

SOUTHERN NEGROS COASTAL DEVELOPMENT PROGRAMME

MUNICIPALITY OF SIPALAY



- 2000 summary report prepared on behalf of -

PHILIPPINE REEF AND RAINFOREST CONSERVATION FOUNDATION INC.

- by -

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EXECUTIVE SUMMARY

Negros Island, as part of the Visayas, Philippines, supports significant areas of coral reef and tropical forest, two of the most diverse ecosystems on earth. The region lies in one of the most diverse areas on Earth and its reefs and rainforests support a large number of endemic species. These ecosystems also provide an important source of food and revenue for local communities. However, both the reefs and forests in Negros are under increasing threat from a range of anthropogenic activities.

The Southern Negros Coastal Development Programme (SNCDP) is an initiative of the regional government to encourage the conservation and sustainable use of their natural resources. The Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI) and Coral Cay Conservation (CCC), have been collaborating within this programme to provide an accurate baseline assessment of the coral reefs in the region. The project also aims to obtain monitoring data from reefs and forests and provide community organising and training, conservation education opportunities for Filipino counterparts and alternative livelihoods in the communities.

From August 1997 until March 1999, CCC conducted baseline surveys in the region of the Municipality of Sipalay. The fringing reef along the coastline was surveyed in order to describe benthic community classes and identify fish communities and gross anthropogenic impacts. The data were used to establish a GIS-compatible database and a detailed qualitative and quantitative data analysis is presented in this report. It describes twelve distinct benthic classes which can be related to the health status of the reefs. Analysis showed that the habitats were physically and biologically diverse and in 'good' to 'fair' health compared to many other Southeast Asian reefs. However, there were also impacts and indicators which showed that damage has occurred in some areas.

The most significant anthropogenic impacts appeared to be sedimentation and over-fishing. Sedimentation has affected the reefs in areas adjacent to rivers and in areas with poor circulation. There was some evidence of sewage and algal overgrowth. Fish communities appeared to be similar across all habitats and were of small size and commercially important fish were rare. The reefs in the Municipality of Sipalay were also affected by the 1998 coral bleaching event although final mortality levels are unknown.

As a result of the analysis, possible sites for marine protected areas in the region were identified. It is recommended that the SNCDP should continue and that baseline surveys in the Municipality of Sipalay should be completed. Establishment of an Integrated Coastal Zone Management Plan for Southern Negros is recommended, which should encompass forests, mangroves and coastal marine resources. Key supporting activities should include the strengthening of conservation education opportunities within local schools and communities and provision of further skills training programmes to establish a Filipino-led team capable of carrying out long-term surveys and monitoring programmes.

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ABBREVIATIONS

ANOSIM	Analysis of Similarities
ASEAN	Association of South East Asian Nations
BC	Benthic Class
CCC	Coral Cay Conservation Ltd.
CCC-TS	CCC Transect Survey
CCC-CS	CCC Contour Survey
CZM	Coastal Zone Management
DENR	Department of Environmental and Natural Resources
ENSO	El Niño Southern Oscillation
GIS	Geographical Information System
GPS	Global Positioning System
ICZMP	Integrated Coastal Zone Management Plan
IUCN	World Conservation Union
LGU	Local Government Unit
PADI	Professional Association of Diving Instructors
PRIMER	Plymouth Routines in Multivariate Ecological Research
PRRCFI	Philippine Reef and Rainforest Conservation Foundation, Inc
PRRP	Philippine Reef and Rainforest Project
SCUBA	Self Contained Underwater Breathing Apparatus
SIMPER	Similarity Percentage
SMB	Surface Marker Buoy
SNCDP	Southern Negros Coastal Development Programme
SNICZMP	Southern Negros Integrated Coastal Zone Management Plan
UNEP	United Nations Environment Programme
UK	United Kingdom
WWW	World Wide Web

1. INTRODUCTION

The Philippines lie within one of the most biologically diverse regions in the world (Wilkinson *et al.*, 1993). Recent evidence⁽¹⁾ shows that more than two-thirds of the earth's biological resources are found within 17 'mega-diverse' countries, including the Philippines. Furthermore, the Philippines is ranked amongst the top six in terms of endemism and species diversity.

The tropical forests and coral reefs of the Philippines are of vital importance both ecologically and economically. However, because of rapid economic and population growth, the Philippines' forests are under increasing threat from logging and agricultural development. Similarly, the country's coral reef ecosystems are being adversely affected by a range of anthropogenic activities including over-fishing, destructive fishing techniques, sedimentation, eutrophication and pollution. These impacts represent substantial long- and short-term threats to the ecological balance of reef ecosystems. If left unchecked, decreasing reef health and deforestation will ultimately lead to increased poverty amongst communities relying on agriculture, fishing and tourism.

Effective management, including conservation of coral reefs and tropical forests, requires a holistic and multi-sectorial approach. This is often a highly technical and costly process which many developing countries cannot adequately afford. With appropriate training, non-scientific, self-financing volunteer divers have been shown to be able to provide useful data for coastal zone management at little or no cost to the host country. This technique has been pioneered and successfully applied by Coral Cay Conservation (CCC), a British non-profit organisation.

Since 1997, the Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI) and Coral Cay Conservation (CCC), have been collaborating in line with the Southern Negros Coastal Development Programme (SNCDP), an initiative of the regional government of Southern Negros to manage the coastal resources on a sustainable basis. PRRCFI and CCC aim to provide technical assistance for a comprehensive and systematic survey of coastal marine resources throughout six municipalities of Southern Negros. The SNCDP has been developed based on the highly successful Philippine Reef and Rainforest Project (PRRP) on Danjungan Island, Southern Negros Occidental. The objectives of this long-term project include to undertake baseline coral reef and rainforest surveys, monitor ecosystem health, provide training, conservation education opportunities and alternative livelihoods for local communities. The ultimate aim of the SNCDP is to implement an Integrated Coastal Zone Management Plan in the region and a detailed description of aims and objectives of the SNCDP is given in this report.

The Municipality of Sipalay contains complex marine resources which were assessed by CCC volunteers from 1997 to early 1999. This report provides the qualitative and quantitative data analysis of these baseline reef surveys and it includes results, a synthesis of the work and offers recommendations for future work.

⁽¹⁾ Conservation International website (<http://www.conservation.org/>)

2. PROJECT BACKGROUND

2.1 Coral reefs in the Philippines

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). In the Philippines, coral reefs provide a vital source of food and revenue for local communities and recently income from tourism in the coastal zone has become increasingly important.

The Philippine Archipelago (Figure 1) consists of more than 7000 islands (UNEP / IUCN, 1988). The coastline extends for over 34,400 km and supports some of the richest and most diverse coral reef systems in the world. Reefs, which cover approximately 25,000 km², are generally fringing and vary in length from tens of metres to 5 km (Chou, 1998). High levels of biodiversity are typified by the high scleractinian diversity with 499 species currently recorded from the Philippines (Chou, 1998) and the final total is likely to be higher (Fenner, pers. com.).

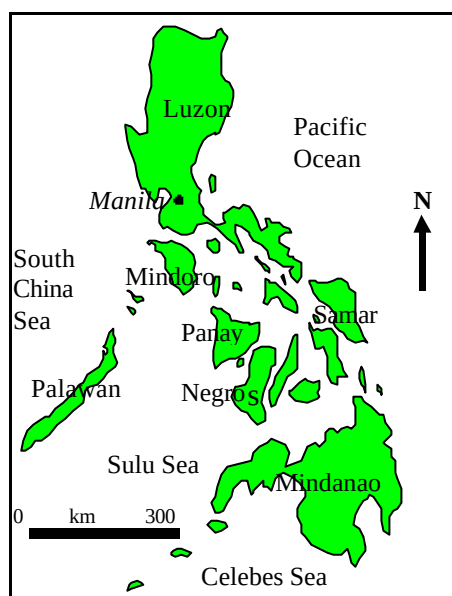


Figure 1. Map of the Philippines.

2.2 Negros and the Municipality of Sipalay

Negros is situated southwest within the Visayas, a central group of islands in the Philippines (Figure 2). It consists of two provinces Negros Occidental and Negros Oriental. The main industry in Negros is sugar production, with more than 50% of the land area utilised by the sugar industry for plantations and refineries. The Municipality of Sipalay is situated in the south west coast of Negros Occidental, south of Kabankalan and the main city is Sipalay.

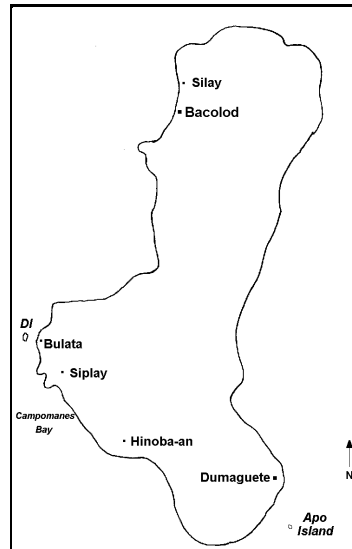


Figure 2. Map of Negros. DI – Danjugan Island.

2.3 Threats to Filipino reefs

Over 80% of the reefs in Southeast Asia, including those in the Philippines, are at ‘risk’ because of anthropogenic impacts (Bryant, *et al.*, 1998). Chou (1998) documents the main threats to reefs as being:

- ?? Forest and mangrove clearance leading to sedimentation;
- ?? Discharge of untreated domestic and industrial wastes;
- ?? Over-fishing of reefal and benthic fish and invertebrate species using traditional techniques;
- ?? Destructive fishing using explosives, cyanide and *muro-ami* (scaring fish into wide nets via the use of sticks or rocks hit against the reef);
- ?? Typhoon damage;
- ?? Infestations of *Drupella* snails and *Acanthaster planci* (crown-of-thorns starfish).

In addition, during 1998 large parts of the reef of the Philippines suffered from massive coral bleaching, due to the ENSO event, although levels of mortality may be low (Wilkinson, 1998).

Bryant *et al.* (1998) estimate that all reefs in the Philippines are at ‘risk’, with 85% at ‘high risk’. These estimates are supported by data collected by the ASEAN-Australia Marine Science Project (1992) which found that only 30.5% of reefs were in good or excellent condition (>50% coral cover) whilst 69.5% were in fair or poor condition (<50% coral cover). Despite the reefs in Palawan being in better condition than many other areas of the Philippines, because of their remoteness, estimates in 1993 still indicated 10% of the reef was degraded (Chou *et al.*, 1994). Sediment damage caused by deforestation for road building has been shown to be particularly damaging (Hodgson, 1993).

3 SOUTHERN NEGROS COASTAL DEVELOPMENT PROGRAMME

3.1 Background

Since 1995, the PRRCFI and CCC have successfully co-operated in implementing programmes to support sustainable resource use and community based coastal zone management. The main aim of these activities is to undertake a resource assessment, raise the environmental awareness amongst local people and build both educational and practical capacities in order to implement the management schemes recommended in this report.

The initial project of this collaboration was the PRRP in Negros Occidental (Section 3.5) in the Municipality of Cauayan. The success of the project raised the awareness about environmental issues and sustainable coastal resource use and thus led to the establishment of the SNCDP (Section 3.3). The SNCDP is a government programme to accommodate coastal zone management and sustainable natural resource use in Southern Negros.

The PRRCFI's remit is to co-ordinate the practical implementation of the whole programme and carry out community based measures. Typically, CCC is responsible for the resource assessment and the preparation of management recommendations utilising the workforce of self financing, non- professional and appropriately trained volunteer researchers.

3.2 Collaborating organisations

3.2.1 Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI)

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



PRRCFI is a non-stock, non-profit corporation which is 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.

3.2.2 Coral Cay Conservation Ltd (CCC)

Mission Statement: *Providing resources to help sustain livelihoods and alleviate poverty through the protection, restoration and management of coral reefs and tropical forests.*



Founded in 1986, CCC is an award-winning international organisation dedicated to providing resources to protect livelihoods and alleviate poverty through the protection and sustainable use of

coral reefs and tropical forests in collaboration with government and non-government organisations within a host country. CCC does not charge the host country for the services it provides and is primarily self-financed through a pioneering volunteer participatory scheme whereby, international volunteers are given the opportunity to join a phase of each project in return for a financial contribution towards the project costs. Finances generated from the volunteer programme allow CCC to provide a range of services which include data acquisition, assimilation and synthesis, conservation education, technical skills training and other capacity building programmes. CCC is associated with the Coral Cay Conservation Trust, the only British-based charity dedicated to protecting coral reefs.

Upon arrival at a project site, volunteers undergo a training programme in marine life identification and underwater survey techniques, under the guidance of qualified project scientists, prior to assisting in the acquisition of data. These data sets are then assimilated into a Geographic Information System (GIS) database and used for the synthesis of resource maps for subsequent coastal zone management initiatives. Data derived from CCC volunteers have been used to establish eight marine reserves and wildlife sanctuaries in the Caribbean and Asia-Pacific, including the designation of the Belize Barrier Reef as a World Heritage Site.

3.3 Aims, objectives and implementation of the SNCDP

PRRCFI have established, led and co-ordinated a programme called PACE (Poverty Alleviation and Conservation Education) in line with the objectives of SNCDP. PACE facilitates a modular approach to coastal management and conservation, conservation education and community work towards alternative livelihoods and was initially funded by a grant from the British Partnership Programme (BPS) over a three-year period (1997- 1999) following a joint application from PRRCFI and CCC. The main aims and objectives of the programme are detailed in Table 1.

The aim of PACE is to develop and establish a prototype for an alternative approach to establishing integrated coastal zone management. The modular approach used by PRRCFI is unique in that community involvement as well as research is volunteer driven. PRRCFI depends on voluntary participation of the community in the initial, preparatory stages of community work for alternative livelihood schemes as well as after establishment of such schemes. This means that the process is extremely slow but sustainable beyond the availability of external funding.

The community work within PACE aims to bring the community to appreciate their natural resources and to establish the foundation for their sustainable use, including an inventory of those resources through research, education, organisation and skills development.

Table 1. Main aims, objectives and anticipated outputs of PACE in line with SNCDP.

AIM	OBJECTIVE	ANTICIPATED OUTPUTS
Resource assessment – coral reefs.	- Undertake a scientific survey of target coral reefs. - Conduct preliminary human impact assessment studies. - Establish a baseline database. - Provide management tools and recommendations for the establishment of marine reserves and sanctuaries.	- Initial baseline database. - Topographical maps. - Description of habitat types, physical parameters and fish communities. - Preliminary species list. - Documentation of anthropogenic impacts. - Preliminary management recommendations.
Resource assessment and restoration – mangroves.	- Undertake a scientific survey of mangroves. - Re – establish mangroves in coastal areas.	- Inventory of mangroves. - Mangrove nurseries for a range of species. - Restored mangrove areas.
Environmental Monitoring.	Establish and validate a monitoring programme within the project area.	- Identification of permanent monitoring sites. - Validation of monitoring protocols. - Baseline data set. - Assess human and natural impacts on the resources.
Training and conservation education.	- Provide coral reef ecology and SCUBA training for local counterparts and CCC volunteers. - Heighten awareness of marine and coastal resources, their use and protection.	- Trained project members. - Interaction and understanding between CCC volunteers and local people. - Teacher training where marine conservation is part of the curriculum.
Community organisation and alternative livelihood.	- Provide organisational training for local communities. - Organise environmental activities with local and CCC volunteer groups. - Develop a sense of community stewardship in monitoring and managing the coastal zone. - Develop alternative livelihood projects.	- Awareness amongst local school children, communities and fisherfolk. - Local organisational cells able to manage coastal resources. - Model projects in alternative livelihood: mud crab farming, pandan weaving, fruit processing, reserve warden. - Community based eco – tourism.
Resource management.	- Establish community based coastal zone management plan. - Establish a chain of marine reserves in six municipalities: - Hinoba'an - Sipalay - Cauayan - Ilog - Himamaylan - Kabankalan - Community based and controlled nature tourism.	- Develop and establish a model for community based integrated coastal zone management. - Maintained biodiversity and sustained fisheries as a direct effect of a chain of marine reserves. - Increased income and expertise in the community through sustainable tourism.

3.4 PACE in the Municipality of Sipalay

Activities within PACE are carried out in all participating municipalities. The initial stages of the project are primarily baseline resource assessment and community organisation. As a direct result of the scientific investigations, coastal management recommendations are then presented to the community for implementation. The social preparation and skills acquired in previous stages of the project provides the enthusiasm and expertise to carry this through. The aim is to undergo this process and establish a chain of marine reserves in six municipalities in Southern Negros:

?? Hinoba'an;	?? Ilog;
?? Sipalay;	?? Himamaylan;
?? Cauayan;	?? Kabankalan.

Within the region of SNCDP, the Municipality of Sipalay plays an important role since it contains extensive fringing reefs and coastal resources and small islands. There is anecdotal evidence that these resources may be under threat from overexploitation and lack of management.

Activities under PACE started in the region in 1997, when a two-month coral reef assessment pilot project was carried out by CCC in Campomanes Bay. From July 1998 until January 1999 the project was permanently based in Campomanes Bay where both coral reef assessments and community work took place. Campomanes Bay is a deep sheltered bay south of Sipalay. The CCC researchers established a base near the 'Campomanes Bay Resort', situated on the north bank of the bay beneath steep cliffs. PRRCFI community workers were based in Maricalum (adjacent to Campomanes Bay) and Sipalay.

Within the Municipality of Sipalay, CCC aim to survey the entire coastline and adjacent patch reefs from north of Cartagena Bay to Nabulao Bay and produce a habitat map to assist with coastal zone management recommendations (Figure 3).

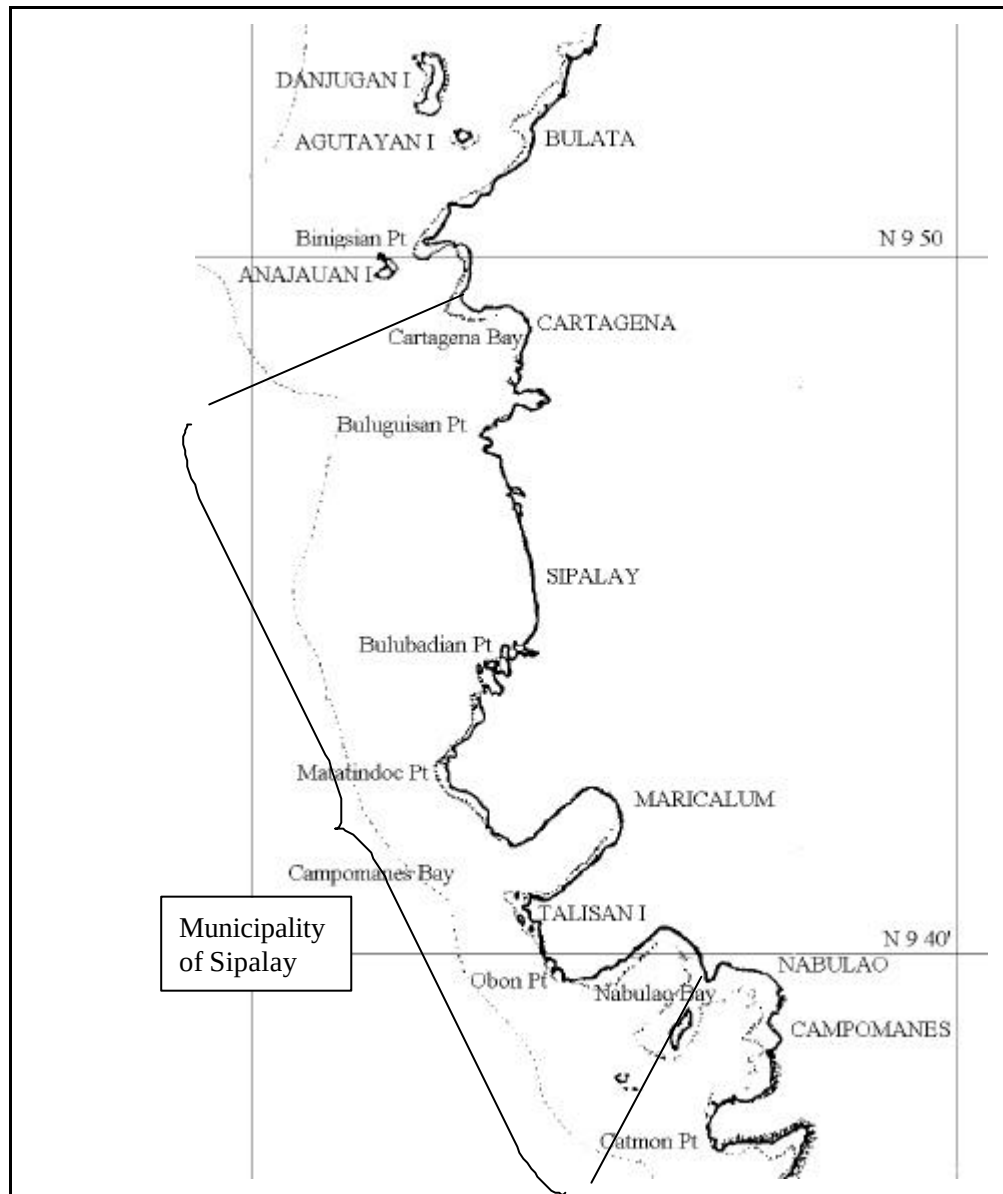


Figure 3. Municipality of Sipalay – coastal region and prominent points. Source: National Mapping and Resource Information Authority (1984).

3.5 The Philippines Reef and Rainforest Project

The SNCDP is an extension of the PRRP and uses the same model of integrated coastal management. In 1994, following the successful work in Belize, CCC was contacted by PRRCFI to give support to the small island of Danjugan Island and the neighbouring village of Bulata. In collaboration with the PRRCFI and the World Land Trust (WLT), CCC helped establish the PRRP in 1995. The PRRP aims to protect Danjugan Island, one of the few remaining intact tropical islands in the province of Negros Occidental. The project was established to address the problems of reef and forest destruction and ultimately to alleviate the increasing poverty of the fishing and farming communities via the provision of alternative livelihoods. The project also aims to simultaneously establish environmental awareness programmes involving the active participation of local communities and schools. A core

component of the PRRP is to establish community-driven reserves and sanctuaries in order to protect the reefal resources, increase fish catches and provide income from eco-tourism.

Over the course of the project CCC have provided teams of volunteer divers to undertake baseline survey work around Danjungan Island and recommended a zoning scheme (Harborne *et al.*, 1996). CCC has also collaborated with the SeaMap Research Group (University of Newcastle) to undertake the first assessment of the use of the RoxAnn side-scan sonar on coral reefs in order to develop a detailed baseline marine habitat map. CCC has given numerous training and counter-part opportunities to the local community and has developed an interactive educational awareness poster and interactive marine ecology teaching and activity cards.

The success of the project at Danjungan Island has lead to the establishment of the Southern Negros Coastal Development Programme (SNCDP). Through an extension of the PRRP, CCC has agreed to provide technical assistance for resource assessment within the SNCDP area over a period of five years from 1997 until 2002.

4 METHODS

The principle aims of the baseline marine surveys along the coastline of the Municipality of Sipalay were to map and describe the topography and habitat types of the reefs; collect basic oceanographic data; assess the extent of anthropogenic disturbance to the reefs; collate a fish species list and contribute baseline data to a global reef health assessment.

In order to achieve these aims, the following assessment methodologies were utilised:

- ?? CCC baseline marine survey method for reef assessments;
- ?? Taxonomy;
- ?? Reef Check survey method.

The Southern Negros coastline, including the Municipality of Sipalay, was divided into distinct survey sectors. Borders of survey sectors were established using major features in the landscape such as river estuaries or conspicuous headlands.

Following an intensive training programme, CCC's techniques have been shown to generate precise and consistent data appropriate for baseline mapping (Mumby *et.al.*, 1995). All surveys are co-ordinated by qualified Project Scientists and Science Officers to ensure accurate and efficient data collection.

4.1 Volunteer training

Prior to assisting with data acquisition, CCC volunteers were required to undertake an intensive nine day training course in marine life identification and survey methods (Table 2). The training programme included assessments of volunteers' identification skills and their competence at undertaking reef surveys. Assessments were in the form of written tests to determine the level of competence of each volunteer in marine life identification. Only those volunteers who passed the assessments satisfactorily (score of greater than 80%) were permitted to gather data.

Table 2. CCC science training programme schedule.

DAY		AM	PM	EVENING
1	 	- -	Lecture 1. Introduction Familiarisation snorkel and buoyancy checks.	-
2	 	Lecture 2. Introduction to coral biology and reefs. Identification of hard coral life forms. Snorkel and dive to 12 m – reef orientation	Lecture 3. Identification of target hard coral species. 6m dive – reef orientation.	Knowledge review & coral slide show. -
3	 	Lecture 4. Identification of hard coral species. Morphotypic variation. 18 m dive – coral ID.	Lecture 5. Knowledge review of coral identification. 15 m dive – coral ID	Knowledge review. -
4	 	Lecture 6. Introduction to fish and fish identification. Major families and species. 24 m dive – fish ID	Lecture 7. Further reef fish Identification. 18 m dive – fish ID	Knowledge review -
5	 	Lecture 8. Invertebrate identification and soft coral growth forms. 24 m dive – invertebrate ID	Lecture 9. Marine plants and algae identification. 18 m dive / snorkel - algal ID.	Study of algal reference collection. -
6	 	Lecture 10. Overview and practice of survey methods (beach dry-run). Completion of boat forms. 18 m dive – practical survey technique.	Lecture 11. Physical and biological forms. Concept of ordinal scale and habitats. 15 m dive – practise survey and form completion.	-
7	 	- 24 m dive – general identification.	- 15 m dive – coral ID trail.	Coral knowledge test. -
8	 	- General identification snorkel / snorkel trail.	- General identification snorkel.	Fish knowledge test. -
9		Validation	Validation	

4.2 Baseline reef surveys

The principle aims of the baseline surveys carried out within the Municipality of Sipalay were to:

- ?? map and describe the topography and habitat types of the reefs;
- ?? collect basic oceanographic data;
- ?? assess the extent of anthropogenic disturbance to the reefs.

In order to achieve these aims, the standard baseline survey technique developed by CCC was utilised. The CCC baseline marine survey method facilitates the rapid and accurate assessment of biological and physical characteristics of reefal communities by trained volunteer divers (Harborne *et al.*, 1996).

4.2.1 Field methodology

The CCC transect survey method uses a series of plotless transects, perpendicular to the reef, starting at a depth of 28 m and terminating at the reef crest to map zonation across a reef profile.

Benthic and fish surveys are focused on a pre-selected number of species and standardised life forms that are either abundant, easily identifiable or ecologically or commercially important.

During the course of each survey, oceanographic data (e.g. salinity, temperature, vertical turbidity, current strength and direction, and wind strength and direction) and observations on obvious anthropogenic impacts and activities (e.g. litter and presence and activity of boats) are recorded at depth by the divers and from the surface support vessel.

Since most transects require two or more dives to complete, surveys are usually divided up into sections (or “sub-transects”) with surveys of each sub-transect being carried out by a team of four trained divers which is divided into two buddy pairs (A and B) as shown in Figure 4. At the start point of each sub-transect, Buddy Pair B remains stationary with Diver 3 holding one end of a 10 m length of rope, whilst Buddy Pair A swims away from them, navigating up or along the reef slope in a pre-determined direction until the 10 m line connecting Divers 1 and 3 becomes taught. Buddy Pair A then remains stationary whilst Buddy Pair B swim towards them. This process is repeated until the end of the planned dive profile, when a surface marker buoy (SMB) carried by Diver 2 is deployed to mark the end of that sub-transect. The SMB acts as the start point for the next survey team and this process is repeated until the entire transect is completed. The positions of the SMB at the start and end of each dive are recorded using a Global Positioning System (GPS).

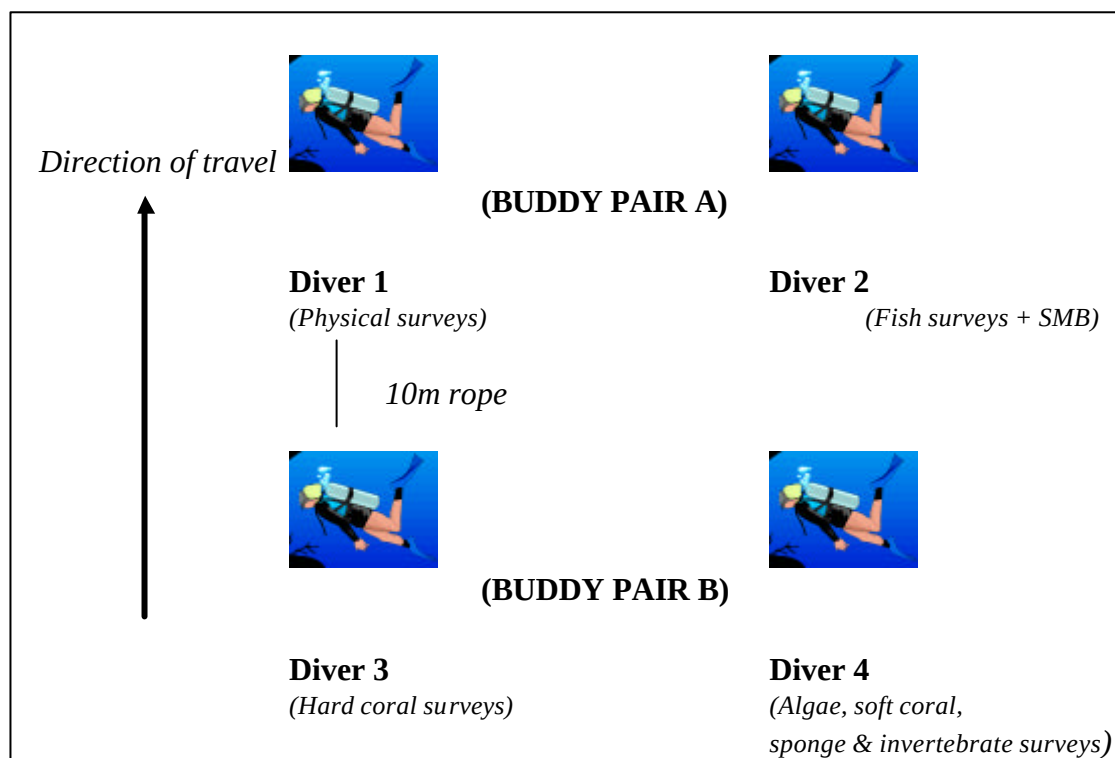


Figure 4. Diagram of a baseline survey dive team showing the positions and data gathering responsibilities of all four divers.

Diver 1 is responsible for leading the dive, taking a depth reading at the end of each 10m interval, and documenting signs of anthropogenic impact such as broken coral or fishing nets. Diver 1 also records the direction and strength of the current and takes the temperature reading

at the start of the sub-transect along with a water sample for subsequent salinity measurements. Diver 1 also describes the substratum along the sub-transect by recording the presence of five substrate categories (dead coral, bedrock, rubble, sand and mud).

Fish are normally recorded at a family level by Diver 2 with the exception of a number of important target species which are recorded to the species level. Stony corals are recorded by Diver 3 using the life forms described by English *et al.* (1997) along with additional target coral species. Sponges and octocorals are recorded in various life form categories by Diver 4 who also identifies the marine flora which is classified into three groups (green, red and brown algae) with selected target species recorded (Appendix 1).

Diver 3 surveys an area of approximately 1 metre to each side of the transect line whilst Divers 1, 2 and 4 survey an area of approximately 2.5 metres to either side of the line.

During the course of each sub-transect survey, divers may traverse two or more apparently discrete habitat types, based upon obvious gross geo-morphological or biological differences (e.g. dense coral reef, sand or rubble; Figure 5). The data gathered by each diver from each habitat type are recorded separately for subsequent analysis.

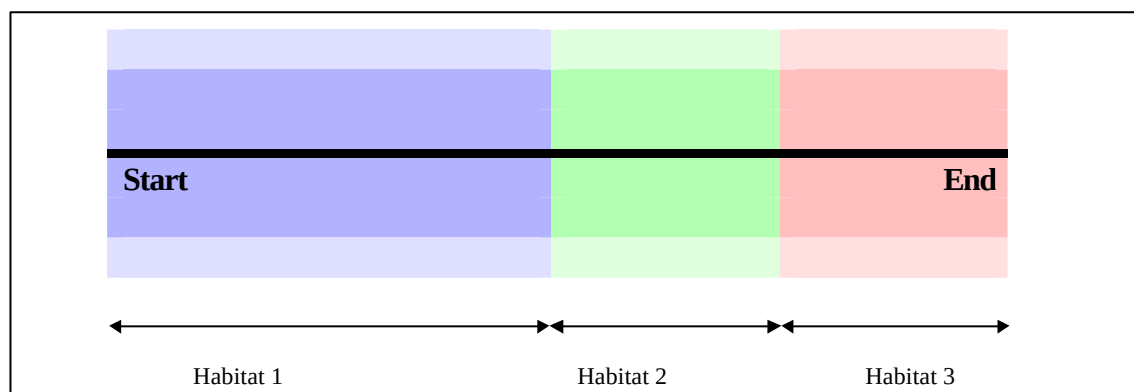


Figure 5. Diagram (aerial aspect) of an example of a reef area mapped by divers during a sub-transect survey. Solid line represents imaginary sub-transect line. Benthic data from habitats 1, 2 and 3 (e.g. reef, sand and rubble) are recorded separately.

Each species, life form or substratum category within each habitat type encountered is assigned an abundance rating from the ordinal scale shown in Table 3.

Table 3. Ordinal scale assigned to life forms and target species during baseline surveys.

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+

During each dive, data on surface water temperature and salinity, vertical turbidity and wind strength / direction are collected by the Boat Marshall on board the surface support vessel. Wind strength is estimated using the Beaufort Scale and the vertical turbidity measured using a secchi disk. The Boat Marshall also records the numbers and activities (classed as fishing, diving, commercial or pleasure) of any boats observed during the course of the survey dive.

Data collected from each sub-transect survey were transferred to recording forms routinely used by CCC for data recording (Appendix 1), prior to incorporation into CCC's GIS-compatible database.

4.2.2 Data analysis methodology

The data collected with the CCC baseline survey method were analysed regarding the benthic community and the fish populations.

Benthic community

In order to describe the reefal habitats within the project area, benthic and substratum data were analysed using multivariate techniques within PRIMER (Plymouth Routines in Multivariate Ecological Research) software. The data from each Biological Form (which represents a “snapshot” of the benthic community from either part or all of a habitat type distinguished by the survey team) are referred to as a Site Record. Multivariate analysis can be used to separate each Site Record into different groups, each representing a distinct benthic class. Firstly, the similarity between benthic assemblages at each Site Record was measured quantitatively using the Bray-Curtis Similarity coefficient (Equation 1; Bray and Curtis, 1957). This coefficient has been shown to be a particularly robust measure of ecological distance (Faith *et al.*, 1987).

$$\text{Bray - Curtis Similarity } S_{jk} = \frac{\sum_{i=1}^p \min(X_{ij}, X_{ik})}{\sum_{i=1}^p (X_{ij} + X_{ik})} \quad \text{Equation 1}$$

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

Agglomerative hierarchical cluster analysis with group-average sorting was then used to classify a subset of the field data. Cluster analysis produces a dendrogram, grouping Site Records together based on biological and physical similarities. Site Records that group together are assumed to constitute a distinct benthic class. Site Records not included in the dendrogram were assigned to one of the benthic classes via a discriminant function.

Characteristic species or substrata of each class were determined using Similarity Percentage (SIMPER) analysis (Clarke, 1993). To identify characteristic features, SIMPER calculates the average Bray-Curtis similarity between all pairs of intra-group samples (e.g. between all Site Records of the first cluster). Since the Bray-Curtis similarity is the algebraic sum of contributions from each species, the average similarity between Site Records of the first cluster can be expressed in terms of the average contribution from each species.

The standard deviation provides a measure of how consistently a given species contributes to the similarity between Site Records. A good characteristic species contributes heavily to intra-habitat similarity and has a small standard deviation. The univariate summary statistics of median abundance, frequency of occurrence of each species, life form and substratum category were also used to aid description of each habitat type.

Fish community

In order to describe the fish communities, all Site Records containing fish were grouped according to benthic class and all fish records were analysed to determine the abundance of the different families and species. The median abundance of each fish group or species in the benthic class was calculated using Equation 2 (Zar, 1984).

$$\text{Median Abundance} = \frac{(0.5n - \text{cum. freq.})}{(\text{number of observations in interval})} \quad \text{Equation 2}$$

Where “cum. freq.” refers to the cumulative frequency of the previous classes and “interval” refers to the ordinal score containing the 0.5nth observation.

The similarity of fish assemblages of different benthic classes was tested using an ANOSIM test (*Analysis of Similarities*) as described by Clarke and Warwick (1994). This test builds on a non-parametric permutation procedure applied to the similarity matrix of fish records underlying the classification of samples (in this case benthic classes). It effectively assesses the significance of differences between multivariate data sets i.e. are the fish communities more similar within Habitat A than they are between Habitat A and Habitat B.

Physical and anthropogenic parameters

The physical and anthropogenic parameters were analysed separately for each survey sector. The mean and standard deviation were calculated for each parameter individually.

Current data and wind data were analysed using a windrose programme, which displays the averages of wind or current strength versus direction. Wind roses summarise the occurrence of winds at a location, showing their strength, direction, and frequency. The centre circle represents the percentage of calms. Each branch represents wind coming from that direction, with north to the top of the diagram. The branches are divided into segments of different thickness, which represent wind speed ranges. For example, the thinnest segment may represent winds between 1 and 10 km/h. The length of each branch segment is proportional to the percentage of winds in that speed range, blowing from that particular direction.

4.3 Taxonomy

During baseline surveys a list of the fish species was compiled to assess biodiversity within the project area. Fish were identified from Kuitert (1992), Lieske and Myers (1994), Allen and Steene (1994) and Muller (1994). The list was collated by the Project Scientist to ensure reliable species level identification.

4.4 Reef Check surveys

Reef Check, co-ordinated by the Hong Kong University of Science and Technology, is the largest international programme involving recreational divers and marine scientists. In 1997, Reef Check teams completed the first global survey of coral reefs during which over 750 volunteer divers were trained and led by 100 volunteer scientists in surveys of more than 300 reefs in 31 countries. The results of Reef Check 97 provided the first solid evidence that coral reefs have been damaged on a global scale (Hodgson, 1999). Reef Check was repeated in 1998 and CCC undertook surveys in both years in Campomanes Bay.

Reef Check's survey methods are specially designed for recreational divers, so that training is rapid and organism identification is accurate. Key "indicator" organisms such as groupers are used as a measure of the impact of cyanide fishing, while butterflyfish indicate the impacts of the aquarium-fish trade. There are also worldwide indicators, such as lobster, and regional indicators, such as humphead wrasse (*Cheilinus undulatus*), in the Indo-Pacific for general fishing pressure.

The null hypothesis of Reef Check is that reefs are not significantly affected by human impacts. Hence the 'best' site (e.g. least likely to have been affected by fishing or pollution) is selected for the survey. Surveys are undertaken at two depth contours, 3 and 10 m below chart datum (lowest low water). Along each contour, four 20m transects are surveyed. Transects follow the designated depth contour one after the other with start and end points separated by a 5 m gap.

Three transect surveys are made along the same transect line:

?? *Fish belt transect.* Four 5m wide by 20m long transects (centred on the transect line) are sampled for fish species typically targeted by spear fishermen, aquarium collectors and others. In the Indo-Pacific these species are groupers (Epinephelini) over 30 cm, barrimundi cod (*Cromileptes altivelis*), sweetlips (*Plectorhincus* spp.), humphead wrasse (*Cheilinus undulatus*), bumphead parrotfish (*Bolbometopon muricatum*) and butterflyfish (Chaetodontidae).

?? *Invertebrate belt transect.* Four 5 m wide by 20 m long transects (centred on the transect line) are sampled for invertebrate species typically targeted as food species or collected as curios. In the Indo-Pacific these are banded coral shrimp (*Stenopus hispidus*), long-spined black sea urchins (*Diadema* spp.), lobster, giant clams (*Tridacna* spp.), pencil urchin (*Heterocentrotus mammilatus*), edible sea cucumbers (Holothuridae), crown-of-thorns starfish (*Acanthaster planci*) and triton shell (*Charonia tritonis*).

?? *Substratum line transect.* Four 20 m long transects are point sampled at 0.5 m intervals to determine the substratum types on the reef. The categories recorded under each 50 cm point are: hard coral, soft coral, dead coral, fleshy seaweed, sponge, rock, rubble, sand, silt / clay and 'other'.

The location of each site is recorded using a GPS along with a general description of the oceanographic and climatic conditions and perceived anthropogenic effects. All data are entered into specially designed spreadsheets (Appendix 2).

5. RESULTS

5.1 Volunteer training

Under the supervision of the CCC Project Scientists and the Science Officers all CCC volunteers successfully completed the nine-day training programme by passing their tests.

5.2 Baseline reef surveys

During the course of surveys within the SNCDP in the Municipality of Sipalay, baseline survey dives were conducted in July and August 1997 and from November 1997 to March 1999.

5.2.1 Survey sectors

The southern Negros coastline was divided into 16 survey sectors, 7 of which lie in the Municipality of Sipalay (Table 4, Figure 6). CCC baseline surveys were completed in sectors SP and CB. A limited number of transects were surveyed in RS, BP and OP, but more surveys are required to provide full coverage. Surveys in sectors ET and NB are still outstanding.

Table 4. Name and location of survey sectors within the Municipality of Sipalay.

Sector	Name	Location
SP	Cartagena Bay	North of Sipalay town, to Buluguisan Pt.
RS	River Sipalay	Sipalay Bay
BP	Bulubadian Pt.	From south end of Sipalay Bay to Matadindoc Pt.
CB	Campomanes Bay North	From Matadindoc Pt to the north side of Campomanes Bay, up to old pier
ET	Campomanes Bay South	Campomanes Bay south, from old pier to small islands on the south side, excluding those
OP	Obon Pt	East of small islands on south side of Campomanes Bay to Obon Point
NB	Nabulao Bay North	Obon Pt to Nabulao Island (border of Municipalities)

366 survey dives were undertaken in order to complete the 71 survey transects with an average of five survey sections per transect. These surveys generated 388 completed biological forms and approximately 20,000 species records (in terms of abundance and location) (Table 5).

Table 5. Number of survey transects, sections and Site Records in the survey sectors contained in this study.

Sector	Transects	Sections	Site Records
SP	23	88	99
OP	6	34	34
CB	21	146	152
RS	3	3	3
BP	18	95	100
Total:	71	366	388

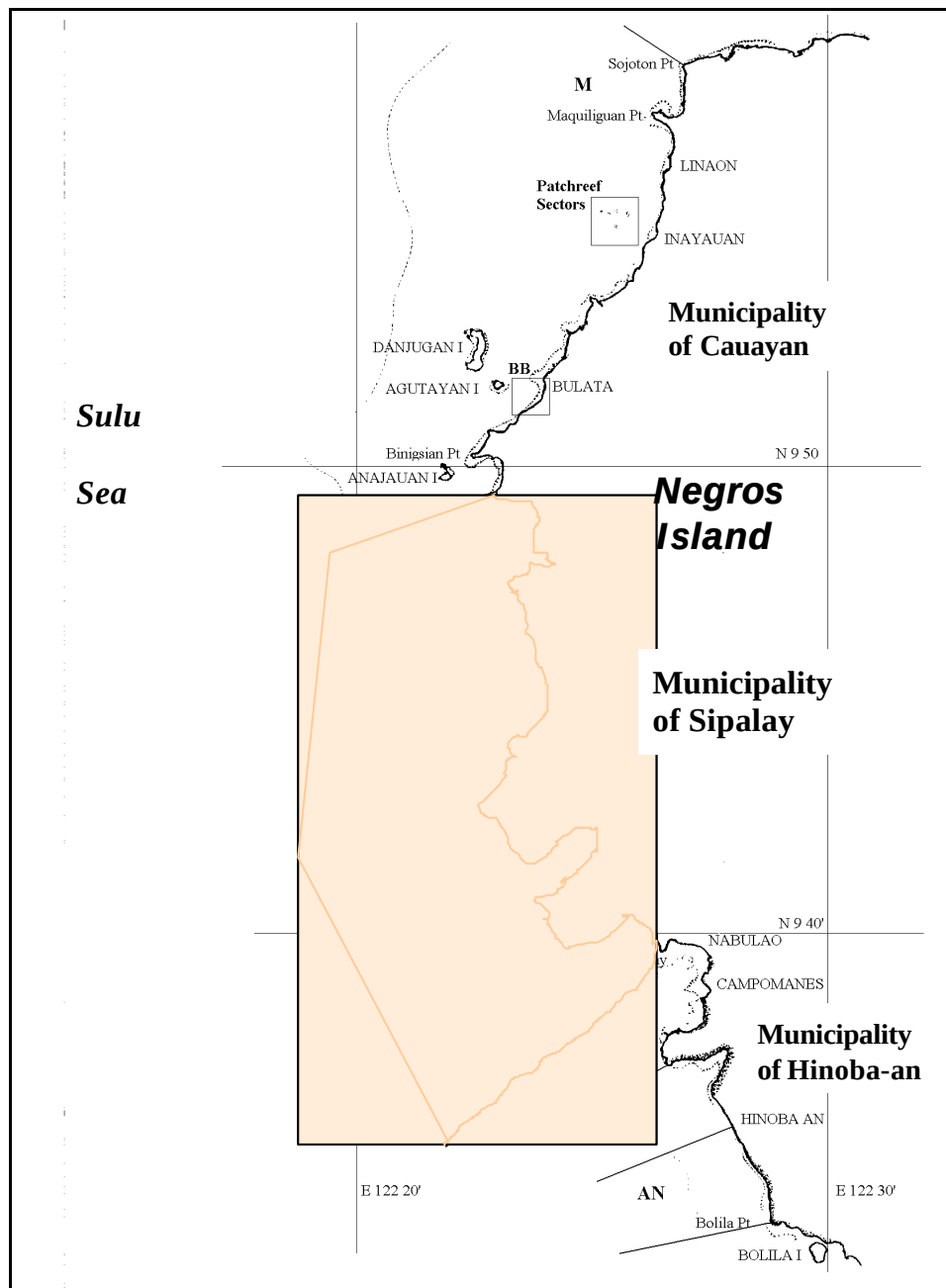


Figure 6. Map of survey sectors in Southern Negros during the SNCDP. Source: National Mapping and Resource Information Authority (1984).

5.2.2 Habitat classification

The dendrogram resulting from a cluster analysis of the baseline survey data highlighted eleven major benthic classes, each containing a minimum of three site records. Of the 388 initial records, a subset of 200 were analysed to create the dendrogram (Figure 7). Discriminate analysis identified a twelfth grouping and also assigned most of the remaining records into one of the total of twelve benthic classes. A remaining 36 records were discarded because they represented either erroneous data or extremely rare habitats. Using the characteristics of the benthic class defined by SIMPER and univariate analysis (Table 6), the following twelve benthic classes were labelled:

- BC 1 - Sand with sparse coral and algae
- BC 2 - Bedrock and soft coral
- BC 3 - Mud
- BC 4 - Rubble and sand with mixed coral boulders
- BC 5 - Dense mixed corals
- BC 6 - Foliose corals and soft corals
- BC 7 - Bedrock and medium dense corals
- BC 8 - Bedrock and dense mixed corals with dead coral
- BC 9 - Dead coral and mixed corals and algae
- BC 10 - Bedrock, algae and medium dense corals
- BC 11 - Sand and coral patches
- BC 12 - Mud with coral patches

The univariate summary statistics of each of these classes is presented in Appendix 3.

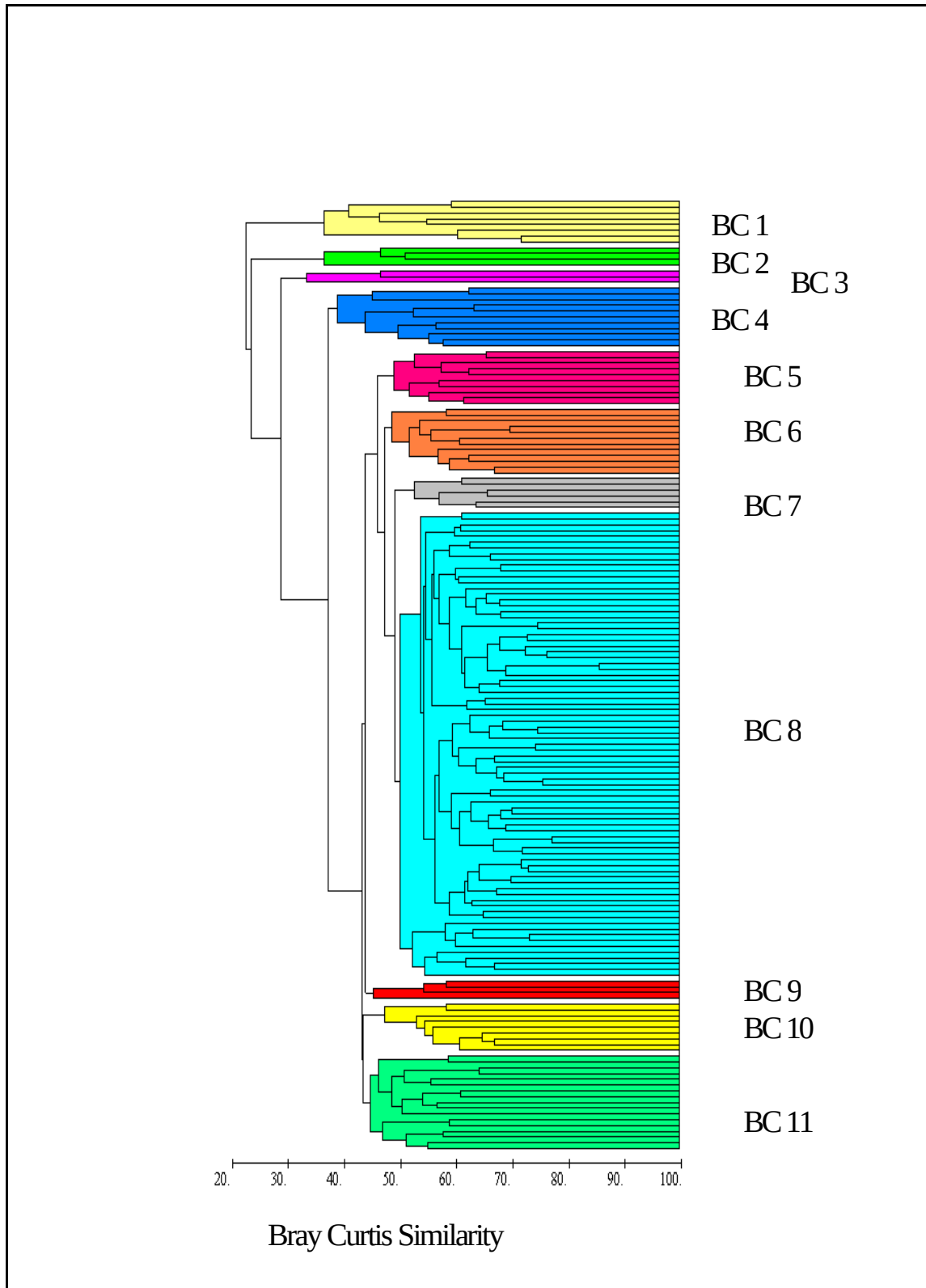
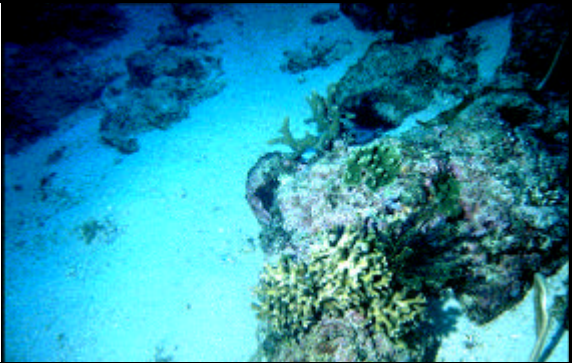
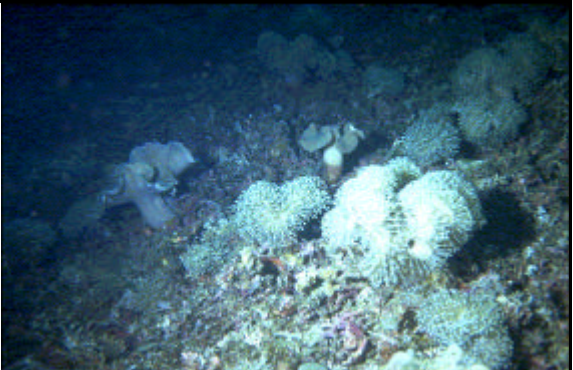
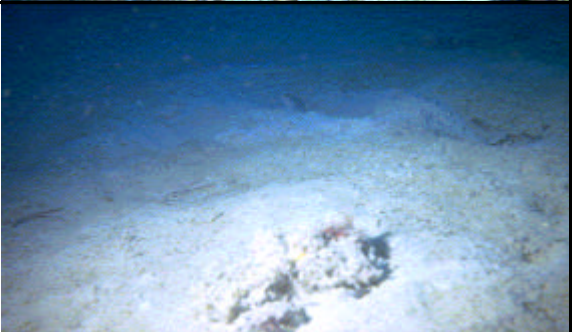
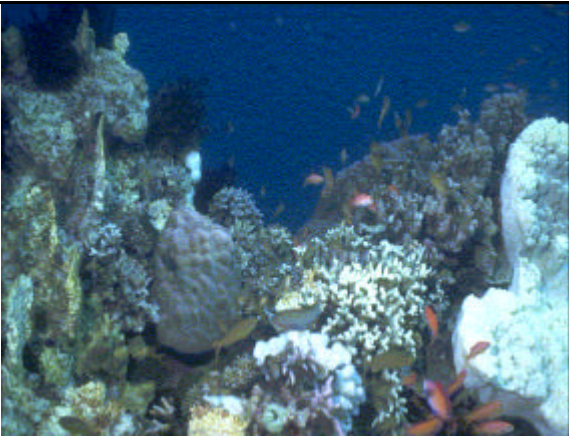


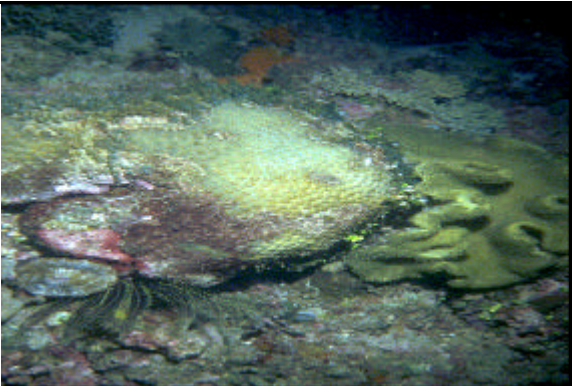
Figure 7. Dendrogram from cluster analysis of CCC baseline survey data from the Municipality of Sipalay. Each line represents benthic and substratum data from each Site Record (one completed biological form). The different colours highlight the major clusters representing the benthic classes discriminated. Horizontal axis represents similarity as calculated with the Bray-Curtis coefficient (%).

Table 6. Major characteristics of the twelve discriminated benthic classes on the coastline of Municipality of Sipalay. Figures in parentheses indicate median abundance derived from 0 – 5 ratings assigned during surveys. Images depict typical habitats described by the benthic classes.

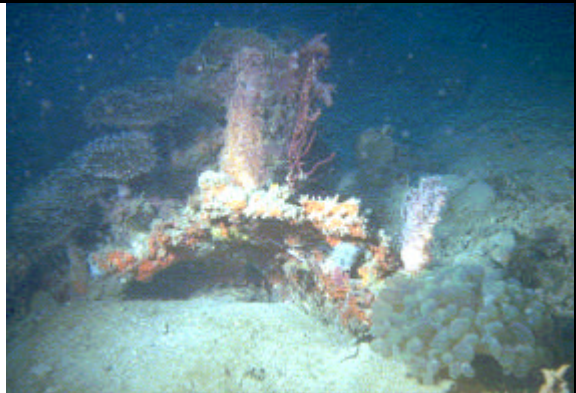
BENTHIC CLASS	No. SURVEYS	SUBSTRATUM	HARD CORALS	OCTOCORALS	SPONGES	ALGAE/ SEAGRASS	IMAGE
BC 1 Sand with sparse coral and algae	23	Sand (4.3), Newly dead coral (0.21), Dead coral substratum (0.65)	Non <i>Acropora</i> massive (0.45), <i>Porites</i> massive (0.38), Non <i>Acropora</i> encrusting (0.32), Non <i>Acropora</i> branching, <i>Favia</i> , <i>Favites</i> (0.26),	Leather SC (0.21)	Encrusting sponge (0.26)	Blue green algae (0.32), <i>Halimeda</i> (0.32), Filamentous green algae (0.32)	
BC 2 Bedrock and soft coral	7	Bedrock (3.75), Dead coral substratum (0.8), Sand (0.75), Rubble (0.37)	None	Leather SC (2.6), Dead mans fingers SC (1.75), Tree/ cauliflower SC (0.75), Anemone (0.6)	Branching sponge (1) Encrusting sponge (0.87), Vase, lumpy, plate sponge (0.37)	Filamentous green (1), Blue green algae, <i>Halimeda</i> (0.37), <i>Valonia</i>	
BC 3 Mud	40	Mud (4.8), Bedrock (0.19), Rubble (0.125)	Non <i>Acropora</i> foliose (0.14)	Sea pen (0.14)		Blue green algae (0.1)	

BENTHIC CLASS	No. SURVEYS	SUBSTRATUM	HARD CORALS	OCTOCORALS	SPONGES	ALGAE/ SEAGRASS	
BC 4 Rubble and sand with mixed coral boulders	13	Rubble (2.1), Sand (2.1), Bedrock, Newly dead coral (1.1)	<i>Pachyseris speciosa</i> (2), <i>Acropora</i> branching (1.8), <i>Seriatopora hystrix</i> (1.6), <i>Mycedium elephantotus</i> (1), Non <i>Acropora</i> mushroom (0.9), <i>Ctenactis echinata</i> (0.9), Non <i>Acropora</i> branching (0.8)	Leather SC, sea fan, sea whip, flower SC (0.2)	Lumpy sponge (0.8), Branching sponge (0.8) Vase sponge (0.7)	Filamentous green algae (1), Blue green algae (0.7)	
BC 5 Dense mixed corals	15	Rubble (1.6), Bedrock (1.4), Dead coral substratum (0.9), Sand (0.8)	Non <i>Acropora</i> branching (3), Non <i>Acropora</i> foliose (2.4), Non <i>Acropora</i> mushroom, <i>Acropora</i> branching, <i>Seriatopora hystrix</i> , <i>Pachyseris speciosa</i> (2), Non <i>Acropora</i> encrusting (1.8), Non <i>Acropora</i> massive (1.4) <i>Montipora foliosa</i> (1.3), <i>Mycedium elephantotus</i> (1.2), <i>Acropora</i> tabulate (1.1), <i>Ctenactis echinata</i> (1), <i>Favia</i> (1)	Sea whip (0.58)	Elephant ear sponge (1.6), Vase sponge (1.3), Rope, encrusting, tube sponge (0.7),	Blue green algae, Filamentous green algae (0.25)	
BC 6 Foliose corals and soft corals	23	Bedrock (1.6), Newly dead coral, Newly dead coral with algae (0.7)	Non <i>Acropora</i> foliose (2.5), <i>Pachyseris speciosa</i> (2.4), <i>Mycedium elephantotus</i> (1.4), <i>Favites</i> (1.4), Non <i>Acropora</i> encrusting (1.3), Non <i>Acropora</i> massive (1.18), <i>Diploastrea heliopora</i> (1.1), <i>Favia</i> (1.1), Non <i>Acropora</i> mushroom (1), Non <i>Acropora</i> branching (1), <i>Pachyseris rugosa</i> (1)	Leather SC (1.9), Dead mans fingers SC (1.6) Tree/ cauliflower SC (1), Flower SC (0.7)	Encrusting sponge (1.8), Lumpy sponge (0.8), Branching sponge (0.7)	Red filamentous algae (0.8), Blue green algae (0.7), <i>Halimeda</i> (0.6), Filamentous green algae (0.58)	

BENTHIC CLASS	NO. SURVEYS	SUBSTRATUM	HARD CORALS	OCTOCORALS	SPONGES	ALGAE/ SEAGRASS	
BC 7 Bedrock and medium dense corals	42	Bedrock (3), Rubble (1.3), Sand (1.2), Dead coral substratum (1.14), Newly dead coral with algae (1.12), Newly dead coral (1)	Non <i>Acropora</i> branching (2.14), Non <i>Acropora</i> massive (2.1), <i>Porites</i> massive (1.9) <i>Seriatopora hystrix</i> (1.75), <i>Galaxea</i> (1.4), <i>Pocillopora</i> : medium (1.3), <i>Pocillopora</i> : small (1.2), <i>Favites</i> (1), <i>Favia</i> (1), <i>Acropora</i> branching (1)	Leather SC (1.8), Dead mans fingers SC (1.75)	Encrusting sponge (1.8), Vase, lumpy sponge (0.6)	Filamentous green algae (1), Filamentous brown algae (0.9), Red filamentous algae (0.58)	
BC 8 Bedrock and dense mixed corals with dead coral	131	Bedrock (2.3), Newly dead coral (1.5), Newly dead coral with algae (1.46), Sand (1.2), Dead coral substratum (1.2), Rubble (0.98)	Non <i>Acropora</i> massive (2.4), <i>Porites</i> massive (2.4), Non <i>Acropora</i> encrusting (2.3), <i>Favites</i> (2.2), Non <i>Acropora</i> branching (2.2), <i>Acropora</i> branching (2.1), <i>Favia</i> (2), Non <i>Acropora</i> mushroom (1.8), <i>Galaxea</i> (1.8), <i>Pachyseris speciosa</i> (1.77), Non <i>Acropora</i> foliose (1.5), <i>Diploastrea heliopora</i> (1.4), <i>Seriatopora hystrix</i> (1.4), <i>Pocillopora</i> : medium (1.3), <i>Pocillopora</i> : small (1.2), <i>Lobophyllia</i> (1.2), <i>Mycedium elephantotus</i> (1.1), <i>Pachyseris rugosa</i> (1.1), <i>Acropora</i> tabulate (0.98)	Leather SC (2), Dead mans fingers SC (1.9)	Encrusting sponge (1.28), Lumpy sponge (0.64)	Filamentous green algae (0.8),	

BC 9 Dead coral and mixed corals and algae	8	Newly dead coral with algae (3.75), Newly dead coral, Dead coral substratum (2.5), Bedrock (2.25), Sand (1.16)	<i>Favites</i> (3.5), <i>Porites</i> massive (3.5), Non <i>Acropora</i> massive (3.1), <i>Favia</i> (2.8), Non <i>Acropora</i> branching (1.8), Non <i>Acropora</i> encrusting (1.75), Brain small (1.5), <i>Acropora</i> branching (1), <i>Galaxea</i> (1)	Dead mans fingers SC (1.5), Tree/ cauliflower SC (1), Leather SC (0.9)	Encrusting sponge (0.5)	Filamentous green algae (3.1), Filamentous brown algae (1.5),	
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BENTHIC CLASS	No. SURVEYS	SUBSTRATUM	HARD CORALS	OCTOCORALS	SPONGES	ALGAE/ SEAGRASS	
BC 10 Bedrock, algae and medium dense corals	13	Bedrock (3.5), Dead coral substratum (2.1), Newly dead coral with algae (1.7), Dead coral (1.3), Sand (1)	Non <i>Acropora</i> foliose (2.5), Non <i>Acropora</i> encrusting (2.1), <i>Pachyseris speciosa</i> (2.1), <i>Porites</i> massive (2), Non <i>Acropora</i> massive (1.7), <i>Pachyseris rugosa</i> (1.7), <i>Montipora foliosa</i> (1.16), <i>Galaxea</i> (1)	Dead mans fingers SC (1.5), Flower SC (0.85), Leather SC, Sea fan (0.83)	Lumpy sponge (1.16), Encrusting sponge (1.1)	Blue green algae (3.3), Filamentous green algae (0.7),	No image available

BC 11 Sand and coral patches	31	Sand (2.5), Newly dead coral with algae (2), Newly dead coral (1.4), Dead coral substratum (1.18)	Non <i>Acropora</i> encrusting (2.1), <i>Pachyseris speciosa</i> (1.8), <i>Acropora</i> branching (1.4), Non <i>Acropora</i> branching (1.38), Non <i>Acropora</i> foliose (1.35), <i>Favia</i> (1.12), Non <i>Acropora</i> massive (1.1), Non <i>Acropora</i> mushroom (1)	Leather SC (1.12), Dead mans fingers SC (0.7)	Encrusting sponge (0.95), Branching sponge (0.75),	Filamentous green algae (0.85),	
BC 12 Mud with coral patches	6	Mud (2.5), Newly dead coral (2.1), Bedrock (2), Dead coral substratum (1.9)	Non <i>Acropora</i> encrusting (2), <i>Pachyseris speciosa</i> (1.9), Non <i>Acropora</i> massive (1.75), <i>Favia</i> (1.75), Non <i>Acropora</i> branching (1.5), Non <i>Acropora</i> foliose, <i>Porites</i> massive (1.5), Non <i>Acropora</i> mushroom, <i>Galaxea</i> (1)	Leather SC (1), Dead mans fingers SC (1)	Encrusting sponge (0.5)	<i>Halimeda</i> (1.5)	No image available

The benthic classes were distributed relatively evenly along the coastline of Southern Negros (Figure 8) and the full distribution of transects within benthic classes can be seen in Appendix 4. The most common habitat (BC 8) was found in all survey sectors.

The sector SP, including Cartagena Bay to Buluguisan Pt in the south supported a very diverse reef north of Cartagena Bay where the fringing reef starts at 28 m depth. The reef is characterised by a matrix of bedrock and medium dense corals (BC 7) and bedrock and dense mixed coral with dead coral (BC 8). In the shallow areas the substratum is mainly sand with small to medium coral boulders (BC 11). In Cartagena Bay, a mixture of several benthic classes was encountered, all of which contain relatively dense and diverse corals (BC 5, 6, 7 and 8). Occasional evidence of damage (dead coral and filamentous algae) was found. In the shallows there was a mixture of sandy substratum with coral patches and bare rock with soft corals. In the area from Cartagena to Buluguisan Pt., the reef is diverse and characterised mainly by bedrock and dense mixed corals with dead coral (BC 8) and some patches which were similar, but contained more foliose corals and soft corals (BC 6). Towards Buluguisan Pt, the start of the reef becomes slowly shallower going southwards. Close to the adjacent survey sector (RS), is a deep (28 m) mud habitat (BC 3) which also contained some rubble with sand and small coral boulders (BC 4).

Three transects were carried out in survey sector RS (Sipalay Bay) and consisted of primarily sand and coral patches (BC 11) and bedrock with dense mixed coral and dead coral (BC 8). Anecdotal evidence suggests that the bay mainly consists of sand and mud and does not support any significant reef structures. More surveys are needed in this area in order to describe the habitats properly.

The survey sector BP stretches from Bulupadin Pt to Matadindoc Pt. and generally supported a very diverse reef with abundant reef organisms. Where BP joins RS the reef structures started at a fairly shallow depth (10 to 15 m) and gradually moved deeper in a southerly direction. On transects adjacent to RS, a deep mud and sand dominated habitat was present (BC 1, 3) which often contained small coral boulders (BC 11). Towards the south in this sector the fringing reef became deeper and was characterised by benthic classes of: bedrock and dense mixed corals with dead coral (BC 8), dense mixed corals (BC 5), foliose corals and soft corals (BC 6) and bedrock with medium dense corals (BC 7). Amongst the coral matrix there were large sandy areas (BC 1). The benthic class BC 10 accounted for approximately half of the total area of survey sector BP, which indicates some coral damage was present (high levels of dead coral and blue green and filamentous algae).

The survey sector CB reaches from Matadindoc Pt to the north side of Campomanes Bay. The reef area was varied and can be best described in two parts. The more northerly part contained a mixture of diverse and dense coral habitats, including bedrock and dense mixed corals and dead corals (BC 8), foliose corals and soft corals (BC 6) and bedrock with medium dense corals (BC 7). These were interspersed with areas containing mud (BC 3), sand with sparse coral and algae (BC 1), sand with coral patches (BC 11) and mud with coral patches (BC 12). Benthic classes which indicate damaged coral (BC 9 and 10) were frequent in this area. Further south in the sector CB the quality of the reef increased, with some of the best coral reef areas in the region around the north corner of Campomanes Bay (MB, pers. obs.). The reef in this area can be described as an assemblage of large coral boulders which supported a very diverse and abundant

community (BC 5, 6,7,8), interspersed with areas of sand and bedrock (BC 4). On the north corner of Campomanes Bay a vertical, steep wall of about 50 m width was found, rising from 35 to 3 m of depth. This feature supports a unique and extremely rich community and was classed as dense mixed corals (BC 5). The north side of Campomanes Bay was found to have a very steep reef slope and can be described as bedrock and dense mixed corals with dead coral (BC 8).

Surveys inside Campomanes Bay have not yet been carried out (survey sector ET). The adjacent sector OP starts east of the south corner of Campomanes Bay and ends at Obon Pt. Only 6 transects have been completed to date, describing the north end of the survey sector. It was classed as bedrock and dense mixed corals with dead corals mixed with sand (BC 1) and mud (BC 3) and rubble with sand and mixed coral boulders.

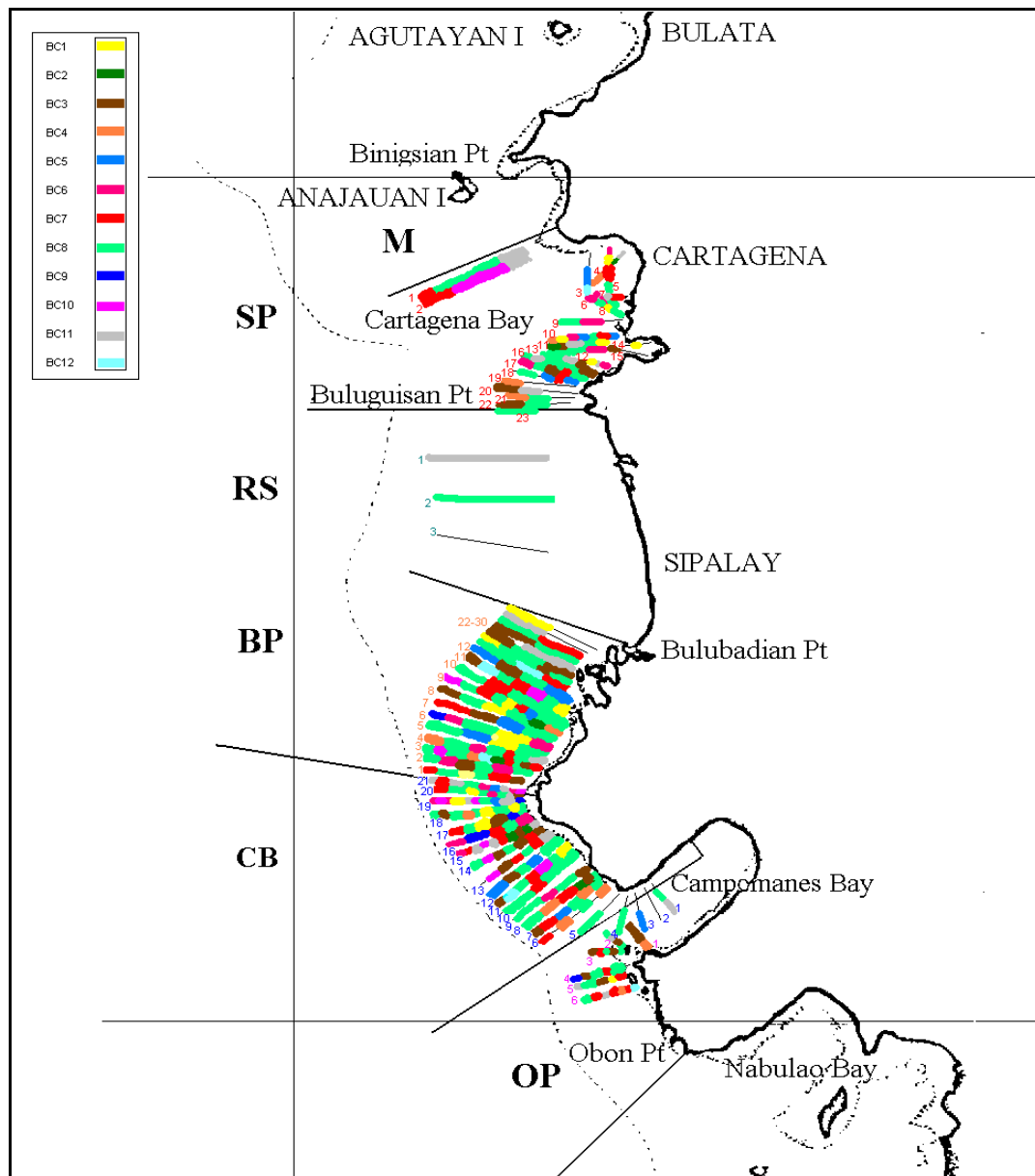


Figure 8. Distribution of benthic classes along the survey transects along the Southern Negros coastline. Different colours indicate various benthic classes; transects length, location and benthic classes are approximations. Transect sections without colouring represent the rejected Site Records.

The various benthic classes occurred distributed relatively evenly across the depth classes (Figure 9). There appears to be a greater frequency of bedrock and soft coral (BC 2) in the shallow areas. Sand and coral patches (BC 11) seems to be more frequent in the deep areas below 21 m. The benthic classes supporting rich and abundant benthic life, for example dense mixed corals (BC 5) or foliose corals and soft corals (BC 6), are evenly distributed throughout the spectrum. The benthic classes indicating damage such as dead coral and mixed corals and algae (BC 9) occur in the depth classes below 16 m and shallower than 10 m.

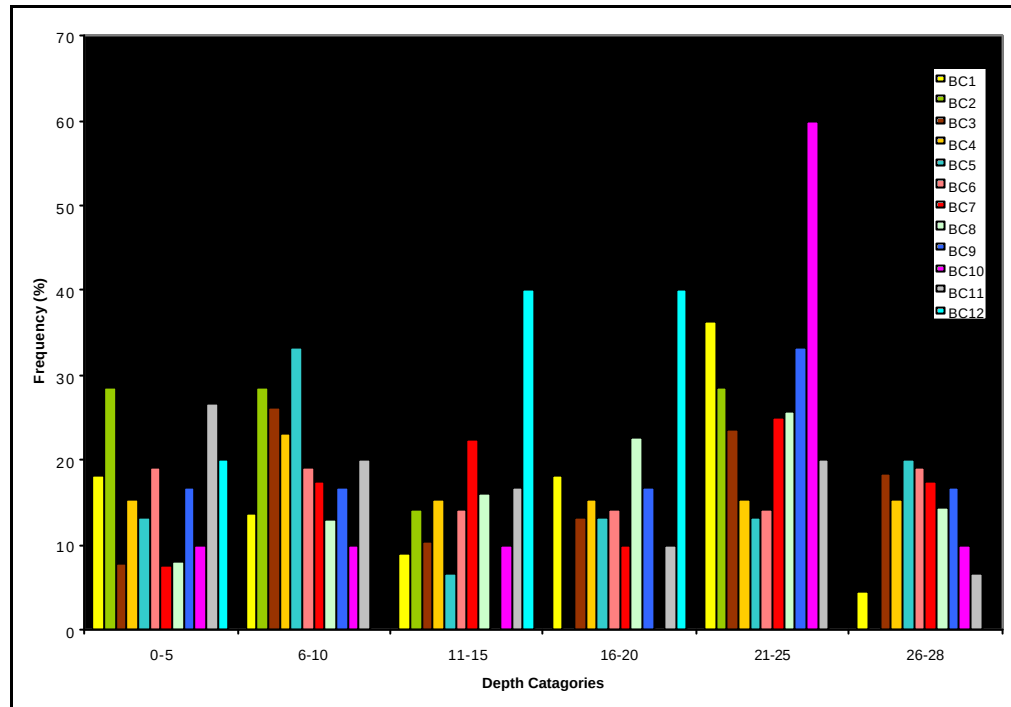


Figure 9. Frequency of benthic classes within depth classes, recorded on transects along the coastline of the Municipality of Sipalay.

5.2.3 Fish assemblages

The analysis of fish records in each benthic class is documented below (Table 7). It shows the median abundance of most common fish families and species recorded in the benthic classes (median values above 0.5). In order to present the status of commercially exploited fish stocks an assessment of commonly fished groups is listed. The most commonly seen groups are damselfish, butterflyfish and wrasse. Of the main commercial fish groups only surgeonfish were recorded in significant abundance. Humphead wrasse (*Cheilinus undulatus*) and Jacks (Carangidae) were not recorded in any of the surveys.

Table 7. Median abundance of most common and of commercially exploited fish groups within the benthic classes. The full data set is provided in Appendix 5.

BENTHIC CLASS	NO. SURVEYS	MOST COMMON FISH GROUPS	COMMERCIALY EXPLOITED FISH FAMILIES
BC1	23	Damselfish (Pomacentridae) (2.6) Butterflyfish (Chaetodonidae) (1.3) Wrasse (Labridae) (1.1) Surgeonfish (Acanthuridae) (0.9)	Grouper (Serranidae) (0.1) Surgeonfish (Acanthuridae) (0.8) Snappers (Lutjanidae) (0.2) Goatfish (Mullidae) (0.2) Parrotfish (Scaridae) (0.0) Spinecheeks (Nemipteridae) (0.1) Fusiliers (Caesionidae) (0.1) Rabbitfish (Siganidae) (0.0)
BC 2	7	Damselfish (Pomacentridae) (2.1) Wrasse (Labridae) (1.8) Surgeonfish (Acanthuridae) (1.0) Butterflyfish (Chaetodonidae) (1.0) <i>Thalassoma lunare</i> (0.8) <i>Chaetodon baronessa</i> (0.7) <i>Pomacanthus</i> sp. (0.7)	Grouper (Serranidae) (0.0) Surgeonfish (Acanthuridae) (1.0) Snappers (Lutjanidae) (0.0) Goatfish (Mullidae) (0.0) Parrotfish (Scaridae) (0.0) Spinecheeks (Nemipteridae) (0.0) Fusiliers (Caesionidae) (0.0) Rabbitfish (Siganidae) (0.0)
BC 3	40	Damselfish (Pomacentridae) (2.2) Surgeonfish (Acanthuridae) (1.5) Butterflyfish (Chaetodonidae) (1.3) Wrasse (Labridae) (0.9) <i>Pomacanthus</i> sp. (0.8) <i>Thalassoma lunare</i> (0.8) <i>Chromis</i> sp. (0.7) <i>Parupeneus</i> sp. (0.5) <i>Zebrasoma scopas</i> (0.5)	Grouper (Serranidae) (0.1) Surgeonfish (Acanthuridae) (1.5) Snappers (Lutjanidae) (0.0) Goatfish (Mullidae) (0.5) Parrotfish (Scaridae) (0.0) Spinecheeks (Nemipteridae) (0.0) Fusiliers (Caesionidae) (0.0) Rabbitfish (Siganidae) (0.0)
BC 4	13	Damselfish (Pomacentridae) (2.6) <i>Chromis</i> sp. (1.6) Butterflyfish (Chaetodonidae) (1.3) Wrasse (Labridae) (1.0) Surgeonfish (Acanthuridae) (0.6)	Grouper (Serranidae) (0.0) Surgeonfish (Acanthuridae) (0.6) Snappers (Lutjanidae) (0.0) Goatfish (Mullidae) (0.2) Parrotfish (Scaridae) (0.0) Spinecheeks (Nemipteridae) (0.0) Fusiliers (Caesionidae) (0.1) Rabbitfish (Siganidae) (0.0)
BC 5	15	Damselfish (Pomacentridae) (2.1) Wrasse (Labridae) (1.2) Butterflyfish (0.9) <i>Labroides</i> sp. (0.7) <i>Thalassoma lunare</i> (0.7)	Grouper (Serranidae) (0.0) Surgeonfish (Acanthuridae) (0.3) Snappers (Lutjanidae) (0.1) Goatfish (Mullidae) (0.2) Parrotfish (Scaridae) (0.0) Spinecheeks (Nemipteridae) (0.1) Fusiliers (Caesionidae) (0.1) Rabbitfish (Siganidae) (0.1)

BC 6	23	Damselfish (Pomacentridae) (1.9)	Grouper (Serranidae) (0.1)
		Butterflyfish (Chaetodonidae) (0.9)	Surgeonfish (Acanthuridae) (0.6)
		Surgeonfish (Acanthuridae) (0.6)	Snappers (Lutjanidae) (0.1)
			Goatfish (Mullidae) (0.3)
			Parrotfish (Scaridae) (0.1)
			Spinecheeks (Nemipteridae) (0.1)
			Fusiliers (Caesionidae) (0.3)
			Rabbitfish (Siganidae) (0.0)

BENTHIC CLASS	NO. SURVEYS	MOST COMMON FISH GROUPS	COMMERCIALY EXPLOITED FISH FAMILIES
BC 7	42	Damselfish (Pomacentridae) (1.8) Butterflyfish (Chaetodonidae) (1.2) <i>Chromis retrofasciatus</i> (0.7) <i>Zanclus cornutus</i> (0.6)	Grouper (Serranidae) (0.0) Surgeonfish (Acanthuridae) (0.4) Snappers (Lutjanidae) (0.0) Goatfish (Mullidae) (0.2) Parrotfish (Scaridae) (0.0) Spinecheeks (Nemipteridae) (0.0) Fusiliers (Caesionidae) (0.2) Rabbitfish (Siganiidae) (0.0)
BC 8	131	Damselfish (Pomacentridae) (2.2) Butterflyfish (Chaetodonidae) (1.2) Surgeonfish (Acanthuridae) (0.9) Wrasse (Labridae) (0.8) <i>Pomacanthus</i> sp. (0.6)	Grouper (Serranidae) (0.1) Surgeonfish (Acanthuridae) (0.9) Snappers (Lutjanidae) (0.1) Goatfish (Mullidae) (0.3) Parrotfish (Scaridae) (0.0) Spinecheeks (Nemipteridae) (0.1) Fusiliers (Caesionidae) (0.2) Rabbitfish (Siganiidae) (0.0)
BC 9	8	Damselfish (Pomacentridae) (2.2) <i>Chromis</i> sp. (1.8) Butterflyfish (Chaetodonidae) (1.2) Wrasse (Labridae) (1.0) <i>Labroides</i> sp. (1.0) <i>Pomacanthus</i> sp. (1.0) <i>Parupeneus</i> sp. (0.9) <i>Zanclus cornutus</i> (0.8) <i>Acanthurus thompsoni</i> (0.7) <i>Chaetodon vagabundus</i> (0.7)	Grouper (Serranidae) (0.1) Surgeonfish (Acanthuridae) (0.4) Snappers (Lutjanidae) (0.4) Goatfish (Mullidae) (0.9) Parrotfish (Scaridae) (0.1) Spinecheeks (Nemipteridae) (0.1) Fusiliers (Caesionidae) (0.4) Rabbitfish (Siganiidae) (0.0)
BC 10	13	Damselfish (Pomacentridae) (2.0) <i>Pomacanthus</i> sp. (0.8) Surgeonfish (Acanthuridae) (0.8) <i>Amblyglyphidodon leucogaster</i> (0.7) Butterflyfish (Chaetodonidae) (0.6) Wrasse (Labridae) (0.5)	Grouper (Serranidae) (0.0) Surgeonfish (Acanthuridae) (0.8) Snappers (Lutjanidae) (0.1) Goatfish (Mullidae) (0.0) Parrotfish (Scaridae) (0.0) Spinecheeks (Nemipteridae) (0.1) Fusiliers (Caesionidae) (0.2) Rabbitfish (Siganiidae) (0.0)
BC 11	31	Damselfish (Pomacentridae) (2.1) Butterflyfish (Chaetodonidae) (1.1) Surgeonfish (Acanthuridae) (0.9) Wrasse (Labridae) (0.8)	Grouper (Serranidae) (0.1) Surgeonfish (Acanthuridae) (0.9) Snappers (Lutjanidae) (0.0) Goatfish (Mullidae) (0.3) Parrotfish (Scaridae) (0.1) Spinecheeks (Nemipteridae) (0.0) Fusiliers (Caesionidae) (0.1) Rabbitfish (Siganiidae) (0.0)

BC 12	6	Damselfish (Pomacentridae) (2.5)	Grouper (Serranidae) (0.2)
		Butterflyfish (Chaetodonidae) (1.2)	Surgeonfish (Acanthuridae) (1.0)
		Surgeonfish (Acanthuridae) (1.0)	Snappers (Lutjanidae) (0.2)
		<i>Pomacanthus</i> sp. (0.9)	Goatfish (Mullidae) (0.2)
		<i>Chaetodon kleinii</i> (0.5)	Parrotfish (Scaridae) (0.1)
		<i>Chaetodon trifascialis</i> (0.5)	Spinecheeks (Nemipteridae) (0.1)
		Wrasse (Labridae) (0.5)	Fusiliers (Caesionidae) (0.1)
		<i>Labroides</i> sp. (0.5)	Rabbitfish (Siganidae) (0.0)
		<i>Centropyge bicolor</i> (0.5)	

ANOSIM analysis assumed that different benthic classes support different fish communities as a result of varied habitat requirements. In order to statistically prove this, the H_0 hypothesis stated that there were no differences in fish assemblages between benthic classes. Hence, percentages below 5% significance of similarity ($p < 0.05$) were required to disprove H_0 and thus prove the above assumption. A percentage of 5% to prove the power of a statistical analysis is commonly applied. The values of significance of similarity are detailed in Table 8, comparing fish data in pairs of each class versus every other class.

Table 8. ANOSIM significance of similarity [%], comparing each benthic class in pairs, values below 5% ($p < 0.05$) shaded grey.

1												
2	83.80%											
3	2.40%	68.10%										
4	31.70%	63.30%	12.30%									
5	36.00%	96.30%	11.90%	20.80%								
6	51.90%	94.20%	2.30%	81.20%	73.70%							
7	24.40%	77.60%	2.50%	20.90%	55.00%	32.20%						
8	32.30%	89.60%	84.90%	61.50%	27.60%	10.80%	12.60%					
9	37.70%	11.20%	21.70%	37.70%	48.10%	66.70%	60.50%	31.10%				
10	23.10%	73.40%	0.90%	22.50%	11.30%	48.70%	61.50%	17.60%	31.30%			
11	58.20%	80.80%	5.00%	45.00%	50.30%	45.40%	41.50%	53.70%	51.90%	18.70%		
12	74.70%	19.90%	43.40%	58.30%	62.40%	94.40%	78.00%	71.00%	70.70%	72.90%	68.60%	
	1	2	3	4	5	6	7	8	9	10	11	12

Table 8 shows that high values of significance were computed in most comparisons, thus supporting H_0 . It proves that fish communities vary insignificantly between benthic classes and the above assumption is only true for the following benthic classes ($p < 0.05$):

- 1 and 3; 3 and 7; 3 and 11.
3 and 6; 3 and 10;

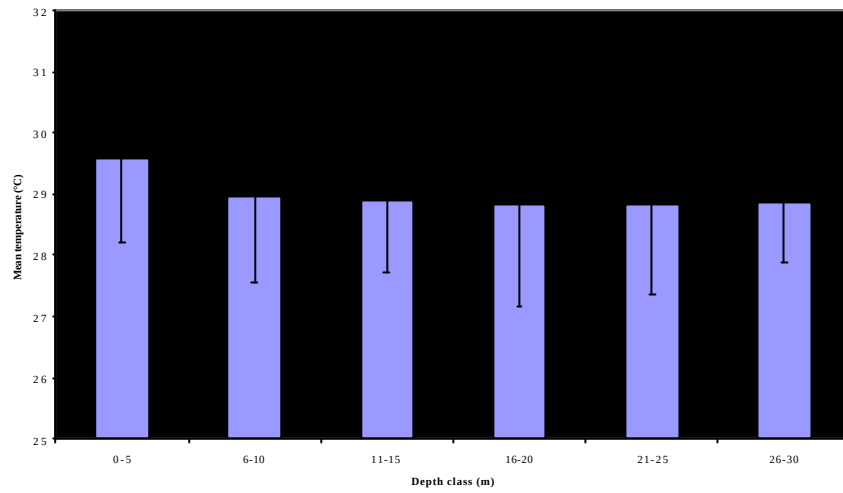
Where 1 = Sand with sparse coral and algae; 3 = Mud; 6 = Foliose corals and soft corals; 7 = Bedrock and medium dense corals; 10 = Bedrock, algae and medium dense corals and 11 = Sand and coral patches.

5.2.4 Physical parameters

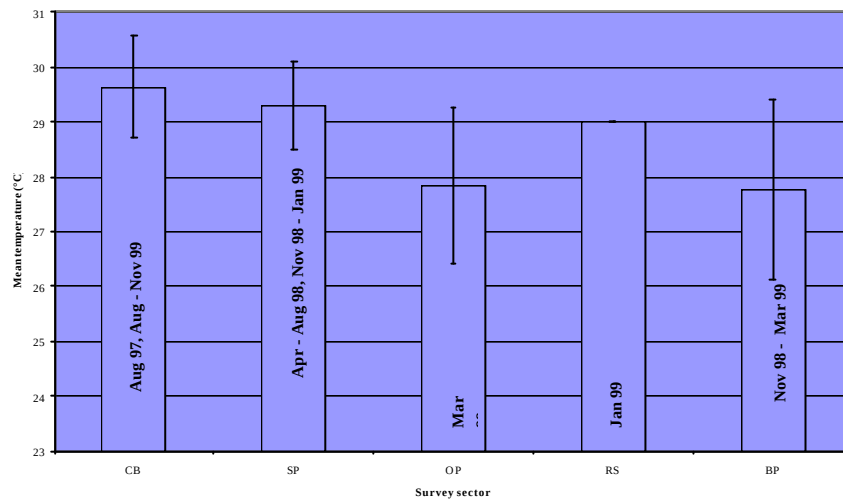
Data on water temperature, wind strength and direction, current strength and direction, vertical turbidity and salinity were gathered during the course of each baseline survey. Measurements of sub-surface water temperature throughout the water column remained constant at approximately

28.8°C, with an exception of the shallow areas between 0 to 5 m at 29.5°C (Figure 10a). The mean temperature was calculated for each survey sector (Figure 10b) and related to temperatures in the different seasons of surveying each sector (Figure 10c). Figure 10c shows that during July until December 1998 the sea temperatures were slightly higher than average, which may account for higher mean temperatures in sectors CB and SP, which were surveyed during these periods. This also coincides with the global elevated sea temperatures in 1998 which led to coral bleaching (Wilkinson ed., 1998).

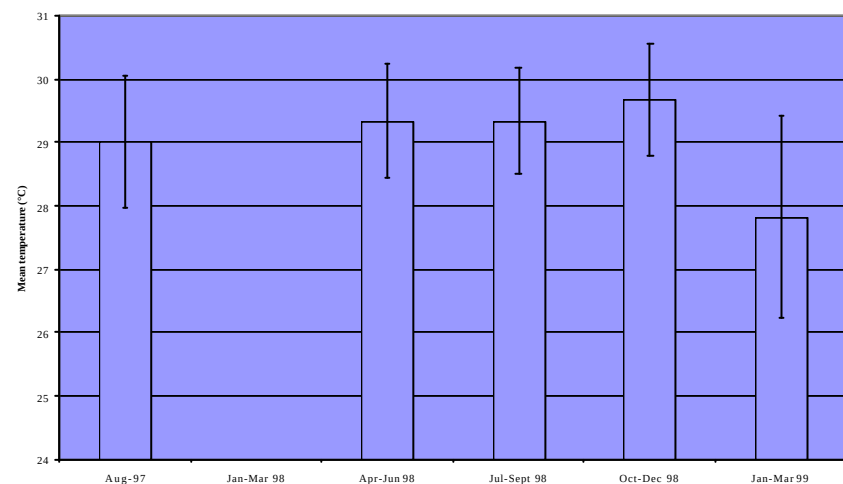
The prevailing wind direction was from the north and most commonly '2' (Light breeze) on the Beaufort Scale (Figure 11). Current data were analysed by creating current roses for each survey sector (Figure 12). Figure 12 shows that the water generally flooded towards the south or south-west or north. Vertical turbidity throughout the project area had a mean value of 10.9 (standard deviation 4.9), as measured by secchi disc. It varies for the different survey sectors (Figure 13). Mean salinity within the project area was 28.9‰ (standard deviation 2.1‰).



a) Mean water temperature measured in the Municipality of Sipalay in depth classes.



b) Mean water temperature measured in different survey sectors. Additional labels indicate the time of year they were surveyed.



c) Temperature according to seasonality.

Figure 10. Mean water temperature recorded in the Municipality of Sipalay. Bars represent standard deviation.

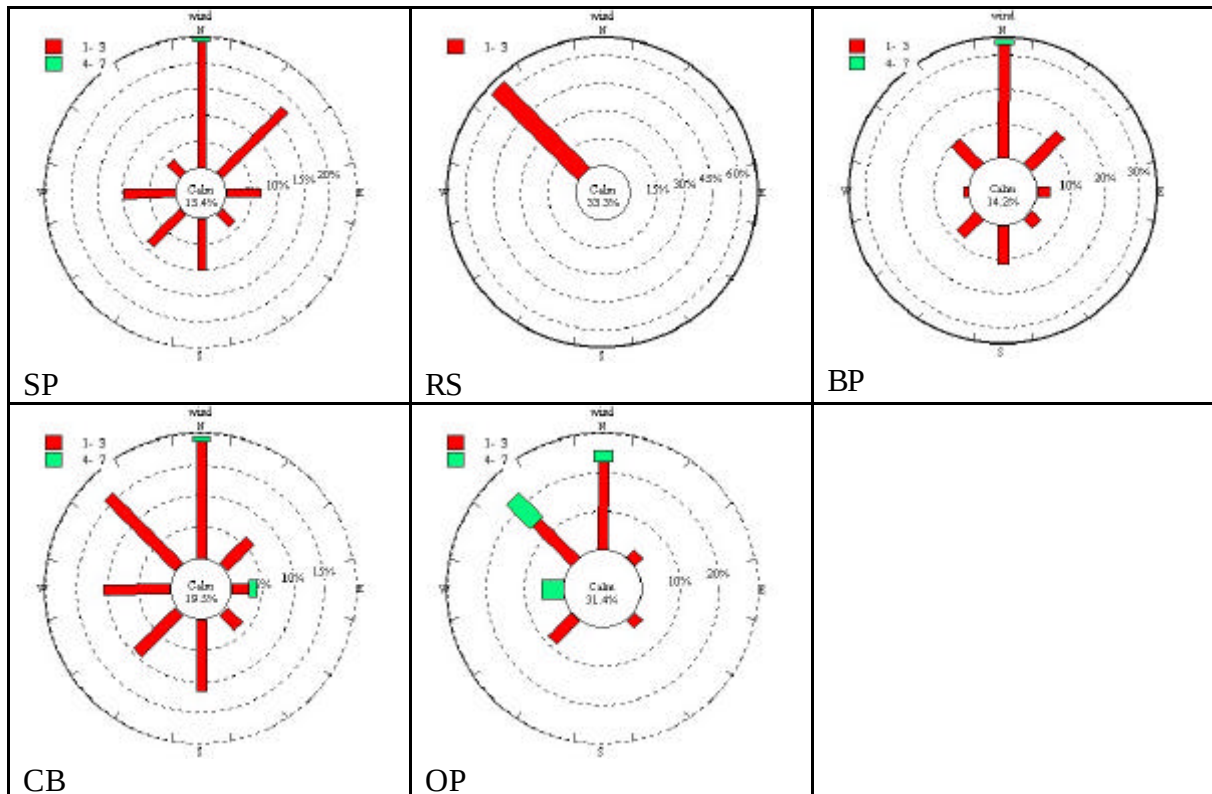


Figure 11. Wind roses depicting the strength and occurrence of wind in each survey sector. 'Calm' indicates wind strengths of 0 (Beaufort Scale).

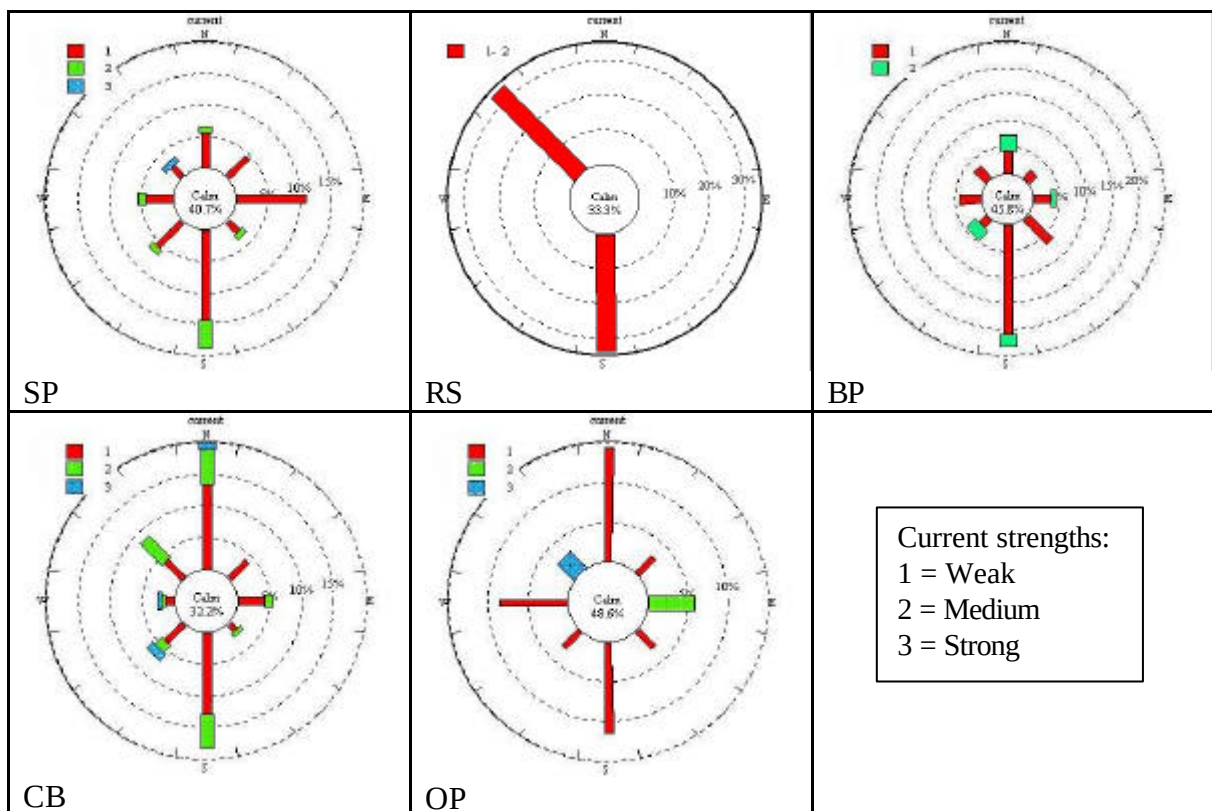


Figure 12. Current roses depicting the strength and occurrence of currents in each survey sector in the Municipality of Sipalay. The legend indicates the different strength classes. 'Calm' indicates no or insignificant currents.

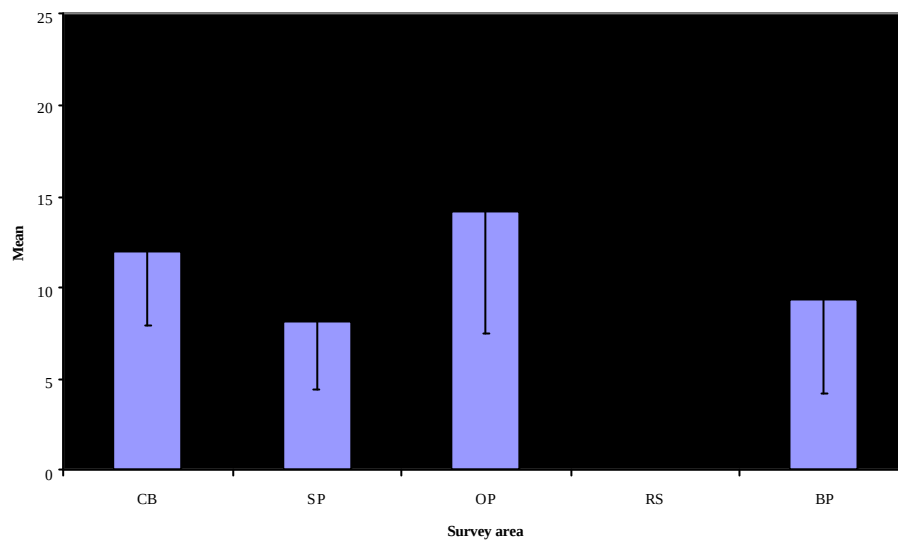


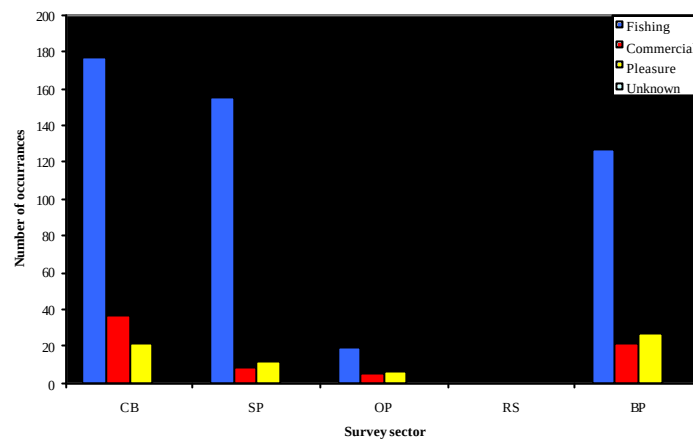
Figure 13. Mean water turbidity measured by the depth reached by secchi disk. Bars represent standard deviation. Additional figures show sample size.

5.2.5 Anthropogenic impacts

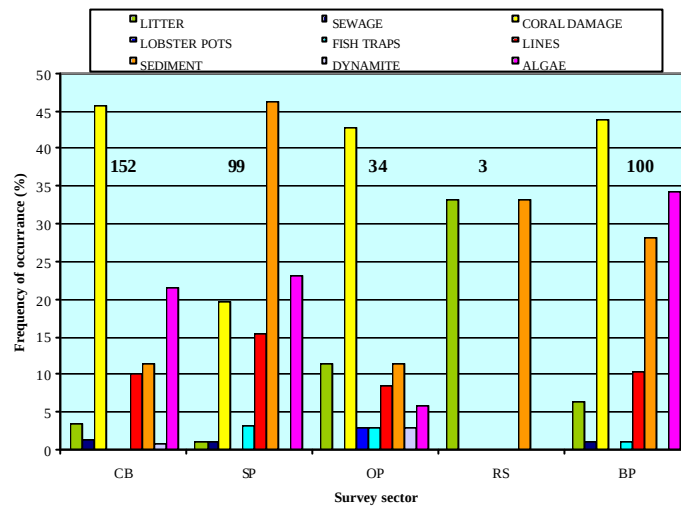
During the course of each baseline survey, anthropogenic impacts were assessed from observations of the number and activity of boats sighted in the vicinity of the survey sites and observations of gross physical damage to reefs during each dive and on the surface. Data on boat numbers and activities distinguished three main activities: fishing, commercial and pleasure, along with some boats whose activities were unknown. To compare boat activity in each sector, these data were converted into sightings per survey (i.e. number of boats divided by number of surveys; Figure 14a). Most boats observed were actively fishing.

During the surveys the presence or absence of litter, broken coral, fishing traps, lines, sedimentation, explosive impacts, algae overgrowth and sewage on each survey were recorded. Figure 14b shows these data expressed as the frequency of occurrence per survey sector (i.e. the number of times each impact was recorded in each sector divided by the number of surveys in that sector expressed as a percentage). The most commonly observed impact was broken coral, with a high frequency in CB, OP and BP (recorded on more than 40% of surveys). High frequencies of sedimentation were observed in SP and RS (recorded on 45% and 33% of surveys respectively). Litter and fishing lines were observed in most areas but evidence of sewage, fish traps and lines and the impacts from the use of explosives were rare. In BP a high frequency of algal overgrowth was observed (recorded on more than 30% of surveys).

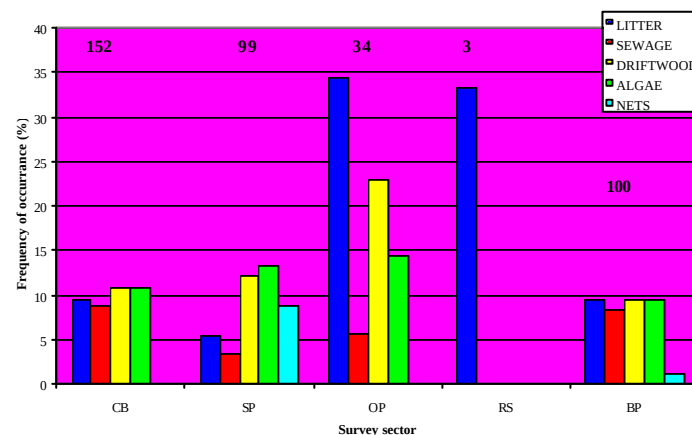
Data on the presence or absence of surface impacts such as litter, sewage, driftwood, algae and nets. Figure 14c shows these data expressed as the frequency of occurrence per survey sector (i.e. the number of times each impact was recorded in each sector divided by the number of surveys in that sector expressed as a percentage). The most frequent impact was litter in OP and RS (recorded on more than 30% of surveys). Sewage, driftwood and algae were recorded occasionally in all sectors, nets were only seen in sector SP.



a) Number and activity of boats seen at each reef. Additional figures show sample size.



b) Frequency of occurrence of subsurface anthropogenic impacts in each survey sector. Additional figures show sample size.



c) Frequency of occurrence of surface anthropogenic impacts in each survey sector. Additional figures show sample size.

Figure 14. Summary of anthropogenic impact data from 388 surveys in the Municipality of Sipalay.

5.3 Taxonomy

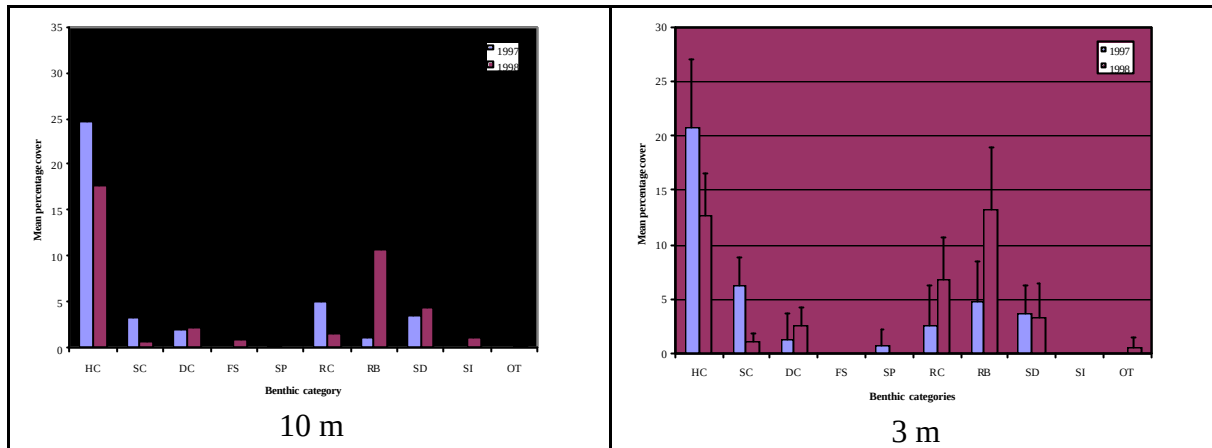
During the SNCDP 391 species of reef fish were identified (Appendix 6).

5.4 Reef Check surveys

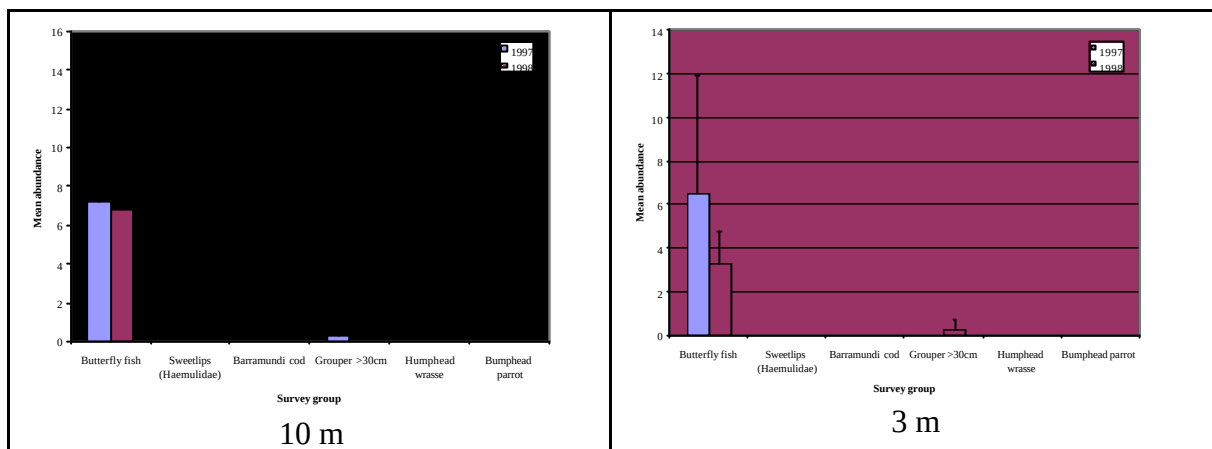
Reef Check surveys were carried out at the north side of Campomanes Bay in 1997 and 1998. 'Site 1' (thought to be the most pristine site in the area) was completed in 1997 and repeated in 1998.

Results from the substratum survey (Figure 15a) indicate that hard coral cover decreased in both the medium and the shallow depths. The percentage of rubble increased by more than 100% and the dead coral showed a very slight increase.

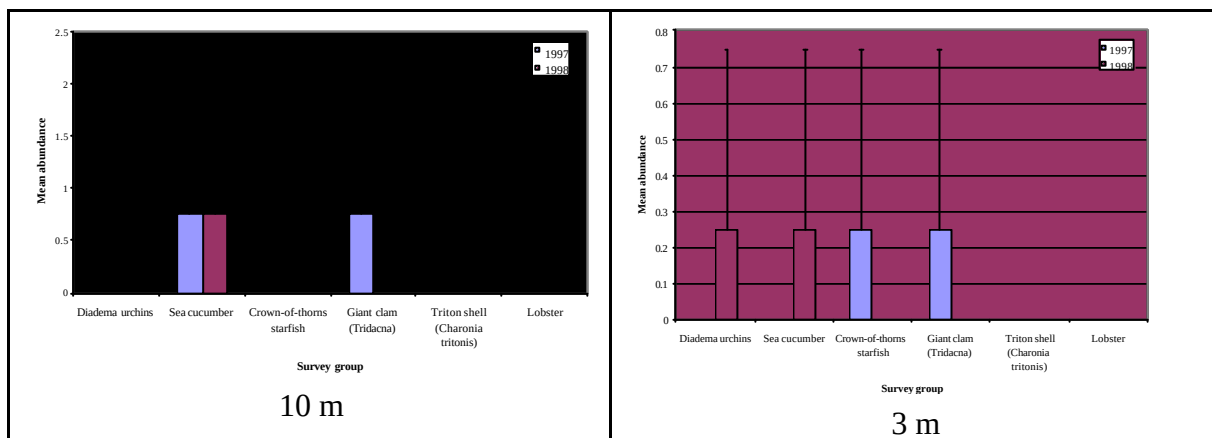
The fish and invertebrate surveys show few target species were recorded (Figure 15b,c). Butterflyfish (Chaetodontidae) were the most abundant with a mean abundance of 6.7 and 6.2 fish for 10 and 3 m respectively in 1997. On the shallow transect this value decreased significantly in 1998 to 2.5 fish per transect. The only other taxa present were groupers (Epinephelini) in extremely low numbers. Invertebrates were sparse and different target groups were observed in the two years. The numbers of giant clams (*Tridacna* spp.; 0.25 individuals) remained constant.



a) Benthic groups in point intercept transects



b) Fish in belt transects



c) Invertebrates belt transects

Figure 15. Summary of data collected from four 20 m transects during Reef Check assessment in 1997 and 1998. Bars represent standard deviation.

6 DISCUSSION

6.1 Baseline reef surveys

6.1.1 Habitat classification

The survey sectors within the Municipality of Sipalay were found to have a varied marine environment including pristine and damaged reefs. Qualitative and quantitative assessments have enabled a description of some of these reefs. However, in some sectors information is still lacking.

The reefs were found to support rich and varied marine communities, which can be distinguished into muddy flats (found on the seabed below the coral reef growth and in shallow sheltered areas), sand with coral patches (found below the coral reef fringe, within the reefal areas and in shallow areas) and the reef areas (found between 28 to 3 m, in some areas between 15 to 4 m of depth). The cluster analysis distinguished 12 benthic classes, describing these groups in more detail. Within the reef areas, relatively healthy habitats (*BC 5,6 and 7*) and habitats containing features indicating damage (*BC 9 and 10*) were classified. There also were habitats which supported very diverse hard coral and fish communities but also showed signs of damage (*BC 4 and 8*). Some benthic classes described areas where the substratum was mixed or which formed intermediate zones between distinguished communities (*BC 2, 11 and 12*). *BC 3* characterised muddy areas, *BC 1* described sand dominated habitats.

BC 1 – Sand with sparse coral and algae was characterised by a sandy substratum and sparse small coral boulders which supported mainly massive and encrusting coral life forms and some leather soft corals. This habitat was situated on the shallow and medium depth reefs. An intermediate habitat between *BC 1* and benthic classes with dense corals appeared to be *BC 11 – Sand and coral patches*.

BC 2 – Bedrock with soft coral contains only seven Site Records. There was a relatively high abundance of leather soft corals which normally dominate the shallow and well lit areas of a reef. It was a rare habitat which was found in shallow areas.

BC 3 – Mud dominated the deep flats at the foot of the fringing reef. Although in the initial clustering it was only represented by three Site Records, in the discriminate analysis more records were included. A number of *BC 3* records were located within the reef matrix, particularly in the sectors BP and SP. This may suggest that sedimentation of the reefs has occurred in those areas. Another mud habitat was represented by *BC 12 – Mud with coral patches*. This benthic class was not included in the initial clustering and was determined by discriminate analysis. It describes a reef dominated by mud, and coral boulders with massive and encrusting Non- *Acropora* life forms, branching *Acropora* lifeforms and *Halimeda* macroalgae. This suggests that this habitat may have been subjected to damage as massive and encrusting corals have been shown to be more resistant to damage and therefore survive longer (Edinger *et al.*, 2000). *BC 12* was a rare habitat which had six Site Records.

A mixed substratum and a mixed coral community characterised *BC 4 – Rubble and sand with mixed coral boulders*.

The benthic classes *BC 5, 6 and 7* described very rich and healthy habitats. They differed in the density of corals and abundance of soft corals. All habitats were evenly distributed in the project area which suggests that patches of pristine reef were present on most reefs.

The most common benthic class was *BC 8 – Bedrock and dense mixed corals with dead coral*. This habitat supported a very dense and diverse hard coral community, including massive, encrusting and branching Non- *Acropora* and *Acropora* branching life forms. The genera *Porites*, *Favites* and *Favia* had the highest abundance. *BC 8* was also characterised by an abundant and diverse assemblage of octocorals and sponges. There also was a relatively high abundance of newly dead coral and newly dead coral with algae which indicates that the reefs were subjected to adverse impacts such as pollution, storm damage, sedimentation or bleaching in the past (Done, 1992).

This hypothesis is also supported by the characteristics of *BC 9 – Dead coral and mixed corals and algae* and *BC 10 – Bedrock, algae and medium dense corals*. Both habitats had a high percentage of newly dead coral and newly dead coral with algae. In *BC 9* more damage-resistant massive *Porites* and other massive Non- *Acropora* life forms dominated, and a very high abundance of filamentous algae may indicate nutrient enrichment and the increased availability of substratum. *BC 10* showed a high abundance of blue green algae which also can be an indication of eutrophication.

In addition to these key habitats, it is possible that there are other habitat types that were either rare and included in the Site Records that were discarded or were simply not surveyed. Further surveys are required in the Municipality of Sipalay to complete the habitat inventory.

There was an emphasis on “dead coral” in the analysis, describing dead coral substratum, newly dead coral and newly dead coral with algae. Dead coral substratum was classed as any substratum which still had recognisable coral growth forms, i.e. a massive coral head which was now overgrown by other corals, algae and invertebrates. The high abundance of newly dead coral (white colour) could be attributed to the coral bleaching event which occurred in the second half of 1998 when surveying was in progress. Coral bleaching was observed throughout the area during this time. Its impacts can be attributed to increased sea water temperature levels caused by El Niño (Section 6.1.4).

The twelve habitats classified in this report help to describe the health of the reef in detail. For the production of habitat maps based on remotely sensed images of the area it would probably be necessary to group them into coarser classes. Owing to the resolution of remotely sensed imagery, similar benthic classes (such as *BC 7: Bedrock and medium dense corals* and *BC 10: Bedrock, algae and medium dense corals*) could not be distinguished.

6.1.3 Fish assemblages

Fish assemblages were relatively similar between the different benthic classes. The community was dominated by a high abundance of damselfish, followed by butterflyfish, wrasse, surgeonfish, recorded on family level, and occasionally specific species. The ANOSIM analysis showed that fish communities were generally uniform and varied only for a limited number of combinations of habitats. This was consistent with the pattern of habitat distribution along the coast of the Municipality of Sipalay. Habitats were mixed, and motile organisms such as fish are not restricted to any one habitat. It indicated that fish ranges may be larger than habitat patches and even in distinct habitats such as mud (where fish normally would be expected at a lower frequency) fish were seen. This was likely to be because of the close proximity to other habitats which supported fish. However, *BC 3 – Mud* was the only habitat where a significant difference in fish communities was computed, indicating a very low abundance and diversity. The Site Records typical for this habitat were often situated at the beginning of the transects, representing the mudflat below the fringing reef. The most common fish species in this area were prawn gobies (Gobiidae) and sand tile fish (Malacanthidae) (MB, pers. obs.). Some areas classed as *BC 3 – Mud* were located within the reef matrix and these were likely to have contained fish roaming from the adjacent habitats. This may have caused high fish counts in *BC 3* in the analysis.

Commercially exploited fish were very infrequent with the most common family being surgeonfish (Acanthuridae). All other commercially exploited fish species had a median abundance below 1. High value large predators such as humphead wrasse (*Cheilinus undulatus*) and jacks (Carangidae) were not seen. These figures indicate that there was high fishing pressure in the area. The fact that fish abundance in all habitats was relatively uniform and low is a sign of over-fishing and depletion of the resources, assuming that fish abundance on a healthy reef would generally be higher in a habitat with diverse and varied benthic life.

Although specimens of commercially important fish were generally of small size (Goby, pers. comm.) and abundances were low, the reefs in the project area seem to support a diverse fish community. With adequate protective measures the populations are likely to recover and support a sustainable fishery.

It is important to note that the median analysis does not account for fish having different ranges and behaviours. Large predators, such as sharks, with large ranges usually have small numbers within any one territory. Therefore, predators present in a relatively high abundance will rarely feature in the analysis, as it is not weighted.

6.1.4 Physical parameters

Physical parameters averaged to similar values across the whole project area. However, during the course of surveying in late 1998, a rise in sea water temperature was experienced, as shown by the higher mean temperatures in the survey sectors investigated during this time. These higher temperatures are also concurrent with recorded sea temperature rises in the region which have been linked with recent climatic abnormalities (El Niño/ La Niña) (Chambers and Tapley, 1999). It can be further assessed by using satellite images from August to December 1998, which show

the Municipality of Sipalay to be in the midst of an area with higher than normal sea water temperature⁽²⁾.

The analysis of wind strength and direction showed that the prevailing wind direction was from the north and remained relatively constant throughout the survey activities. Wind strength was most commonly weak (nil or between 1 to 3 on the Beaufort Scale). Surveys were generally not conducted during wind stronger than 4 or 5 on the Beaufort Scale owing to safety considerations.

Currents recorded were mostly nil or weak and were predominantly from the north or south. This suggests that no major coastal circulations influenced the near-shore surveys. Further investigations on water circulation and oceanographic parameters are required for more detailed interpretation. Oceanography is an important factor when considering the establishment of MPA's since currents carry coral and fish larvae which can assist recovery of reefs not included within the reserves.

Vertical water turbidity varied between the different survey sectors. This suggests that the sectors SP and BP had more suspended solids in the water column than CB and OP. High turbidity in SP could be caused by restricted water exchange in Cartagena Bay and the sediment load of a small river. High levels of turbidity in the sector BP may indicate that it was influenced by Sipalay River, which has its estuary to the north of the sector and discharged its sediment load into Sipalay Bay. This interpretation was supported by the prevalence of southerly currents within this sector, facilitating the distribution of suspended matter along this coast. It may be evidence that Sipalay River carries a high load of suspended solids because of up-land development. There were no records of turbidity in the sector RS in Sipalay Bay.

The salinity stayed constant throughout the survey sectors suggesting that the water column was homogenous and, therefore, well mixed.

6.1.5 Anthropogenic impacts

Fishing in small boats was the most common boat activity observed. Fishing lines were recorded as a common sub-surface impact in all survey sectors but there was little evidence of recent dynamite fishing. These data suggest that the main fishing methods used in the Municipality of Sipalay were line and hook fishing from small boats. Fishing with lobster pots and lines was not evident during the course of the survey.

There was a high frequency of coral damage which may have been caused by storm damage, anchor damage, bleaching or sedimentation. There was a high record of sedimentation and algal overgrowth in the survey sector BP. This is consistent with the physical records and may be caused by the disposal of suspended solids by Sipalay River which are then carried in a southerly direction onto the reef in BP by the prevailing current. Surface impacts were generally low; however in the survey sectors OP and RS a high frequency of litter was noted.

⁽²⁾ (<http://coral.aoml.noaa.gov/>)

6.2 Taxonomy

The Indo-Pacific region is one of the most diverse areas in the world and may support more than 2500 reef fish species (Lieske and Myers, 1994). The preliminary fish species list generated on the southern Negros coastline was representative for the area covered by the Municipality of Sipalay. The 391 species identified are the most common but the list will be expanded as the project continues. This represents approximately 33 % of all the reef fish recorded in the Philippines (DENR, 1997).

6.3 Reef Check surveys

The medium and shallow depth Reef Check contours showed a similar pattern of distribution of different benthic categories and their change from 1997 to 1998. The most apparent changes seemed to be a decline in hard coral cover and soft coral cover with an increase in the percentage of rubble. The only fish seen in significant numbers are butterflyfish, all other target species were not present or only seen in very small numbers (groupers, Epinephelini). The invertebrate counts show that small numbers of sea cucumbers and giant clams are present, although not in both years. No lobsters and triton shells were seen which could suggest that their numbers were reduced because of heavy fishing pressure.

3m Contour

The shallow transect showed a decline of hard coral cover from about 20 % to 13 % between 1997 and 1998. The rubble cover rose from about 5% to 14%, suggesting that live corals were damaged and became rubble within the 12 month period. Relocation of the transect in 1998 might not have been exactly accurate (allowing for a GPS error of $\pm 30\text{m}$) which could have altered the percentage covers via natural spatial patchiness on coral reefs. A mean coral cover of approximately 25% indicates reefs that are 'good' to 'fair' and reefs with less than 25% mean hard coral cover (as seen in Sipalay) are 'poor', using the criteria of the ASEAN-Australia Marine Science Project (Wilkinson, 1994). There also was a drop in soft coral cover. Butterflyfish counts declined from 1997 to 1998 by almost 50%. This may be a result of the reduction of food for these obligate corallivores which are considered to be indicators of reef quality (Reese, 1977). Changes in the shallow area seemed to be more severe than in the deeper reef area. Giant clams and crown of thorn starfish were recorded in 1997, and sea urchins and sea cucumbers in 1998.

10m Contour

The trends described above are less obvious on the medium depth transect. There was a drop in hard coral cover from about 25% to 18%, indicating that reef status declined from 'good' to 'fair', using the criteria of the ASEAN-Australia Marine Science Project (Wilkinson, 1994). A significant rise in the percentage of rubble (from 2% to about 11%) occurred between 1997 and 1998. Butterflyfish counts remained constant, suggesting that there was still sufficient habitat to support them. Numbers of sea cucumbers remained constant.

Few of the fish or invertebrate indicators were present and since they were selected to provide information on anthropogenic impacts (Hodgson, 1999) there was evidence that the area is over-harvested. The conclusion that the benthic community was reasonably healthy in 1997 and started to deteriorate in the following year is supported by the decline of formerly abundant butterflyfish, since they may be correlated to coral cover and hence reef health (see Crosby and Reese, 1996, for a review). The fish and invertebrate species highly prized by fisherfolk were rare or absent although this pattern is almost ubiquitous throughout the Indo-Pacific (Hodgson, 1999). Data suggest that the shallow reef area was more adversely affected than the medium depth reef. Further data will highlight any consistent, long-term trends.

7 CONCLUSION

During the course of the assessment, the status and biodiversity of the reef along the coastline of the Municipality of Sipalay were described and analysed using qualitative and quantitative data. It was found that they support diverse marine communities of hard corals, invertebrates, algae and fish. The reefs along the coastline are fringing reefs subjected to anthropogenic impacts, for example sedimentation. This impacts are amplified by the close proximity of communities and land based developments such as rice farming or road construction. This has led to patches and areas where the well developed and diverse reefs have been smothered by sediment and coral damage has occurred.

Baseline surveys identified the distribution of twelve major benthic classes. These are relatively evenly distributed in the five survey sectors assessed. The reefs along the coastline rise from a mud dominated sea bed. They can exhibit dense coral cover, coral distributed in patches with sand and sandy or barren rocky areas. The reefs with the highest coral density and reef health were found in the north of sector SP, in CB and to a limited extend in OP. In SP there is a 'good' to 'fair' reef area where habitats representing diverse and healthy assemblages of benthic organisms and fish were located. The survey sector CB also contains a variety of those habitats. The area appears to be flushed well and sedimentation occurs to a lesser extent. A unique reef wall was found in the southern end of sector CB, containing rare reef features and organisms. This wall and the surrounding reef have been classified by a mixture of benthic classes most of which contain high coral cover. The sector OP only contained six transects which describe the south corner of Campomanes Bay as an area containing mixed coral boulders, rubble and some mud dominated benthic classes.

Patches and areas of recent damage (for example recent sedimented zones and recently dead coral) and indicators of past damage (for example barren areas with rubble and opportunistic soft corals) are also present. Anthropogenic impacts such as dynamite and cyanide fishing appear to be low. This can be attributed to the high population density where prohibited fishing practises are difficult to conduct without prosecution. However, impacts from sedimentation, sewage, coral bleaching and storms appear to be significant throughout the project area.

Sedimentation appears to be a major impact in the region, especially in the survey sectors SP and BP. Part of SP is situated in a shallow enclosed bay, thus sedimentation can be attributed to the lack of water circulation. Sector BP seems to be affected by suspended solids from Sipalay River being carried onto the reefs by southerly currents. The sector BP contained a higher amount of benthic classes exhibiting indicators of damage and there was a high percentage of mud and sand dominated habitats within the reef matrix, indicating sedimentation.

In autumn 1998 the reefs in the Municipality were subjected to the global coral bleaching event caused by elevated sea water temperatures owing to El Niño. In the project area both coral mortality and recovery from bleaching was observed. It is likely that such bleaching events decrease the overall health and resistance of corals to other impacts. The combination of bleaching and high levels of suspended solids in the water column could cause increased damage to the reefs.

There were relatively high levels of coral death due to sedimentation and bleaching, the full extent of which is not yet known. Further work would hope to be able to identify the level of damage caused by sedimentation as opposed to bleaching or storm impacts.

Owing to unforeseen operational difficulties, which led to a suspension of the survey activities in the area, more data are required for a number of survey sectors. Only three sectors have been fully surveyed. More baseline transects within the Municipality of Sipalay are required for the survey sectors RS, ET, OP and NB to provide a representation of this part of the coastline and its marine habitats. More work will resume in 2000.

Even though there was a high abundance of fish on the surveyed reefs, the fish were of a small size or were juveniles, presumably as a result of over-fishing. Typically commercially exploited species were rare or of small size, indicating a heavy fishing pressure. However, it also indicates that recruitment occurs and it is possible that fish stocks will recover quickly if given the chance to rehabilitate.

In conclusion, the assessment of the marine resources along the coastline of the Municipality of Sipalay proved the existence of a diverse and abundant reef community. However, there was evidence of damaging impacts that may endanger this environment. The abundance of benthic classes representing rich and abundant benthic life, limited damage and the least likelihood to be adversely affected by sedimentation will qualify a reef in this region to be considered as a suitable location for a protected area. These criteria are matched by the small peninsula north of Cartagena Bay, the north corner of Campomanes Bay and the adjacent reef areas extending both north and into the bay and the south corner of Campomanes Bay. Further surveying is required to identify other areas within the region.

8 RECOMMENDATIONS

The assessment of the marine environment in the Municipality of Sipalay presented in this report is an example of the information and conclusions that can be derived from an environmental database. The problems and values that were addressed in this report are likely to be similar along the whole of the coastline of Southern Negros.

It is recommended that this report is viewed as a basis for further work in the whole of Southern Negros since the Municipality of Sipalay needs to be incorporated into a Southern Negros Integrated Coastal Zone Management (SNICZM) plan as addressed by the SNCDP. A priority should be to address the issue of sedimentation on the region by applying an inter-sectoral approach and integrating management of the up-land areas and coastal areas. This management plan should include a chain of marine reserves and sanctuaries along the coastline of Southern Negros. For the Municipality of Sipalay three locations would be suitable for a reserve, characterised by high numbers and abundance of reef organisms and low exposure to sedimentation. They are situated north of Cartagena Bay, the north corner of Campomanes Bay and the outer south bank of Campomanes Bay. Further surveys in the municipality are required to identify other possible locations. It is also recommended to:

- ?? Establish several permanent monitoring sites on the coastline to monitor the change of benthic and fish communities. These monitoring surveys should be carried out by qualified scientific personnel;
- ?? Complete the baseline assessment of the missing survey sectors;
- ?? Establish a permanent monitoring programme for physical parameters such as rainfall, sedimentation and currents.

These measures should form part of an integrated programme for the whole of the Southern Negros coastline. In order to protect the valuable resources and utilise them sustainably, it is recommended to establish the SNCDP on a long-term basis, including all natural and human resources within the region. This could lead to the development and implementation of an SNICZM plan in within six municipalities, based on information derived from a database generated by the presented and additional surveys throughout the area.

Within the SNICZM plan, the following points need to be addressed:

- ?? The areas of high diversity that need to be protected;
- ?? A monitoring plan is required to detect changes in the environment;
- ?? Resource use needs to be carried out in a sustainable manner;
- ?? Alternative income for fishermen using unsustainable methods needs to be targeted e.g. eco-tourism;
- ?? Community involvement and education need to be implemented to give the local people the capacity to manage their resources sustainably;
- ?? The support of the Local Government Units (LGU) needs to be maintained to instigate the SNICZM plan.

It is recommended that marine protected areas, a commonly used fisheries management tool (Roberts and Polunin, 1991), are established throughout the region. A chain of marine reserves

along the coastline is recommended to be established, preferably at least one in each participating municipality. The major objectives of marine protected areas are to manage coral reef fisheries to ensure protection of a critical spawning stock biomass to ensure recruitment supply to fished areas via larval dispersal, and possible maintenance or enhancement of yields in areas adjacent to reserves by adult movements (Alcala, 1998). It is imperative to include all stakeholders such as NGO's, regional government, LGU's and community representatives in the process.

In order to implement an SNICZM plan, the following steps are recommended:

- ?? Completion of the detailed baseline surveys and species inventories, using CCC baseline surveys;
- ?? A survey of socio-economic factors;
- ?? Social preparation of the community, including community organising, education and skills development;
- ?? Development of alternative livelihood schemes; for example mudcrab farming;
- ?? Incorporation of all information into a Geographical Information System (GIS);
- ?? Development of an SNICZM plan including the establishment of several MPAs.

The core issues that need to be addressed are described below:

?? **Research and monitoring**

The completion of the systematic baseline survey of the reefs and adjacent mainland coastal areas will be required in order to provide data to create habitat maps required for the development of the SNICZM plan. The baseline survey data can be incorporated into a GIS database and overlaid onto geo-rectified base maps (prepared from aerial or satellite imagery) for the synthesis of habitat maps.

Monitoring programmes should be established in designated locations throughout the Southern Negros area. This should include the monitoring of living resources and parameters related to climate, anthropogenic reef use and damage.

?? **Social preparation**

A programme to establish and maintain dialogue with local communities and stake-holders is required in order to ascertain the socio-economic and cultural basis upon which a realistic SNICZM plan can be prepared and to build consensus within the local community. This should include regular meetings with representatives from local communities, stake-holders, government units and co-opted experts.

?? **Conservation education**

There is an urgent need to further improve environmental awareness within schools and local communities. A schools curriculum for conservation education, including field trips to local forest and coral reef habitats, should be developed and a range of appropriate educational materials distributed to local schools, such as the educational wall chart: *Philippine Reefs and Rainforests* (Appendix 7). Teacher-training workshops will be required in order to train schoolteachers in conservation issues and the use of supporting educational materials. Outreach

programmes to provide conservation education opportunities for local communities should also be developed.

?? Training

Training programmes should be established to provide key personnel, community representatives and staff of other involved groups with the technical skills necessary to conduct marine surveys and monitoring programmes and analyse data. The development of skills and knowledge that may provide an alternative livelihood should be encouraged with communities throughout the project area.

?? Capacity strengthening

Development of an SNICZM plan will require co-ordination via a CZM unit at the local, provincial and national level and linking with relevant agencies and universities.

The foundation of local community resource centres would help facilitate educational and training programmes, project management and data management. The centres would also serve as focal point for public meetings, displays (including aquariums) and exhibitions designed to promote environmental awareness within the area.

?? Alternative livelihood

Programmes to provide alternative livelihoods should include knowledge and technology transfer from participating organisations, training in skills and control mechanisms. The participation of women should be encouraged. Alternative livelihood schemes could include:

- ?? Surveillance and wardening in protected areas;
- ?? Nature tourism;
- ?? Aquaculture, for example mangrove friendly mudcrab cultures;
- ?? Pandan weaving;
- ?? Mangrove nurseries.

Over the next five years, PRRCFI and CCC will be able to continue to support key components of some of the activities suggested above and it is recommended that the SNCDP should continue in the future.

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