THE 1996 BANGGAI ISLANDS CONSERVATION PROJECT (CENTRAL SULAWESI, INDONESIA)

- 1996 summary report prepared on behalf of -

YAYASAN PENGEMBANGAN SUMBER DAYA LAUT

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OCTOBER 1997

CORAL CAY CONSERVATION Expeditions

INTERNATIONAL YEAR of the REEF 97

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EXECUTIVE SUMMARY

The Banggai Islands (Central Sulawesi, Indonesia) lie within possibly the most biodiverse region on earth. The marine resources within the Banggai Islands include extensive and diverse reef systems such as fringing reefs, barrier reefs and true atolls. However, like much of Indonesia these reef systems are under increasing threat from deforestation, sedimentation, over-fishing, destructive fishing and coral mining.

In 1996 Yayasan Pengembangan Sumber Daya Laut (YSDL) and Coral Cay Conservation (CCC) initiated the Banggai Islands Conservation Project with the aim of alleviating the environmental and economic problems caused by reefal degradation in the region. The project aims are to: provide marine ecology training to Indonesian counterparts; carry out baseline survey work of the marine resources; establish monitoring programmes; provide recommendations to aid the establishment of a marine protected area and establish education and alternative livelihood schemes.

This report details the results of 11 weeks of fieldwork by 24 CCC volunteers and 11 Indonesian counterparts based on Bangkulu Island between the 26th September and 16th December 1996. During this period the volunteers and counterparts completed 159 reef transects in 15 different areas in the Banggai Islands. Rapid Ecological Assessments (REA's) were carried out in nine areas. A further six areas were surveyed in greater detail to map the physical and biological characteristics. The volunteer training programme and survey techniques used were based on those developed by CCC for similar projects in Belize and the Philippines. In addition to the baseline survey work five additional research projects were conducted. These included: point intercept transects to collect quantitative information on the benthic communities; an *Acanthaster planci* survey; a *Tridacna* survey; the establishment of hydrographic monitoring sites and beach sand sediment analysis.

The fieldwork revealed a diverse ecosystem that has received significant damage, in particular from destructive and over fishing. All nine REA sites contained areas that were either destroyed, in a poor state or showed signs of established regrowth following damage. The data from the six areas surveyed in detail were analysed using multivariate cluster and SIMPER analysis, along with the univariate statistic of median abundance to distinguish major benthic classes. Similarly to the REA sites, the sites surveyed in detail showed considerable human impact with the benthic class "green algae and hard corals" common at all sites. This benthic class indicates human impact and established regrowth. Areas of dead coral were also found and there were few reef areas without signs of destructive fishing. The only areas which appeared to have low levels of human impact were the steep escarpments of Tolumbakan, an offshore atoll away from fishing communities. A preliminary fish species list was compiled during the fieldwork and 438 species sightings, including the endemic Banggai Cardinalfish (*Pterapogon kauderni*) were confirmed.

The data collected by point intercept transects revealed a healthy shallow water community with a high percentage of coral cover in front of the expedition base camp. A total of 15 *Acanthaster planci* were found, indicating a limited threat to reef health.

During the course of the project, an education programme, utilizing illustrated talks, video and practical exercises, was established to provide an introduction to coral reefs for 10 students from each of the 16 schools on Bangkulu Island. A further training programme provided courses in SCUBA diving, marine ecology and coral reef surveys to five counterparts from the local community and marine ecology and coral reef survey experience to a six counterparts from conservation institutions in Jakarta and Luwuk.

Having initiated a preliminary environmental database for the Banggai Islands and established the threats to the health of the ecosystem and the economy of the local people, it is recommended that the Banggai Island Conservation Project is continued and extended. Further work by CCC volunteers and local counter-parts would provide, for example, detailed habitat maps, monitoring programmes and documentation of the biodiversity of the area and allow the establishment of a community-driven marine protected area.

ABBREVIATIONS

CCC	-	Coral Cay Conservation
GIS	-	Geographic Information System
GPS	-	Global Positioning System
MPA	-	Marine Protected Area
PHPA	-	Directorate of Forest Protection and Nature Conservation
PRIMER	-	Plymouth Routines in Multivariate Ecological Research
REA	-	Rapid Ecological Assessment
SCUBA	-	Self-contained underwater breathing apparatus
SIMPER	-	Similarity Percentage
YSDL	-	Yayasan Pengembangan Sumber Daya Laut

ACKNOWLEDGMENTS

CCC would like to thank the hard work and dedication of R. Rr Sita Wachyo and the staff of the Yayasan Pengembangan Sumber Daya Laut (YSDL) for making the Banggai Island project possible. CCC are also indebted to Minister Ir. Sarwono Kusumaatmadja (Ministry of Environment). CCC would also like to thank Bapak Sudarto (Bupati of Kabupaten Banggai), Dr William Collier (BAPEDAL), the Camat of Kecamatan Labobo-Bangkurung, the Kepala Desa of Lantibung, Dr H.S. Batuna (Manado Underwater Explorations) and Juanita Mandagi (Yayasan Rinjani Bahari) for their help during the course of the project.

CCC are also very grateful to:

Noviana Andalusi (PHPA)
Ir. Firmansyah Basri (BAPPEDA, Kabupaten Banggai)
Bapak Charles
Dr Allan Darwis (PT Wahana Bursamaya)
Dr Heather Hall
HarperCollins Publishers
Bapak Ilyas
Chris Jeavens (Singapore Airlines)
Dr Rene de Jongh (AEA International, Jakarta)
Ratna Kartikasari (BAPEDAL)
Thomas Korompis (Boulevard Seaview Hotel, Manado)
David Littlehale
Ghislaine Llewellyn (Harvard University)
Suryani Mile and Jerome Doucet (PT Banggai Sentral Shrimp)
PT Aneka Gas Industri
Bapak Hasyim Saleh
Tim Scott (Barrick Gold Corp.)
Tim Severin
Seymour Publications
Rainer Sigel and Asian Diver
Ibu Sonya
Bapak Sugiyo (Manado Immigration Office)
TFH Publications
Dr Tom Tomascik
Prof. Hans E. Wagey (ORARI, Manado)
Debra Wood (Trailfinders)
Muhammad Yunus (BAPEDAL)

Finally CCC would also like to thank all the staff and volunteers on the expedition for their hard work and dedication: Alex Page (*Expedition Leader*), Mark Tomlinson (*Medical Officer and Scuba Instructor*), Alfred Abbatt, Sue Atkinson, Robert Buxton, Simon Caines, Matthew Cooper, Michael Cox, Justin Evershed-Martin, Peter Faulkner, Katharine Fussell, Tarquin Grossman, Kerstin Herden, Andrew Hewitt, Buffy McAfee, Georgia Noy, Joanne Preston, Brian Rutherford, Andrew Stronach, Serena Turle and Robin Verwest.

FIGURES

APPENDICES

“Coral reefs in Indonesia are extensive and represent the most significant reef resource in southeast Asia.”

Jameson et al. (1995)

"There is a need for Indonesia to evolve from unsustainable single-purpose resource uses toward sustainable multiple resource uses supported by planning and management integrated at the national and provincial levels."

Sloan and Sugandhy (1994)

1. INTRODUCTION

1.1. Background to the Banggai Islands Conservation Project

In 1996 the Banggai Islands Conservation Project was established by Coral Cay Conservation (CCC) and Yayasan Pengembangan Sumber Daya Laut (YSDL). The aim of the project is to alleviate the threat to the marine resources of the Banggai Islands (Central Sulawesi) and the concurrent threat to the economy of the local community through integrated coastal zone management.

The components of this project are:

?? *Marine ecology training*
To train local Indonesians in all aspects of marine life identification and CCC survey techniques to enhance their capability to carry out surveys of the area’s marine resources.

?? *Baseline survey work*
To establish a comprehensive database of information on the coral reef ecosystem in the Banggai Islands. This database will include details of the nature and distribution of different habitat types and an inventory of the biodiversity for the generation of GIS (geographic information system) resource maps, habitat descriptions and species lists.

?? *Monitoring*
To utilize trained CCC volunteers and Indonesian counterparts to establish permanent monitoring sites to assess the health of the coral reef ecosystem.

?? *Management*
To utilize the baseline survey data to provide recommendations for the establishment of a community-driven marine protected area in the Banggai Islands.

?? *Environmental education and alternative livelihood schemes*
To raise awareness within the local communities of the importance of reefs, threats to reef health and to develop a sense of community stewardship of the marine resources. The project also aims to initiate alternative livelihood schemes to alleviate poverty and reduce the threats to the health of the marine resources.

This report details the scientific work undertaken during the first 11 week period of fieldwork (26th September and 16th December 1996) by 24 CCC volunteers and 11 Indonesian counterparts based on P. Bangkulu Island (Figure 1).

1.2. Indonesia

Indonesia is the world's largest archipelagic state with approximately 81,000 km of coastline and over 17,500 islands which cover approximately 5.085 million km² (Sloan and Sugandhy, 1993; The Economist Intelligence Unit Ltd, 1996). The marine coastal environment comprises nearly 80% of the country and exhibits high physical, chemical and biological diversity. Although it is widely recognized that Indonesia's marine resources are outstanding (for example Polunin, 1983) the biodiversity remains poorly documented. The marine resources include extensive coral reef formations which are among the most complex and highly productive shallow water tropical marine ecosystems. Coral reefs have been identified as one of the "essential life-support systems" necessary for food production, health and other aspects of human survival and sustainable development (IUCN, 1980).

The marine resources of Indonesia, especially the coral reefs, are under increasing stress. Indonesia has a population of approximately 196.6 million (1995 estimate - The Economist Intelligence Unit Ltd, 1996) and 50% of their protein is from seafood. This has placed a chronic strain on the integrity of the coral reef systems which has been exacerbated by the increasing use of destructive fishing methods such as explosives and cyanide. Other serious threats to Indonesia's coral reefs are sedimentation, eutrophication, coral mining and damage from anchors and SCUBA divers.

Indonesia now has an ambitious programme for establishing marine protected areas (UNEP/IUCN, 1988). Salm and Halim (1984a and b) list over 100 proposed marine protected areas (MPAs) and seaward extensions of terrestrial protected areas. Currently there are 24 established MPAs, including six national parks, covering over 2.5 million ha. (Sloan and Sugandhy, 1994). Within Indonesia the lead agency is the Directorate of Forest Protection and Nature Conservation (PHPA), a conservation sub-directorate within the Ministry of Forestry. One role of PHPA is to protect and manage coastal and marine habitats valuable to fisheries and tourism and to establish protected areas.

1.3. The Banggai Islands

The Banggai Islands are located off the east coast of Central Sulawesi (Figure 1) and have an area of approximately 12,064 km² with a population estimated 337,000. The islands are separated from the mainland by the Peleng Strait which is 15-30km wide and 950m deep. Peleng is the largest island in the area although other major islands include the smaller Banggai and P. Bangkulu (Figure 1). The Banggai Islands are separated from the Sula Islands to the east by the Bote Strait.

The Banggai Islands lie within the biogeographic divide between Asia and Australasia known as "Wallacea", possibly the most species rich region on earth. There is also a great diversity of reef systems within the islands, including fringing reefs, barrier reefs, offshore patch reefs, oceanic high islands with barrier reefs, faro atolls and true atolls (Tomascik et al., 1995).

The Banggai Islands are part of the Sula Spur which is a stable crustal belt extending eastwards through the Sula Islands to Irian Jaya. The geology of the Banggai Islands is described by Tomascik et al. (1995) as islands comprising of fragments of Triassic continental crust covered by Mesozoic sedimentary rocks. The major basement rock type is granite which is covered in many places by fossiliferous Jurassic black shales, inferring that the Banggai Islands were once part of the Australian continent. There are numerous raised coral reef terraces that create a spectacular landscape.

A rapid environmental assessment by Tomascik et al. (1995) concluded that the main threats to the coral reefs of the area are:

?? *Deforestation and water quality*.
Poor water quality is particularly acute in areas with human settlements and are related to a lack of sanitation. Rapid deforestation, leading to an increased sedimentation rate on the reef systems is apparent on all the larger islands.

?? *Over-fishing*.
Unsustainable fishing is evident at several reef sites indicating that the reef fisheries are over-exploited. This observation is supported by a lack of sharks and large fish schools although the non-edible or non-commercial reef fish seem to be abundant and diverse. The schools of tuna seen during boat journeys indicate that the offshore pelagic fisheries may be under-exploited.

?? *Destructive fishing*.
Destructive fishing, characterised by the use of explosives and cyanide, is prevalent throughout south-east Asia. Fish bombing has been observed in the Banggai Islands and there is an abundance of hydrogen peroxide containers. Cyanide fishing is also becoming a major threat to the area with an increasing live grouper fishery. Potassium cyanide is used to stun the fish so they can be captured and exported alive. It is estimated that at current rates the grouper population within the whole Banggai region will be severely depleted within two to three years. Furthermore, the cyanide has a damaging effect on the benthic community and smaller fish.

?? *Coral mining*.
The majority of coral extraction is found on shallow water fringing reefs close to settlements.

1.4. Principal partnership organisations

Yayasan Pengembangan Sumber Daya Laut
Yayasan Pengembangan Sumber Daya Laut (YSDL) is "*an independent, non-profit organisation established by a few caring individuals to serve the Government and the people of Indonesia with ideas and applications for conserving, while exploiting, the nation's huge natural resources of ocean, wetlands and marine biodiversity which primarily works with disadvantaged people along the coasts and wetlands to promote sustainable use of marine resources*".

Coral Cay Conservation Ltd
Mission Statement: *To provide resources for the protection and sustainable use of coastal environments*.
Coral Cay Conservation Ltd is a UK-based, non-profit organisation which was founded in 1986. CCC 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).

2. SURVEY WORK

2.1. CCC marine ecology training programme

Prior to undertaking survey work the CCC volunteers and Indonesian counterparts undertook an intensive eight day training course in marine life identification and survey techniques (Table 1). The training programme included assessments of each diver's identification skills and their competence at undertaking reef surveys. Only volunteers and counterparts who passed the assessments to the satisfaction of the Science Officer (a trained marine biologist) were able to participate on survey dives.

2.2. CCC baseline survey technique

The main aim of the baseline survey work undertaken during the 1996 fieldwork was to assess the extent and nature of the major habitat types found on the reefs close to the base camp (Figure 1) and to determine the extent and effects of destructive fishing. The fieldwork utilized CCC's baseline survey technique developed for use in the Indo-Pacific (Harborne et al., 1996). This technique allows trained volunteers and local counterparts to rapidly and accurately describe the nature of reefal communities.

The CCC baseline survey technique utilizes a series of plotless transects, perpendicular to the reef, starting from the 30 metre contour and terminating at the reef crest, in water of less than 1 metre or in a shallow seagrass bed. Benthic and fish surveys are focused on a pre-selected number of species and standardized life forms (from English et al., 1994) that are either abundant, easily identifiable or ecologically or commercially important. Octocorals and sponges are identified in various life form categories. The octocoral life forms include "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 are listed on the example biological survey form shown in Appendix 1.

Each survey team is comprised of four trained divers:

(direction of travel)

^ (***BUDDY PAIR A)***

^ **Diver 1** *(physical)* **Diver 2** *(fish, buoy)*

^ |

^ |*(10m rope)*

^ |

^ **Diver 3** *(hard corals)* **Diver 4** *(algae, soft coral, invertebrates)*

^ ***(BUDDY PAIR B)***

From the start point of each transect, buddy pair B remains stationary with Diver 3 holding one end of a 10 metre length rope, whilst buddy pair A swims away from them, navigating up the reef slope until the 10 metre line connecting Diver 1 and 3 becomes taught. Diver 1 records data on the depth and physical nature of the seabed and any signs of anthropogenic impacts. Diver 2 records data on the fish species encountered along the 10 metre distance travelled and also carries the survey buoy. Buddy pair A then wait for buddy pair B to swim towards them. Diver 3 records the hard corals encountered, whilst Diver 4 records the soft corals, invertebrates and algae. Algae are also collected for identification purposes. Diver 3 surveys approximately 1 metre each side of the transect line whilst divers 1, 2 and 4 survey 2.5 metres on either side.

DAY		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 schedule for the CCC training programme.

This process is repeated until the end of the planned dive profile, when a buoy carried by Diver 2 is tied to the reef. The buoy then acts as the start point for the next team and this is repeated until the survey is completed. Occasionally surveys are completed in shallow water by teams of snorkellers utilising the same protocol. The position of each buoy is recorded using a Global Positioning System (GPS) to allow the transects to be plotted within a GIS.

Data from different habitat types, for example dense coral reef, sand and seagrass, are recorded separately by each survey team as they are encountered. Each species or life form in each habitat type is recorded and assigned an abundance rating from the ordinal scale shown in Table 2.

ABUNDANCE RATING	CORAL 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. The ordinal scale assigned to life forms and target species during CCC baseline surveys.

All the data collected during the surveys are transferred to specially designed recording forms (Appendix 1). The biological form used for the fieldwork in the Banggai Islands was modified from that used by CCC in the Philippines. All the data recorded during the 1996 fieldwork were transferred and assimilated on CCC's windows-driven GIS compatible database.

During the baseline survey work the CCC Science Officer, aided by the volunteers, collated a list of the fish species observed in order to initiate a quantification of the biodiversity of the Banggai Islands. A preliminary list of the invertebrate and coral species was also compiled.

2.3. Point intercept transects

In addition to the standard CCC survey technique (Section 2.2), the reefs of P. Bangkulu (Figure 1) were assessed using point intercept transects. Point intercept transects provide quantitative data on the benthic cover of the reef.

Surveys, modified from English et al. (1994), were carried out by two divers using a weighted 10 metre line which was marked at 50cm intervals. The line was placed along the contour of the reef slope at depths of 18, 15, 12, 9, 6, 3 and 1 metres. Surveyors identified the life form, species or substratum category found directly below each mark.

2.4. Crown of thorns starfish *(Acanthaster planci)* survey

The crown of thorns starfish *(Acanthaster planci)* is a predator of live hard corals and is known for its capacity to multiply into plague numbers, causing large areas of reef to be decimated in a short time (Veron, 1993). Information about *A. planci* populations in Indonesia is limited and during the project CCC investigated the size of the *A. planci* population on the fringing reef in front of the CCC base camp on P. Bangkulu (Figure 1).

The survey technique designed by the Great Barrier Reef Marine Park Authority was utilised to facilitate data submission to an international database. The survey was conducted by

teams of two divers surveying from 18 metres perpendicularly up the reef slope, looking for *A. planci* on and under corals. For each *A. planci*, its size, location and whether it was in a "cluster" or alone was recorded.

2.5. Giant clam (*Tridacna* species) survey

Giant clams (*Tridacna* species) are perhaps the best known bivalve encountered on Indo-Pacific coral reefs. They can reach a diameter of 1.5 metres and have been reported to live up to 200 years. In many areas of south-east Asia the number of clams has been reduced by over-harvesting. During the course of the Banggai project the number of *Tridacna* individuals on the fringing reef in front of the base camp on P. Bangkulu (Figure 1) was quantified.

The survey technique used was similar to that used to survey *A. planci* (Section 2.4). Surveys were conducted by teams of two divers, working perpendicular to the reef slope, recording the numbers, size, colour and water depth of each individual.

2.6. Physical data

Wind speed, water temperature and current speed and salinity are routinely collected on each baseline survey. To compliment this data, two permanent stations were established at P. Bangkulu. During the first week of the fieldwork daily readings of water salinity, depth and temperature were recorded at 07.00, 13.00 and 17.30 from the top and bottom of the water column. From the second week onwards recordings were obtained three times a week, three times a day.

2.7. Sediment analysis

Surface sediment samples were taken from the high water and low water marks on the beach in front of the CCC base camp and analyzed to determine their geology and origin. Analysis was undertaken by microscopic observation and separation of the samples into grain size classes.

3. RAPID ECOLOGICAL ASSESSMENTS

3.1. Extent of surveys

During the fieldwork, 159 complete reef transects were completed by CCC volunteers and Indonesian counterparts in 15 different areas (Figure 2a). These transects encompassed 260 survey dives and provided over 18,000 individual species records (location and abundance). Of the 15 areas surveyed, nine were subjected to rapid ecological assessments (less than eight complete reef transects). The rapid ecological assessments (REA's) provide a qualitative evaluation of the reefs but there are insufficient data for detailed analysis.

3.2 Results of rapid ecological assessments

REA's were carried out on the reefs adjacent to: Palau Sago, P. Maringki, Karang Vesuvius, K. Krakatoa, P. Panteh, P. Galula, P. Sidula, P. Togonglantang and P. Labobo Kecil (Figure 2a).

The REA's used the following scale:

Destroyed:	Little or no live coral; predominantly rubble with or without algae growth.
Poor State:	Significant signs of impact, such as patches of rubble, only small live hard corals or algal overgrowth.
Established regrowth:	Evidence of damage, but significant growth of soft corals and signs of scleractinians becoming established, usually branching *Acropora* spp..
Pristine / primary growth:	Negligible signs of impact.

P. Panteh (four transects)

Appearance: The areas surveyed appeared to be in a poor or destroyed condition with patches of established regrowth. An unsurveyed area was also visited and appeared to be in the same condition as those surveyed. There was considerable fishing activity on the reef crest on the day of the surveys.

P. Sidula (five transects)

Appearance: Pristine condition on the lower slope, with patches of established regrowth and areas in poor condition nearer the reef crest. The island is used as a base for fishermen from Southern Sulawesi.

P. Galula (five transects)

Appearance: The southern end of the reef has a wide, undulating slope which has been largely detroyed. The northern slope is composed of sand to 15 metres followed by a steeply rising slope in poor condition with areas of established regrowth.

P. Togonglantang (four transects)

Appearance: The eastern slope was comprised of sand with a few coral heads up to a depth of 14 metres followed by a steeply rising reef with established *Acropora* regrowth on the reef crest. The western slope was also observed and appeared to be in poor condition with some areas completely destroyed.

P. Labobo Kecil (four transects)

Appearance: The southeastern slope had sand to 15 metres followed by a steeply rising slope in pristine condition with areas of established regrowth.

P. Sago (three transects)

Appearance: The southern wall was found to be in pristine condition. The reef crest was in poor state with certain areas of established regrowth.

P. Maringki (three transects)

Appearance: The southern wall was in pristine condition and the reef crest was in poor condition.

K. Vesuvius (four transects)

Appearance: The wall was in pristine condition

K. Krakatoa (four transects)

Appearance: The wall was in pristine condition and the reef crest had signs of established regrowth.

4. DETAILED BASELINE SURVEYS

4.1. Introduction

Detailed baseline survey work (more than eight full reef transects) was undertaken at: P. Tolobundu, P. Bangkulu, Bungin, Molombo, P. Balasapan and Tolumbakan (Figure 2b).

The data from these areas can be used to:
?? identify and describe discrete habitat types in the areas surveyed;
?? highlight the extent of destructive fishing;
?? ground-truthing remotely sensed imagery (when available) to produce a baseline habitat map.

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

Similarity Percentages (SIMPER) analysis, within PRIMER, show how characteristic each species, life form and substratum category is to each benthic class and also how important each is in distinguishing between classes. Such information is useful for describing the diagnostic features of each habitat type. The univariate summary statistics of median abundance and frequency of occurrence of each species, life form and substratum category are also used to aid description of each habitat type.

4.2. Results of multivariate data analysis

The dendrogram resulting from cluster analysis of the detailed baseline survey data discriminated six major benthic classes (minimum of four sites; Figure 3). The characteristics of each of these six benthic classes were summarized using SIMPER and univariate analysis. The major characteristics of each benthic class are described in Table 3 and listed in more detail in Appendix 2. Thirty five sites (13.5%) could not be assigned to one of the six major benthic classes and represent either unusual habitats which were surveyed less than four times or erroneous data. These sites represent a seventh, currently “unknown” benthic class.

4.3. Reef descriptions

Figures 4a-f schematically display the nature of the reefs found in the six areas surveyed in detail by combining the results of the data analysis with selected reef profiles. Each profile is representative of a particular section of the reef around each island and highlights the topography and locations of the different habitat types. The habitat labels used in Figures 4a-f follow the example of the systematic classification scheme derived for Belize (Mumby and Harborne, 1997). Habitat may be strictly defined as a description of geomorphology and the associated composition of benthic species (or life forms) and substratum. Each habitat type thus possesses a geomorphological and benthic class and this is reflected in the labels used here.

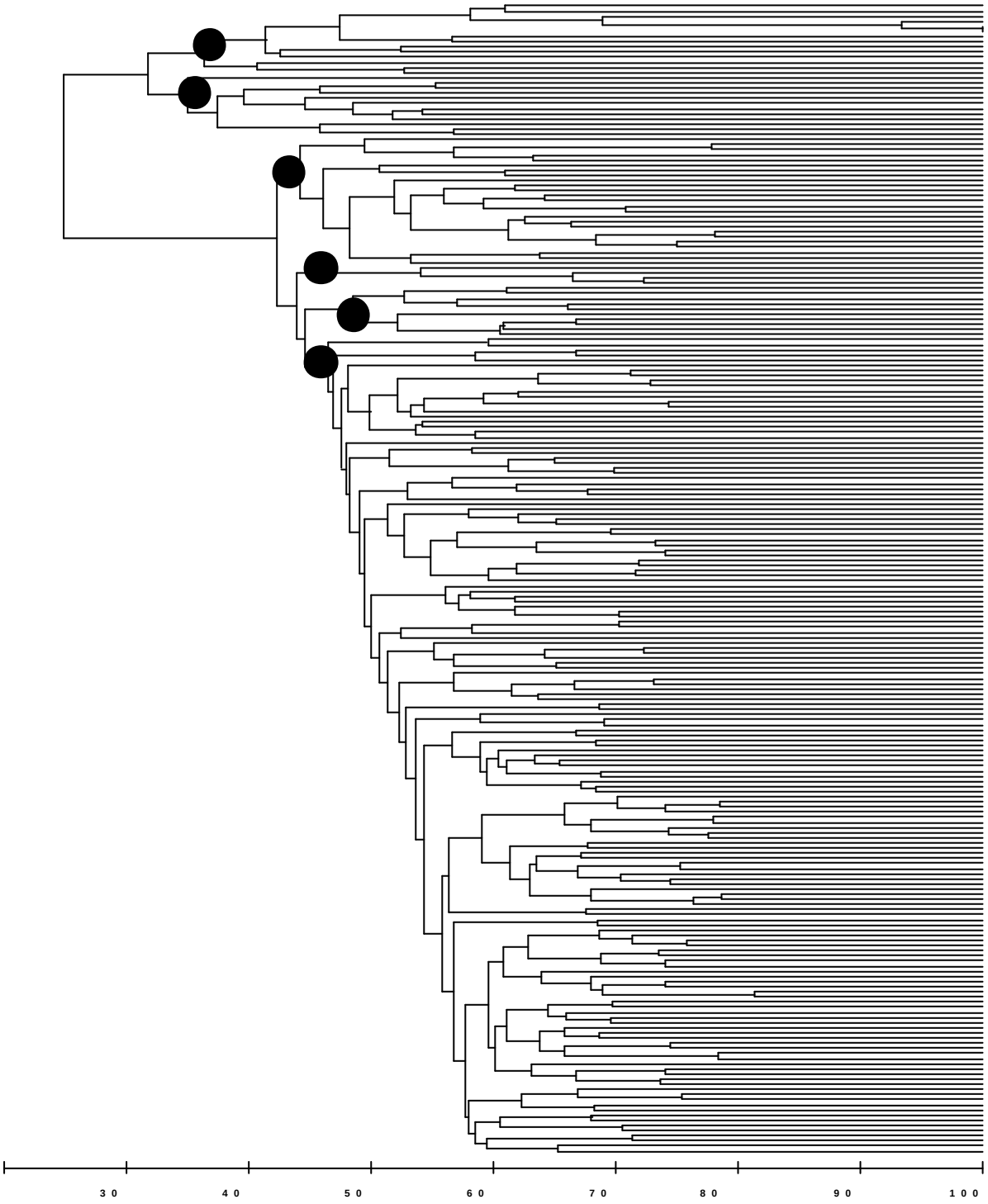

Figure 3 The dendrogram from cluster analysis of the baseline survey data from the six areas surveyed in detail. Each line represents one survey site. Solid black circles highlight the six major groups representing the benthic classes discriminated with this analysis. Y-axis represents Bray-Curtis similarity (%).

Interpretation of the reef profiles (Figures 4a-f) facilitated descriptions of the reefal resources of each of the six areas surveyed in detail:

P. Balasapan

The reef profiles around P. Balasapan (Figure 4a) show that the forereef becomes wider and steeper at the southern end of the reef (transects 13-15). This area also has a separate "sand with sparse algae" habitat in deep water. However, it is likely that this habitat is also present below the maximum survey depth (30m) in the central and northern sections (transects 1-12 and 16-17). The forereef at Balasapan is dominated by the "green algae and hard corals" benthic class. The high level of *Halimeda* indicates that the area has been affected by human impact, for example by the removal of herbivores. The poor state of the reef is likely to be a result of destructive fishing since the reef is close to a number of fishing villages.

Molombo

The reef profiles around Molombo (Figure 4b) show that this area generally has a reasonably wide forereef with limited escarpment development. Escarpments are limited to the south western end of the island, which is consistent with the edge of the continental slope (Figure 2a). The only benthic class found in the area was “green algae and hard corals" indicating human impact, possibly through destructive fishing, although there is evidence of established regrowth. Destructive fishing is likely to have occurred in this area because of the proximity of several fishing communities.

Bungin

The reef profiles around Bungin (Figure 4c) show that there is a wide forereef and no clear escarpment above 20m. However, there is some variation in the topography since it varies from a homogeneous slope (transects 12-16) to a slope incorporating a mini-wall (transect 7). The forereef appears to support only one major benthic class which is "green algae and hard corals". This indicates that the area is in poor condition with some regrowth. The poor state of the reef is likely to be a result of destructive fishing since the island is in close proximity to a number of fishing villages.

P. Tolobundu

The reef profiles around Tolobundu (Figure 4d) show that the area has a variety of profiles and benthic classes. The eastern side shows a relatively narrow forereef which becomes steeper with increasing depth, as is evident on transects 4-6. The dominant benthic class is "green algae and hard corals" indicating established regrowth following human impacts, possibly from destructive fishing since there are a number of fishing communities in close proximity. The western side has a wider forereef than the eastern side and also appears to have signs of human impact since “green algae and hard corals” is the dominant benthic class. There are also some areas which have been heavily impacted (particularly transects 4-6) and have extensive dead coral. The north western area is characterised by increasing occurrences of the benthic class "sand and sparse algae", perhaps indicating a change in substratum.

Figure 4a. The major reef profiles and habitat types found by survey work around P. Balasapan. Each individual profile represents a full CCC survey transect which is representative of the section of reef indicated.

Figure 4b. The major reef profiles and habitat types found by survey work around Molombo. Each individual profile represents a full CCC survey transect which is representative of the section of reef indicated.

Figure 4c. The major reef profiles and habitat types found by survey work around Bungin. Each individual profile represents a full CCC survey transect which is representative of the section of reef indicated.

Figure 4d. The major reef profiles and habitat types found by survey work around P. Tolobundu. Each individual profile represents a full CCC survey transect which is representative of the section of reef indicated.

Figure 4e. The major reef profiles and habitat types found by survey work around Tolumbakan. Each individual profile represents a full CCC survey transect which is representative of the section of reef indicated.

Figure 4f. The major reef profiles and habitat types found by survey work around P. Bangkulu. Each individual profile represents a full CCC survey transect which is representative of the section of reef indicated.

Tolumbakan

Tolumbakan is one of the true atolls in the Banggai Islands and this is reflected in the reef profiles (Figure 4e) which show a steep outer escarpment, the top of which can be exposed at low tide, and a narrow, shallow forereef (transects 1-21). The zonation found on the outer wall can be seen to generally include a deeper area of "bedrock and octocorals". The lack of a high hard coral cover is likely to be caused by the sheer topography of the escarpment rather than any human influence. The forereef has been impacted by destructive fishing since the benthic class "green algae and hard corals" is common, along with other small areas with the "sand and sparse algae and coral" class, extends across the forereef. The outer escarpment is aesthetically excellent.

Transects 22 and 23 show the profile of the inner or internal wall found in the northern section of the atoll. This internal wall joins the outer wall via a narrow ridge and generally supports the "green algae and hard corals" benthic class.

P. Bangkulu

The reef along the eastern side of Bangkulu is relatively homogeneous with a relatively narrow forereef consisting of a deep zone of "sand and sparse algae" and a shallow zone of "green algae and hard corals". The deep sandy zone is natural and likely to be caused by a change of substratum and the high sediment load (pers. obs.). The presence of the "green algae and hard corals" benthic class indicates human impact, possibly via destructive fishing as there are a number of fishing communities in close proximity. In some areas, particularly in front of the CCC camp, the reef crest appears to be in good condition and it is possible that further survey work in shallow water will be able to distinguish a benthic class characterized by a high abundance of *Acropora* spp..

4.4. Summary of detailed baseline surveys

The descriptions in Section 4.3 suggest that all of the areas surveyed in detail, but particularly those in areas close to fishing communities, have been impacted by human influences, especially destructive and over fishing. The reefs that appeared to be the least affected were found at Tolumbakan, because there is no land on the atoll and hence has no resident fishing community. This atoll also appeared to have the highest abundance and diversity of fish (pers. obs.).

This initial survey work provides evidence of significant threats to the health of the coral reef ecosystem and hence to the economy of local communities. There is, therefore, an urgent need for further survey work and subsequent management initiatives in the Banggai Islands before the reefs are degraded further. For example, a community-driven, marine protected area would provide additional income to local people, allow sustainable management of the fisheries and maintain the integrity of the reef system.

5. RESULTS OF ADDITIONAL SURVEY WORK

5.1. Point intercept transects

A total of 16 surveys were carried out close to the CCC base camp at P. Bangkulu. The results of this work are summarized in Table 4 and also on Figure 5.

	DEPTH (M)						
	1	**3**	**6**	**9**	**12**	**15**	**18**
Sand	15.0 (7.1)	29.4 (17.2)	40.9 (22.8)	43.0 (21.6)	46.5 (28.8)	67.8 (35.2)	83.6 (21.7)
Rubble	2.5 (3.5)	20.6 (15.4)	29.6 (19.8)	12.9 (14.5)	6.4 (8.9)	12.1 (18.7)	2.1 (3.9)
Dead coral	0.0 (0.0)	9.1 (8.1)	6.4 (7.3)	9.3 (12.0)	7.6 (10.7)	3.4 (5.9)	0.0 (0.0)
Bedrock	0.0 (0.0)	0.5 (2.2)	0.2 (0.9)	0.6 (1.6)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Hard coral	67.5 (10.6)	31.9 (18.9)	14.5 (12.6)	22.4 (15.5)	27.5 (20.2)	9.7 (17.1)	5.0 (11.2)
Soft coral	0.0 (0.0)	2.5 (3.8)	1.4 (2.3)	3.1 (7.1)	4.8 (6.2)	1.3 (3.0)	0.0 (0.0)
Invertebrates	15.0 (14.1)	2.4 (3.8)	2.7 (3.4)	3.5 (5.4)	2.1 (3.2)	2.0 (3.2)	2.9 (3.9)
Sponges	0.0 (0.0)	0.8 (2.4)	0.9 (2.0)	2.5 (3.1)	3.2 (3.7)	1.0 (2.8)	2.9 (3.9)
Seagrass	0.0 (0.0)	2.5 (6.8)	0.5 (1.5)	1.1 (2.7)	0.6 (1.6)	1.0 (2.8)	0.7 (1.9)
Algae	0.0 (0.0)	0.5 (1.5)	3.0 (4.0)	1.7 (3.4)	1.4 (2.9)	1.7 (5.2)	2.9 (7.6)

Table 4. The mean percentage cover of the major substratum and benthic categories from point intercept surveys on the reef at P. Bangkulu. Standard deviation shown in parentheses. Sample sizes: 1m = 2, 3m = 20, 6m = 22, 9m = 18, 12m = 18, 15m = 15 and 18m = 7.

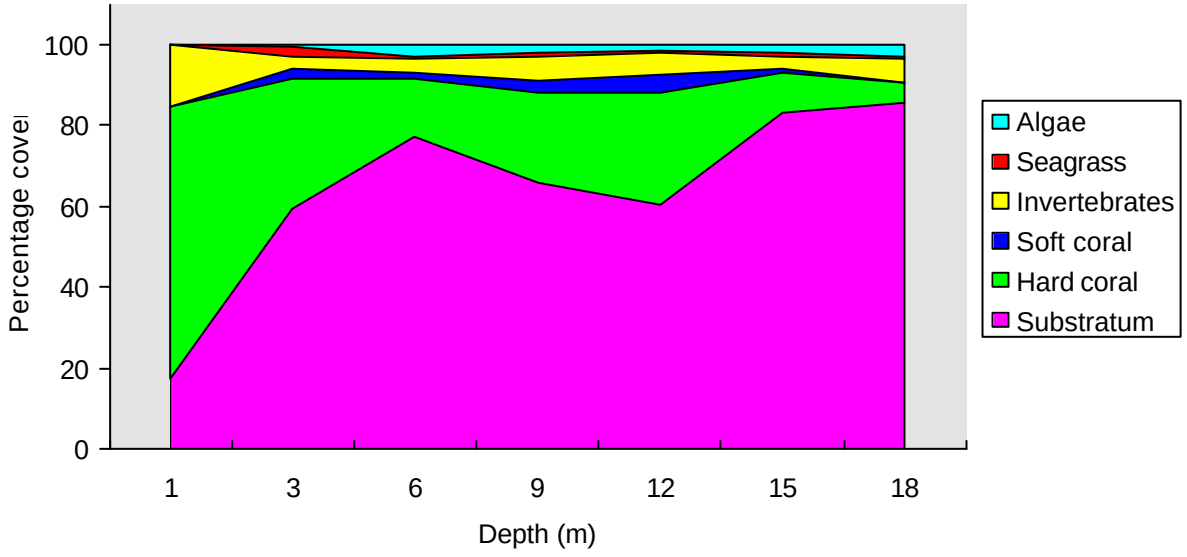

Figure 5. A summary diagram of the composition of the fringing reef at P. Bangkulu from data collected during point intercept surveys.

The results from the point intercept surveys show a clear trend of increasing bare substratum and decreasing hard coral cover with increasing depth. This corresponds with the baseline surveys of this area which revealed a change in habitat type from sand bed to coral dominated reef at approximately 12m. The high coral cover in shallow water (maximum 67.5%) represents an established and healthy reef flat area. The other benthic categories are relatively constant with increasing depth.

5.2. Crown of thorns starfish (*Acanthaster planci*) survey

A total of 15 live *A. planci* were observed by seven survey teams. The majority of the individuals were located under live *Acropora* spp., both in clusters and as individuals and in water from 1.5 to 9 metres deep (mean 4.0m, standard deviation 2.4m). The starfish were between 20 and 40cm in diameter (mean 28cm, standard deviation 6cm). The completed Great Barrier Reef Marine Park Authority survey form is included in Appendix 3.

A known predator of *A. planci*, the triton shell *Charonia tritonis*, was observed only once during the three month fieldwork period. Triton shells are considered a delicacy in the Banggai Islands (Local counter-parts, pers. comms). The over-harvesting of *Charonia tritonis* and other predators such as the humphead wrasse (*Cheilinus undulatus*) may lead to future increases in the number of *A. planci*.

The low population density revealed during this survey work suggest that there is currently not a serious threat to the health of the reefs from *A. planci*. However, since *A. planci* is known to reproduce rapidly and the population of known predators has been reduced it is recommended that starfish numbers are monitored closely and sustainable fishing of the predators is introduced.

5.3. Giant clam (*Tridacna* species*)* survey

A total of 28 clams were observed by seven survey teams. The average size of the clams observed was 12.8cm (standard deviation 7.6cm). The average depth clams were recorded in water between 1 and 13m deep (mean 5.1m, standard deviation 3.7m).

CCC also observed three giant clams *(Tridacna gigas)* 1.5m in diameter located in front of the most northern house of Lantibung village at approximately 12 metres depth.

This survey suggests that the reef close to the CCC base camp at P. Bangkulu still supports a good population of clams. However, numbers should be monitored because of the pressure on the fishery resources of the area.

5.4. Taxonomy

A preliminary fish species list for the Banggai Islands was compiled using Lieske and Myers (1994), Kuiter (1992), Allen and Steene (1994) and Muller (1994). A total of 438 fish species were confirmed by the science officer, aided by experienced CCC volunteers. The list is included as Appendix 4. A number of “probable” and “possible” fish species were also recorded but have not been confirmed and thus have been omitted from the main list.

Perhaps the most interesting record in Appendix 4 is of the poorly known Banggai Cardinalfish (*Pterapogon kauderni*) which is endemic to the Banggai Islands. These fish were

first described in the 1920's but only recently rediscovered (Heather Hall, pers. comm.). *P. kauderni* are thought to have remained endemic to the area because of their life history since the male fish are mouthbrooders and the young remain in the mouth for 20 days. This restricts the geographical range of the species compared to many other reef fish which have a pelagic life stage.

5.5. Physical data

Table 5 summarizes the results of the salinity and temperature readings taken from each of the two monitoring sites at P. Bangkulu over a period of ten weeks.

	TIME	SAMPLE SIZE	STATION 1		STATION 2	
			Surface	Bottom	Surface	Bottom
Salinity (‰)	7am	28	32.6 (3.0)	33.7 (1.4)	33.3 (1.5)	33.7 (1.3)
	1pm	24	32.0 (2.7)	32.8 (1.5)	31.8 (1.9)	32.9 (2.1)
	5.30pm	16	33.0 (1.8)	33.8 (1.1)	33.5 (1.6)	33.1 (1.8)
Temperature (^{0}C)	7am	28	29.3 (1.9)	29.1 (2.3)	29.2 (0.5)	29.1 (0.5)
	1pm	24	29.7 (0.6)	29.7 (0.6)	29.8 (0.7)	29.8 (0.8)
	5.30pm	16	29.1 (0.7)	29.1 (0.7)	29.1 (0.8)	29.2 (0.7)
Depth (cm)	7am	28	98.4 (51.1)		143.0 (43.2)	
	1pm	24	80.0 (45.3)		109.0 (52.9)	
	5.30pm	16	61.9 (35.5)		93.1 (43.3)	

Table 5. Mean salinity, temperature and depth readings from the stations 1 and 2 in front of the CCC base camp at P. Bangkulu. Standard deviations shown in parentheses.

The results from the monitoring sites indicate that the structure of the water column is relatively stable throughout the day. The mean temperature range was 29.1-29.8^{o}C and the mean salinity range was 31.8-33.8‰. The generally higher salinity at the bottom of the water column than at the surface may indicate a significant, terrestrial freshwater run-off.

Tidal observations showed that around P. Bangkulu the tide floods to the south and ebbs to the north. The tidal range reached a maximum of 2m (on a high spring tide) and a minimum range (on small neap tide) of approximately 0.8 metres. High water time for the spring tides around P. Bangkulu was calculated to range from about midday on the first day to about 15:30 hours after four or five days. Low water was approximately six hours either side of high water. The high water was generally higher at night followed by a low low water.

5.6. Sediment analysis

Analysis of the two beach sediment samples collected from the CCC base camp on P. Bangkulu shows that they were similar in composition. The grains were composed of quartz, plagioclase and orthoclase felspar, muscovite and biotite micas, implying a granite source rock. Very occasional coral and mollusc fragments are also observed and may be derived from pleiatocene or recent reef sources. The poor degree of sorting (see Figure 6), mixed

mineralogy and sub-angular nature of the constituent grains imply a short transport distance from source area.

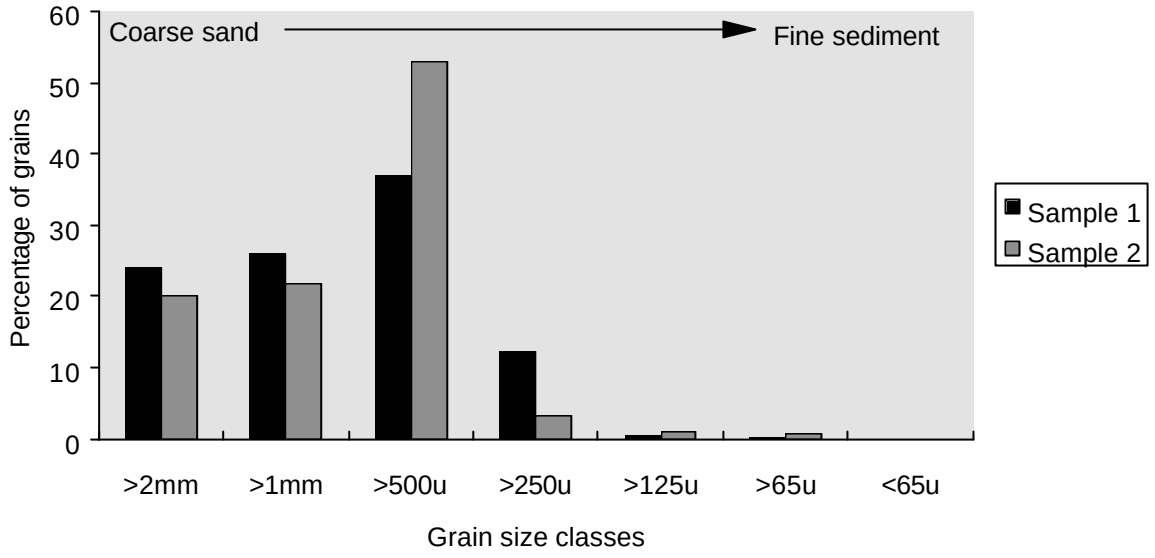

Figure 6. Results of grain size analysis of beach sand from the CCC base camp. Sample 1 is from the high water mark and Sample 2 is from the low water mark. u = microns.

6. EDUCATION PROGRAMME

6.1. Introduction

Establishing education and environmental awareness programmes is a key component of all CCC projects. During the 1996 fieldwork CCC initiated an education programme for local schools and training opportunities for Indonesian counterparts.

6.2 School education programme

This programme was conducted between the 3rd and 28th of November and every school on Bangkulu Island (4 Junior High and 12 Elementary) was invited to send approximately 10 students to the CCC base camp. All 16 schools accepted and participated in the education programme which was conducted for two or three schools at a time.

The children were allocated three hours within which time they were given a short introduction to coral reefs, shown a video and were then asked to produce drawings and models of a subject related to the marine environment.

The education programme incorporated illustrated talks on:

- an introduction to CCC; the reasons for CCC being in the Banggai Islands;
- basic coral biology;
- the importance of coral reefs;
- the threats to the health of coral reefs.

The video shown during the education programme was produced by CCC during the expedition and incorporated examples of the different types of marine life found in the Banggai Islands, healthy and the damaged coral reefs and footage of teams of divers surveying along a transect. A full commentary in Indonesian was provided throughout the video presentation.

6.3. Training programme

A total of 11 Indonesian counterparts from both the local community and from regional and national government departments were trained by CCC during the fieldwork. This training incorporated SCUBA diving certification, an introduction to marine ecology and taxonomy and participation in survey work. This training was designed to improve environmental awareness and the capacity for biodiversity assessment and monitoring. Five places were available to the local community and were funded by scholarships from the Coral Cay Conservation Trust.

A summary of the training and experience received by the counterparts is summarized in Table 6.

NAME	ORIGIN	PADI OPEN WATER TRAINING	SCIENTIFIC TRAINING	PARTICIPATION IN SURVEY WORK
Nita Mandagi	Yayasan Rinjani Bahari	✍✍	✍✍	✍✍
Ibu Lusi	PHPA, Ministry of Forestry	*	✍✍	✍✍
Ir. Firmansyah Basri	BAPPEDA, Kab. Banggai		✍✍	✍
Hendrata	Media Indonesia	*	✍✍	✍✍
Ratna Kartikasari	BAPEDAL, Jakarta	*	✍✍	✍✍
Muhammad Yunus	BAPEDAL, Jakarta	*	✍✍	✍✍
Indra Diman	Scholar, Desa Lantibung	✍✍	✍✍	✍✍
Jibran Dilamo	Scholar, Desa Lantibung	✍✍	✍✍	✍✍
Arman Yasibang	Scholar, Desa Lantibung	✍✍	✍✍	✍✍
Abdul Hafid	Scholar, Desa Lantibung	✍✍	✍✍	✍✍
Abdi Bukamo	Scholar, Desa Lantibung	✍✍	✍✍	✍✍

Table 6. A summary of the training and experience gained by the Indonesian counterparts during the 1996 fieldwork. Scientific training refers to the marine life identification course documented in Section 2.1.* indicates dive training prior to joining the Banggai Islands Conservation Project.

7. FUTURE WORK

The 1996 fieldwork carried out by CCC volunteers and Indonesian counter-parts has established a preliminary database for the diverse reefs of the Banggai Islands and has begun to document the threats and effects from human impacts. It is recommended that the work initiated by YSDL and CCC in 1996 should be continued and extended in order to establish management initiatives, particularly for the sustainable use of the marine resources. Further work should incorporate:

- Completing baseline surveys around the islands explored during the 1996 fieldwork and also to assess other islands in the area;
- Production of an accurate geo-rectified base map from aerial photographs and satellite imagery from which GIS-generated habitat maps can be produced;
- Gathering quantitative data on the reefs around the Banggai Islands. This should incorporate study of the benthic communities, numbers of commercially and ecologically important fish species and commercially and ecologically important invertebrates;
- Establishing monitoring programmes, measuring a range of biological and physical parameters, at key locations throughout the Banggai Islands;
- Establishing collaborative research links with specialised taxonomists to fully document the species richness of the area;
- Extension of the education and training programmes.

Conclusion

It is recommended that, because of the diversity of the species and habitat types found on the reefs in the Banggai Islands and the obvious threats to their health, the work outlined above should be undertaken as soon as possible. Furthermore, the work could be undertaken by CCC volunteers and Indonesian counter-parts as part of a systematic assessment of the Banggai Islands over a minimum of three years. The results from a long-term project could then be used to propose sanctuary (no-fishing) areas throughout the area to maintain the integrity of the coral reef ecosystem, provide sustainable fishing to local people and encourage tourism and the associated investment in the Banggai Islands. However, in order to designate effective sanctuary areas, baseline data is essential to ensure that they incorporate as many of the major benthic classes as possible, provide suitable refuges for commercially important fish species and protect any particularly rare or fragile communities or species.

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APPENDIX 1

A sample boat, physical and 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

APPENDIX 2

The median abundances of each of the algae, sponge life forms, octocoral life forms, coral life forms and target species / genera and substratum categories in each of the six major benthic classes identified during the 1996 fieldwork.

	Sand and sparse algae	Sand and sparse algae and coral	Bedrock and octocorals	Dead coral and algae	Green algae and octocorals	Green algae and hard corals
Cyanophyta						
Blue-green algae	0.1	0.1	0.1	0	0.3	0.4
Chlorophyta						
"Filamentous"	0.8	0.2	0.3	0	0.1	0.3
Bornetella	0		0	0	0.1	0
Caulerpa	0	0.2	0	0	0	0.3
Chaetomorpha	0	0	0	0	0	0
Codium	0	0.1	0	0	0	0
Halimeda	0.5	0.5	0.9	1.8	2.3	2.5
Neomeris	0	0	0	0	0.1	0
Tydemania	0.1	0	0	0	0	0.1
Valonia	0	0	0	0	0	0.2
Phaeophyta						
"Filamentous"	0	0.1	0.2	0	0.2	0.2
Dictyota	0.1	0.3	0.7	0	1	0.4
Lobophora	0	0.2	0.1	0.2	0.2	0.3
Padina	0	0.4	0.1	0.5	0.5	0.8
Ralfsia	0	0	0	0	0.1	0
Rosenvingea	0	0	0	0.2	0.1	0
Turbinaria	0	0.7	0	0.8	0.5	0.4
Rhodophyta						
"Calcified"	0	0.1	1.8	1	0.1	0.2
"Filamentous"	0.9	0.2	0.1	0	0.3	0.4
Actinotrichia	0	0	0.1	0	0	0
Amphiroa	0	0	0	0	0	0
Ceramium	0	0	0	0	0.1	0
Eucheuma	0	0	0.1	0	0	0
Galaxaura	0.1	0.1	0.2	0.5	1.5	0.8
Gelidiella	0	0	0	0	0	0
Gelidium	0	0	0	0	0.1	0
Halymenia	0	0	0	0	0	0
Jania	0	0.3	0.2	0	0.3	0.2
Angiospermae						
"Seagrass"	0.3	0.5	0	0.5	0.3	0.2
Thalassia	0.1	0.3	0	0.5	0	0

	Sand and sparse algae	Sand and sparse algae and coral	Bedrock and octocorals	Dead coral and algae	Green algae and octocorals	Green algae and hard corals
Porifera						
Ball	0	0	0.1	0	0.1	0
Barrel	0.1	0	1.1	0	0.3	0.5
Branching	0.2	0.1	1.1	0	1.3	0.9
Elephant Ear	0.2	0	0.7	0	0.2	0.7
Encrusting	0.3	0.3	1.6	0.8	2	1.3
Lumpy	0.4	0.1	1.1	0	2	1
Tube	0.3	0	1.7	0.5	1.5	1.2
Vase	0	0	0.2	0	0	0.1
Octocorals						
"Deadmans fingers"	0.1	0.3	0.8	1	1.7	1.1
"Leathery"	0.4	0.4	1.2	0.2	2.1	1.2
"Tree"	0.5	0.4	1.9	1.5	2	1.8
Sea fan	0	0	1.6	0.2	1	0.6
Sea whip	0.1	0	1.3	0	1	0.4
Tubipora musica	0	0.1	0.6	1	0.2	0.2
Xenia	0.1	0	0.9	1.5	1.8	1.1
Antipatharia						
Black coral	0	0	1.3	0	0.1	0.1

	Sand and sparse algae	Sand and sparse algae and coral	Bedrock and octocorals	Dead coral and algae	Green algae and octocorals	Green algae and hard corals
Target corals						
"Bottlebrush" *Acropora*	0	0	0.2	1	0	0.6
Brain: small	0	0	0.5	0.5	0	0.2
Brain: medium	0	0	0.3	0	0	0.3
Brain: large	0	0	0.2	0	0.2	0.1
Ctenactis echinata	0	0.2	0.3	1	0.1	1
Diploastrea heliopora	0	0	1.3	1.5	0.1	0.5
Euphyllia	0	0	0	0	0	0
Favia	0	0.4	1.3	0.5	0.5	1
Favites	0	0.7	1.3		0.9	1.2
Galaxea	0	0	0.7	0.5	0.3	0.7
Goniopora	0	0	0.1	0.5	0.2	0.1
Herpolitha limax	0	0	0	0	0.3	0.4
Lobophyllia	0	0	0.7	1.2	0	0.5
Millepora intricata	0	0	0	0	0	0.2
Millepora platyphyllia	0	0	0.1	0	0	0.1
Montipora digitata	0	0	0	0	0	0.1
Montipora foliosa	0	0	0.9	0.2	0.1	0.4
Pachyseris rugosa	0	0	1.2	0.2	0.2	0.4
Pachyseris speciosa	0	0	1.7	0.5	0.2	0.5
Pavona clavus	0	0	0	0	0.1	0.1
Pectinia lactuca	0		0.3	0.2	0.2	0.6
Pleurogyra sinuosa	0	0	0.1	0.2	0	0.1
Pocillopora: small	0	0.1	0.2	0	0.1	0.3
Pocillopora: medium	0	0.3	0.5	0.5	0.3	1.1
Pocillopora: large	0	0	0.2	0	0.1	0.3
Polyphyllia talpina	0	0	0	0.2	0	0.1
Porites cylindrica	0	0.3	0.1	0.2	0	1
Porites "massive"	0.1	1.2	1.1	0.5	1.5	1.9
Porites nigrescens	0	0	0.1	0	0	0.9
Seriatopora hystrix	0	0.1	0.6	0	0.7	1.2
Stylophora mordax	0	0.3	0.1	0.5	0	0.2
Stylophora pistillata	0	0	0.1	0.5	0.1	0.3
"Upsidedown bowl"	0	0	0	0	0.1	0.3

	Sand and sparse algae	Sand and sparse algae and coral	Bedrock and octocorals	Dead coral and algae	Green algae and octocorals	Green algae and hard corals
Coral life forms						
Acropora: Branching	0.2	0.4	1	1	0.8	1.7
Acropora: Digitate	0	0.5	0.1	0	0	0.7
Acropora: Encrusting	0	0	0	0	0	0
Acropora: Submassive	0	0	0.1	0	0.1	0.3
Acropora: Tabulate	0.1	0.4	1.5	0.8	1.2	1.2
Heliopora: Blue Coral	0	0.3	0	0.2	0	0.1
Millepora: Fire Coral	0	0	0.1	0	0	0.6
Non-*Acropora*: Branching	0.1	0	0.6	1.2	1	2
Non-*Acropora*: Encrusting	0	1.3	3.2	1	1.3	1.7
Non-*Acropora*: Foliose	0	0.1	1.6	1	0.2	1.2
Non-*Acropora*: Massive	0.2	1	0.7	0.8	0.2	1.7
Non-*Acropora*: Mushroom	0.1	0.3	0.5	1.5	0.1	1.7
Non-*Acropora*: Sub-massive	0	0.2	0.4	0	0.1	1.1
Substratum						
Bedrock	0.1	0.1	2.9	0	1.7	0.5
Dead coral	0.3	1	0.8	2	1.2	1.6
Dead coral with algae	0.1	0.5	0.7	1	0.5	1.5
Rubble	0	0.8	0.2	2	0.5	1.2
Sand	4.9	4.2	0.2	1.5	1.8	1.7

APPENDIX 3

The completed Great Barrier Reef Marine Park Authority survey form for crown of thorns starfish (*Acanthaster planci*).

APPENDIX 4

A list of the confirmed fish species found by CCC staff and volunteers in the Banggai Islands during the 1996 fieldwork.

Figure 1. The location of the Banggai Islands within Indonesia. *Overleaf:* A detailed map of the Banggai Islands.

Figure 2a. The locations of all the survey transects completed by CCC volunteers and counterparts during the 1996 fieldwork. *Overleaf:* **Figure 2b.** The positions of all the individual transects completed around the six areas surveyed in detail.