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EXECUTIVE SUMMARY

Danjungan Island (Negros Occidental, Philippines) is known through anecdotal reports to be a site of high biodiversity. In recent years, partial deforestation for coconut production combined with increased fishing pressure and use of destructive fisheries practices have denuded Danjungan's littoral forest and fringing coral reef systems. This has been a major contributory factor leading to the impoverishment of local, coastal-dwelling communities.

In 1994 the Philippine Reef and Rainforest Project was launched to provide biodiversity conservation, restoration and education programmes for Danjungan Island and adjacent coastal areas under a tri-partite collaborative arrangement between the Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI), Coral Cay Conservation Ltd (CCC) and the World Land Trust (WLT).

Between August and November 1995 and May and July 1996 CCC and PRRCFI volunteers carried out 51 survey transects on the fringing reef around Danjungan Island and two nearby reef complexes to assess their physical and biological characteristics. The gross features of the physical environment, including the dominant winds and currents, were also recorded together with any obvious indications of anthropogenic disturbance. The volunteer training programme and survey techniques used were based on those developed by CCC for similar projects in Belize.

Three additional research projects were conducted during this phase of the project: identification of suitable areas as permanent monitoring sites; testing a technique for assessing coral health and testing a simple methodology developed by the International Centre for Living Aquatic Resources Management for surveys of coral reefs.

The survey work suggests that the fringing reefs of Danjungan Island are amongst the world's most diverse small reefs, with at least 236 scleractinians and hydrocorals and 229 fish species documented. Of the coral species recorded, 20 are regarded as being rare in the Philippines with possibly one species not previously recorded from the region. Numerous other interesting and unique features were recorded, including four colonies of the rare *Acropora monticulosa*.

Data acquired during this phase of the project were used to create an environmental database for future preparation of habitat maps of the project area. A range of univariate and multivariate techniques were used for data analysis and interpretation of the data. This data analysis, combined with anecdotal observations by CCC and PRRCFI scientists, provided a rationale in support of the establishment of management policies for the protection and sustainable use of Danjungan's coastal marine resources.

This report documents the results of baseline marine surveys undertaken by CCC and PRRCFI personnel at Danjungan Island in 1995 and 1996. It also provides recommendations in support of establishing a marine reserve around the island with a zoning scheme incorporating three Special Management Areas. These recommendations aim to provide a basis for a Danjungan Island Marine Reserve that will protect biodiversity, increase fish yields and provide alternative livelihoods to the local community.

ABBREVIATIONS

CCC	- Coral Cay Conservation Ltd
GCP	- Ground Control Point
GIS	- Geographic Information System
GPS	- Global Positioning System
ICLARM	- International Centre for Living Aquatic Resources Management
IUCN	- The World Conservation Union
PRIMER	- Plymouth Routines in Multivariate Ecological Research
PRRCFI	- Philippine Reef and Rainforest Conservation Foundation Inc.
PRRP	- Philippine Reef and Rainforest Project
SIMPER	- Similarity Percentage
SMA	- Special Management Area
WLT	- World Land Trust

ACKNOWLEDGEMENTS

CCC would like to thank Governor Rafael L. Coscolluela, Province of Negros Occidental, the staff, trustees and volunteers of the Philippine Reef and Rainforest Conservation Foundation Inc., particularly Gerardo L. Ledesma (President) and Pamela L. Coscolluela (General Manager), and the Coral Cay Conservation volunteers for their hard work, enthusiasm and dedication to the project. CCC would also like to give particular thanks to the World Land Trust for their collaboration and partnership and the community of Barangay Bulata.

CCC would also like to thank the following:

Addis Housewares
Avo International Ltd
Bridon Marine
British Airways Assisting Conservation
British Airways World Cargo
The British Council, Manila
The British Embassy, Manila
Celon University
Mayor Ricardo Chua
Mr and Mrs Geric Chua
Coleman UK Plc
Crestbury Ltd
English Braids Ltd
EP Barrus Ltd
Exide Battery Services
Mr Peter Feehan
Fiskers UK Ltd
Gunson Ltd
HarperCollins *Publishers*
The LandBank of the Philippines
Dr Lawrence Liao, De La Salle University
Dr D. Madulid, The National Museum of the Philippines
Dr John McManus, ICLARM
Mr Peter Mumby, University of Sheffield
Pains-Wessex Ltd
Philippine Airlines
The Philippines Embassy, London
P&O Containers
Ribtec Ltd
San Carlos University, Negros Occidental
Sea & Sea Ltd
Silliman University
Stanley Tools Ltd
Tate and Lyle Plc
TFH Publications
Trips Worldwide
UWI Circle Ltd
Uniross Batteries Ltd
WD40 Company Ltd
Dr Elizabeth Wood

FIGURES

- Figure 1.** Location of Danjugan Island within the Philippines.
- Figure 2.** Geographical features of Danjugan Island and the locations of CCC survey transects.
- Figure 3.** General profiles of the reefs around Danjugan Island.
- Figure 4.** Cluster analysis of the survey data.
- Figure 5.** The recommended boundaries for the Danjugan Island Marine Reserve and the Special Management Areas.

1. INTRODUCTION

1.1 Environmental status

The Philippines is the second largest archipelago in the world and is made up of over 7100 individual islands. The Philippines also forms one corner of a triangle which, along with Peninsular Malaysia and Papua New Guinea, is regarded as containing the most diverse coral reefs in the world (Norse, 1993).

Danjungan is a small island of approximately 43 hectares, measuring approximately 1.5km long with a maximum width of 0.5km. The island lies in the Sulu Sea adjacent to Negros Occidental (Barangay Bulata, Cauayan) in the Central Visayas region of the Philippines (Figure 1). It has a high relief topography with limestone hills approximately 60m in height covered in tropical forest and is surrounded by fringing coral reef, a combination of two of the most biodiverse ecosystems in the world. The total area of island and reef is approximately 200 hectares.

Danjungan has five lagoons, two of which are open to the sea and four of which have surrounding mangrove stands. The island has a broken shoreline with numerous inlets of coral rubble and coarse sandy beaches. One of the sandy beaches is a confirmed nesting site for green turtles (*Chelonia mydas*). There is no permanent freshwater on the island.

Danjungan is one of the few small islands in the Philippines with relatively unspoilt vegetation. This vegetation includes plants like *Pandanus* spp. (screw pines), *Veitchia merrillii* (previously only known to occur in Palawan) and the threatened *Pemphis acidula*. The sub-tropical rainforest is an important bird nesting and feeding site for at least 55 resident and migrant avifauna species. The small limestone caves throughout the island act as important refuges of at least six bat species.

The island is completely encircled by fringing coral reef descending to a depth of approximately 30m. Seagrass beds occur along the western and eastern margin of the island. Prior to this report very little was known concerning the physical and biological composition of the reef system surrounding Danjungan (PRRP, 1996).

1.2 Socio-economic status

Under previous ownership two families were living temporarily on the island. Currently the island is inhabited by a caretaker. A small amount of copra extraction is continuing from the island but this activity remains under review. The nearest coastal community is Barangay Bulata (population: 4,379 (1991)).

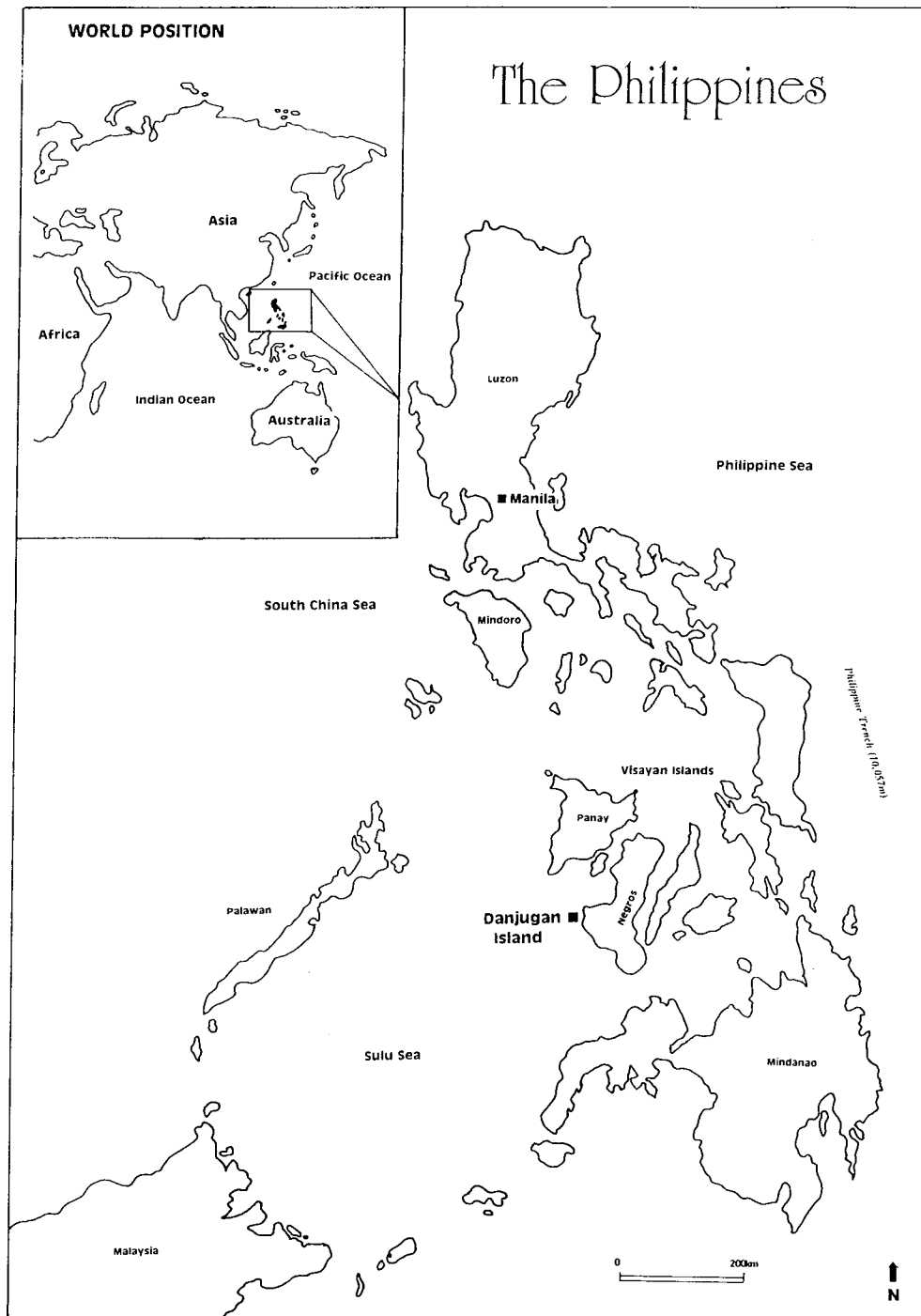


Figure 1. The location of Danjungan Island.

1.3 Environmental issues and concerns

In the mid seventies Danjungan's reefs were comparable to those of the remote islands in the central Sulu Sea. Several factors since this time have, however, lead to the decline of the reef and its marine fauna. In 1984 a nearby mining company temporarily halted operations, resulting in severe unemployment to the Bulata community. The availability of blasting caps from the mine resulted in the subsequent practice of blast fishing on the reef around Danjungan. The combination of destructive fishing and two typhoons in 1984 and 1991 has resulted in the present poor condition of a substantial portion of the reefs although anecdotal evidence indicates good recovery rates of denuded reef areas (Ledesma, pers. comm.).

Commercial fishing operations in municipal waters and other unsustainable fishing methods like illegal compressor ("hookah") fishing continue to threaten the remaining coastal marine resources of Danjungan. Practices such as the use of explosives or cyanide appear to have been discontinued around Danjungan. However, the encroachment of larger, mechanised fishing boats that lure fish out of community fishing grounds at night using strong lights and sophisticated electronic equipment pose a serious threat to the local fishery.

Poor water quality arising from increased siltation as a result of mainland deforestation and pollution from mining spillage and use of agrochemicals also pose serious threats to the reefs of Danjungan Island.

1.4 Project background and current status

The rights of ownership to Danjungan Island were first offered for sale in 1994. At that time, it was clear there would be a strong bid to acquire the island by developers who wished to develop a tourist resort. The unique habitat of the island and its waters had already been recognised and it was resolved by conservationists in the Philippines to make a bid for the island and to conserve it as a wildlife reserve. The Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI) was established to acquire and manage the island in partnership with Coral Cay Conservation Ltd (CCC) and the World Land Trust (WLT) (Section 1.5).

Environmental threats to Danjungan, together with a serious level of degradation to the coastline, were already reducing the potential for sustainable economic development for the local community. The upland forest and mangrove forests of Bulata were seriously degraded and pollution from the local mining operation was damaging marine habitats. The effects of prolonged overfishing with long-established destructive fishing techniques were creating conditions which would ultimately destroy the local coral reefs. The consequent economic hardship for the local fishing community was inevitable. The commitment to the conservation of the island and its purchase, together with the regional sustainable development required to maintain it, became the responsibility of the Philippine Reef and Rainforest Project which was formally launched in the UK in March 1994 and in Manilla in November 1994.

The President and some of the Trustees of the PRRCFI secured a bridging loan to cover the down payment and on the 1st September 1994 ownership rights to the island were transferred

from the original owners to nine appointed representatives of the PRRCFI. By the 9th February 1995 ten titles for the entire island were issued in favour of the nine representatives, who have in turn drawn a Memorandum of Agreement with the PRRCFI allowing the PRRCFI to use the island for the Philippine Reef and Rainforest Project until February 2000 when the ownership rights and titles are transferred to the PRRCFI.

The island was paid for in full on the 1st March 1995 through more bridging loans made by the President and some of the Trustees. The PRRCFI applied for a loan with the LandBank of the Philippines (Bacolod Branch), this time using the island as collateral. Another Memorandum of Understanding was drawn up between the LandBank of the Philippines, the PRRCFI and the WLT stipulating that, while the PRRCFI shall secure the loan, it is the WLT that shall undertake to raise funds on behalf of the PRRCFI to finance the project and pay off the loan. LandBank of the Philippines has given the PRRCFI/WLT until the end of September 1999 for a regular repayment of the loan.

The Philippine Reef and Rainforest Project, while it seeks to address the problems of reef and forest destruction, ultimately aims to address the increasing poverty of the fishing and farming folk via the provision of alternative livelihoods while simultaneously establishing environmental awareness programmes involving the active participation of the local communities. At the core of the conservation programme will be the establishment of an education, training and research facility near to Danjungan for the use of coastal communities, local schools, colleges and universities and also for visiting scientists and researchers.

1.5 Principal partnership organisations

Philippine Reef and Rainforest Conservation Foundation Inc.

Mission Statement: *To ensure the long-term conservation of the marine and terrestrial environment in the Philippines through education and poverty alleviation.*

The Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI) is a non-stock, non-profit corporation duly registered with the Securities and Exchange Commission in the Philippines. It was established to manage and operate the Philippine Reef and Rainforest Project. The primary objectives of the PRRCFI are to establish a marine and wildlife research and education centre near Danjungan Island, develop and implement education and alternative livelihood programmes for the conservation of marine and other wildlife resources and the restoration of natural resources of Negros Occidental and other regions of the Philippines.

Coral Cay Conservation Ltd

Mission Statement: *To provide resources for the protection and sustainable use of coastal environments.*

Coral Cay Conservation Ltd (CCC) is a UK-based, non-profit organisation, founded in 1986 to provide technical and financial assistance for the development of community-driven integrated management programmes for the protection and sustainable use of coastal marine and land resources. CCC is linked to the Coral Cay Conservation Trust, a UK-registered charity (No. 1025534).

CCC's principle areas of activity are the acquisition, assimilation and synthesis of data in support of coastal zone management and environmental monitoring, capacity strengthening and human resource development and provision of education, training and alternative livelihood opportunities for local communities. CCC is currently assisting projects in the Philippines, Indonesia and Belize.

World Land Trust

The World Land Trust (WLT; the operating name of the World Wide Land Conservation Trust) was founded in the UK in 1989 as a conservation organisation aiming *"to enhance the conservation of tropical rainforest by raising funds for land purchase by local conservation organisations and supporting subsequent project development."* WLT also provides technical support and funds for specific projects, international publicity, project education programmes in the UK as well as opportunities for cross-country linkages with representatives of international conservation bodies. WLT is a charity registered in England. WLT is currently supporting projects in the Philippines, Belize and Costa Rica.

1.6 Project objectives

This report provides the results of a programme of marine surveys undertaken by personnel from CCC and the PRRCFI between August and November 1995 and May and July 1996.

The primary objectives of this project were:

- (i) to modify and test the applicability of methodologies designed by CCC to characterise and map Caribbean marine resources for use in the Philippines;
- (ii) to characterise and map the marine resources of Danjungan Island;
- (iii) to identify suitable reefal and lagoonal sites for environmental monitoring;
- (iv) to test other techniques for assessing coral health and abundance.

The data gathered, along with anecdotal observations from CCC's field staff, were then to be used as the basis for draft recommendations for the development of a management plan for the Danjungan Island Marine Reserve.

2 SURVEY TECHNIQUES

2.1 CCC survey technique

The principle survey methodology used during the course of this project was based upon that developed and used by CCC in Belize for mapping biological and physical characteristics of Caribbean coastal marine environments using teams of volunteer SCUBA divers (CCC, 1995; Mumby *et al.*, 1995).

The survey technique developed by CCC for use in the Caribbean had to be modified to take into account the higher number of marine species associated with Indo-Pacific reefs compared with Caribbean reefs. Surveys of marine species around Danjungan were generally focused on a pre-selected number of species and standardized life forms (English *et al.* 1994). In addition, selection of hard corals was also based upon the most abundant and readily identifiable species and genera observed during the initial phase of the project in August 1995. Furthermore, selection of the fish species surveyed incorporated (a) the results of a baseline survey conducted by the PRRCFI during June 1995 to identify species of commercial or food value amongst local communities (Appendix 1) and (b) the most abundant and readily identifiable species and genera observed during the initial phase of the project (August 1995). Octocorals and sponges were identified in various life form categories. The octocoral life forms included "Leather" (mainly from the genera *Lobophyton* and *Sarcophyton*), "Deadman's fingers" (mainly from the genus *Sinularia*) and "Tree" (mainly from the genus *Dendronephthya*). All the species, genera and life forms recorded by CCC volunteers are listed on the example biological survey form, which are completed after each dive, shown in Appendix 2.

Prior to commencing the field work, each team of CCC/PRRCFI volunteers underwent a seven day training programme covering the following subjects:

- ▶ Biogeography of the Philippines; reef zonation; reef ecology; habitat classification
- ▶ Basic biology and identification of the organisms encountered; biologically and ecologically important species and their identification; endemism
- ▶ Local fishing methods; problems, threats and recognizing impacts on coral reefs
- ▶ Survey techniques; data recording and verification; compilation of species lists
- ▶ Estimation of sea state (Beaufort scale), cloud cover (oktas), and turbidity (secchi discs); water temperature measurements (thermometers); position fixing (GPS).

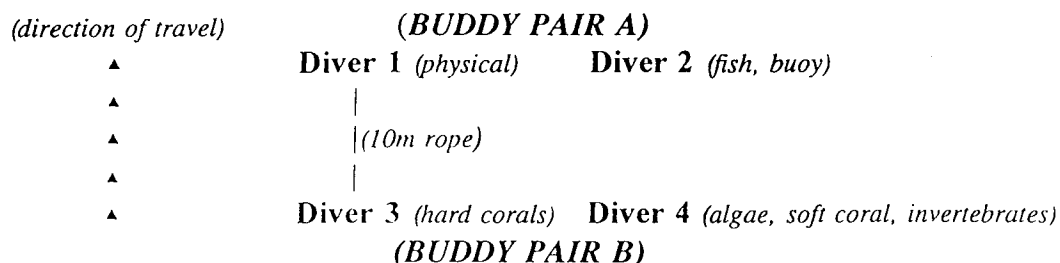
The structure of CCC training programme is detailed in Table 1. At the end of this training period each volunteer was tested to assess their identification and survey abilities prior to participating with the survey work.

The Danjungan Island Marine Reserve: CCC summary report

		AM	PM	EVENING
1	Lecture	-	Lecture 1. Introduction to CCC, training week and dangerous marine animals.	
	Practical	-	Familiarisation snorkel and buoyancy checks.	-
2	Lecture	Lecture 2. Introduction to coral biology and reefs. Identification of hard coral lifeforms.	Lecture 3. Identification of specific hard coral species.	Recap of day's information / coral slide show.
	Practical	Snorkel and dive to 12m.	6m dive.	-
3	Lecture	Lecture 4. Identification of hard coral species. Morphotypic variation.	Lecture 5. Review of coral identification.	Recap of day's information / coral slide show.
	Practical	18m dive.	15m dive.	-
4	Lecture	Lecture 6. Introduction to fish and how to identify them. Major fish families and species.	Lecture 7. Identification of remaining fish species.	Recap of days information / fish slide show.
	Practical	24m dive.	18m dive.	-
5	Lecture	Lecture 8. Invertebrate identification and soft coral growth forms.	Lecture 9. Identifying marine plants and algae.	Study of algal reference collection.
	Practical	24m dive.	18m dive / snorkelling for algal collection.	-
6	Lecture	Lecture 10. Overview of survey method and beach dry-run. Completion of boat forms.	Lecture 11. Physical and biological forms. Concept of ordinal scale and separate habitat types.	Coral test.
	Practical	18m dive practising survey technique.	15m practise survey and form completion.	-
7	Lecture	-	-	-
	Practical	24m general identification dive.	15m dive on coral trail.	-
8	Lecture	-	-	Fish test.
	Practical	General identification snorkel / snorkel trail.	General identification snorkel.	-

Table 1. The lecture schedule for the CCC training programme.

The surveys of Danjungan Island were conducted along a series of plot-less belt transects, from 30m to the reef crest, spaced approximately 100m apart around the island. Each survey team was comprised of four divers:



From the start point on each transect, *Buddy Pair B* remained stationary, with Diver 3 holding one end of a 10m length of rope, whilst *Buddy Pair A* swam away from them, navigating up the reef slope until the 10m line connecting Diver 1 and 3 became taut. Diver 1 recorded data on the depth and physical nature of the seabed and any signs of anthropogenic impacts and Diver 2 recorded data on the fish species encountered along the 10m distance travelled. *Buddy Pair A* then waited for *Buddy Pair B* to swim towards them, recoiling the 10m rope whilst surveying hard corals (Diver 3) and algae, soft corals and other invertebrate species (Diver 4). Diver 3 visually surveyed approximately 1m each side of the transect line while Divers 1, 2 and 4 surveyed 2.5m on either side.

This process was repeated until the end of the planned dive profile when a buoy carried by Diver 2 was tied to the reef. The buoy acted as the start point for the next team as surveys of the transects usually required multiple dives to complete. The position of each buoy was recorded using a global positioning system (GPS) to allow the transects to be plotted within a geographic information system (GIS).

Data from different habitat types, for example reef, sand beds and seagrass beds, encountered during the course of a survey were recorded separately and each species or life form recorded on each survey was assigned an abundance from the ordinal scale shown in Table 2.

ABUNDANCE RATING	CORALS AND ALGAE	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+

Table 2. Relative abundance scale assigned to life forms and target species.

All the data collected during each survey was transferred to specially designed recording forms (Appendices 2 and 3). A Window's driven GIS-compatible database with validation functions was specifically developed for the assimilation and synthesis of data gathered using the standard CCC survey technique.

2.2 Manta tow

Rapid assessments of reef zonation and determination of reef coverage were attempted using manta tow techniques (English *et al.*, 1994). This technique was, however, abandoned because of periodic high turbidity levels in the water column which reduced visibility.

2.3 Coral health survey

Towards the end of the 1995 survey programme a technique was devised and tested to try and assess the health of coral species. The technique required two divers with each assigning corals that were intersected by a weighted 20m transect line to five size classes (0-5cm; 6-20cm; 21-50cm; 51-100cm; 100+cm). The divers also estimated any apparent damage (0; <1/2; ≥1/2 damage of the whole colony).

A number of surveys were conducted in areas of healthy reef which supported large numbers of corals. Other surveys took place in areas of known coral damage.

2.4 ICLARM methodology

A coral reef surveying method for use by volunteer SCUBA divers to assess the benthic community structure of reefs is being developed by ICLARM (the Aquanaut program; McManus, pers. comm.) and was briefly tested by CCC. A 5m line, divided into ten 50cm marked segments, was placed randomly at two reef sites and their positions fixed. The most commonly occurring substratum type lying under each 50cm segment was assessed, using one of the following classifications: live hard coral; dead coral; soft coral; rock; rubble; sand or algae. The coral life form nearest to the midpoint of the segment was identified and the size and health (using the scale 0%, <1/3, <2/3, <100% or 100% damage) of the colony was estimated. Each 5m line took approximately 10 minutes to survey.

3 GENERAL RESULTS OF CCC SURVEY WORK

3.1 Summary of CCC survey work

A total of 39 full survey transects were completed on the fringing reefs around Danjungan Island, 8 on the Convention Reef complex and 4 on Andrea's Reef (Figure 2). These transects comprised a total of 119 dives and produced 130 biological forms incorporating over 5000 individual species and life form records.

Seven snorkel and SCUBA surveys were also undertaken by the Science Officer and experienced volunteers to identify the species present on specific shallow reef areas, the tidal flats and within the lagoon habitats (transects with a "L" prefix in Figure 2).

3.2 General habitat descriptions

3.2.1 Reefal

Fringing reef was found around the whole of Danjungan Island. Most of the areas possess a shallow horizontal zone, the reef front, with high abundances of hard and soft corals to a depth of approximately 3m. From this depth, the reef slope dropped off steeply to a near-horizontal sea bed at a depth of approximately 30m (Figure 3a and b). The reefs on the eastern side of Danjungan were typically narrower than those on the west (Figure 3a and b). An exception to the general profile was at Manta Island (Figure 2) where the bottom of the reef was at around 40m. Soft corals were much less common on the reef slopes and in the deeper waters compared to the reef flat. Seagrass beds were found near to the shoreline on the west and east sides of the island.

On the eastern reef the surveys recorded a shallow vertical wall, known as the "Mini Wall" which had a high abundance of coral growth. Another shallow wall, the "South West Wall", was found on the southern end of the island which extended over a relatively long distance (Figure 3c). North of this lay the "South West Shelf", a large plateau which extended out from the shore of Danjungan Island to a depth of 14m. On the eastern side of the island, the surveys described two parallel ridges, approximately 30m apart, named "Twin Ridge" and "Doug's Ridge", which ran eastwards from the island. These ridges undulated between approximately 10 and 20m in depth and were up to 20m wide. The location of all these features are shown on Figure 2.

Offshore to the east lay Convention Reef, a coral-rich area with three separate peaks and connecting ridges (Figure 2). Surveys also revealed a narrow, deep ridge offshore to the west of Danjungan Island. This was named "Andrea's Reef" (Figure 2). CCC also carried out a discrete survey of a small patch of dense and diverse corals in front of the base camp. This patch, covering approximately 12m² was known as "Gerry's Mini Reef" (Figure 2) and was found to support over 40 coral species including scleractinians, *Millepora* spp. and *Heliopora coerulea*.

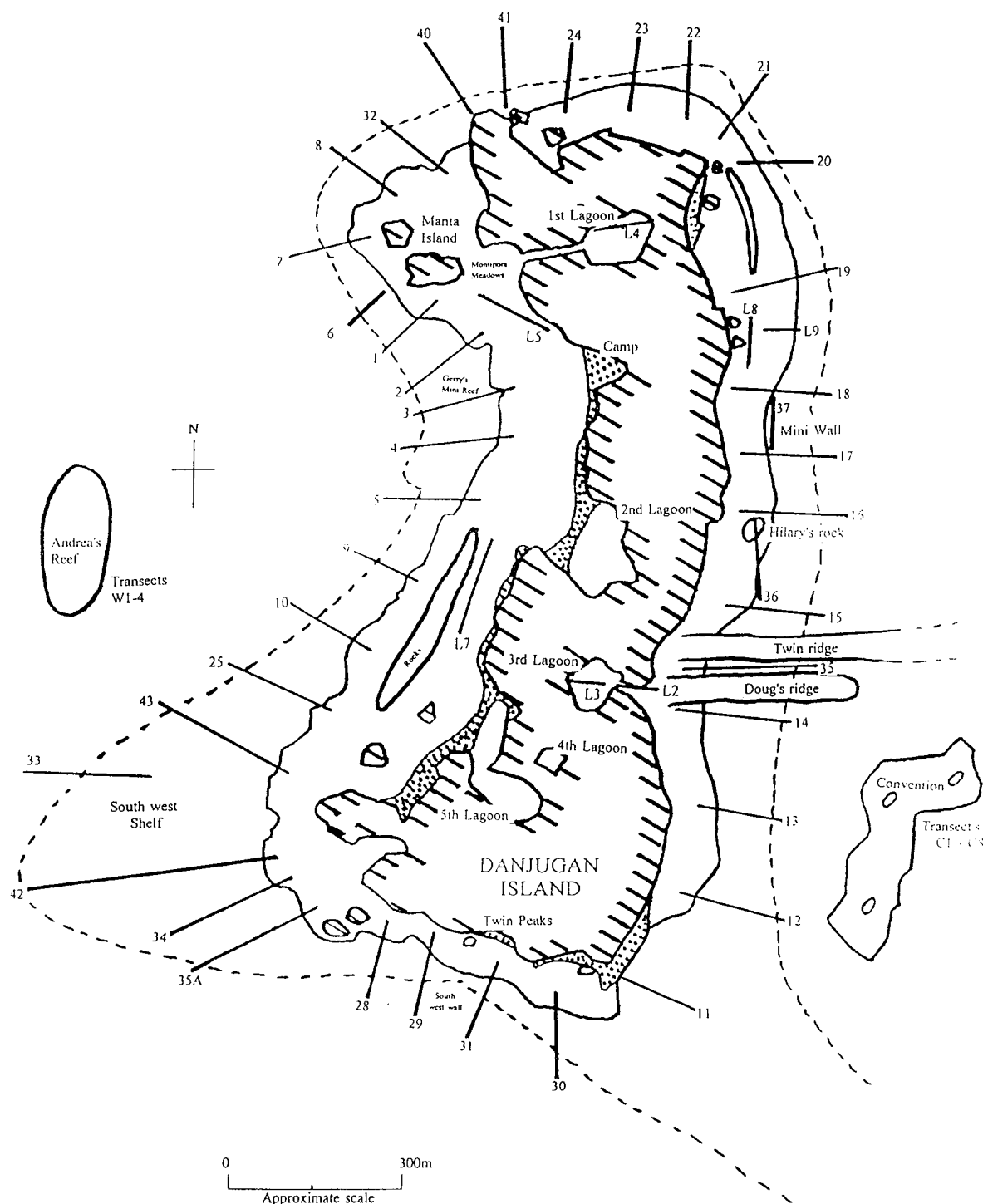


Figure 2. A schematic representation of Danjungan Island and its major geographical features. This figure also shows the position of the CCC survey transects around the island, Convention Reef and Andrea's Reef. Dotted line represents the approximate position of the bottom of the lower reef slope.

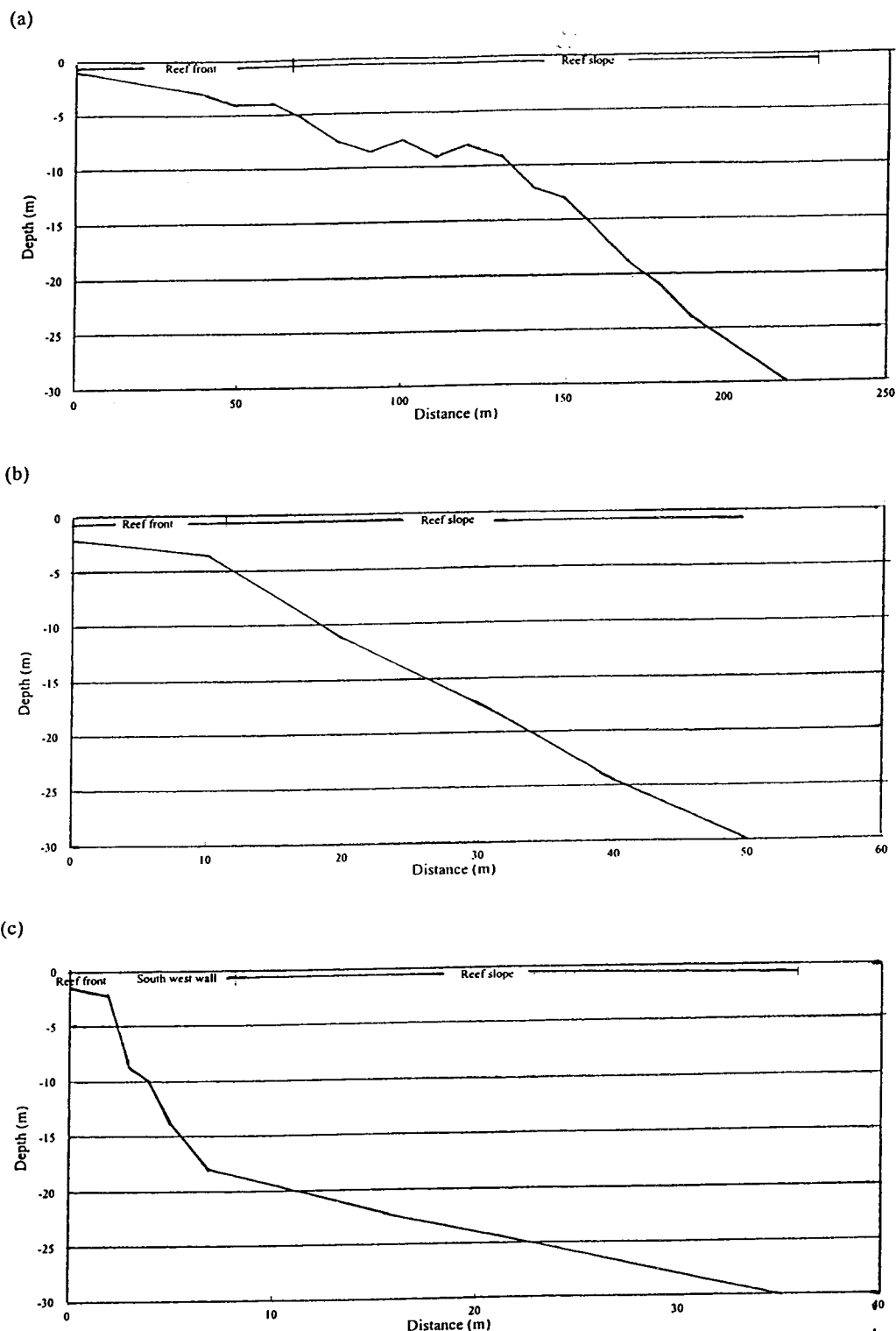


Figure 3. Reef profiles around Danjungan Island. Each profile represents a full CCC survey transect. Note the different lengths of each transect. (a) Transect 3, typical of western Danjungan. (b) Transect 17, typical of eastern Danjungan. (c) Transect 31 from the southern end of Danjungan, highlighting the south west wall. Locations of transects shown on Figure 2.

It was apparent that the reefs around Danjungan have been significantly affected by powerful typhoons in the past decade. The PRRCFI reported that prior to the typhoons there had existed many staghorn corals on the western reefs (in front of the base camp; Figure 2) and that in the shallow water there were large colonies of *Montipora digitata*, a fragile, fragmenting species. During this project, most of the corals in front of the camp were found to be sturdy, typhoon-resistant species which would have developed from sexually produced larvae, rather than through fragmentation (Fenner, pers. comm.). An exception was an area of *Montipora digitata* ("Montipora meadows") just north of the base camp which had survived because of the protection afforded by Manta Island (Figure 2).

3.1.2 Lagoonal

Danjungan Island has five internal lagoons of which three are closed from the sea and two are connected to the sea at high tide (1st and 3rd lagoons; Figure 2). None of these lagoons were subjected to rigorous survey during the course of this project.

The isolated lagoons had no coral species present, although several sponges and a species of tunicate were found in the 5th lagoon. The lagoons connecting to the sea at high tide had a soft substratum, the water was generally turbid and they were inhabited by both corals and fish. The majority of the coral species present grew along the shorelines of these lagoons.

First Lagoon

Outside the entrance to the first lagoon, to the northwest side of the island, there was a considerable growth of hard and soft coral in the shallow water. Seagrass beds were present in the shallow channel connecting the lagoon to the sea. The main lagoon contained turbid water (visibility approximately 2m) to a maximum depth of 3m. The main substratum of the lagoon was fine mud surrounded by rocky ledges supporting isolated corals and sponges and small populations of fish. The corals found within the first lagoon included *Trachyphyllia geoffroyi* which was not found at any other location around Danjungan.

Third Lagoon

The third lagoon opens to the sea on the east side of Danjungan Island. Around the rocky edge of this lagoon considerable growth of the corals *Favia* spp., *Favites* spp., *Pavona decusata* and *Psammocora* spp. was recorded. In the centre of the lagoon the substratum was composed of mud and the water was turbid, reducing visibility to approximately 2m. Large numbers of juvenile damselfish and wrasse were observed. This lagoon is affected by a water spring on the north side of the lagoon, connecting it with the second lagoon. The spring was found to release warm, salt water which caused the temperature of the surface layer of water to be cooler than that of the deeper water layer.

Fifth Lagoon

The fifth lagoon, located in the southern part of the island, was surrounded by mangroves and had a mud substratum. The northern section of the lagoon was very shallow descending to between 2 and 3m in the south. Rock around the sides of the lagoon supported approximately ten species of uncommon sponges and a limited number of fish species.

3.3 Physical parameters

Basic information on water movement, water clarity, water temperature and wind were collected by the volunteers during routine survey work.

The mean horizontal underwater visibility was 13.2m (standard deviation 4.6m). Currents were present on 49.6% of all the dives and were generally weak (74.6%) and were towards either the north or south (25.0% and 21.7% respectively). Guidebooks to the Philippines state that the prevailing winds are northeast monsoon from November to March and the southwest monsoon from June to November (for example Jackson, 1995). Since the CCC survey work was carried out between August and November and May to July the wind, when present, was, as expected, generally from between the south and west (69.8%) and was a 1 or 2 on the Beaufort Scale (88.8%).

3.4 Impacts

A total of 115 underwater and 40 surface impacts were recorded. The underwater impacts were dominated by general coral damage (50.4% of all impacts recorded) and the surface impacts were dominated by driftwood (65.9% of all impacts recorded). Much of the general coral damage is likely to be related to destructive fishing methods such as muro-ami and blast fishing.

A total of 117 boats were recorded during the survey work with a mean occupancy of 1.6 people (standard deviation 1.0), at an average distance of 271m (standard deviation 198m) from the survey transects. 95.7% of the boats were recorded fishing.

4 DETAILED DATA ANALYSES

4.1 Data analysis methods

The data collected were analysed with the aim of identifying discrete habitat types around Danjungan Island. Establishing the location of different habitats is important so that an example of each can be included within a sanctuary zone for maximising biodiversity protection. Identification of the habitat types utilized multivariate and univariate techniques.

Identifying the habitat types around Danjungan is also important for producing a baseline habitat map. However, since there is currently no easily accessible remotely sensed imagery of Danjungan the production of a geographically accurate base map of the area is not currently possible. However, CCC has collected a series of ground control points (GCP's) that will allow geo-rectification of remotely sensed imagery when it becomes available. The GCP's were collected using a differential GPS.

The benthic and substratum data were analysed via cluster analysis within PRIMER (Plymouth Routines in Multivariate Ecological Research) software from which a dendrogram grouping sites with similar biological and physical composition was produced. Sites that were grouped together were assumed to constitute a distinct habitat type. The analysis was based on the Bray-Curtis similarity coefficient without transformation of the data.

Similarity Percentages (SIMPER) analysis, within PRIMER, showed how characteristic each species, life form and substratum category was to each habitat type and also how important each was in distinguishing between habitats. Such information is useful for describing the diagnostic features of each habitat type. Univariate techniques utilised were the median abundance and frequency of occurrence of each species, life form and substratum category and the location of rare or commercially important species.

Univariate analysis of the fish data for each habitat gave the median abundance of the most abundant families. In addition, the positions of commercially important fish families recorded during the survey work were plotted. The data on commercially important fish were plotted out simply on a presence / absence basis because it is difficult to compare ratings on the ordinal scale because they were generated by differing survey efforts (each survey covers a different distance). These analyses of the fish data provide information to aid the rationale for the positions of the proposed no-fishing areas.

4.2 Results of data analysis

Cluster analysis of the benthic and substratum data gave three distinct clusters at a Bray-Curtis similarity of 0.48 (48%). These clusters related to specific geographic areas that represent three different habitat types with discrete species assemblages and substratum composition (Figure 4; Table 3).

CLUSTER	GEOGRAPHIC AREA	BOUNDARIES	NO. OF SURVEYS
1	Central eastern reef	13 and 15	9
2	Northern half; southern end	3 and 15; 11 and 43	41
3	Central western reef	1 - 42	19

Table 3. The three areas identified by cluster analysis of the benthos and substratum. Boundaries refers to the transects delineating the extent of each area (transects shown on Figure 3). Cluster number refers to Figure 4.

The SIMPER analysis carried out on the data for the three habitats is summarized in Table 4. Table 4 shows the five most characteristic species, life forms or substratum categories for each habitat along with the five species, life forms or substratum categories most diagnostic of the differences between each area. For each comparison, the five species, life forms or substratum categories are listed in descending order, with each column reflecting those most abundant in that habitat. Thus in the comparison between habitats 1 and 2 the most important species in distinguishing these two habitats because of a higher abundance in habitat 1 was the coral life form non-*Acropora* foliose. In contrast, rock was the most important difference between habitat 1 and 2 because of a higher coverage in habitat 2.

Habitat	1	2	3
1		Rock <i>Acropora</i> tabulate Leathery soft coral <i>Acropora</i> branching <i>Sinularia</i> spp.	Sand Rubble Rock <i>Acropora</i> branching <i>Sinularia</i> spp.
2	Non- <i>Acropora</i> foliose <i>Pachyseris speciosa</i> Non- <i>Acropora</i> mushroom Dead coral <i>Porites nigrescens</i>		<i>Favites</i> spp. <i>Lobophyllia</i> spp. Branching sponge <i>Stylophora pistillata</i> Brain: medium
3	Non- <i>Acropora</i> foliose <i>Pachyseris speciosa</i> Non- <i>Acropora</i> mushroom <i>Herpolitha limax</i> Non- <i>Acropora</i> branching	Non- <i>Acropora</i> branching Rock Tree Leathery soft coral <i>Sinularia</i> spp.	
	Non- <i>Acropora</i> foliose Non- <i>Acropora</i> mushroom Non- <i>Acropora</i> massive Non- <i>Acropora</i> encrusting Non- <i>Acropora</i> branching	Non- <i>Acropora</i> branching Non- <i>Acropora</i> encrusting Leathery soft coral <i>Acropora</i> tabulate Non- <i>Acropora</i> massive	Non- <i>Acropora</i> mushroom <i>Favites</i> spp. Sand Non- <i>Acropora</i> encrusting <i>Acropora</i> branching

Table 4. SIMPER analysis between the 3 habitats identified around Danjungan by cluster analysis (1- Central eastern reef; 2- Northern half and southern end; 3- Central western reef). The five most characteristic species, life forms or substratum categories responsible for the difference between the three habitats are shown in descending order. See text for further details of comparisons. The bottom row shows the five species, life forms or substratum most characteristic of each habitat.

The results of the SIMPER analysis and the supplementary univariate statistics of median abundance and frequency of occurrence of each species provided the characteristic benthos and substratum of each of the three habitats identified through the cluster analyses. The following habitat descriptions summarize these data and also include descriptions of Convention Reef and Andrea's Reef. It should be noted that, although the following descriptions refer to the main habitat types in certain specific areas, the reef around Danjungan is not homogeneous and other, smaller habitat types can be found within the area described.

Habitat 1: Central eastern reef.

This habitat, although found between transects 13 and 15, is restricted to the lower reef slope (mean depth 21.5m). It is characterised by a diverse assemblage of non-*Acropora* scleractinian life forms but is dominated by non-*Acropora* foliose corals (median abundance 4.0). Of the foliose corals recorded by CCC volunteers the most abundant was *Pachyseris speciosa* (median abundance 1.1). Also abundant were the mushroom corals (median abundance 2.3). The mushroom corals are mainly *Fungia* spp. but *Herpolitha limax* and *Ctenactis echinata* were also common (median abundances 1.1 and 0.8 respectively). The commonest non-*Acropora* branching corals (median abundance 1.4) recorded by CCC was *Porites nigrescens* (median abundance 0.8). Massive *Porites* corals were also common (median abundance 1.1) along with non-*Acropora* encrusting corals (median abundance 1.4). *Acropora* spp. were unusually uncommon, presumably because of the depth, with the most abundant life form being tabulate (median abundance 0.8).

The high coral cover reduced the amount of substratum visible, however, the commonest categories were dead coral (median abundance 0.9) and rock (median abundance 0.7). In addition to the scleractinians, the leathery soft corals were found with a median abundance of 1.0 and *Millepora* spp. had a median abundance of 0.6.

Habitat 2: Northern half and southern end.

This habitat type is found throughout the northern half and at the southern end, including the southwest wall, of the fringing reef around Danjungan. It is not restricted to a particular depth, with a mean depth of 11.4m (standard deviation 6.6m). The substratum was found to be composed mainly of rock (median abundance 2.0), sand (median abundance 1.7) and rubble (median abundance 1.0).

This habitat is known contain a diverse and abundant assemblage of scleractinians, particularly the southwest wall (Fenner, pers. comm.). This abundance is shown by six coral life forms having a median abundance of 2.0 or greater (maximum 2.5): non-*Acropora* branching; *Acropora* tabulate; non-*Acropora* encrusting; *Acropora* branching; non-*Acropora* massive and non-*Acropora* mushroom. The most common genera and species recorded by CCC volunteers were *Pocillopora*: medium (median abundance 1.8), *Porites* massive (median abundance 1.8) and *Galaxea* (median abundance 1.7). Octocorals were also abundant, with leathery soft corals (median abundance 2.4) one of the most characteristic categories in this habitat along with tree soft corals and *Sinularia* spp. (median abundances 1.8 and 1.6 respectively). *Millepora* spp. was also common with a median abundance of 1.5.

Habitat 3: Central western reef.

This habitat was found mainly along the western side of Danjungan from Manta Island to the southern end of the Fifth Lagoon. Habitat 3 is not restricted to a particular depth although the slight overlap with habitat 2 is caused by zonation across the profile of the reef. This habitat is not as biologically rich as other parts of the reef and this may be a result of typhoon damage in 1984 and 1991, which are known to have particularly struck the west side of the island (Ledesma, pers. comm.).

The substratum in this habitat was comprised mainly of sand (median abundance 1.7), rock (median abundance 1.2) and rubble (median abundance 1.0). The most abundant scleractinian life form was non-*Acropora* mushroom (median abundance 1.7). *Acropora* life forms were also common with the branching and tabulate categories having a median abundance of 1.3. The commonest coral genera were *Favites* (median abundance 1.3) and *Pocillopora*, *Galaxea* and *Lobophyllia* (median abundance 1.0). Leathery soft corals were also common (median abundance 1.3) along with encrusting sponges (median abundance 1.1).

Convention Reef.

Convention Reef is a relatively large reef to the east of Danjungan (Figure 2). It has three distinct peaks at its southern end, north eastern corner and north west corner. These peaks vary in depth, with the shallowest being the southern peak at approximately 5m. The rest of the top of Convention is relatively flat and surrounded by steep drop-offs starting at approximately 15m. The substratum is a mixture of sand (median abundance 1.5), rock (median abundance 1.0), dead coral and rubble (median abundances 0.9).

Convention Reef supports a diverse and dense coral community. This community is dominated by the *Acropora* branching and non-*Acropora* foliose life forms (median abundances 3.0 and 2.9 respectively). Although CCC volunteers do not record the abundance of individual *Acropora* species, they do survey the "Bottlebrush" growth form (which includes several very similar *Acropora* species). Bottlebrush *Acropora* was found to be very common (median abundance 2.8) and monospecific stands are found on areas of Convention. The most abundant foliose corals recorded by CCC were *Montipora foliosa* (median abundance 2.3) and *Pachyseris speciosa* (median abundance 1.6). Mushroom corals and the non-*Acropora* encrusting life form were also abundant (median abundances 2.6 and 2.1 respectively). Leathery soft corals were also common (median abundance 1.3).

Andrea's Reef.

Andrea's Reef is an isolated pinnacle of coral found slightly south of the base camp and west of the main fringing reef around Danjungan. Andrea's Reef is found in relatively deep water, with a minimum depth recorded on the surveys of 20m. The top of the reef is a flat plateau with steep walls surrounding it on all sides. The substratum is dominated by rock (median abundance 2.5) and dead coral (median abundance 0.8).

The scleractinians on Andrea's Reef are dominated by non-*Acropora* encrusting corals (median abundance 3.0). Non-*Acropora* foliose corals were also common (median abundance 1.5). The dominant species and genera recorded by CCC were *Favia* (median abundance 2.2),

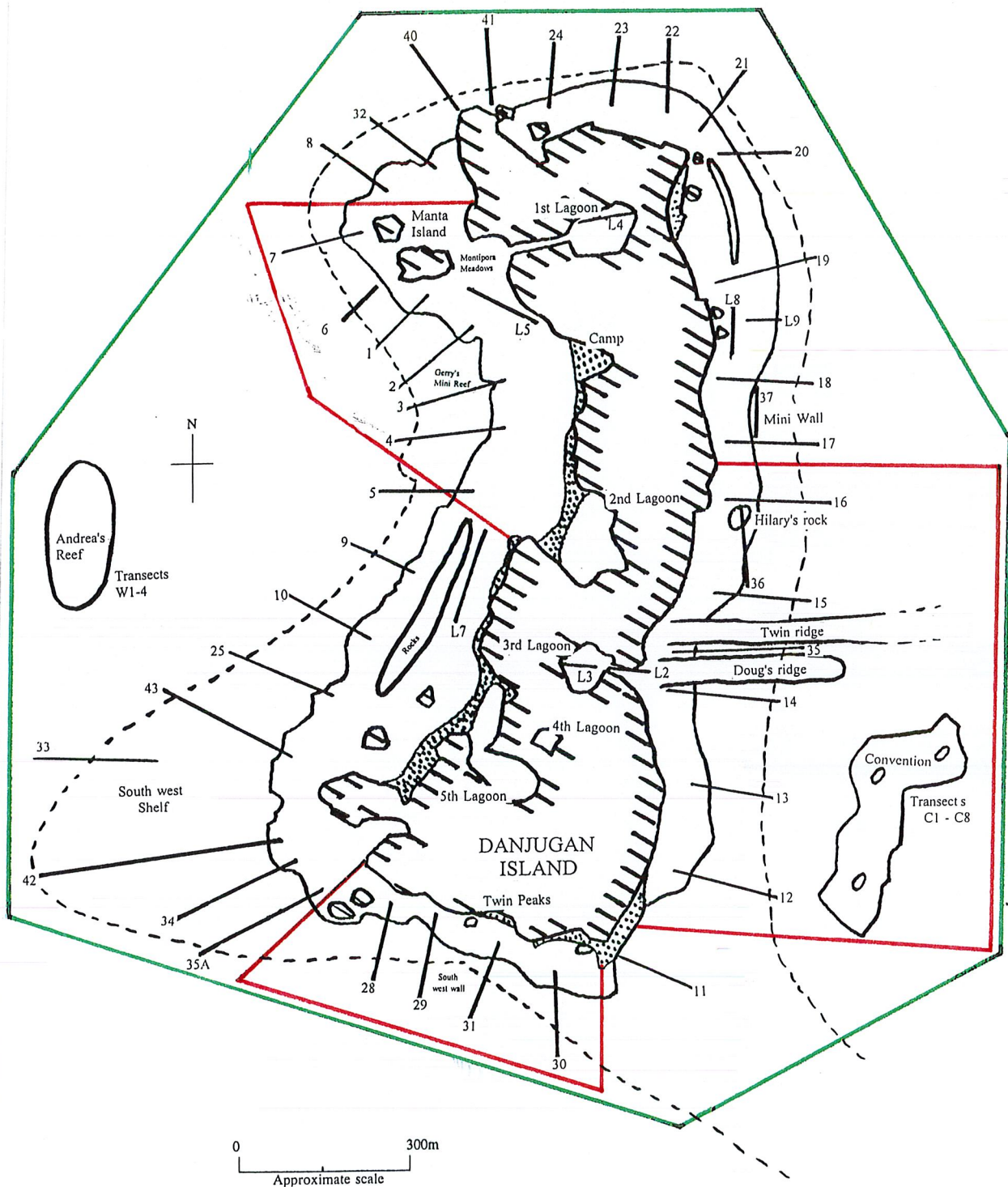


Figure 5. The recommended boundaries for the Danjungan Island Marine Reserve (green) and Special Management Areas (red).

It is recommended that the entire marine habitat from the high tide mark to a distance extending below the lowest extremes of the reef slope should be included within the reserve boundaries. Within the boundaries of the reserve all activities should be monitored and regulated by a community based management committee. The entire marine habitat within the reserve should be protected by a total ban on destructive or unsustainable fishing practices. A regulated fishery would be permitted within the boundaries of the reserve but excluded from within the SMA's. Anchoring within the reserve should be prohibited and, therefore, mooring buoys will be required throughout the reserve for use by fisherfolk, divers and other users. The boundaries to the reserve and the position of the SMA's should be designated by buoys with information notifying boat users of their significance.

The above designation and recommendations are based upon those successfully employed elsewhere within the Philippines (White, 1988).

6.2.2 *Special Management Areas*

SMA 1 (eastern side of Danjungan).

1. SMA 1 offers protection to habitat types 1 and 2 (Section 4.2). Protection of examples of all major habitat types in an area is an important consideration in coastal zone management (Kelleher and Kenchington, 1992).
2. The reefs within this SMA are topographically rich, thus providing a variety of ecological niches which maximises the biodiversity that is protected. For example, the two biologically and physically interesting and unusual underwater ridges, known as "Doug's Ridge" and "Twin Ridge", that extended eastwards from the shore of Danjungan Island are included within SMA 1.
3. This SMA contains Convention Reef which has possibly the greatest percentage coral cover of any area around Danjungan and supports large areas of apparently monospecific foliose and branching corals. Furthermore, the deep areas of fringing reef close to Convention have large monospecific stands of the foliose coral *Pachyseris foliosa*. Close examination showed a clonal structure in these species, with clonemates grouped together. Fragmentation was likely to be a major mode of natural reproduction in these species, producing the large stands (Fenner, pers. comm.).

Large areas of monospecific corals are important because of their aesthetic value and the variety of ecological niches offered to other organisms including fish and invertebrates. The abundance of foliose corals at depths greater than 25m, as in SMA 1, are an unusual feature in the Philippines (Fenner, pers. comm.).

4. This SMA also includes "Hilary's Rock" which was formed by a relatively rare coral (*Pavona clavus*). At the base of the formation, on the east side in 28m of water, were three large, dead colonies of this coral. Hilary's Rock is the only large colony of *Pavona clavus* around Danjungan and in addition supports a large number of other corals, fish and invertebrates.

5. This SMA would also protect the *Tubastrea micranthus* colony which may be one of the largest examples of this coral species in the world.
6. The large area of branching coral (including *Acropora* spp. and *Montipora digitata*) located south of the opening to the 3rd lagoon that is susceptible to damage by boat activity would be protected within SMA 1.
7. Habitat type 2, protected within this SMA, has a relatively high abundance of the commercially important wrasse (Labridae) with a median abundance of 1.1.
8. Convention Reef, included within SMA 1, has a relatively high abundance of the commercially important wrasse (Labridae) with a median abundance of 1.5.

SMA 2(southern end of Danjungan).

1. SMA 2 offers protection to habitat type 2 (Section 4.2). Protection of examples of all major habitat types in an area is an important consideration in coastal zone management (Kelleher and Kenchington, 1992).
2. SMA 2 incorporates the south west wall which supports a very high diversity of corals (Fenner, pers. comm.).
3. The south west wall was the only place where *Pavona xarifae* was recorded.
4. The southern end of Danjungan is also worthy of protection to aid the coral regeneration following past blast fishing. The southern end of the island was particularly badly affected but is recovering well (Ledesma, pers. comm.). Furthermore, the fish community in this area supported an unusually high number of large fish before the advent of spearfishing (Ledesma, pers. comm.). It is likely this community would recover given protection from fishing.
5. Habitat type 2, protected within this SMA, has a relatively high abundance of the commercially important wrasse (Labridae) with a median abundance of 1.1.

SMA 3 (north western side of Danjungan).

1. SMA 3 offers protection to habitat types 2 and 3 (Section 4.2). Protection of examples of all major habitat types in an area is an important consideration in coastal zone management (Kelleher and Kenchington, 1992).
2. SMA 3 also protects a representative part of the extensive seagrass habitat close to the western shore. This seagrass bed is also known to contain a high diversity of invertebrates and algae (Fenner and Liao, pers. comm.).
3. Small sharks have been spotted in this SMA, particularly over the seagrass bed, possibly indicating a nursery area.

4. SMA 3 also includes "Montipora Meadows", an unusual and extensive area of *Montipora digitata* in shallow water.
5. SMA 3 would protect the large colonies of the rare *Acropora monticulosa* (Section 6.1.4).
6. SMA 3 offers protection to possibly the best and most accessible snorkelling on Danjungan, directly opposite the base camp. Such a snorkelling area may be important for education purposes.

6.2.3 The effect of the SMA's on commercially important fish stocks

The SMA's have been located to efficiently protect the habitats and biodiversity of Danjungan. Furthermore, by excluding fishing from certain areas catches should increase in the areas open to fishing via the emigration and spawning of the increased stocks within the SMA's (Bohnsack, 1990).

Although fish are obviously mobile in nature it is important that the habitats included within the SMA's are suitable for commercially important fish families to live, grow and reproduce. The SMA's recommended in this report should be appropriate for the most important fish families around Danjungan (Lutjanidae, Haemulidae, Serranidae, Carangidae and Scaridae) because, firstly, representative samples of all the major habitat types discovered around Danjungan have been included within the SMA's. Secondly, some of the commercially important species are pelagic and thus can be protected within any no-fishing area.

Finally, the data recorded during the CCC survey work indicates that each of the five families seems to have an above average presence in one of the SMA's. These data are very qualitative and will be complimented by more quantitative information. However, it is possible to compare the percentage of surveys in each of the SMA's with the percentage of sightings of each family. Any occasion one of proposed areas contains a higher percentage of sightings than surveys indicates that it may be a suitable area for that family. The results of this analysis are shown in Table 7.

SMA	% OF SURVEYS	% OF SIGHTINGS				
		Lutjanidae	Haemulidae	Serranidae	Carangidae	Scaridae
1	37.3	41.2	23.1	34.5	14.3	35.6
2	8.7	0.0	15.4	10.3	0.0	2.2
3	11.9	5.9	7.7	6.9	28.6	17.8

Table 7. The percentage of surveys and sightings of five commercially important fish families within the three proposed Special Management Area's (SMA's). Bold type indicates occasions where the percentage of sightings is greater than the percentage of surveys. Total number of sightings: Lutjanidae 17, Haemulidae 13, Serranidae 29, Carangidae 7 and Scaridae 45.

Table 7 shows that SMA contains a higher than expected presence of Lutjanidae, SMA 2 a higher than expected presence of Haemulidae and Serranidae and SMA 3 a higher than expected presence of Scaridae.

6.2.4 Other potential SMA's

In addition to the areas outlined above, it is possible that some of the five lagoons found on the island may be worthy of special protection. A few species, such as the coral *Trachyphyllia geoffroy* and the cardinalfish *Sphaeramia nematoptera*, found in the lagoons were not found elsewhere and a few species remain unidentified.

6.2.5 Effect on local fisherfolk

As stated in Section 6.2.3, the SMA's have been located to increase catches for local fisherfolk. The SMA's have also been located to ensure that fishing can continue during both monsoon seasons. Thus fishing will continue to be possible in the north east and south west corners.

7. FUTURE WORK

CCC survey work will continue to be based at Danjungan throughout 1996 and 1997. This work will include a further series of projects to consolidate and add to the current database of information gathered from the reefs surrounding Danjungan Island. CCC will also expand the surveys to reefs in adjacent areas, including other islands and the coastline (PRRP, 1996).

Particular emphasis will initially be placed on the production of accurate geo-rectified base maps from aerial photographs and satellite imagery from which GIS-generated habitat maps will be produced.

Further survey work will include gathering quantitative data on the reefs around Danjungan. This will incorporate study of the benthic communities, numbers of commercially and ecologically important fish species and commercially and ecologically important invertebrates.

Monitoring programmes, including biological, physical and water quality parameters, at key locations throughout Danjungan's reefs and adjacent sites will be established. These will assess anthropogenic and natural influences on reefs in the region. Monitoring will also study the rejuvenation rates of reefs and associated fish stocks.

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APPENDIX 1

The list of fish species and genera targeted by the fisherman of Brgy. Bulata
and the techniques used to catch them

Latin Name	Common Name	Local Name	Method
	Scorpionfish	Bantol	Gillnet
	Snapper	Manlian-on	Spear
<i>Acanthurus blochii</i>	Ringtailed surgeon	Indangan	Gillnet / Spear
<i>Acanthurus dussumieri</i>	Eyestripe surgeon	Aliwakwak	Gillnet
<i>Acanthurus triostegus</i>	Convict surgeon	Kabalan	Gillnet
<i>Aluterus spp.</i>	Filefish	Sulay bagyo	Gillnet
<i>Amphiprion spp.</i>	Anemonefish	Palata	Gillnet
<i>Apogon spp.</i>	Cardinalfish	Paragan	Gillnet / hook
<i>Balistapus undulatus</i>	Orangestripped triggerfish	Pugot	Gillnet / hook
<i>Balistoides conspicillum</i>	Clown triggerfish	Pugot	Gillnet / hook
<i>Caesio cuning</i>	Deep bodied fusilier	Solid	Gillnet
<i>Caesio spp.</i>	Fusilier	Bilason	Gillnet
<i>Cantherhines spp.</i>	Leather jacket	Saguksuk	Gillnet
<i>Carangoides spp.</i>	Jacks	Lison	Spear, hook & line
<i>Carangoides spp.</i>	Trevalley	Ba-ulo	Gillnet
<i>Cheilinus undulatus</i>	Humphead wrasse	Mamena	Spear / Gillnet
<i>Chromis spp.</i>	Blue puller	Kapal	Gillnet
<i>Coryphaena hippunus</i>	Dolphin fish	Dorado	Gillnet, hook & line
<i>Diodon spp.</i>	Porcupine fish	Karatungan	Spear
<i>Epinephelus spp.</i>	Grouper	Inid	Hook / Spear
<i>Gymnothorax spp.</i>	Moral eel	Indong	Spear, hook & line
<i>Lutjanus argentimaculatus</i>	Mangrove jack	Mangagat	Gillnet
<i>Lutjanus sebae</i>	Emperor snapper	Kanlay	Spear
<i>Myripristis murdjan</i>	Red soldierfish	Ganting	Gillnet
<i>Naso tuberosus</i>	Humpnose unicornfish	Kumay-kumay	Gillnet
<i>Naso unicornis</i>	Blue spine unicornfish	Kumay	Gillnet / Spear
<i>Parupeneus spp.</i>	Goatfish	Hinok	Gillnet
<i>Platax spp.</i>	Batfish	Bayang	Spear
<i>Plectorhinchus spp.</i>	Sweetlip	Atalan	Spear
<i>Priacanthus spp.</i>	Bigeyes	Buca-buca	Hook
<i>Pterois spp.</i>	Lionfish	Nampurok	Gillnet
<i>Rhinecanthus escharpe</i>	Wedge picasso	Mangadlit	Gillnet
<i>Scarus spp.</i>	Parrotfish	Mol-mol	Gillnet / Spear
<i>Scolopsis spp.</i>	Spinecheek	Baupos	Gillnet
<i>Scomberomorus spp.</i>	Spanish mackerel	Tanguigue	Spear, hook & line
<i>Siganus spp.</i>	Rabbitfish	Samaral	Gillnet / Spear
<i>Sphyrnaena genie</i>	Barracuda	Bansa	Spear
<i>Strongylura spp.</i>	Reef needlefish	Balo	Gillnet
<i>Synanceia spp.</i>	Stonefish	Gatasan	Gillnet
<i>Thalassoma spp.</i>	Wrasse	Indoy-indoy	Gillnet
<i>Thunnus albacares</i>	Yellow fin tuna	Bantala-an	Hook & line
<i>Upeneus spp.</i>	Goatfish	Salmonate	Gillnet

APPENDIX 2

A sample biological form used by the teams to record the data collected during survey dives. The biological form lists all the species, genera and life forms identified during each dive.

BIOLOGICAL RECORDING FORM

Study:

Transect No:

Section:

Habitat No: _____ of: _____

Width of habitat: _____ m

Total distance of dive: _____ m

Database Code.

Date: ____ / ____ / ____

Start time: _____

End time: _____

No. dives/snorkels
in Indo-Pacific:Recorder's
name

Phys.

Fish

Coral

Algae / Inverts

/ Octocorals

Depth limits of habitat:

Min: _____ m Max: _____ m

Underwater visibility _____ m

Cox _____

BM _____

Zone**Substratum**

(0-5)*

Biological Cover

(0-5)*

- | | |
|--------------------------|---------------------------|
| ☐ | Lagoon |
| ☐ | Reef Flat (0-3m) |
| ☐ | Reef Front (3-10m) |
| ☐ | Upper Reef Slope (10-20m) |
| ☐ | Lower Reef Slope (20-30m) |

- | | |
|--------------------------|------------|
| ☐ | Dead coral |
| ☐ | Bedrock |
| ☐ | Sand |
| ☐ | Mud |
| ☐ | Rubble |

- | | |
|--------------------------|------------------|
| ☐ | Live Hard Corals |
| ☐ | Soft corals |
| ☐ | Sponges |
| ☐ | Invertebrates |
| ☐ | Algae |
| ☐ | Seagrass |
| ☐ | Mangrove |

*These figures need not add up to 5 total.

HABITAT DESCRIPTION

1. Substratum types within the Habitat: _____

2. Main animal groups in Habitat: Coral: _____

Fish: _____

Inverts: _____

3. Main Plant groups in Habitat: _____

4. Other comments: _____

Rating	Corals/Substratum/Algae	Fish/Inverts
0	None	0
1	Rare	1-5
2	Occasional	6-20
3	Frequent	21-50
4	Abundant	51-250
5	Dominant	250+

Gastropods:	- Abalone	390
	- <i>Murex</i> sp.	394
	- Conch	398
	- Cowrie	402
	- Triton	406
	- Cone shell	408
	- <i>Drupella</i> sp.	419
	- Limpet	445
	- Topshell	404
	- Other	389
Bi-valves:	- Oyster	426
	- Clam	438
	- Other	425
Chiton		442
Nudibranch		448
Cephalopods:	- Cuttlefish	469
	- Squid	470
	- Octopus	468

Bi-valves:

ECHINODERMS

Sea stars

- Crown of thorns	472
- <i>Linkia laevigata</i> (Blue)	478
- <i>Nardoa</i> sp. (Brown)	479
- <i>Culcita novaeguineae</i>	474
- <i>Protoreaster nodosus</i>	482
- <i>Choriaster granulatus</i>	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

TUNICATE	529
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BRYOZOAN	526
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Further species:

TOTAL INVERTEBRATES

TARGET FISH

Butterflyfish	540
(Big) Long-nosed	752
Klein's	651
Vagabond	541
Pyramid	750
Eastern triangle	783
Latticed	681
Redfin	760
Chevroned	677
Orange-banded coralfish	923
Humphead bannerfish	669
Pennant bannerfish	939
Angelfish	544
Regal	663
Bicolour	673
Pearlscale	545
Emperor	756
Blue-girdled	937
Vermiculated	938
Surgeonfish	546
Convict	547
"Ringtail" sp.	548
Brushtail tang	638
Thompson's	747
Mimic	700
Dusky	679
Eye-stripe	549
Unicorn sp.	550

Tunas / Mackerels

Narrow-banded king mackerel

Fusiliers

"Blue and yellow" sp.
Bluestreak

Damselfish

<i>Chromis</i> sp.
Black bar chromis
Blue devil
Threespot dascyllus
Humbug dascyllus
Reticulated dascyllus
Whitebelly damselfish
Staghorn damselfish
Black damselfish

Black-spot damselfish

Anemonefish sp.

Sergeant sp.

Wrasse

Diana's hogfish
Mesothorax hogfish
Humphead
Red-banded
Checkerboard

Twotone

Crescent

Sixbar

Jansen's

Bird

Cleaner

Parrot fish

Bumphead

Goatfish

Half-and-half

Two-barred

Dash-and-dot

Multibarred

Triggerfish

Redtooth

Orangestriped

Clown

Blackbelly picassofish

Pinktail

Scythe

Halfmoon

Grouper

Flagtail

Peacock

Humpback

"Honeycomb" sp.

Soapfish

Anthias sp.

940 ☐ **Rabbitfish**

558 ☐ **Foxface**

571 ☐

929 ☐ **Spinecheek**

930 ☐ **Twoline**

589 ☐ **Snapper**

590 ☐ **Two-spot**

646 ☐ **Checkered**

657 ☐ **Black-and-white**

671 ☐ **"Bluelined" sp.**

767 ☐

771 ☐ **Dartfish**

654 ☐ **Blackfin**

745 ☐

OTHER MAJOR FAMILIES:

758 ☐ **Jack/Trevally**

591 ☐ **Sweetlips**

656 ☐ **Barracuda**

598 ☐ **Moorish Idol**

931 ☐ **Emperor**

611 ☐

MISCELLANEOUS FAMILIES:

600 ☐ **Spadefish / Batfish**

932 ☐ **Cardinalfish**

725 ☐ **Squirrelfish / Soldierfish**

768 ☐ **Filefish**

647 ☐ **Lionfish**

744 ☐ **Scorpionfish / Stonefish**

678 ☐ **Lizardfish**

610 ☐

605 ☐ **Hawkfish**

613 ☐ **Sandperch**

933 ☐ **Dottyback**

615 ☐ **Porcupine / Puffer / Toby**

648 ☐ **Trunk / Box / Cowfish**

666 ☐ **Goby**

781 ☐ **Blenny**

934 ☐ **Sharksucker**

624 ☐ **Needlefish**

786 ☐ **Pipefish**

625 ☐ **Shrimpfish**

626 ☐ **Trumpetfish**

927 ☐ **Morayeel**

782 ☐

692 ☐

796 ☐

583 ☐

682 ☐

935 ☐

936 ☐

586 ☐

928 ☐

642 ☐

☐

TOTAL FISH

☐

579 ☐

757 ☐

☐

581 ☐

582 ☐

565 ☐

753 ☐

665 ☐

569 ☐

925 ☐

☐

774 ☐

695 ☐

☐

☐

553 ☐

577 ☐

560 ☐

551 ☐

924 ☐

☐

☐

595 ☐

621 ☐

619 ☐

629 ☐

631 ☐

632 ☐

643 ☐

902 ☐

675 ☐

900 ☐

634 ☐

640 ☐

749 ☐

926 ☐

787 ☐

562 ☐

911 ☐

790 ☐

664 ☐

637 ☐

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HARDCORAL

Life forms

Target life form, genera and species

Further species

DEAD CORAL

148 ☐ Pocillopora

Pocillopora: small

164 ☐

DEADCORAL WITH ALGAE

149 ☐ medium
large

165 ☐

166 ☐

ACROPORA:

Seriatopora hystrix

834 ☐

BRANCHING

150 ☐ *Stylophora pistillata*

833 ☐

ENCrustING

151 ☐ *Stylophora mordax*

803 ☐

SUBMASSIVE

152 ☐ Acroporidae

DIGITATE

153 ☐ *Montipora foliose*

836 ☐

TABULATE

154 ☐ *Montipora digitata*

808 ☐

Bottlebrush *Acropora*

163 ☐

Poritidae

Massive *Porites*

844 ☐

Porites cylindrica

845 ☐

Porites nigrescens

846 ☐

Goniopora / Alveopora

893 ☐

Agariciidae

Pavona clavus

855 ☐

Pachyseris speciosa

859 ☐

Pachyseris rugosa

858 ☐

Fungiidae

Ctenactis echinata

208 ☐

Herpolitha limax

248 ☐

Polyphyllia talpina

861 ☐

Upsidedown bowl

167 ☐

Oculinidae

Galaxea

236 ☐

Pectiniidae

Pectinia lactuca

865 ☐

Mycedium elephantotus

815 ☐

Mussidae

Lobophyllia

269 ☐

Faviidae

Favia

222 ☐

Favites

227 ☐

Diploastrea heliopora

215 ☐

Caryophylliidae

Euphyllia

895 ☐

Plerogyra

874 ☐

Milleporidae

Millepora platyphylla

827 ☐

Millepora intricata

826 ☐

Miscellaneous

Brain: small

202 ☐

medium

273 ☐

large

253 ☐

TOTAL TARGET CORALS

☐

APPENDIX 3

Examples of the boat and physical forms used by the teams to record the data collected during survey dives.

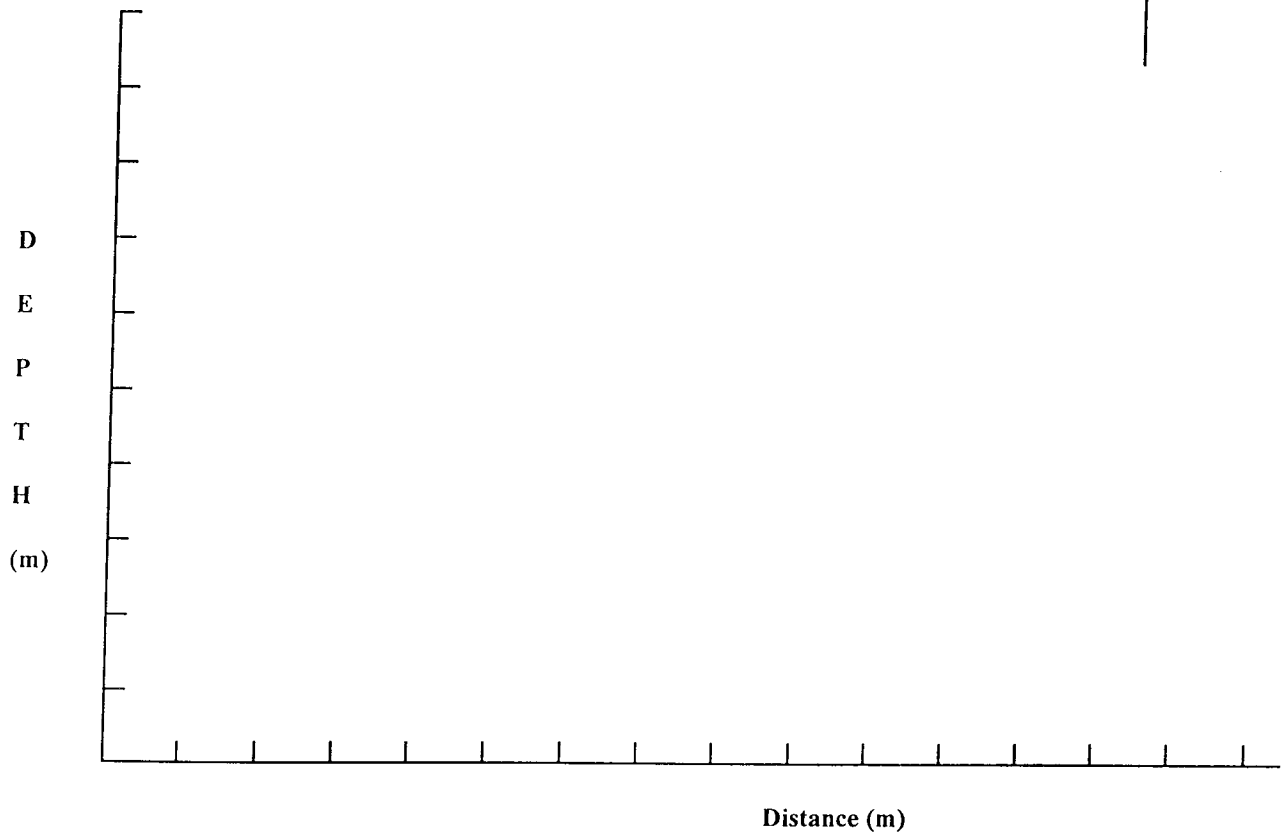
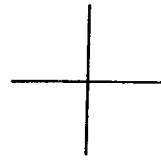
APPENDIX 4

A preliminary list of coral, fish, invertebrate, algae and seagrasses recorded during surveys of the fringing reef of Danjungan Island and surrounding reef complexes. The coral, fish and invertebrate lists were compiled by CCC science staff and experienced project personnel. Dr Lawrence Liao compiled the list of algae and seagrasses.

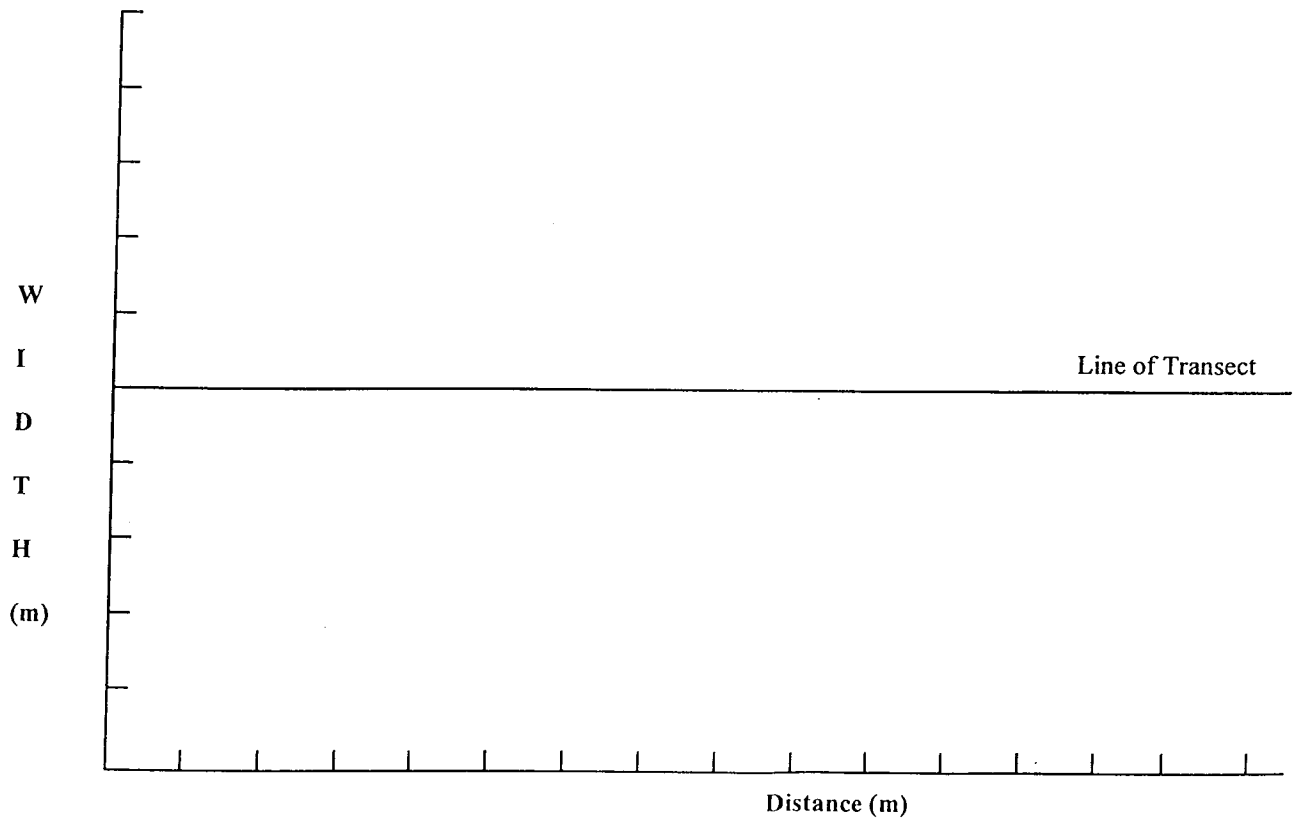
SITE PROFILE /PLAN DRAWING (Note depths, distances and habitats)

SIDE VIEW:

Orientation:



AERIAL VIEW:



PHYSICAL RECORDING FORM

Study.

Transect No.

Zone Code.

Date: ____ / ____ / ____

Start Time: ____ End Time: ____

Recorder's
Name: _____

Phys.

Depth Limits - Min: ____ m

Fish

- Max: ____ m

Coral/Sponge

Underwater visibility ____ m

Algae/Inverts.

Repeat visit? Y/N

TYPE OF SURVEY

Spot dive

Transect

Photography

Other

ZONE

Lagoon

Reef Flat

Reef Front

Upper Reef Slope

Lower Reef Slope

IMPACTS

Broken Coral

Litter

Fishing Traps

Lines/nets

Sedimentation

Dynamite

Algal overgrowth

Sewage

Other

YOUR IMPRESSION OF THE SITE

	AESTHETIC	BIOLOGICAL
Excellent		
V. 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 _____

BOAT RECORDING FORM

Date: _____
Site: _____
Transect No.: _____
Zone code: _____

Cox: _____
DM: _____
Buoy I.D.: _____

GPS COORDINATES

START

GPS unit: _____

	LATITUDE(N)	LONGITUDE(W)	TIME	SATS	HDOP	EST ERROR*
1.						
2.						
3.						

END

	LATITUDE(N)	LONGTITUDE(W)	TIME	SATS	HDOP	EST. ERROR*
1.						
2.						
3.						

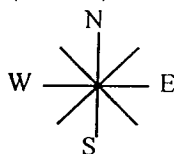
* If available

PHYSICAL PARAMETERS

Divers: CURRENT
STRENGTH

none
weak
medium
strong

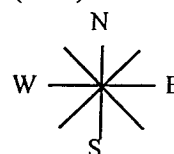
CURRENT
DIRECTION
(towards)



Boat: WIND
STRENGTH
(1-12)

1 5
2 6
3 7
4 8

WIND
DIRECTION
(from)



Temperature: _____ °C Depth: _____ m Secchi disc: _____ m Surface Temperature _____ °C

SURFACE ACTIVITY

No. Boats	No. Occupants	Distance away (m)	Activity
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

SURFACE IMPACTS (please tick)

Litter ☐ Sewage ☐ Driftwood ☐ Algae ☐ Nets/pots ☐

Other Impacts/Details: _____

CORAL SPECIES

Acanthastrea echinata
Acanthastrea rotundiflora
Acrhelia horrescens
Acropora accuminata
Acropora aculeus
Acropora anthocoris
Acropora aspera
Acropora brueggemanni
Acropora clathrata
Acropora cytherea
Acropora danai
Acropora donei
Acropora echinata
Acropora elseyi
Acropora florida
Acropora gemmifera
Acropora granulosa
Acropora humilis
Acropora hyacinthus
Acropora kirstyi
Acropora loripes
Acropora micropthalma
Acropora millepora
Acropora monticulosa
Acropora nana
Acropora palifera
Acropora parilis
Acropora robusta
Acropora samoensis
Acropora selago
Acropora sp. 1
Acropora valenciennesi
Acropora valida
Acropora vaughani
Acropora yongei
Anacropora forebesi
Anacropora puertogalerae
Anacropora sp. 1
Astreopora ocellata
Astreopora explanata
Astreopora gracilis
Australomussa rowleyensis
Blastomussa merleti
Caulastrea curvata
Caulastrea furcata
Caulastrea tumida
Coelosera mayeri
Coscinaraea columna
Ctenactis albertentaculata
Ctenactis crassa
Ctenactis echinata
Cycloseris tenuis
Cynarina lacrymalis
Cyphastrea agasszi
Cyphastrea decadia
Cyphastrea sp. massive
Dendrophyllia spl.
Diasera fragilis
Diploastrea heliophora
Distichopora violacea
Echinophyllia aspera
Echinophyllia echinata
Echinopora ashmorensis
Echinopora gemmacea
Echinopora lamellosa
Echinopora mammitormis
Echinopora pacificus
Euphyllia ancora
Euphyllia divisa
Euphyllia glabrescens
Favia matthai
Favia pallida
Favia rotundata
Favia speciosa
Favia sp. 1
Favia sp. 2
Favia stelligera
Favia veroni
Favites abdita
Favites chinensis

Favites flexuosa
Favites pentagona
Favites russelli
Fungia concinna
Fungia fungites
Fungia granulosa
Fungia horrida
Fungia klunzingeri
Fungia molluccensis
Fungia paumotensis
Fungia spinifer
Fungia valida
Galaxaura paucisepta
Galaxea alta
Galaxea astreata
Galaxea fascicularis
Gardinosera planulata
Goniastrea deformis
Goniastrea edwardsi
Goniastrea palauensis
Goniastrea pectinata
Goniastrea retiformis
Goniopora panadoreaensis
Goniopora somaliensis
Goniopora tenuidans
Halomitra pileus
Heliopora actiniformis
Heliopora coerulea
Heliopora sp. 1
Hydnophora exesa
Hydnophora grandis
Hydnophora microconos
Hydnophora pilosa
Hydnophora rigida
Leptastrea bewickensis
Leptastrea purpurea
Leptastrea transversa
Leptoria phrygia
Leptoseris explanata
Leptoseris foliosa
Leptoseris gardineri
Leptoseris hawaiiensis
Leptoseris mycetoseroides
Leptoseris papyracea
Leptoseris scabra
Leptoseris sp. 1
Leptoseris yabei
Lithophyllon undulatum
Lobophyllia corymbosa
Lobophyllia hatai
Lobophyllia hemptichii
Madracis kirbyi
Merulina ampliata
Merulina scabricula
Millepora dichotoma
Millepora exaesa
Millepora intricata
Millepora platyphyllia
Montastrea curta
Montastrea magnistellata
Montastrea sp. 1
Montastrea valenciennesi
Montipora aequituberculata
Montipora angulata
Montipora capitata
Montipora confusa
Montipora digitata
Montipora florida
Montipora foliosa
Montipora foveolata
Montipora hispida
Montipora incrassata
Montipora informis
Montipora mini-hispida
Montipora mollis
Montipora spongodes
Montipora sp. 1
Montipora stellata
Montipora verrucosa
Mussa viitensis

Mycidium elephantotus
Mycidium robokakai
Oulastrea crispata
Oulophyllia crispa
Oxyphora lacera
Pachyseris foliosa
Pachyseris rugosa
Pachyseris speciosa
Palauastrea ramosa
Pavona cactus
Pavona clavus
Pavona decussata
Pavona explanulata
Pavona frondifera
Pavona minuta
Pavona sp. 1
Pavona sp. 2
Pavona varians
Pavona venosa
Pavona xarifae
Pectinia alcornis
Pectinia lactuca
Pectinia paeonia
Physogyra lichtensteini
Platygyra contorta
Platygyra daedalea
Platygyra lamellina
Platygyra pini
Platygyra sinensis
Plesiastrea versipora
Pleurogyra sinuosa
Pocillopora damicornis
Pocillopora eydouxi
Pocillopora meandrina
Pocillopora verrucosa
Podabacia crustacea
Polyphyllia talpina
Porites annae
Porites attenuata
Porites cylindrica
Porites evermanni
Porites horizontalata
Porites lichen
Porites monticulosa
Porites negrosensis
Porites nigrescens
Porites rus
Psammocora contigua
Psammocora digitata
Psammocora nierstraszi
Psammocora profundacella
Psammocora superficialis
Sandalolitha dentata
Sandalolitha robusta
Scapophyllia cylindrica
Seriopora calidrum
Seriopora hystris
Stylaster sp.
Stylocoeniella armata
Stylocoeniella guentheri
Stylophora mordax
Stylophora pistillata
Symphyllia agaricia
Symphyllia radians
Symphyllia recta
Symphyllia valenciennesi
Trachyphyllia geoffroyi
Tubastrea coccinea
Tubastrea micranthus
Tubipora musica
Tubipora sp. 1
Turbinaria frondens
Turbinaria heronensis
Turbinaria mesenteria
Turbinaria peltata
Turbinaria reniformis
Turbinaria stellata
Zoopilus echinata

FISH SPECIES

<i>Abudefduf saxatilis</i>	Scissortail Sergeant	<i>Cheilodipterus quinquellatus</i>	Five-lined cardinalfish	<i>Paracaesio xanthura</i>	Yellowtail false fusilier
<i>Abudefduf virgens</i>	Indo-Pacific Sergeant Major	<i>Chromis acares</i>	Midjet chromis	<i>Paraperca clathrata</i>	Latticed sandperch
<i>Acanthurus blochii</i>	Kingtail	<i>Chromis analis</i>	Yellow Chromis	<i>Paraperca cylindrica</i>	Cylindrical sand perch
<i>Acanthurus chromis</i>	Chromis surgeonfish	<i>Chromis dimidiata</i>	Twotone chromis	<i>Paraperca mullipunctata</i>	Black-dotted Sandperch
<i>Acanthurus dussumieri</i>	Eyestripe	<i>Chromis margaritifer</i>	Twotone Chromis	<i>Paralichthys marmoratus</i>	Moses sole
<i>Acanthurus gahani</i>	Striped Surgeonfish	<i>Chromis nigrilabris</i>	Hikokor Chromis	<i>Parapercus barbarioides</i>	Half & Half Goatfish
<i>Acanthurus lineatus</i>	Dusky Surgeonfish	<i>Chromis nigrilabris</i>	Blackbar Chromis	<i>Parapercus bifasciatus</i>	Dash and dot goatfish
<i>Acanthurus nigrofasciatus</i>	Blue-lined surgeon	<i>Chromis nigrilabris</i>	Black chromis	<i>Parapercus cyclostomus</i>	Two-barred Goatfish
<i>Acanthurus nigrostriatus</i>	Mimic Surgeonfish	<i>Chrysiptera cyanea</i>	Blue Devil	<i>Parapercus macronotus</i>	Longbarbel Goatfish
<i>Acanthurus thompsoni</i>	Thompson's surgeonfish	<i>Chrysiptera keniyanus</i>	Azure demibelle	<i>Parapercus multifasciatus</i>	Multibarred Goatfish
<i>Acanthurus triostegus</i>	Convict	<i>Chrysiptera rex</i>	King demibelle	<i>Parapercus ovalensis</i>	Copper sweeper
<i>Acanthurus triostegus</i>	Shrimpfish	<i>Chrysiptera rollandi</i>	Rolland's Demibelle	<i>Parapercus vanicolensis</i>	Vanikoro Sweeper
<i>Amblygobius aureus</i>	Golden damselfish	<i>Chrysiptera springeri</i>	Springer's Demibelle	<i>Parapercus jacksoniana</i>	Blackbar Filefish
<i>Amblygobius curacao</i>	Staghorn damselfish	<i>Chrysiptera tricolor</i>	Tricolor demibelle	<i>Parapercus melanocephalus</i>	Blackheaded Filefish
<i>Amblygobius leucogaster</i>	White Belly Damselfish	<i>Cirrhilichthys aprinus</i>	Thraudfin hawkfish	<i>Platax pinnatus</i>	Pinnate Spadefish (Hattfish)
<i>Amphiprion frenatus</i>	Tomato anemonefish	<i>Coralaxia melanopus</i>	Orange banded coralfish	<i>Plectrogobius lacrymans</i>	Jewel Damselfish
<i>Amphiprion sandaracanthus</i>	Orange Anemonefish	<i>Coryphopterus glaucofraenum</i>	Dolphin fish	<i>Pomacentrus lineatus</i>	Striped Catfish
<i>Amphiprion thalassidroma</i>	Thiell's Anemonefish	<i>Ctenopoma striatum</i>	Striped Surgeonfish	<i>Pomacentrus sexstriatus</i>	Six banded Angel
<i>Amphiprion thalassidroma</i>	Clark's anemonefish	<i>Ctenopoma kribiaensis</i>	Hawaiian surgeonfish	<i>Pomacentrus imperator</i>	Emperor angelfish
<i>Anagrus melanopus</i>	Blue-Spotted Wrasse	<i>Ctenopoma kribiaensis</i>	Striped Hisselknot	<i>Pomacentrus lele</i>	Obscure Damselfish
<i>Apogon erythrinus</i>	Yellowtail wrasse	<i>Ctenopoma kribiaensis</i>	Tomini surgeonfish	<i>Pomacentrus alexanderae</i>	Alexander's damselfish
<i>Apogon niger</i>	Many-lined Cardinalfish	<i>Dascyllus reticulatus</i>	Humbug dascyllus	<i>Pomacentrus bipinnatus</i>	Speckled damselfish
<i>Apogon compressus</i>	Orange-striped Cardinalfish	<i>Dascyllus trimaculatus</i>	Reticulated dascyllus	<i>Pomacentrus lepidogenys</i>	Scaly Damselfish
<i>Apogon coelestis</i>	Black-striped Cardinalfish	<i>Diplodus bifasciatus</i>	Three spot Dascyllus	<i>Pomacentrus nigromarginatus</i>	Lenon Damselfish
<i>Apogon niger</i>	Sangi cardinalfish	<i>Dicathodus melanotus</i>	Two-banded Scapfish	<i>Pomacentrus nigromarginatus</i>	Blackmarginated Damselfish
<i>Apogon niger</i>	Three-spot Angelfish	<i>Dicathodus peripallidus</i>	Black-vent Damselfish	<i>Pomacentrus nigromarginatus</i>	Black-dot damselfish
<i>Apolemichthys trimaculatus</i>	Blackbelly Cardinalfish	<i>Doryrhamphus dactylopterus</i>	Banded Damsel	<i>Pomacentrus nigromarginatus</i>	Three spot Damselfish
<i>Archamia zosterophora</i>	Inmaculate pufferfish	<i>Echinops nanus</i>	Kinglet pipefish	<i>Pomacentrus nigromarginatus</i>	Goam Damselfish
<i>Archamia zosterophora</i>	Guineafowl Puffer	<i>Echinops bicolor</i>	Ringed pipefish	<i>Pomacentrus nigromarginatus</i>	Black's Hippy
<i>Archamia nigropunctatus</i>	Blackspotted Puffer	<i>Epinephelus caeruleus</i>	Hickory Henny	<i>Pseudanthias nika</i>	Yellow-striped anthias
<i>Archamia stellatus</i>	Star pufferfish	<i>Epinephelus microdon</i>	Coral grouper	<i>Pseudanthias pleurotaenia</i>	Squarespot Anthias
<i>Aspidionus aculeatus</i>	Cleaner Mimic	<i>Epinephelus microdon</i>	Honeycomb Grouper	<i>Pseudochromis hexataenia</i>	Sicline Wrasse
<i>Aulostomus chinensis</i>	Trumpetfish	<i>Epinephelus microdon</i>	Haffimoon Grouper	<i>Pseudochromis diadema</i>	Diadem Dottyback
<i>Balastapus undulatus</i>	Orange-striped Triggerfish	<i>Epinephelus microdon</i>	Cometfish	<i>Pseudochromis paracaudatus</i>	Royal dottyback
<i>Balastapus rufipinnatus</i>	Crown triggerfish	<i>Forcipiger longirostris</i>	Long-nosed butterflyfish	<i>Pterocoris evelina</i>	Philippine wrasse
<i>Bodianus diadema</i>	Diana's Holfish	<i>Forcipiger longirostris</i>	Hig Longnosed Butterflyfish	<i>Pterocoris evelina</i>	Blackfin Dartfish
<i>Bodianus mesoleptus</i>	Mesothorax Hogfish	<i>Goniistius axillaris</i>	Lamarck's Angelfish	<i>Pterocoris evelina</i>	Goldband fusilier
<i>Cassio zinnia</i>	Deep-bodied Fusilier	<i>Goniistius axillaris</i>	Yellowspot Emperor	<i>Pterocoris evelina</i>	Widestripe Fusilier
<i>Cassio humilis</i>	Lunar Fusilier	<i>Goniistius axillaris</i>	Sixstripe Snappers	<i>Pterocoris evelina</i>	Ruddy Fusilier
<i>Cassio terra</i>	Yellowback fusilier	<i>Goniistius axillaris</i>	Diamond wrasse	<i>Pterocoris evelina</i>	Bluestreaked fusilier
<i>Canthigaster compressa</i>	Fingerprint toby	<i>Goniistius axillaris</i>	Checkerboard Wrasse	<i>Pterocoris evelina</i>	Lionfish
<i>Canthigaster curvatus</i>	Crown toby	<i>Goniistius axillaris</i>	Zigzag Wrasse	<i>Pterocoris evelina</i>	Regal Angelfish
<i>Canthigaster valentini</i>	Black-saddled toby	<i>Goniistius axillaris</i>	Blackedge thicklip wrasse	<i>Rhinocanthus rectangulus</i>	Wedge Picasso fish
<i>Centropyge bicolor</i>	Bicolor Angelfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Rhinocanthus quatuor</i>	Ribbon eel
<i>Centropyge nux</i>	Midnight Angelfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Sargocentrus caudimaculatus</i>	Tailspot Squirrelfish
<i>Centropyge thienii</i>	Keyhole Angelfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Sargocentrus pinnatus</i>	Dark-striped squirrelfish
<i>Centropyge venustus</i>	Purple-mask angelfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus ghobius</i>	Bluebarred Parrotfish
<i>Centropyge vrolikii</i>	Pearlscale Angelfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Redtail parrotfish
<i>Cephalopholis urolepis</i>	Flagtail Grouper	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Bullethead Parrotfish
<i>Chaetodon auriga</i>	Threadfin Butterflyfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Twoline Spinecheek
<i>Chaetodon aurolineatus</i>	Exquisite	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Black & white spinecheek
<i>Chaetodon baronessa</i>	Eastern triangle butterflyfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Threelined Spinecheek
<i>Chaetodon benettii</i>	Bennet's butterfly	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Narrow-banded king mackerel
<i>Chaetodon citrinellus</i>	Speckled butterfly	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Golden Rabbitfish
<i>Chaetodon kleinii</i>	Klein's Butterfly Fish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Masked Rabbitfish
<i>Chaetodon lineolatus</i>	Lined Butterfly	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Peppered rabbitfish
<i>Chaetodon lunula</i>	Racoon Butterfly	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Goldspotted Rabbitfish
<i>Chaetodon melanopus</i>	Black backed butterfly	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Sellate Rabbitfish
<i>Chaetodon modestus</i>	Brown banded Butterfly	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Foxface rabbitfish
<i>Chaetodon ocellatus</i>	Spot-nape butterflyfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Pajama cardinalfish
<i>Chaetodon ornatissimus</i>	Spot-nape butterflyfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Catfish Wrasse
<i>Chaetodon oxycephalus</i>	Bluespot butterfly	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Reef needle fish
<i>Chaetodon pinnatus</i>	Spot-banded butterfly	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Bluefin Triggerfish
<i>Chaetodon punctatofasciatus</i>	Latticed Butterflyfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Halfmoon triggerfish
<i>Chaetodon rafflesi</i>	Ovalspot butterfly	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Crescent-banded Grouper
<i>Chaetodon speculum</i>	Chevroned Butterflyfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Two-tone wrasse
<i>Chaetodon trifasciatus</i>	Redfin butterflyfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Six bar wrasse
<i>Chaetodon trifasciatus</i>	Redfin butterflyfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	James's Wrasse
<i>Chaetodon vagabundus</i>	Vagabond Butterflyfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Crescent Wrasse
<i>Chaetodon xanthurus</i>	Yellowtail Butterflyfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Albacore
<i>Chaetodon xanthurus</i>	Vermiculated butterflyfish	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Whitebarred pigmy wrasse
<i>Chelodactylus melanoleucus</i>	Floral wrasse	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Moorish Idol
<i>Chelodactylus melanoleucus</i>	Red-handed Wrasse	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	Brushtail Tang
<i>Chelodactylus melanoleucus</i>	Humphead Wrasse	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	
<i>Chelodactylus melanoleucus</i>	Cigar Wrasse	<i>Goniistius axillaris</i>	Pyramid butterflyfish	<i>Scarus porphyreus</i>	

INVERTEBRATES

PORIFERA

Life forms

Basket
Branching
Elephant Ear
Encrusting
Horny
Lumpy
Rope
Tube
Vase

Species and genera

Aka spp.
Carterospongia spp.
Cinachyra tenuividaea
Clathria spp.
Crambe spp.
Gelliodes fulatus
Halichondra spp.
Ianthella basta
Leiodermatium spp.
Siphonochalinae siphonella
Stylotella aurantium
Xestospongia exigua

ANTIPATHARIA

Antipathes dichotoma
Cirripathes anguina
Feathery white
Yellow fan

ACTINARIA

Actinodendrum spp.
Actinodendrum arboreum
Broccoli anemone
Cryptodendrum adhaesivum
Entacmaea quadricolor
Heteractis aurora

ZOANTHIDS

Palythoa lesueuri

CORALLIMORPHARIA

Amplexidiscus fenestrafer
Discosoma spp.

CERIANTHARIA

Ceranthus spp.
Pachyoceranthus spp.

SCYPHOZOA

Cassiopsea ornata
Thysanostoma loriferum
Carybdea alata

SEA PENS

Pteroeides spp.

PLATYHELMINTHES

Planocera reticulata
Pseudoceros affinis
Pseudoceros bifurcus
Pseudoceros splendidus

ANNELIDA

Chone spp.
Filograna elatensis
Loimia spp.
Sabellastart sancti-josephi
Spirobranchus giganteus

ARTHROPODA

Atergatis reticulata
Atergatis subdentatus
Grapsus albolineatus
Odontodactylus scyllarus
Panulirus versicolor
Pereclimenes brevicarpalis
Pereclimenes cyrtorhynchus
Pereclimenes soror
Pereclimenes sp.
Periclimenes holthusi
Stegopantia commensalis
Stenopus hispidus
Thor amboinensis
Trapezia cymodoce
Trapezia rufopunctata

MOLLUSCA

Casella atrmarginata
Chelidonura spp.
Chelidonura hirundinina
Chromodoris kuniei
Conus cactus
Conus ebraeus
Conus flavidus
Conus leopardus
Conus litoblyphus
Conus nyorea
Conus striatus
Conus textile
Curalliohila violacea
Dendropoma maxima
Drupella spp.
Fryenia rippelli
Haminoea cymbalum
Jorunna funebris
Lopha cristagalli
Nethembroa spp.
Ovula ovum
Pedum spondylium
Penicillus giganteus
Phyllidia spp.
Pinctachnary aritifera
Pteria bevilata
Saccostrea spp.
Sepia spp.
Spondylus varius
Strombus sp.
Tridacna crocea
Tridacna squamosa

ECHINODERMATA

Acanthaster planci
Asthenosoma spp.
Astroboa granulatus
Bohadshia argus
Choriaster granularis
Comanthus solaster
Culcita novae-guineae
Diadema setosa
Echinaster callosus
Echinaster luzonicus
Echinometra mathaei
Echinothrix calamaris
Fromia monilis
Heterocentrotus mammillatus
Holothuria atra
Leptosynapta lamberti
Linckia laevigata
Nardoa spp.
Nidorella armata
Opheodesma grisea
Synapta maculata
Thelenota ananas
Thelenota rubrolineata
Toxopneustes pileolus
Tripneustes gracilis
Tripneustes gratilla

TUNICATES

Clavelina spp.
Didemnum molle
Ecteinascida spp.
Eudistoma laysoni
Polycarpa aurata
Polycitorella spp.
Rhopalaea spp.

SEAGRASS GENERA

Cymodocea
Enhalus
Halodule
Halophila
Halodule
Syringodium
Thalassia

ALGAL GENERA

Phaeophyta

Dictyota
Lobophora
Padina
Sargassum
Sphacelaria
Turbinaria

Chlorophyta

Acetabularia
Avrainvillea
Boergesenia
Bornetella
Boodlea
Caulerpa
Chaetomorpha
Cladophora
Cladophoropsis
Codium
Dictyosphaeria
Enteromorpha
Gracilara
Halicoryne
Halimeda
Melamansia
Ulva
Ventricaria

Rhodophyta

Actinotrichia
Amphiroa
Asparagopsis
Carpopeltis
Champia
Coelothrix
Cryptonemia
Eucheuma
Galaxaura
Gelidiella
Hypnea
Jania
Laurencia
Lomentaria
Mastophora
Rhodymenia
Titanophora
Wurdemannia
Zellera

Cyanophyta

Lyngbya
Microcoleus
Phormidium
Symploca

Favites (median abundance 1.8), large brain corals and *Diploastrea heliopora* (median abundances 1.5). Octocorals are also abundant on Andrea's Reef, particularly the tree life form, sea whips and leathery soft corals (median abundances 1.5). Tube sponges were also common (median abundance 1.2).

4.3 Results of analysis of fish communities

The five most abundant (highest median abundance) fish families recorded in each of the three habitat types, Convention Reef and Andrea's Reef are shown in Table 5. Fish which are important for the local fishery (Appendix 1) are highlighted.

HABITAT	FAMILY	MEDIAN ABUNDANCE
1	Butterflyfish	1.0
	* Wrasse	0.6
	Damselfish	0.4
	* Fusiliers	0.4
	* Surgeonfish	0.4
	Angelfish	0.4
2	Damselfish	2.9
	Butterflyfish	2.0
	* Wrasse	1.1
	Angelfish	0.7
	* Triggerfish	0.6
	* Surgeonfish	0.6
3	Damselfish	2.2
	Butterflyfish	0.9
	* Surgeonfish	0.6
	* Wrasse	0.5
	* Spinecheek	0.4
	* Goatfish	0.4
Convention	Damselfish	2.8
	Butterflyfish	1.9
	* Wrasse	1.5
	Angelfish	0.5
	* Parrotfish	0.3
	* Surgeonfish	0.3
Andrea's	Damselfish	2.8
	Angelfish	1.5
	Butterflyfish	1.5
	* Parrotfish	0.5
	* Scorpionfish	0.5

Table 5. The most abundant fish families in each of the three habitat types, Convention Reef and Andrea's Reef.
* indicates important fisheries species.

5 RESULTS OF ADDITIONAL PROJECTS

5.1 Coral health survey

Taking measurements of coral size and health was found to be very difficult and potentially unreliable in clonal corals (foliose, finger, staghorn) as it was found to be difficult to distinguish where a coral colony began and ended. The use of a 20m transect line required the divers to measure a large number of coral colonies which took a long time to complete.

The method will be reviewed and may be refined for further testing during the 1996 and 1997 field seasons.

5.2 ICLARM methodology

Results of this work have yet to be analysed.

5.3 Environmental monitoring

During the course of the survey work a number of sites were visually assessed for their suitability as permanent monitoring sites. It is recommended that monitoring of benthic cover and fish stocks occur within each major habitat type and also inside and outside each of the zones designated as sanctuary areas. This will monitor the general health of the reef and also the effectiveness of the management policies. Furthermore there are a number of areas that should be monitored to assess specific impacts. These include:

1. 3m depth off East Beach where expanses of particularly healthy coral colonies occur.
2. 3m depth off the Western Beach to monitor recruitment and reef regrowth following typhoon damage.
3. The southern end of Danjungan to monitor recruitment and reef regrowth following blast fishing damage.
4. Close to the southern part of Hilary's Rock to monitor damage by the crown-of-thorns seastar (*Acanthaster planci*).
5. At approximately 25m depth within the fragile foliose beds of the south east to monitor anchor and typhoon damage and siltation rates.

5.4 Community involvement

The Bulata community were integrated into the project through education projects on conservation at open days at Danjungan for teachers and members of the local fishing cooperative. A beach cleanup involving the local community was also conducted. Furthermore CCC assisted with marine and wildlife camps that were organized by the PRRCFI for the secondary school children of Bulata.

6 RESOURCE PROTECTION AND MANAGEMENT

6.1 Rationale for the protection of Danjungan Island

The reefs around Danjungan Island were found to support a high biodiversity and appear to be in good condition relative to many other reefs of the Philippines. Even though the PRRCFI has observed blast fishing and muro ami damage in the past this seems to have stopped and the affected areas are recovering. Thus the reefs around Danjungan seem to have escaped the chronic damage visible on reefs in other areas of the Philippines. It is possible that Danjungan's reefs rate as among the most diverse small reefs in the world (Fenner, pers. comm.). For example, a preliminary comparison suggests that the reefs around Danjungan Island are as topographically rich, as biologically diverse and as healthy as those in the renowned Apo Island Marine Reserve, Negros Oriental (Fenner, pers. comm.).

The following sections set out the rationale for protecting the reefs of Danjungan.

6.1.1 High diversity of fauna

1. A total of 236 scleractinians and hydrocorals, plus *Heliopora coerulea* and *H. sp.*, representing 72 genera were recorded (Appendix 4). Some identifications are to be verified through further taxonomic study. Of the coral species identified, or pending confirmation, 20 species are thought to be rare in the Philippines (Veron and Hodgson, 1989). The rare corals are listed in Table 6. In addition to the rare corals, one species requiring taxonomic confirmation, *Coscinarea mcneilli*, would represent a new report for the Philippines (Veron and Hodgson, 1989).

<i>Acropora monticulosa</i>	<i>Oulastrea crispa</i>
<i>Acropora valenciennesi</i>	<i>Psammocora neistraszi</i>
<i>Acropora kirstyi</i>	<i>Psammocora profundacella</i>
<i>Astreopora ocellata</i>	<i>Scapophyllia cylindrica</i>
<i>Caulastrea curvata</i>	<i>Scolymia vitiensis</i>
<i>Cynarina lacrymalis</i>	<i>Symphyllia agaricia</i>
<i>Cyphastrea agasszi</i>	<i>Symphyllia valenciennesii</i>
<i>Hydnophora microconos</i>	<i>Turbinaria heronensis</i>
<i>Leptoseris gardineri</i>	<i>Turbinaria peltata</i>
<i>Madracis kirbyi</i>	<i>Zoopilus echinatus</i>

Table 6. Rare coral species found at Danjungan Island, based on data in Veron and Hodgson, 1989.

The number of coral genera is comparable with the number of coral genera found throughout the entire Great Barrier Reef of Australia (70-80 genera).

2. 229 species of fish were recorded (Appendix 4).
3. The rare and commercially valuable bamboo coral (an octocoral species, probably from the genus *Isis*) was common in shallow and medium depths on the east side of

Danjungan.

4. 43 genera of macro-algae, 4 genera of blue-green algae and 7 genera of seagrasses were identified by Dr Lawrence Liao from De La Salle University (Appendix 4).

6.1.2 *Low environmental damage*

1. A low number of the coral eating Crown-of-Thorns (*Acanthaster planci*) seastars were recorded and there was no evidence of recent significant damage to the island's reefs except in one area south of "Hilary's Rock".
2. *Drupella* snails, which can also cause significant coral damage via predation, were more common than *Acanthaster planci* but did not appear to have caused significant damage the coral communities.
3. A low incidence of coral breakage and overturning were encountered on all the reefs. Three anchor drag paths were recorded.
4. Although water visibility was at times reduced to moderate levels, there were no obvious signs of significant impacts from terrigenous sediments.
5. Algae and synaptid sea cucumbers, which have been associated with eutrophication, were uncommon on the reefs.
6. Mushroom corals, popular for collection by tourists, were common on the reefs.
7. Incidents of coral bleaching were uncommon.

6.1.3 *High topographic complexity*

1. Danjungan Island and its surrounding reefs are topographically complex. This includes the lagoons, distinct features on the reef such as the two eastern ridges, the Convention complex and Andrea's Reef. This level of complexity presents a wide variety of habitats and ecological niches that can increase the species diversity relative to the size of the area. The range of topographic features is also aesthetically pleasing and offers visitors a range of diving experiences in a small area.

6.1.4 *Miscellaneous features*

1. On Doug's Ridge (Figure 2), south of the entrance to the 3rd lagoon, a colony of *Tubastrea micranthus* was found standing approximately 2m high and 30cm in diameter at its base. This may be among the world's largest known colonies since field guides and scientific descriptions give a maximum height and diameter of 1m and 5cm respectively for this species (Fenner, pers. comm.).
2. During the surveys, three to four large colonies of *Acropora monticulosa* north of Manta Island (Figure 3) were discovered. Although *Acropora monticulosa* is common in Australia, this species was previously only known in the Philippines from one

museum specimen and it has been suggested that the Danjugan colonies may perhaps be the only ones capable of breeding by cross-fertilization in this area (Fenner, pers. comm.).

6.1.5 *Commercially important species*

1. The fish population densities recorded were low and very few large specimens were observed. However, stocks of small size classes of commercially important fish species and the existence of their habitats suggest that the fisheries in the project area has the potential to recover.
2. In addition to the commercially important fish species recorded around Danjugan, two species of giant clam (*Tridacna crocea* and *T. squamosa*) and the lobster (*Panulirus versicolor*) were recorded.
3. Four species of black coral (*Antipathes dichotoma*, *Cirrhipathes anguina*, Feathery white and Yellow fan), which are sometimes collected for making jewellery, were recorded.
4. The leathery soft corals, primarily from the genera *Sarcophyton*, *Lobophyton* and *Sinularia*, were common. These species may contain medically important chemicals.

6.2 The Danjugan Island Marine Reserve

The whole of Danjugan Island is surrounded by topographically rich and biologically diverse coral reefs. According to IUCN standard ecological criteria for selecting protected areas Danjugan Island exemplifies the following (Salm and Clark, 1989):

1. A large variety and richness of ecosystems, habitats, communities and species.
2. A high degree of naturalness.
3. Representative of the native flora and fauna.
4. A habitat for species possibly not reported from this part of the world before.
5. The area is naturally productive and has been utilised for generations by local communities.
6. Is vulnerable to degradation from both natural typhoons and human related activities. Of particular concern is the indirect effects from terrestrial based human activities.

These criteria support the rationale for the protection of Danjugan Island and its reefs through the implementation of a marine reserve and zoning scheme for the sustainable utilisation of the island's biological and physical resources.

6.2.1 *Marine reserve boundaries and zoning scheme*

Based on the results of the data analyses, supplemented by anecdotal records from field science staff, an island-wide marine reserve and zoning plan for Danjugan Island is recommended. This zoning plan includes three areas recommended for special protection, designated as Special Management Areas (SMA's; Figure 5).