continue coral reef monitoring in key areas (which will be identified in following reports) after CCC has departed. Ideally candidates should have a good command of the English language and either be employed in a relevant field or have a strong interest in the marine environment.

Counterpart training began in April 2002 and CCC has successfully trained the following four employees of the Provincial Government:

Dag Hilmar Navarrete	Office of Tourism.
Lloyd Abiera	Staff of the Governor's office.
Jairus Bagao	Monitoring officer for ENRO (Environment and Natural Resources Office).
Neil Pretentio	Marine warden and consultant to the PGSL.

The group spent one week learning how to SCUBA dive and then returned a week later to learn about the marine environment and its conservation. They spent another week with us being trained by our science team in the basics of reef ecology, identification of commercially or biologically significant species and learnt about our survey strategy for the bay. Apart from increasing their knowledge about the marine environment the group stated that they very much enjoyed the time they spent with us, gaining an insight into the day to day life on a CCC expedition site.

Further groups of local counterparts are being scheduled for both SCUBA and marine awareness or conservation training courses.

At a later stage in the project, members of the municipal fisheries councils, who are local fishermen, could be trained in basic snorkeling and coastal zone survey techniques. It would be possible that those who have already received training by CCC could assist in this training, in particular by helping to overcome the language barrier.

5. Conclusion

The aim of this report is to summarize CCC's activities over the first six months in Sogod Bay, during the early stages of the SLCRCP. Surveying began in September 2002 and is planned to continue for at least another two and a half years. Several different types of surveys have been conducted by CCC in order to assess the coral reef resources and identify causes of degradation. In this report the preliminary results for baseline surveys in Sector 10 have been presented as well as the results of the Rapid Reef Assessments carried out within two sectors on opposite sides of the bay. Furthermore, detailed results from the COTs survey programme are presented and plans for the sedimentation study introduced. Results for the Reef Check surveys carried out in three different sectors are also presented.

The results and observations to date indicate that some of the reefs in Sogod Bay are still relatively healthy with high coral cover and abundant fish life. However it has been identified in previous studies that habitat deterioration has occurred and is ongoing as a result of anthropogenic activities (Koch, 1993; Calumpong, 1994). Rapid Reef Assessments indicate that the fish sanctuary at Napantau and coral reefs in Sector 3 at Limasawa are the richest areas in terms of abundance and diversity of all target groups. Detailed baseline surveys which will be carried out in the following months will quantitatively assess these resources. Apart from these two sites, all other sites surveyed had a low abundance of fish and were dominated by Damselfish (Pomacentridae) and Wrasse (Labridae). There is a notable absence of commercially important species such as Snapper (Lutjanidae), Emperor (Lethrinidae), Sweetlips (Haemulidae) and Grouper (Serranidae). There is also a tendency for species from these families to be small in size.

Rapid Reef Assessments also indicate that coral reefs on the west coast of the Bay tend to be less extensive than on the east coast of the Bay. This may be attributed to the greater shelter from wind and hydrodynamic action offered on the east coast of Sogod Bay. Further Rapid Reef Assessment will be carried out within sectors that have not been covered to date.

Reef Check surveys follow similar trends to those mentioned above but also specifically indicate a lack of 'target' fish species at all sites. Surprisingly the one site with no protection had the highest abundance and diversity of commercially important fish. Reef Check surveys will continue within established fish sanctuaries, on the outskirts of the sanctuaries and in other areas of high coral cover. These sites will be permanently marked and monitored annually.

The results for baseline surveys conducted in Sector 10 have been presented and show an area which is poor both aesthetically and biologically. Coral abundance was low throughout the sector and subsequently fish abundance was also low. Baseline surveys are presently being continued in Sector 8, 11 and 19 and will be carried out every 1km until all sectors have been completed.

Finally sediment traps have been put in place in two locations and traps will be collected on a monthly basis for analysis. Four further sites have been chosen for the placement of sediment traps.

CCC is dedicated to building local capacity and providing training in SCUBA diving and surveying to local counterparts. Marine Education Open Days for local children are a monthly event at the CCC base and their purpose is to develop environmental awareness. Four members of the SLPG have received both SCUBA and science training. Education and training will continue and expand during the next few years so that monitoring and surveying can be carried out by local teams in the future.

6. References

- Birkeland, C., (1982). Terrestrial Run-off as a cause of outbreaks of *Acanthaster planci*. *Mar. Biol.* **69**, pp. 175-185.
- Bray, J.R., and J.T. Curtis (1957). An ordination of the upland forest communities of Southern Wisconsin. *Ecological Monographs* **27**: 325-349.
- Calumpong H.P., L.J. Raymundo, E.P. Solis- Duran, M.N.R. Alava and R.O. de Leon (Eds.). (1994). *Resource and Ecological Assessment of Sogod Bay, Leyte, Philippines- Final Report*.
- Chou, LM (1998). Status if Southeast Asian coral reefs. In: Wilkinson CR (Ed.) Status of coral reefs of the world: 1998. *Australian Institute of Marine Science*. 184 pp.
- Clarke, K.R. (1993). Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology* **18**: 117-143.
- Colin, P.L. and Aneson, C. (1995). *Tropical Pacific Invertebrates*. A field Guide to the Marine invertebrates occurring on Tropical Pacific Coral Reefs, Seagrass Beds and Mangroves. Coral Reef Press.
- Courtney, CA, Atchue JA, Carreon, M, White, AT, Pestano-Smith, R, Deguit,E, Sievert, R, Navarro, R, (Ed.) (1999). In *Coastal Resource Management Programme for Food Security*, Cebu City, Philippines. 27 pages.
- Doyle, J. (2002). Laminar coral abundance and morphology with changes in depth, light and sedimentation rates. *MSc thesis. University of Wales Bangor*.
- English, S., C.R. Wilkinson and V. Baker (1997). Survey manual for tropical marine resources. *Australian Institute of Marine Science*. 2nd edition.
- Faith, D.P., Minchin, P.R., and L. Belbin (1987). Compositional dissimilarity as a robust measure of ecological distance. *Vegetation* **69**: 57-68.
- Harborne, A.R., Gill, A. Raines, P. and Ridley, J. (1996). Danjungan Island Marine Reserve. *Coral Cay Conservation report, London, UK* 26 pp.
- Hay, M.E. (1996). Marine chemical ecology: what is known and what is next? *J. Exp. Mar. Biol. Ecol.* **200**, 103-134.
- Hoegh-Guldberg, O. (1999). Climate change, coral bleaching and the future of the world's coral reefs. *Marine and freshwater research*, **50 (8)** pp.839-866
- Hodgson, G. (1997). Resource use: Conflicts and management solutions. In *Life and death of coral reefs*. Birkeland C. (Ed.), Chapman and Hall, London, chapter 17, pp386-409.

- Goreau, T.F. and Wells J.W. (1967). The shallow water Scleractinia of Jamaica: revised list of species and their vertical distribution range. *Bull. Mar. Sci.* **17**: 442-453.
- Jacinto G.L., Alino P.M., Villanoy C.L., Talaue-McManus L. and E.D. Gomez (2000). The Philippines. In *Seas of the Millennium: An environmental evaluation*. C. Sheppard (Ed.), Elsevier Science, chapter 79, 405-423.
- Koch, S.L. (1993). *A survey of the marine resources of Southern Leyte*. R.A.N.A Consultancy Inc.
- Lang, J.C., Hartman, W.D., Land, L.S. (1975). Sclerosponges: primary framework constructors on the Jamaican deep fore-reef. *J. mar. Res.* **33**: 223-231.
- Leiske, E. and Myers, R. (2001). *Coral Reef Fishes: Indo-Pacific and Caribbean*. HarperCollins Publishers, London. 2nd Edition. 400 pp.
- Lourey, M.J., Ryan, D.A.J., Miller, I.R., (2000). Rates of decline and recovery of coral cover on reefs impacted by, recovering from and unaffected by crown-of-thorns starfish, *Acanthaster planci*: a regional perspective of the Great Barrier Reef. *Mar. Ecol. Prog. Ser.* **196**, pp. 179-186.
- Moran, P.J., (1986). The *Acanthaster* Phenomenon. *Oceanographic Marine Biology Annual Review* **24**, pp. 379-480.
- McCook, L.J. (1999.) Macroalgae, nutrients and phase shifts on coral reefs: Scientific issues and management consequences for the Great Barrier Reef. *Coral Reefs* **18**: 357-367.
- Mumby, P.J., A.R. Harborne, P.S. Raines and J.M. Ridley (1995). A critical assessment of data derived from Coral Cay Conservation volunteers. *Bulletin of Marine Science* **56**: 737-751.
- Mumby, P.J. and A.R. Harborne. (1999). Development of a systematic classification scheme of marine habitats to facilitate regional management and mapping of Caribbean coral reefs. *Biological Conservation* **8**: 155-163.
- Roberts, C.M. (2000). Selecting Marine Reserve locations: Optimality versus Optimism. *Bulletin of Marine Science* **66**(3): 581-592.
- Roberts, C.M. and J.P. Hawkins (2000). *Fully- protected Marine Reserves: a guide*. WWF Endangered Seas Campaign, 1250 24th Street, NW, Washington, DC 20037, USA and Environmental Department, University of York, York, YO10 5DD, UK. 131 pp.
- Russ, G.R. and A.C. Alcala (1996). Do marine reserves export adult fish biomass? Evidence from Apo Island, central Philippines. *Mar. Ecol. Prog. Series* **132**: 1-9

Sale, P.F., (1991). Reef fish communities; open nonequilibrium systems. In Sale, P.f. (ed.) the ecology of fishes on coral reefs. Academic Press. New York, p. 564-598.

Seymour, R.M., Bradbury, R.H., 1999. Lengthening Reef Recovery times from crown-of-thorns outbreaks signal systematic degradation of the Great Barrier Reef. *Mar. Ecol. Prog. Ser.* **176** pp. 1-10.

Sheppard (1982). Coral Populations on Reef Slopes and Their Major Controls. *Mar. Ecol. Prog. Ser.* **7**: 83-115.

Solandt, J-L. Berger, M. T.D. Dacles (2000). Coral Reef Bleaching at Danjungan Island, Negros Occidental, Philippines: A two year monitoring programme. Coral Cay Conservation report, London, UK 20 pp.

Spalding, M.D., Ravilious, C. and E.P. Green (2001). *World Atlas of coral reefs*. Prepared at the UNEP World Conservation Monitoring Centre. University of California Press, Berkeley, USA.

Wesseling I., Uychiaoco, A.J., Alino, P.M., Aurin, T., Vermaat, J.E., (1999). Recovery of corals after sediment burial. *Mar. Ecol. Prog. Ser.* **176**; 11-15.

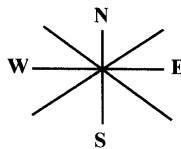
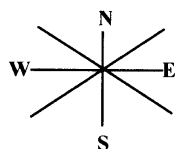
APPENDIX A

Recording form used for data collected during rapid reef assessment

Rapid Reef Assessment Form		
Survey Sector: _____ Reef Name: _____ No.: _____ Date: _____ (if applicable)		
Divers names: 1) _____ 2) _____		
Location		Location of RRA within survey sector (map):
GPS Position: Lat: N _____ Long: E _____ Source: _____		
Physical description (include dimensions and substrate type and main habitats)		
Profile/ cross section:		Aerial view:
Topography:		
Habitat description (describe main habitats, located on reef slope, reef flat and others as they are encountered, use additional sheet if necessary)		
1) _____	2) _____	3) _____
Substratum (describe the substratum, i.e. bedrock, dead coral, sand, mud, rubble, and quantify using semi - quantitative scale 0 -5 in the main habitats)		
1) _____	2) _____	3) _____
Biological description (biological cover 0 - 5 on semi - quantitative scale)		
1) Soft coral ☐ Hard coral ☐ Algae ☐ Sponges ☐ Inverts ☐	2) Soft coral ☐ Hard coral ☐ Algae ☐ Sponges ☐ Inverts ☐	3) Soft coral ☐ Hard coral ☐ Algae ☐ Sponges ☐ Inverts ☐
Main hard corals in each habitat:		
1) _____	2) _____	3) _____
Main soft corals in each habitat:		
1) _____	2) _____	3) _____
Main invertebrates in each habitat (including sessile (e.g. tunicates) and motile (e.g. cowries):		
1) _____	2) _____	3) _____
Main algae in each habitat:		
1) _____	2) _____	3) _____
Main fish in each habitat:		
1) _____	2) _____	3) _____
Human and natural impacts (please tick)		
Sedimentation ☐ Coral damage ☐ Litter ☐ Sewage ☐	Fishing lines ☐ Fishing pots ☐ Dynamite fishing ☐ Anchoring ☐	Algal overgrowth ☐ Coral bleaching ☐ Crown of Thorns starfish ☐ (include No. counted)
Your impression of the site, outstanding observations		

APPENDIX B

Recording forms used for data collected during CCC standard baseline surveys.

BOAT FORM				
DATE: _____		COX: _____		
STUDY: _____		BM: _____		
TRANSECT: _____		BUOY: _____		
SUBZONE: _____				
COORDINATES		GPS Unit: _____		
START:		Datum: _____		
1.	Latitude(UTM)	Longitude(UTM)	Time	Est.error
2.				
3.				
END:				
1.	Latitude(UTM)	Longitude (UTM)	Time	Est.error
2.				
3.				
CURRENT STRENGTH none weak medium strong CURRENT DIRECTION (towards)  WIND STRENGTH (1-12) 1 5 2 6 3 7 4 8 WIND DIRECTION (from) 				
Temperature: _____ °C at depth of: _____ m		Surface temperature: _____ °C Secchi disc: _____ m		
Salinity: _____ at depth of: _____ m		Surface salinity: _____		
<u>SURFACE ACTIVITY</u>				
BOAT	No. OCCUPANTS	PROXIMITY (m)	ACTIVITY eg diving/fishing/pleasure/commercial	
1.	_____	_____	_____	
2.	_____	_____	_____	
3.	_____	_____	_____	
4.	_____	_____	_____	
<u>SURFACE IMPACTS</u>				
LITTER (please tick) ☐	SEWAGE ☐	DRIFTWOOD ☐	ALGAE ☐	NETS/POTS ☐
Other Impacts/Details.....				
OTHER COMMENTS:.....				

PHYSICAL RECORDING FORM

Study. _____ Transect No. _____ Zone Code. _____

Date: ____/____/____

Start Time: _____ End Time: _____

Recorder's Name: _____ Phys. _____

Depth Limits - Min: _____m

_____ Fish

- Max: _____m

_____ Corals

Underwater visibility _____m

_____ Algae/Inverts.

Repeat visit? _____ Y/N

TYPE OF SURVEY**ZONE (Tick all that apply)****IMPACTS**Spot dive
Transect
General
Mapping
Photography
Sounding
Other☐
☐
☐
☐
☐
☐
☐

Backreef

Reef crest

Spur & groove

*Low spur & groove**High spur & groove*

Forereef

Escarpment

☐
☐
☐
☐
☐
☐
☐

Patch reef

*Dense patch reef**Diffuse patch reef*

Lagoon floor

*Shallow lagoon**Deep lagoon*☐
☐
☐
☐
☐
☐
☐

Litter

Sewage

Coral damage

Lines / nets

Fish traps

Sedimentation

Coral disease

Bleaching

Dynamite

Other: _____

☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐**YOUR IMPRESSION OF THE SITE**

	AESTHETIC	BIOLOGICAL
Excellent		
Very good		
Good		
Average		
Poor		
Other comments:		

Navigation bearing: _____°

Depth buoy tied: _____m

Buoy colour/I.D.: _____

SITE DESCRIPTION (Describe general location of the site, topography and main habitats - coral, sand, etc.)

General Location _____

Topography _____

Main Habitats _____

SITE PROFILE/PLAN DRAWING (Note depths, distances and habitats)

SIDE VIEW: Orientation: _____ degrees

DEPTH (m)

Distance (m) / Depth (m)

AERIAL VIEW:

WIDTH (m)

Distance (m)

Line of Transect

BIOLOGICAL RECORDING FORM

Study: _____ Transect No: _____ Zone Code: _____

Habitat No: _____ of _____ Date: _____

Database Code: _____

Percentage of Dive: _____ % Start time: _____ End time: _____

	First:	Last:	No. dives/snorkels in Fji	Depth Limits:
Recorder's Name	_____	Phys	_____	Min: _____ m
	_____	Fish	_____	Max: _____ m
	_____	Coral	_____	Underwater Visibility: _____ m
	_____	Algae	_____	Cox: _____

GEOMORPHOLOGICAL CLASS - TICK ONE ONLY.**Remember that if the geomorphology changes you must start another habitat**

Backreef	☐	Shallow zone between the reef crest and lagoon or land. Usually hard substratum pavement
Reef crest	☐	Shallowest and often emergent part of the reef, separating forereef from backreef / lagoon
Spur and groove	☐	Spurs of hard corals / calcified green algae with sand / bedrock grooves.
<i>Low spur and groove</i>	☐	Spurs less than 5m high
<i>High spur and groove</i>	☐	Spurs greater than 5m high
Forereef	☐	Any area of reef with an incline of between 0 and 45°
Escarpment	☐	Any area of benthos whose angle of slope exceeds 45°
Patch reef	☐	Coral formations in the lagoon which are surrounded by either seagrass, sand or algae
<i>Dense patch reef</i>	☐	Areas of aggregated coral colonies (living or dead) which cover > 70% of the benthos
<i>Diffuse patch reef</i>	☐	Areas of dispersed coral colonies where < 30% of the benthos is covered by coral colonies
Lagoon floor	☐	The lagoon floor where the angle of the slope does not exceed 45°
<i>Shallow lagoon floor</i>	☐	Lagoon with a depth of > 12m
<i>Deep lagoon floor</i>	☐	Lagoon with a depth of < 12m

*Italics indicate a sub-class of a main class and if there is any uncertainty, the main class should be used.***SUBSTRATUM AND BIOLOGICAL COVER**

Rating from 0-5 (figures need not add up to 5 total)

Bedrock	☐	Any exposed area of hard, bare substratum without visible coralline structures
Dead Coral with Algae	☐	Any area of hard bare substratum with visible corallite structure covered in algae
Dead Corals	☐	Any area of hard bare substratum with visible corallite structure
Rubble	☐	Any area of oose bedrock or hard substratum
Sand	☐	Coarse sediment (diameter > 1mm). "Grainy" when disturbed
Mud	☐	Fine sediment (diameter < 1mm). "Milky" when disturbed
Hard corals	☐	
Soft corals	☐	
Sponges	☐	
Green algae	☐	Non-calcerous algae forming mats or turfs
Brown fleshy algae	☐	e.g. Lobophora, Padina, Sargassum, Turbinaria
Red/brown branching algae	☐	e.g. Dictyota, Galaxaura, Amphiroa, Jania
Green calcified algae	☐	e.g. Halimeda, Tydemania
Red coralline algae	☐	e.g. Cement, crustose coralline
Seagrass	☐	

Substratum types within the habitat: (e.g. sand / bedrock) _____

Other comments : _____

HARD CORAL		Target Life forms, genera and species			
Life Forms		Pocilloporidae		Merulinidae	
DEAD CORAL	148 ☐	<i>Pocillopora</i> :	Small 164 ☐	<i>Hydnophora</i> spp.	247 ☐
DEAD CORAL WITH ALGAE	149 ☐		Medium 165 ☐		
			Large 166 ☐	Miscellaneous	
ACROPORA:		<i>Seriatopora hystrix</i>	834 ☐	Brain: Small	202 ☐
BRANCHING	150 ☐	<i>Stylophora pistillata</i>	833 ☐	Medium	273 ☐
ENCrustING	151 ☐	Acroporidae		Large	253 ☐
SUBMASSIVE	152 ☐	Bottlebrush <i>Acropora</i>	163 ☐	Further Species	
DIGITATE	153 ☐	"Foliose" <i>Montipora</i> spp.	167 ☐		
TABULATE	154 ☐	<i>Montipora digitata</i>	808 ☐		
		Poritidae			
		Massive <i>Porites</i>	844 ☐		
NON-ACROPORA:		<i>Porites cylindrica</i>	845 ☐		
BRANCHING	155 ☐	<i>Porites nigrescens</i>	846 ☐		
ENCrustING	156 ☐	<i>Porites rus</i>	848 ☐		
FOLIOSE	157 ☐	<i>Goniopora / Alveopora</i>	893 ☐		
MASSIVE	158 ☐	Agariciidae			
SUB-MASSIVE	159 ☐	<i>Pavona clavus</i>	855 ☐		
MUSHROOM	160 ☐	<i>Pachyseris speciosa</i>	859 ☐		
		<i>Pachyseris rugosa</i>	858 ☐		
		Fungiidae			
OTHER:		<i>Ctenactis echinata</i>	208 ☐		
FIRE (<i>Millepora</i>)	161 ☐	<i>Herpolitha limax</i>	248 ☐		
BLUE (<i>Heliopora</i>)	162 ☐	<i>Polyphyllia talpina</i>	861 ☐		
ORGAN PIPE (<i>Tubipora</i>)	293 ☐	Upsidedown bowl	167 ☐		
TOTAL CORAL LIFE FORMS	☐	Oculinidae			
		<i>Galaxea</i>	236 ☐		
		Pectiniidae			
		<i>Pectinia lactuca</i>	865 ☐		
		<i>Mycedium elephantotus</i>	815 ☐		
		Mussidae			
		<i>Lobophyllia</i>	269 ☐		
		Faviidae			
		<i>Favia</i>	222 ☐		
		<i>Favites</i>	227 ☐		
		<i>Diploastrea heliopora</i>	215 ☐		
		<i>Echinopora</i> spp.	886 ☐		
		Caryophylliidae			
		<i>Euphyllia</i>	895 ☐		
		<i>Plerogyra</i>	874 ☐		
		Milleporidae			
		<i>Millepora platyphylla</i>	827 ☐		
		<i>Millepora intricata</i>	826 ☐		
		Dendrophylliidae			
		<i>Tubastrea micrantha</i>	877 ☐		
		<i>Turbinaria</i> spp.	888 ☐		
				TOTAL TARGET CORALS	☐
				N.B. ALL CORAL TARGET SPECIES MUST ALSO BE COUNTED IN THE APPROPRIATE LIFEFORM.	

Coral Cay Conservation – 2003

SPECIES ABUNDANCE		Rating	Abundance Scale (coral, substratum, algae)	Numbers (Fish/ Inverts)
N.B. ALL CORAL AND FISH TARGET SPECIES MUST ALSO BE COUNTED IN THE APPROPRIATE FAMILY OR LIFEFORM		0	None	0
		1	Rare	1-5
		2	Occasional	6-20
		3	Frequent	21-50
		4	Abundant	51-250
5	Dominant	250+		
MICRO-ALGAE Cyano-Bacteria: Blue-Green 1 ☐				
MACRO-ALGAE <u>Chlorophyta: Green</u> Green Filamentous 39 ☐ Chaetomorpha sp. 15 ☐ Marble (Valonia ventricosa) 36 ☐ Bornetella sp. 10 ☐ Neomeris sp. 29 ☐ Codium sp. 18 ☐ Caulerpa sp. 12 ☐ Halimeda sp. 24 ☐ Tydemania sp. 33 ☐ Further Green Algae: ☐ ☐ ☐ TOTAL GREEN ALGAE ☐ <u>Phaeophyta: Brown</u> Dictyota sp. (Flat-Branched) 44 ☐ Padina sp. (Fan Blade) 50 ☐ Lobophora sp. (Blade/Ruffle) 49 ☐ Hydroclathrus sp. 48 ☐ Turbinaria sp. (Pyramid) 55 ☐ Brown Filamentous 42 ☐ Sargassum sp. (Bladder) 53 ☐ Further Brown Algae: ☐ ☐ ☐ TOTAL BROWN ALGAE ☐ <u>Rhodophyta: Red</u> Encrusting coralline algae 70 ☐ Galaxaura sp. 73 ☐ Amphiroa sp. 63 ☐ Jania sp. 83 ☐ Red Filamentous 60 ☐ Sheet 80 ☐ Actinotrichia - spikeweed 61 ☐ Wiry branched (Gelidiella sp.) 74 ☐ Further Red Algae ☐ ☐ ☐ TOTAL RED ALGAE ☐				
MARINE PLANTS (Angiospermophyta) Sea Grass 102 ☐ Thalassia sp. 108 ☐ Halophila sp. 105 ☐ Other: ☐ Mangroves 114 ☐ TOTAL PLANTS (Not Including Algae) ☐ TARGET INVERTEBRATES <u>Porifera: Sponges</u> Tube 126 ☐ Barrel 146 ☐ Elephant Ear 128 ☐ Branching 143 ☐ Encrusting 130 ☐ Lumpy 145 ☐ Rope 144 ☐ Vase 125 ☐ <u>Octocorallia: Soft Coral Forms</u> Deadman's Fingers 275 ☐ Leather 277 ☐ Tree 278 ☐ Pulsing 295 ☐ Sea Fan 280 ☐ Sea Whip 281 ☐ Bamboo 283 ☐ Flower 294 ☐ Sea pen 338 ☐ <u>Other Cnidarians</u> Black Coral 303 ☐ Anemone (Sea and tube) 306 ☐ Zoanthid 315 ☐ Jellyfish (Medusa) 327 ☐ Hydroid 333 ☐ Corallimorph 320 ☐ <u>Annelid Worms</u> Segmented Worms 348 ☐ Feather Duster 349 ☐ Christmas Tree 350 ☐ <u>Flatworms</u> 341 ☐ <u>Arthropoda: Crustacea</u> Shrimps 361 ☐ Rock lobster (Panulirus spp.) 366 ☐ Crab 381 ☐				
<u>Mollusca:</u> Gastropods: Abalone 390 ☐ Murex sp. 394 ☐ Conch 398 ☐ Cowrie 402 ☐ Triton 406 ☐ Cone Shell 408 ☐ Drupella sp. 419 ☐ Limpet 445 ☐ Topshell 404 ☐ Nudibranch 448 ☐ Other 389 ☐ Bi-Valves: Oyster 426 ☐ Giant Clam 438 ☐ Other Clam 443 ☐ Other 425 ☐ Chiton 442 ☐ Cephalopods: Cuttlefish 469 ☐ Squid 470 ☐ Octopus 468 ☐				
<u>Echinodermata:</u> Sea Stars: Acanthaster planci (COT) 472 ☐ Linkia laevigata (Blue) 478 ☐ Nardoa sp. (Brown) 479 ☐ Culcita novaeguineae 474 ☐ Protoreaster nodosus 482 ☐ Choriaster granulatus 473 ☐ Other 471 ☐ Brittle Star 483 ☐ Feather Star 489 ☐ Basket Star 495 ☐ Sea Urchin: Short Spine 502 ☐ Long Spine 503 ☐ Sea Cucumber: Synaptid 515 ☐ Other 520 ☐ <u>Tunicate (Phylum Chordata)</u> 529 ☐ <u>Bryozoan (Phylum Bryozoa)</u> 526 ☐ FURTHER SPECIES: ☐ ☐ ☐ TOTAL INVERTEBRATES (including tunicates and bryozoans) ☐				

APPENDIX C

**Recording forms used for data collected during Reef Check surveys.
Note that these are modified from the standard forms available at
<http://www.ReefCheck.org/>**

Site name: _____**BASIC INFORMATION**

Country:	_____	State/Province:	_____	City/town:	_____
Date:	_____	Time:	_____	Start of survey:	_____
Latitude (deg. min. sec):	_____	Longitude (deg. min. sec):	_____	End of survey:	_____
Distance from shore (m):	_____	Distance from nearest river (km):	_____		
River mouth width:	<10 m _____	11-50 m _____	51-100 m _____	101-500 m _____	
Distance to nearest population center (km):	_____	Population size (x1000):	_____		
Weather:	sunny _____	cloudy _____	raining _____		
Visibility (m):	_____				
Why is this site selected:	It is the house reef we use for our _____		Is this best reef in the area?	Yes: _____	No: _____

IMPACTS:

Is this site:	Always sheltered: _____	Sometimes: _____	Exposed: _____
Major coral damaging storms	Yes: _____	No: _____	If yes, When was last storm: _____
Overall anthropogenic impact	None: _____	Low: _____	Med: _____ High: _____
Is siltation a problem	Never: _____	Occasionally: _____	Often: _____ Always: _____
Blast fishing	None: _____	Low: _____	Med: _____ High: _____
Poison fishing	None: _____	Low: _____	Med: _____ High: _____
Aquarium fishing	None: _____	Low: _____	Med: _____ High: _____
Harvest inverts for food	None: _____	Low: _____	Med: _____ High: _____
Harvest inverts for curio sales	None: _____	Low: _____	Med: _____ High: _____
Tourist diving/snorkeling:	None: _____	Low: _____	Med: _____ High: _____
Sewage pollution (outfall or boat)	None: _____	Low: _____	Med: _____ High: _____
Industrial pollution	None: _____	Low: _____	Med: _____ High: _____
Commercial fishing (fish caught to sell for food)	None: _____	Low: _____	Med: _____ High: _____
Live food fish trade	None: _____	Low: _____	Med: _____ High: _____
Artisinal/recreational (personal consumption)	None: _____	Low: _____	Med: _____ High: _____
How many yachts are typically present within 1km of this site	None: _____	Few (1-2): _____	Med (3-5): _____ Many (>5): _____

Other impacts: _____

PROTECTION:

Any protection (legal or other) at this site?	Yes: _____	No: _____	If yes, answer questions below	
Is protection enforced	Yes: _____	No: _____		
What is the level of poaching in protected area?	None: _____	Low: _____	Med: _____	High: _____
Check which activities below are banned:				
Spearfishing	_____			
Commercial fishing	_____			
Recreational fishing	_____			
Invertebrate or shell collecting	_____			
Anchoring	_____			
Diving	_____			
Other (please specify)	_____			

Other comments _____

TEAM INFORMATION

Submitted by	_____	Regional Coordinator:	_____
		Team Leader:	_____
		Team Members:	_____

Site name and code: _____ Date: _____

Depth: _____ Time: _____

Point Codes

ACB Acropora branching	SC Soft coral	RKC Recently killed coral	Code	Sps	Code	Sps	Code	Sps	Code	Sps
ACE Acropora encrusting	SP Sponge	RC Rock	PS	Psylliopsis small	PN	Porites nigrescens	G	Galaxea	Mill	Millepora intricata
ACS Acropora submassive	ZO Zoanthids	SI Silt/mud	PM	Psylliopsis medium	PR	Porites rus	PLA	Pectinia lucida	TM	Tubastrea micrantha
ACD Acropora digitate	AA Algal assemblage	RB Rubble	PL	Psylliopsis large	GA	Goniopora / Alveopora	ME	Medidium elephantidus	TR	Tubastrea eunomia
ACT Acropora tabulate	CA Coralline algae	SD Sand	SH	Seriatopora hystrix	PCL	Pavona clavus	L	Lobophyllia	BS	Brain small
CB Non-Acropora branching	HA Halimeda	OT Other	S	Syngnathia	PAS	Pachyseris speciosa	FVA	Favia	BM	Brain medium
CE Non-Acropora encrusting	MA Macroalgae	WA Water	MF	Montipora foliosa	PAR	Pachyseris rugosa	FVT	Favites	BL	Brain large
CF Non-Acropora foliose	TA Turf algae		MD	Montipora digitata	CEC	Ctenactis schistosa	DH	Diplastrea heliopora		
CM Non-Acropora massive			BA	Bottlebrush Acropora	HL	Herpolitha linearis	EU	Euphyllia		
CS Non-Acropora submassive			MP	Massive Porites	PT	Polyphyllia laipina	PLE	Plerogorgia		
CMR Non-Acropora mushroom			PC	Porites cylindrica	UB	Upside-down bowl	MIP	Millepora platyphylla		
CME Millepora										
CTU Tubipora										

"Sps" is for coral only - if non-coral, leave blank

(For first segment, if start point is 0 m, last point is 19.5 m)

SEGMENT 1				SEGMENT 2				SEGMENT 3				SEGMENT 4			
0 - 19.5 m				25 - 44.5 m				50 - 69.5 m				75 - 94.5 m			
Form	Sps	Form	Sps	Form	Sps	Form	Sps	Form	Sps	Form	Sps	Form	Sps	Form	Sps
1	21		41		61		81		101		121		141		
2	22		42		62		82		102		122		142		
3	23		43		63		83		103		123		143		
4	24		44		64		84		104		124		144		
5	25		45		65		85		105		125		145		
6	26		46		66		86		106		126		146		
7	27		47		67		87		107		127		147		
8	28		48		68		88		108		128		148		
9	29		49		69		89		109		129		149		
10	30		50		70		90		110		130		150		
11	31		51		71		91		111		131		151		
12	32		52		72		92		112		132		152		
13	33		53		73		93		113		133		153		
14	34		54		74		94		114		134		154		
15	35		55		75		95		115		135		155		
16	36		56		76		96		116		136		156		
17	37		57		77		97		117		137		157		
18	38		58		78		98		118		138		158		
19	39		59		79		99		119		139		159		
20	40		60		80		100		120		140		160		

MAKE CORAL CATEGORIES BOLD IF THEY ARE RECRUITS (I.E. < 5 CM DIAMETER)

TOTAL NUMBER OF RECRUITS (ALL LIFE FORMS COMBINED)

MAKE CORAL CATEGORIES ITALICS IF THEY ARE BLEACHED

TOTAL NUMBER OF BLEACHED CORALS (ALL LIFE FORMS COMBINED)

REEF CHECK 2001 - Please fill in all Black outlined boxes

Site Name:

Depth:

Date: Time:

Indo-Pacific Belt Transect : Fish

Data recorded by:

	0-20m	25-45m	50-70m	75-100m
Butterfly fish (ALL SPS)				
Sweetlips (Haemulidae) (ALL SPS)				
Snapper (Lutjanidae) (ALL SPS)				
Two-spot				
Checkered				
Black-and-white				
"Bluelined"				
Paddletail				
Barramundi Cod (<i>Cromileptes</i>)				
Grouper >30cm (Give sizes in comments) (ALL SPS)				
Flagtail				
Peacock				
"Honeycomb"				
Lyretail				
Humphead wrasse				
Bumphead parrot				
Other Parrotfish (>20cm)				
Tuna / Mackerel				
Fusslers				
Surgeonfish				
Rabbitfish				
Barracuda				
Jacks / Trevally				
Moray eel				

Indo-Pacific Belt Transect : Invertebrates

Data recorded by:

	0-20m	25-45m	50-70m	75-100m
Banded coral shrimp (<i>Stenopus hispidus</i>)				
<i>Diadema</i> urchins				
Pencil urchin (<i>Heterocentrotus mammillatus</i>)				
Sea cucumber (edible only)				
Crown-of-thorns star (<i>Acanthaster</i>)				
Giant clam (<i>Tridacna</i>)				
Triton shell (<i>Charonia tritonis</i>)				
<i>Drupella</i> sp				
Squid				
Octopus				
Lobster				

For each segment, rate the following as: None=0, Low=1, Medium=2, High=3

Coral damage : Anchor				
Coral damage: Dynamite				
Coral damage : Other				
Trash : Fish nets				
Trash : Other				

Comments:

Grouper sizes (cm)				
Bleaching (% of coral population)				
Bleach (% of colony)				
Suspected disease (type/%):				
Rare animals sighted (type/#):				
Other:				

"ALL SPS" means that all individuals from that family should be counted in the box and additional target species are counted a second time on subsequent line e.g. a paddletail snapper is counted both as a snapper AND as a paddletail snapper

APPENDIX D:

Identification Codes used for benthic substrata and hard coral species identification purposes

Descriptions of the codes used for substrate identification purposes. Codes have been modified from English *et al.*, (1998).

Code	Substrate	Code	Substrate
ACB	<i>Acropora</i> branching	SC	Soft coral
ACE	<i>Acropora</i> encrusting	SP	Sponge
ACS	<i>Acropora</i> submassive	ZO	Zoanthids
ACD	<i>Acropora</i> digitate	AA	Algal assemblage
ACT	<i>Acropora</i> tabulate	CA	Coralline algae
CB	Non- <i>Acropora</i> branching	HA	<i>Halimeda</i>
CE	Non- <i>Acropora</i> encrusting	MA	Macroalgae
CF	Non- <i>Acropora</i> foliose	TA	Turf algae
CM	Non- <i>Acropora</i> massive		
CS	Non- <i>Acropora</i> submassive		
CMR	Non- <i>Acropora</i> mushroom	RKC	Recently killed coral
CHL	<i>Heliopora</i>	RC	Rock
CME	<i>Millepora</i>	SI	Silt/mud
CTU	<i>Tubipora</i>	RB	Rubble
ACB	<i>Acropora</i> branching	SD	Sand
ACE	<i>Acropora</i> encrusting	OT	Other
ACS	<i>Acropora</i> submassive	WA	Water

Descriptions of the codes used for hard coral species identification purposes.

Code	Hard coral species	Code	Hard coral species
PS	<i>Pocillopora</i> 'small'	UB	'Upsidedown bowl'
PM	<i>Pocillopora</i> medium'	G	<i>Galaxea</i> spp.
PL	<i>Pocillopora</i> large'	PLA	<i>Pectinia lactuca</i>
SH	<i>Seriatopora hystrix</i>	ME	<i>Mycedium elephantotus</i>
S	<i>Stylophora</i> spp.	L	<i>Lobophyllia</i> spp.
MF	<i>Montipora foliosa</i>	FVA	<i>Favia</i> spp.
MD	<i>Montipora digitata</i>	FVT	<i>Favites</i> spp.
BA	'Bottlebrush' <i>Acropora</i>	DH	<i>Diploastrea heliopora</i>
MP	'Massive' <i>Porites</i>	EU	<i>Euphyllia</i> spp.
PC	<i>Porites cylindrica</i>	PLE	<i>Plerogyra</i> spp.
PN	<i>Porites nigrescens</i>	MIP	<i>Millepora platyphylla</i>
GA	<i>Goniopora</i> / <i>Alveopora</i> spp.	MII	<i>Millepora intricata</i>
PCL	<i>Pavona clavus</i>	TM	<i>Tubastrea micrantha</i>
PAS	<i>Pachyseris speciosa</i>	TR	<i>Turbinaria reniformis</i>
PAR	<i>Pachyseris rugosa</i>	BS	Brain 'small'
CEC	<i>Ctenactis echinata</i>	BM	Brain 'medium'
HL	<i>Herpolitha limax</i>	BL	Brain 'large'
PT	<i>Polyphyllia talpina</i>		