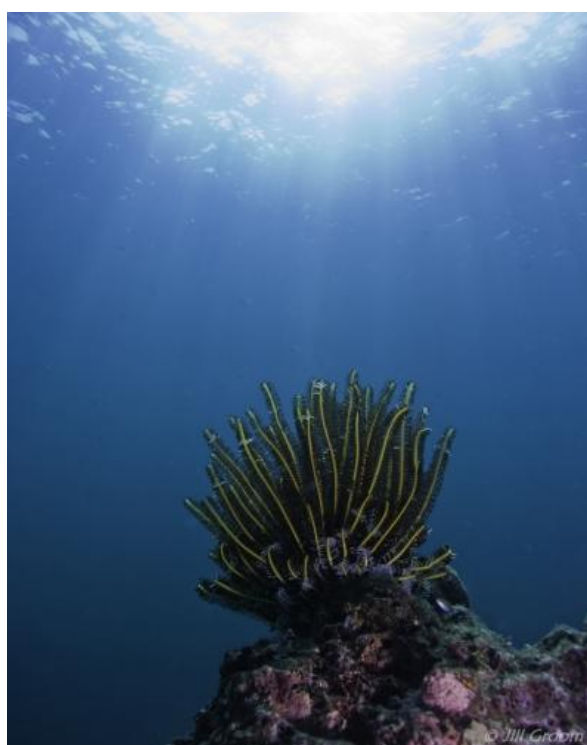


# **SOUTHERN LEYTE CORAL REEF CONSERVATION PROJECT**

## **Annual Report**

### **RESULTS OF COMMUNITY AND SCIENTIFIC WORK**

**JANUARY 2009 – JULY 2010**



© CORAL CAY CONSERVATION (2011)

**In partnership with:**



**The Provincial Government of Southern Leyte, Philippines**

**Report by**

**Jan-Willem van Bochove**, Head of Marine Science<sup>1</sup>,

**Melissa McVee**, GIS Assistant<sup>1</sup>

**Peter Raines**, Founder and CEO<sup>1</sup>

<sup>1</sup>*Coral Cay Conservation*, [info@coralcay.org](mailto:info@coralcay.org)

**The Philippine Reef and  
Rainforest Foundation Inc.**  
South Capitol Road  
Bacolod City 6100  
Philippines  
[www.prrcf.org](http://www.prrcf.org)  
[glledesma@gmail.com](mailto:glledesma@gmail.com)

**Coral Cay Conservation**  
Elizabeth House  
39 York Road  
London SE1 7NQ  
United Kingdom  
[www.coralcay.org](http://www.coralcay.org)  
[info@coralcay.org](mailto:info@coralcay.org)

## Executive Summary

The Southern Leyte Coral Reef Conservation Project (SLCRP) was undertaken with the main objective of assisting the Provincial Government of Southern Leyte (PGSL) in the conservation of the coral reefs of Sogod Bay for the long-term benefit and food-security of the residents of the Province. This assistance has been provided under successive Memorandum of Understandings (MoU) between PGSL, CCC and the Philippine Reef & Rainforest Conservation Foundation, Inc. (PRRCFI).

Three strategies have been identified as appropriate for achieving this objective, namely:

- 1 - Conservation education for the fisherfolk, schools, colleges, and Local Government Units (LGUs) of the Province
- 2 - Capacity building of technical skills amongst the employees of the Provincial Government of Southern Leyte
- 3 - Resource appraisal of the current status of the coral reefs of the bay

From September 2002 to April 2004, the SLCRCP was based near the town of Malitbog, from where CCC dive teams assessed the north-eastern and north-western reefs. In May 2004, the project moved to the Municipality of Padre Burgos, from where the reefs of the southwest and Limasawa Island could be assessed. In April of 2008, the project site again moved, this time to the island of Panaon on the eastern side of Sogod Bay. From here, the remaining survey sites along the more remote south-eastern coastline of Sogod Bay can be surveyed. This report contains an analysis of all of the data gathered by CCC survey teams from the project's inception in September 2002, until July 2010. It also contains a synopsis of community work and capacity building activities undertaken between January 2009 and July 2010. Community and capacity building work undertaken prior to December 2005 have previously been presented in Taylor et al (2004), O'Farrell et al (2006) and van Bochove et al. (2007, 2009).

Since the project's inception in September 2002, CCC has successfully installed community based Marine Protected Areas (MPAs), trained local government representatives, scholars and suitable community representatives to both dive and conduct scientific surveys whilst also instigating and delivering a wealth of community educational work.

Over the past 19 months, CCC project staff and volunteers undertook an extensive community education programmes that included teacher and student training days, educational open days at the project site, presentations and interactive lessons for schools, beach cleanups and attendance at local fairs, symposia and workshops. The CCC Scholarship Programme provided 17 scholars with 4-week SCUBA dive and scientific survey training.

CCC survey teams have thus far conducted 1654 survey dives, producing a total of 1911 individual survey records for the reefs of Sogod Bay. Because the location of each of these

surveys was determined using a Global Positioning System (GPS) receiver, these data can be imported to a Geographic Information System (GIS), to facilitate spatial analysis. These data will be made freely available to the resource managers of Southern Leyte, to allow for target specific querying of the dataset, as well as the selected analysis presented herein.

Hard coral cover was higher towards the mouth of the bay, which may be linked to higher sediment input into the bay's head in the north. Hard coral species diversity was very high in certain areas of the bay with a number of rare species recorded. A total of 257 species of hard coral have been identified thus far.

Low abundance of commercially important fish and invertebrate species indicates that there is severe over-fishing of the reef fish populations within Sogod Bay and follows the trend that fish stocks are considered to be both biologically and economically overfished in most areas of the Philippines. Setting up networks of properly managed MPAs is suggested as the most effective strategy for securing areas of high coral cover and diversity in addition to allowing fish stocks to recover.

The high diversity and abundance of reef fish species and high live hard coral cover in existing fish sanctuaries, such as Napantao on the eastern coast of Sogod Bay and the four fish sanctuaries around Padre Burgos is encouraging and also extremely attractive to divers. The presence of Whale Sharks and other 'megafauna', such as turtles, sharks and marine mammals, indicates that there is great potential for coastal or dive related tourism in the area, assuming it is managed in a sustainable manner.

## Acknowledgements

Coral Cay Conservation would like to extend its heartfelt thanks to the following people and organisations, without whom this project would not have been possible:

Provincial Governor for Southern Leyte, Hon. Damian Mercado, Vice-Governor Miguel Maamo and the Provincial Board members

Gerry L. Ledesma, and all the staff from the Philippine Reef & Rainforest Conservation Foundation Inc (PRRCFI)

Nedgar Garves and all the staff at the Provincial Tourism Office

Mam Eva Abad and all the staff at the Provincial Coastal Resources Management Office

Hon Diego B Yuboc, Municipal Mayor of San Francisco

All the staff of GiZ Southern Leyte

Dr. Violeta Merin-Alocilja, CESO V, Department of Education, Southern Leyte Division

The members of the Padre Burgos MPA Oversight Committee

The members of the Napantao Fish Sanctuary Steering Committee

Professor Senona A. Cesar and the other staff of Leyte State University

Dr. Gloria Reyes, Homer de Dioz and all staff of Southern Leyte State University

In alphabetical order, Günter (Southern Leyte Divers), Pete (Peter's Dive Resort) and Ron and Phil (Sogod Bay Divers), for their continued support and for sharing their knowledge of Sogod Bay

Our Filipino staff, Dag, Delia, Tata, Ariel, Junil, Jesse and Benjamin whose loyalty, trust, and dedication are highly valued

A special thanks goes out to Neil Pretencio, Lloyd "Wang Yu" Abiera, Emmanuel Gulay and Ma'am Beverly Navarette, for their support, advice and friendship.

All the dedicated international volunteers who gathered the data and made this project possible

# Table of Contents

|                                                                          |           |
|--------------------------------------------------------------------------|-----------|
| <b>CORAL CAY CONSERVATION.....</b>                                       | <b>8</b>  |
| <b>1. INTRODUCTION .....</b>                                             | <b>11</b> |
| 1.1 THE PHILIPPINES .....                                                | 11        |
| 1.2 SOUTHERN LEYTE.....                                                  | 12        |
| 1.3 THREATS TO THE CORAL REEFS OF SOGOD BAY .....                        | 14        |
| <i>Global and Regional-Scale Threats and Impacts .....</i>               | <i>15</i> |
| <i>Intermediate and Local-Scale Threats and Impacts .....</i>            | <i>17</i> |
| <b>2. COMMUNITY AND CAPACITY BUILDING WORK .....</b>                     | <b>21</b> |
| <b>3. SCIENTIFIC METHODS.....</b>                                        | <b>32</b> |
| 3.1 BACKGROUND.....                                                      | 32        |
| 3.2 METHODOLOGY .....                                                    | 32        |
| 3.3 GEOGRAPHIC INFORMATION SYSTEM .....                                  | 36        |
| <b>4 SCIENTIFIC RESULTS .....</b>                                        | <b>37</b> |
| 4.1 RESULTS FROM OCEANOGRAPHIC AND ANTHROPOGENIC IMPACT DATA.....        | 40        |
| <i>Surface Temperature and Salinity.....</i>                             | <i>40</i> |
| <i>Boat Frequency and Activity.....</i>                                  | <i>41</i> |
| <i>Fishing Pressure .....</i>                                            | <i>42</i> |
| <i>Underwater Impacts .....</i>                                          | <i>43</i> |
| <i>Coral Bleaching and Disease .....</i>                                 | <i>43</i> |
| <i>Site Impression.....</i>                                              | <i>44</i> |
| 4.2 RESULTS FROM BENTHIC INDICATORS .....                                | 46        |
| <i>Scleractinian corals .....</i>                                        | <i>46</i> |
| <i>Giant Clams (Tridacna spp.) .....</i>                                 | <i>51</i> |
| <i>Sea Urchins (Diadema spp.) .....</i>                                  | <i>51</i> |
| <i>Macro-algae .....</i>                                                 | <i>51</i> |
| 4.2 RESULTS FROM FISH FAMILIES .....                                     | 54        |
| <i>Butterflyfish (Chaetodontidae).....</i>                               | <i>54</i> |
| <i>Parrotfish (Scaridae) .....</i>                                       | <i>54</i> |
| <i>Groupers (Serranidae).....</i>                                        | <i>54</i> |
| <i>Snappers (Lutjanidae).....</i>                                        | <i>55</i> |
| 4.4 CONSERVATION MANAGEMENT VALUES .....                                 | 59        |
| <b>5. DISCUSSION .....</b>                                               | <b>61</b> |
| <b>BIBLIOGRAPHY .....</b>                                                | <b>63</b> |
| <b>APPENDIX A: BASELINE SURVEY FORMS.....</b>                            | <b>67</b> |
| <b>APPENDIX B: SCIENCE DEVELOPMENT PROGRAMME TRAINING SCHEDULE .....</b> | <b>70</b> |
| <b>APPENDIX C: GIS OUTPUTS.....</b>                                      | <b>72</b> |

## List of Tables and Figures

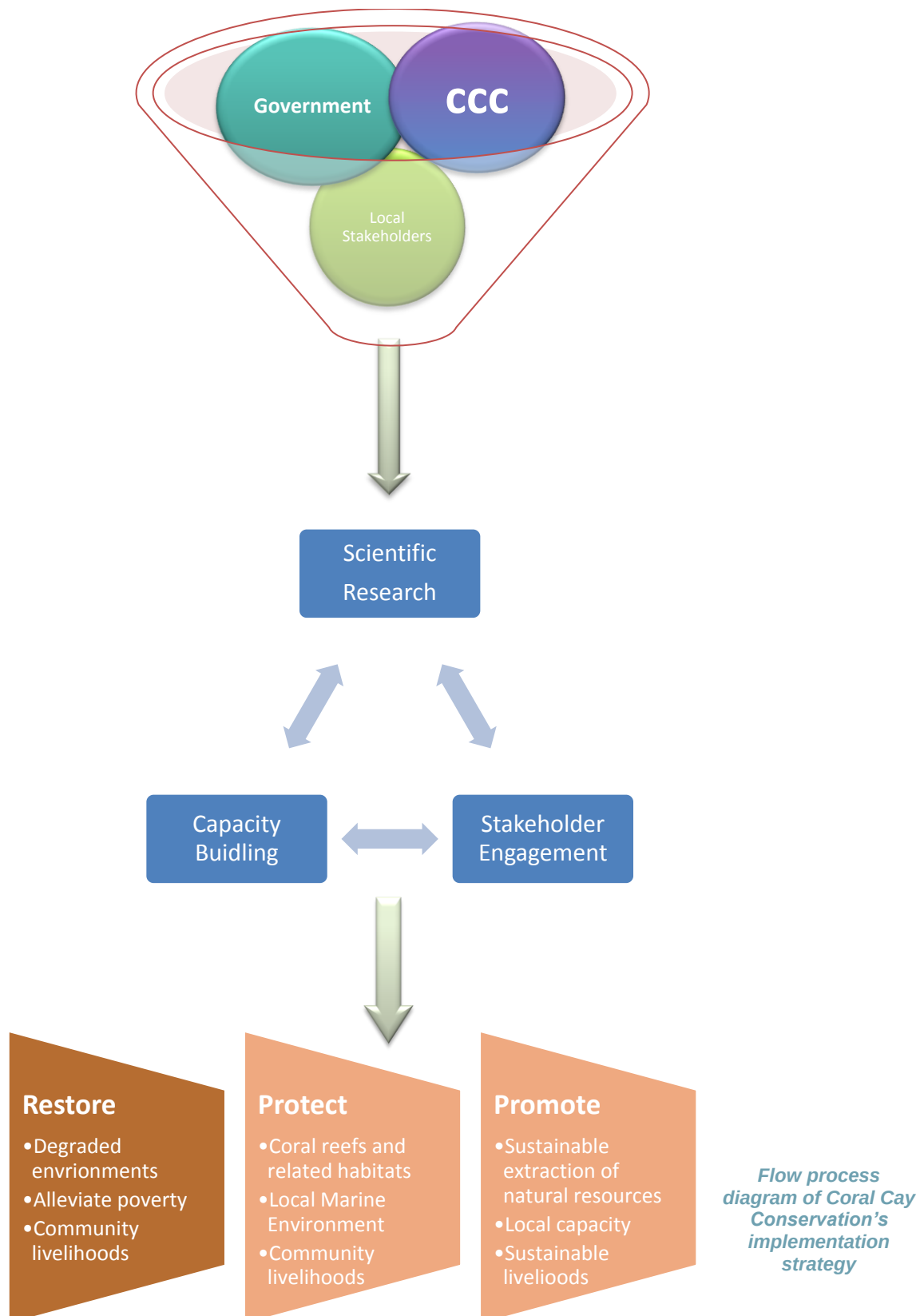
|                                                                                                       |    |
|-------------------------------------------------------------------------------------------------------|----|
| FIGURE 1 MAP OF PHILIPPINES AND SOUTHERN LEYTE PROVINCE .....                                         | 12 |
| FIGURE 2 EDUCATIONAL COORDINATOR TEACHING CHILDREN .....                                              | 23 |
| FIGURE 3 THIRD YEAR MARINE BIOLOGY STUDENTS FROM SLSU BEING GIVEN AN ADVANCED LECTURE .....           | 24 |
| FIGURE 4 PARADE AND PRESENTATION DURING THE ANNUAL EARTH DAY IN MAASIN.....                           | 24 |
| FIGURE 5 GRACE QUITON AT THE FIRST ORC CONFERENCE.....                                                | 25 |
| FIGURE 6 A CORAL CAY REEF RANGER RECORDING INFORMATION ABOUT THE CORAL REEF .....                     | 27 |
| FIGURE 7 CORAL CAY POSE WITH THE NEW MPA ASSESSMENT TRAINERS.....                                     | 28 |
| FIGURE 8 STUDENTS FROM SLSU SOGOD POSE FOR PHOTOS WITH CORAL CAY .....                                | 29 |
| FIGURE 9 CCC MEMBERS AND HABAY CHILDREN PAINTING MARINE LIFE. ....                                    | 30 |
| FIGURE 10 VOLUNTEERS LEARNING CORAL REEF SPECIES IDENTIFICATION UNDER GUIDANCE OF SCIENCE STAFF. .... | 32 |
| FIGURE 11 OUTLINE ILLUSTRATION OF THE CCC BASELINE SURVEY METHODOLOGY.....                            | 33 |
| FIGURE 12 DESCRIPTION OF SPECIFIC DIVER ROLES WITHIN THE SURVEY TEAMS .....                           | 34 |
| FIGURE 13 THE USE OF A SECCHI DISC TO ASSESS VERTICAL WATER CLARITY. ....                             | 35 |
| FIGURE 14 SATELLITE IMAGE OF SOGOD BAY.....                                                           | 38 |
| FIGURE 15 LOCATIONS OF 1911 SURVEY STATIONS VISITED IN SOGOD BAY. ....                                | 39 |
| FIGURE 16 SURVEYS CONDUCTED PREVIOUSLY TO THIS REPORT .....                                           | 39 |
| FIGURE 17 AVERAGE READINGS FOR SEA SURFACE TEMPERATURE (°C) AND SURFACE SALINITY (PPM).....           | 40 |
| FIGURE 19 PERCENTAGE OF 5 DIFFERENT BOAT ACTIVITIES OBSERVED.....                                     | 41 |
| FIGURE 18 VERTICAL VISIBILITY .....                                                                   | 41 |
| FIGURE 20 FISHING PRESSURE AROUND SOGOD BAY. ....                                                     | 42 |
| FIGURE 21 UNDERWATER IMPACTS AROUND SOGOD BAY.....                                                    | 43 |
| FIGURE 22: SURVEY SITES AT WHICH CORAL DISEASE AND BLEACHING WERE OBSERVED.....                       | 44 |
| FIGURE 23 AESTHETIC VALUE AND BIOLOGICAL VALUE .....                                                  | 44 |
| FIGURE 24 BIOLOGICAL VALUE OF SURVEY SITES AROUND SOGOD BAY.....                                      | 45 |
| FIGURE 25 AESTHETIC VALUE OF SURVEY SITES AROUND SOGOD BAY.....                                       | 45 |
| FIGURE 26 REGRESSION PLOT FOR THE NUMBER OF CORAL SPECIES VS. NUMBER OF FISH SPECIES.....             | 46 |
| FIGURE 27 HARD CORAL COVER ON A DAFOR SCALE. ....                                                     | 48 |
| FIGURE 28 SOFT CORAL COVER ON A DAFOR SCALE.....                                                      | 49 |
| FIGURE 29 GIANT CLAM ( <i>TRIDACNA</i> ) ABUNDANCE ON A DAFOR SCALE.....                              | 52 |
| FIGURE 30 SEA URCHIN ( <i>DIADEMA</i> ) ABUNDANCE ON A DAFOR SCALE.....                               | 52 |
| FIGURE 31 NUTRIENT INDICATOR ALGAE ABUNDANCE ON A DAFOR SCALE. ....                                   | 53 |
| FIGURE 32 ABUNDANCE OF BUTTERFLYFISH, DISPLAYED AS A COLOUR RAMP.....                                 | 56 |
| FIGURE 33 ABUNDANCE OF PARROTFISH, DISPLAYED AS A COLOUR RAMP. ....                                   | 56 |
| FIGURE 34 ABUNDANCE OF GROUPERS, DISPLAYED AS A COLOUR RAMP .....                                     | 57 |
| FIGURE 35 ABUNDANCE OF SNAPPERS, DISPLAYED AS A COLOUR RAMP. ....                                     | 57 |
| FIGURE 36 ABUNDANCE OF SWEETLIPS, DISPLAYED AS A COLOUR RAMP.....                                     | 58 |
| FIGURE 38 CONSERVATION MANAGEMENT VALUES (CMVs).....                                                  | 60 |

# Coral Cay Conservation

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

Founded in 1985, CCC is dedicated to ‘providing resources to protect livelihoods and alleviate poverty through the protection, restoration and sustainable use of coral reefs and tropical forests’. CCC works in collaboration with government and non-governmental organisations within a host country and does not charge that country for the services provided. CCC is primarily self-financed through a pioneering volunteer participatory scheme whereby international volunteers are given the opportunity to join a phase of each project in return for a financial contribution towards the project costs. Upon arrival at a project site, volunteers undergo a training programme in marine life identification and underwater survey techniques, under the guidance of qualified marine scientists, prior to assisting in the acquisition of data. Finances generated from the volunteer programme allow CCC to provide a range of services, including data acquisition, assimilation and synthesis, conservation education, technical skills training and other capacity building programmes. CCC is associated with the Coral Cay Conservation Trust (the only British-based charity dedicated to protecting coral reefs).

CCC has been successfully operating volunteer based conservation programmes in developing countries over the past 25 years with several internationally notable accomplishments, including the establishment of several Marine Protected Areas around the world. Examples of CCC action include the creation of the UNESCO World Heritage Site in Belize, the Danjungan Marine Reserve and Wildlife Sanctuary for Negros in Philippines, and the development of 12 no-take marine parks around Sogod Bay in the Philippines.





Southern Leyte's incredible seascapes highlight its stunning diversity of marine life.  
*All images taken by Jill Groom*

# 1. Introduction

## 1.1 *The Philippines*

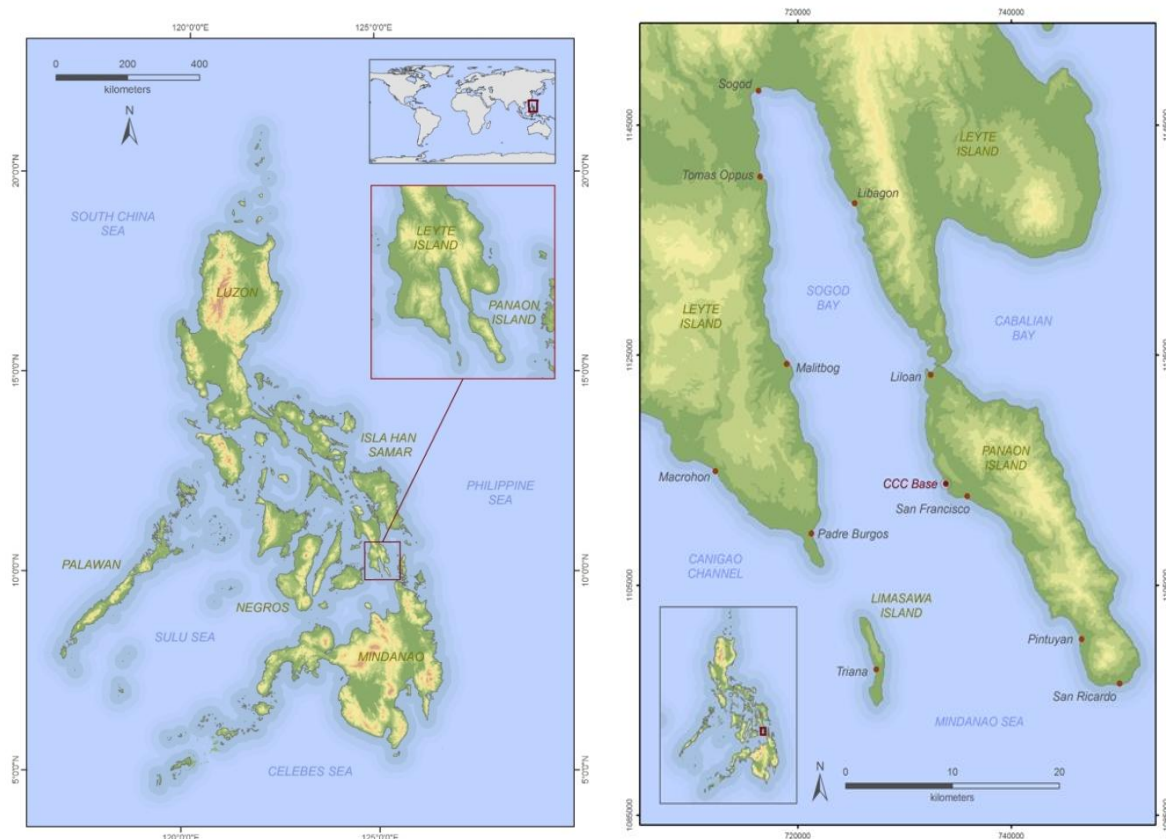
The Philippine archipelago of approximately 7100 islands forms part of the Wallacea triangle, an area renowned for its high terrestrial and marine biodiversity. Some 499 hard coral species (Chou, 1998) and more than 2500 fish species (Lieske and Myers, 2001), have been identified. This is a higher concentration of fish species per unit area than anywhere else in the world (Carpenter and Springer, 2005). The Philippines has 36,289km of coastline, 25,000km<sup>2</sup> of which are fringed with coral reefs (Wilkinson, 2008)

Although many cities in South East Asia are developing very rapidly, most people in the Philippines remain highly dependent on coastal resources for their livelihoods, inducing pressure on the marine environment (Wilkinson 2008). Coral reefs provide livelihoods for coastal communities through fishing, aquaculture and tourism. Reef fish are the primary source of protein for most Filipinos, whilst many invertebrates such as giant clams (*Tridacna* spp.) and sea cucumbers (Holothurians) are also commercially harvested, fetching high market prices. Coastal tourism and diving tourism in particular can provide alternative means of income for coastal communities as long as the industry is managed sustainably, in terms of the environmental effects of development and the local communities are in favour of it.

The majority of the population (approximately 94 million) of the Philippines is concentrated along the coastline putting intense pressure on the marine resources through a range of impacts. The greatest anthropogenic impacts are caused by solid and liquid pollution, overfishing, habitat degradation and elevated sedimentation levels. These impacts, when coupled with the current global increase in temperatures, induce a severe threat to the survival of coral reefs (Wilkinson 2008). Future projections made by GCRMN (Global Coral Reef Monitoring Network) estimate that the level of risk in Philippines' reefs range from 'high' (90% of reefs) to 'very high' (10% of reefs) (Wilkinson, 2008).

Coral reefs act as important physical barriers, which, along with mangroves, protect coastal communities from storm damage and coastal erosion. Coastal habitat loss can therefore have a dramatic influence on the success and future livelihoods of coastal populations. Hard corals require environmental stability in order to thrive and have a narrow band of tolerance for physical parameters such as temperature, salinity and sediment loads. Small changes in these properties can have dramatic impacts on the coral reef ecosystem. The next section provides further information on local and regional threats to Cambodia's coral reef habitats.

## 1.2 Southern Leyte



**Figure 1 Map of Philippines (left) and Southern Leyte Province (right) with Sogod Bay in the centre. The CCC Project site is located in the Municipality of San Francisco on the south-eastern side of the Bay.**

Southern Leyte, one of the six provinces of Eastern Visayas (Figure 1) is bounded in the north by Leyte province, in the south by Mindanao Sea, in the east by the Pacific Ocean and in the west by the Canigao Channel. Sogod Bay ( $10^{\circ} 12' N$ ,  $125^{\circ} 12' E$ ) is surrounded by 131.67 km of coastline and is shared by 11 municipalities: Padre Burgos, Malitbog, Tomas Oppus, Bontoc, Sogod, Libagon, Liloan, San Francisco, Limasawa, Pintuyan, and San Ricardo. The islands of Panaon and Limasawa also form part of Sogod Bay (Figure 2). Within the bay, Sogod town is the centre for trade, commerce and industry.

The coral reefs of Southern Leyte remain some of the least disturbed habitats in the Philippines. Sogod Bay is an important fishing ground and the area is rich in tuna, flying fish, herrings, anchovies, shell-fish and spanish mackerel. The bay has been targeted by the Fisheries Sector Program of the Department of Agriculture as one of the country's ten largest bays in need of assessment and management (Calumpong *et al.*, 1994). Sogod Bay is also a feeding ground for attractive mega-fauna such as pilot whales, melon-headed whales, dolphins, manta rays and whale sharks.

The bay is characterised by naturally limited mangrove areas, narrow fringing coral reefs, limited seagrass beds and narrow intertidal areas and beaches (Calumpong *et al.*, 1994).

Depths in the bay reach a maximum of approximately 1,400 metres in the central channel. Aquaculture is limited in the province and mainly consists of seaweed farming, clam and abalone culturing programmes, mud-crab farming and also fin-fish operations. However, some of these ventures have been unsuccessful, possibly due to inappropriate placement. The bay is ideal for nearshore fish farms and aquaculture procedures as the seabed is often steeply sloping and current patterns carry water away from the coast to the centre of the bay where they are flushed out during ebb tides.

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

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

Southern Leyte is the second least populated area in the region. The population in the province has recently started to increase again since 2000 at 1.13% per year according to a 2007 census (census.gov.ph). It stands at 390,847 with a population density of 217.5/km<sup>2</sup>. The low human population density is a factor that has contributed to the protection of coral reefs locally to date. However, a further rise in population and subsequent pressure on all marine resources could result in marine habitat degradation and consequently the loss of income or whole livelihoods. The ecosystem diversity in Sogod Bay is limited and the processes of degradation are prevailing (Calumpong *et al.*, 1994).

The first comprehensive survey of marine resources in the area was carried out between 1990 and 1993 (Koch, 1993). The study was aimed at determining the physical and biological condition of the near-shore marine environment of the Province of Southern Leyte as well as the state of the fisheries resource. Interviews carried out with local people revealed that the fish catches of coastal areas had decreased. These statements have been confirmed by recent socio-economic assessments carried out by CCC in San Francisco (See Heuër *et al.*, 2008). Marine surveys confirmed extensive damage to coral reefs and other critical habitats. The damage can be linked to anthropogenic activities both in the water and on land. Koch recommended the establishment of marine reserves to promote the recovery and protection of the area. The author also identified the need to carry out vigorous education campaigns in order to elucidate the benefits of good marine, land and waste-management practices. From the surveys, it was estimated that 50% of the coral reefs, which were extensive 15 years previously, had been almost totally destroyed. Another 30% had been heavily damaged with less than 25% of the corals remaining.

Silliman University undertook an assessment of the natural resources and coastal ecology in Sogod Bay in 1993/1994 and again in 2001/2002 and more recently in 2007. During the 1993/1994 surveys, water quality and fisheries were assessed and an ecological study of the

bay was carried out. The extent and condition of the coral reef resources was assessed using manta tow surveys and quadrat sampling methods. To date, no comprehensive work has been carried out on the deeper parts of the reefs in Sogod Bay.

### 1.3 Threats to the coral reefs of Sogod Bay

The Philippines is the most highly threatened centre of endemism (Roberts et al. 1998). It has been predicted that 90% of the reefs across the Philippines are at risk (Wilkinson, 2008). Reefs are threatened by a combination of coastal development, marine-based pollution, sedimentation and overfishing (Table 1). Furthermore, it has been estimated that up to 60% of seagrass beds have been destroyed with similar losses to mangrove, mainly due to coastal construction, logging and clearing for aquaculture (Wilkinson, 2008). The main regional and local, anthropogenic impacts to coral reefs are described in more detail on the following pages.

*Table 1 Summary of Coral Reef Status in the Philippines. Adapted from Wilkinson 2008 pp136-137*

|                                                                                | Philippines |
|--------------------------------------------------------------------------------|-------------|
| General reef Statistics                                                        |             |
| Reef Area (km <sup>2</sup> )                                                   | 25,819      |
| <b>Overall Reef Condition (arrows indicate direction of change since 2004)</b> |             |
| No of Hard Coral Species                                                       | 464         |
| Very Healthy (75% coral cover)                                                 | 1% ↔        |
| Healthy (50-75% coral cover)                                                   | 9% ↑        |
| Fair (25-50% coral cover)                                                      | 50% ↓       |
| Poor/Very Poor (<25% coral cover)                                              | 40% ↓       |
| <b>Integrated threat index %</b>                                               |             |
| Low                                                                            | 2           |
| Medium                                                                         | 27          |
| High                                                                           | 63          |
| Very High                                                                      | 7           |
| <b>Threat Indicators</b>                                                       |             |
| Coastal Development                                                            | High        |
| Marine-Based Pollution                                                         | High        |
| Sedimentation                                                                  | Low/Med     |
| Over fishing                                                                   | Med/High    |
| Destructive fishing                                                            | Med/High    |
| <b>Marine Protection Status</b>                                                |             |
| Total number of actively managed MPAs                                          | 339         |
| Total number of MPAs with coral reefs                                          | 294         |
| % of MPAs with good management ratings                                         | 20-30%      |

## Global and Regional-Scale Threats and Impacts

Carbon Dioxide (CO<sub>2</sub>) levels in the earth's atmosphere have been rising steeply since the industrial revolution, mainly due to the burning of fossil fuels. Based on realistic scenarios of future emissions this trend will continue and atmospheric CO<sub>2</sub> concentrations are expected to reach double pre-industrial levels by 2065 (Houghton et al., 2001). Global temperatures are expected to rise anywhere between 1.8 – 4.0°C by the year 2100 (IPCC, 2007).

Climate change is regarded as one of the major threats to the future of coral reefs (Hughes et al., 2003). Coral reefs have evolved in relatively stable climatic conditions for the last tens of thousands of years. It is this relative climatic stability that has allowed them to develop into a complex ecosystem comprised of thousands of species and many intricate inter-specific relationships. Coral reefs can recover from acute stress (e.g. bleaching events) and also tolerate chronic (e.g. sedimentation) ones to a certain degree. However, chronically stressed reefs are far less likely to recover from an acute stress (Kinsey, 1988). A series of acute stresses against a backdrop of continued chronic ones can result in a phase shift and the replacement of the coral dominated community by one dominated by macroalgae or some other non-reef system. Such ecosystem shifts have been well documented in the Caribbean (Buddemeier et al., 2004) and in some cases; the combination of stresses has brought coral reefs to the point of local extinction. Coral reefs have accordingly been dubbed the “canaries in the coalmine of climate change”. What follows is a summary of some of the most concerning climate change induced phenomena that are predicted to have an impact on the coral reefs in Southern Leyte.

## Coral Bleaching

Coral species and their associated microscopic algae are highly sensitive creatures with a limited ‘tolerance zone’ within which they can thrive. Stressors such as increased UV light and thermal stress can threaten their survival. Coral bleaching refers to the loss of the symbiotic algae (zooxanthellae) from the coral tissue as a result of stress. Without these algae, the coral colony appears white. The zooxanthellae provide the bulk of the coral's nutrition via photosynthesis. If a coral colony is not able to regain its population of symbiotic algae, it will starve.

Although there have been records of coral bleaching since 1870 (Glynn, 1993), extensive or regional bleaching appears to be a relatively new phenomenon, with a significant increase in the levels and extent of bleaching recorded in the past 20 years or so (Winter et al, 1998). Recent examples of corals reefs' responses to elevated sea surface temperatures in the Indo-Pacific were demonstrated in 1998 when bleaching due to the *El Niño* Southern Oscillation (ENSO) event effectively killed 16% of the world's coral reefs. Such events are expected to become bi-annual within the next 20-50 years if drastic measures are not taken to reduce carbon emissions (IPCC, 2007).

Within Sogod Bay, large scale bleaching has not been observed since 2002, and the region was not significantly affected during the mass bleaching event of 1998. Taylor *et al.* (2004) suggested that the lack of bleaching was related to the upwelling of cooler water from the deeper parts of the bay to the warmer shallow areas producing a mixed, less stratified water column. A similar effect occurs in the Red Sea where coral bleaching has been minimal.

## **Ocean Acidification**

In addition to rising sea surface temperatures, another phenomenon is expected to affect the very structure and growth capabilities of hard corals through a process known as oceanic acidification. As the oceans absorb more carbon dioxide, their marine chemistry changes. Dissolved in water, CO<sub>2</sub> becomes carbonic acid, reducing the amount of carbonate available to calcifying organisms such as reef building (Scleractinian) corals that need carbonate to create a calcium carbonate (limestone) skeleton. In the last 200 years the surface ocean has absorbed about half of the CO<sub>2</sub> produced by industry, causing a fall in pH of 0.1, which equates to a 30% increase in H<sup>+</sup> ion concentration (Royal Society, 2005). The predicted changes in seawater chemistry could have severe consequences for calcifying organisms, making it increasingly difficult for hard corals to maintain their limestone skeletons (Orr et al. 2005).

## **Coral Diseases**

Disease outbreaks and subsequent mortality among corals and other reef organisms have been a major cause of the recent increase in coral reef degradation (Buddemeier et al., 2004) and are an emerging problem in the Indo-Pacific region (Aeby, 2007). For example, Black Band Disease, previously known only from the Caribbean, has now been recorded in the Indo-Pacific. Black Band Disease was first reported from the Philippines in 1985 and has also been recorded in Australia (Great Barrier Reef), Sulawesi, Indonesia and Fiji (Aeby, 2007).

There is a lack of knowledge about the causative agents of many diseases affecting corals but studies have shown that microbial pathogens are a source of coral diseases such as Black and White-Band disease (Cervino et al., 2004). Some of these pathogens have been linked to sewage and agricultural outputs (Voss et al., 2006, Smith et al., 1996) providing strong evidence for proper waste management in order to minimise disease impacts on coral reefs. Coral disease has not had a significant impact in Sogod Bay to date, but their prevalence over the coming years should be closely monitored.

## **Precipitation and Storm Damage**

Another concerning effect of global climate change is the expected dramatic changes in weather systems. Tropical precipitation has increased over the past century by 0.2–0.3 % per decade in the 10°S–10°N region (Houghton et al., 2001). The frequency of heavy precipitation events is expected to increase (IPCC, 2007). Increases in precipitation can lower salinity and increase sediment discharge and deposition near river mouths, sometimes leading to mass mortalities on nearby coral reefs (Wolanski et al., 2003). Proper management and restoration of natural watersheds can greatly minimise direct runoff from rainwater.

Typhoons are also becoming stronger and more unpredictable (Webster 2005). Healthy reefs can recover from infrequent damage caused by tropical storms but already weakened and stressed reefs can suffer further degradation with little opportunity for recovery.

## Intermediate and Local-Scale Threats and Impacts

Although climate change is now considered to be the overarching threat to tropical marine ecosystems, impacts to coral reefs are exacerbated by local, anthropogenic events. To maintain hard coral populations on reef systems around the world it will be necessary to carefully manage direct pressures such as pollution, sedimentation, overfishing and coastal development, and hope that some coral species are able to adapt to the warmer environment (Wilkinson and Souter, 2008). Studies conducted on relatively undisturbed coral reefs, in the absence of direct human pressures, have indicated that such reefs have a greater ability to recover from bleaching events. This was demonstrated in the remote archipelago of Chagos following the 1998 ENSO event (Sheppard et al., 2008). Threats to reef health, caused by local anthropogenic factors include:

- Changes in water quality due to input of nutrients
- Siltation from construction, dredging and runoff from upland deforestation and agriculture
- Overfishing to the extent where key groups of species are removed and it is no longer sustainable.
- A reduction in coral reef diversity and hard coral cover due to Crown of Thorns Starfish

These are briefly discussed below.

## Pollution and Nutrification

Tropical waters are generally nutrient poor environments (oligotrophic) and anthropogenically-induced nutrient inputs can upset the water chemistry of coral reefs (McCook, 1999). The impact is further exacerbated if overfishing removes key herbivores which normally help to keep algae in check. Knock-on effects have been known to weaken the physiological resistance of corals and make them more susceptible to disease; recent studies have shown a link between increased nutrient levels and the rate of disease spread (Voss et al., 2006)

Excess nutrients (nutrification) in the coastal waters can arise from discharge of untreated effluent and from agricultural run-off containing fertiliser. Pollution may be a particular problem in bay areas where flushing rates are slow and nutrients are not quickly dispersed. Furthermore eddies within coral reef areas can create water circulation patterns which prevent removal of nutrients to the open ocean and result in localised concentrations.

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

Mangrove removal has exacerbated the problems of sedimentation and pollution. Mangroves are important nursery grounds for juvenile fish and invertebrates and their roots help retain and filter nutrients from sediments. Like coral reefs, they also play an important role in coastal stabilisation. Only 120,000 ha of mangrove forest remain in the Philippines, about 25% of the area present in 1920 (Philippine Coastal Management Guidebook Series, No.1).

The main sources of pollution in Sogod Bay identified by Calumpong *et al.*, (1994) are: domestic garbage, faecal matter and waste water from population centres. In the majority of municipalities in Sogod Bay people are responsible for disposing their own domestic waste. This is usually burnt, composted or thrown directly into the sea. Some municipalities have landfill sites and rubbish is collected on a twice-weekly basis. However municipalities such as Padre Burgos have had difficulty locating suitable areas as landfill sites that can also meet the requirements of the Provincial ordinance, although a suitable site has recently been identified within the Padre Burgos Municipality. Some attempts have been made to recycle at least a portion of the waste outputs.

## Sedimentation

Over much of South East Asia, extensive deforestation has resulted from the harvesting of tropical hardwoods (Hodgson, 1999) and land clearance for agriculture. Sedimentation is expected to be considerable in Sogod Bay, particularly on reefs in proximity to river mouths. Runoff from the land is substantial due to the elevation of the surrounding land, where mountains are in close proximity to the sea and reach a maximum of 2650m. The extensive mountain range encompassing Sogod Bay is covered with both primary forests dominated by the Philippine mahogany tree as well as planted coconut palms. Logging in the area has been banned but illegal logging does occur, particularly during bad weather. In the wet season (November to February) and during periods of extreme rainfall, increased runoff is expected to have a considerable impact on the narrow band of fringing reefs.

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

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

Siltation, as a result of natural processes or anthropogenic interference, is thought to be the most important factor influencing the condition of coral reefs (Jacinto *et al.*, 2000). Sedimentation may cause coral mortality and lower recruitment rates leading to decreased rates of accretion of coral reefs and overall habitat degradation. Corals rely on a high level of

light irradiance to survive. Increased sediment loading in the water column reduces the light available for photosynthesis by the symbiotic algae (zooxanthellae) living in the coral tissue. Sedimentation also physically smothers coral polyps and removal of sediment requires the production of large amounts of mucous, which is an energetically demanding activity. Excess mucous production over long time periods stress the coral host, further reducing growth and reproductive capacities. Subsequent coral mortality and decreased coral reef growth rates can have knock-on effects by reducing the diversity of invertebrate and fish life.

## Fishing Pressure

The Philippines is one of the largest island groups in the world with 60% of the population residing in coastal areas (Jacinto *et al.*, 2000). The majority of these people are highly dependent on coastal resources for their livelihood and have sustainably harvested reef resources in the past without causing significant impacts. The current population growth rate will cause the population to double by the year 2035, which will put significant pressure on resources, including fisheries. It has been suggested that the present levels of fishing can no longer be sustained (Courtney *et al.*, 1999).

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

In Sogod Bay, a number official Marine Protected Areas (“fish sanctuaries”) have been established. There are also un-official sanctuaries at present that are proposed for incorporation into legislation in the near future. The sanctuaries are managed by Sanctuary Management Council of the Barangay, which in turn is controlled by the Bureau of Fisheries and Aquatic Resources (BFAR). These sanctuaries were established after initial visual assessments were made by government officials using SCUBA diving (Rio Cahambing, Roy Cahambing and Dag Navarette, pers. comm.). The sanctuaries were placed in areas that possessed the most abundant and diverse coral reefs. Following their establishment, visual assessments were carried out by the same group every 1-3 years. The sanctuaries are protected by locally appointed patrol boats but effective surveillance is limited by inadequate funding and a lack of resources. Another problem facing the sanctuaries is that the buoys marking the boundaries tend to disappear during adverse weather and are expensive to replace. Spearfishing within some of the sanctuaries still occurs, with fishers exploiting the lack of surveillance to fish illegally in the no-take zones. Therefore, many of the sanctuaries have been reduced to ‘paper parks’ and are in need of re-evaluation and effective enforcement.

Coral Cay Conservation has assisted in the establishment of several MPAs throughout the bay, including the establishment of four community-based fish sanctuaries within the municipality of Padre Burgos in 2005. Although relatively small (4-8 ha.), the four sanctuaries are located in areas of high coral cover and are in close proximity of each other, which is believed to aid in the recovery of commercial fish populations. CCC has been working in

close consultation with the fisherfolk conducting socio-economic assessments, community workshops and providing presentations of scientific monitoring results. Through these activities, a sense of involvement and ownership has been instilled within the communities and this is believed to have helped in the success of the sanctuaries over the last 5 years. The success of this project has led to the further establishment and adaptive management of a further 8 MPAs within the bay, including the largest one at 60ha along the eastern coast of Limasawa Island.

## Crown-of-thorns Outbreaks

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

The Crown-of-thorns starfish (COT) was first recognized in an outbreak on the Ryukyu Islands in 1957 and later around Green Island on the Great Barrier Reef in 1962, (Moran, 1986). The number of individuals that constitutes an outbreak varies spatially and temporally but when a population is consuming coral at a rate faster than the growth rate of the corals, an outbreak has been established, (Lourey *et al.*, 2000). *A. planci* prefers to feed on commonly occurring and fast-growing corals such as *Acropora* and *Pocillopora* species. However slow-growing (1cm diameter yr<sup>-1</sup>), massive corals such as *Porites* spp. are also targeted during outbreaks and can suffer significant damage. Local extinction of these long-lived, architectural reef colonies could gradually extend the reefs recovery time, (Seymour & Bradbury, 1999). Lourey, (2000), found evidence that up to 25% of the reefs surveyed on the Great Barrier Reef may not recover, as outbreaks over the last thirty years have been occurring more frequently thus preventing full regeneration of coral cover.

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

In Sogod Bay COTs are abundant in certain areas, and unusually, often in shallow waters (<12m depth). In particular the reefs on the eastern side of Limasawa Island as well as Malitbog and Tomos Oppus have suffered considerable damage by large numbers of COTs since November 2002. From underwater observations, the reefs around the eastern side of Limasawa now have very low hard coral cover with predominantly soft corals growing on the old dead hard coral skeletons.

## 2. Community and Capacity Building Work

One of the key objectives of the Southern Leyte Coral Reef Conservation Project is to assist the Provincial Government of Southern Leyte in strengthening its human resources and providing guidance to develop local capacity in order to ensure the long-term protection and sustainable use of marine resources throughout the region. The training of host country counterparts, educators, Provincial and local government employees, and students ensures that the Province is able to conduct its marine monitoring activities in the future without external support.

In addition to one-day Coastal Zone Management workshops, Coral Cay provides scholars with 2 training modules.

- **Reef Check Scuba Award:** A two-week award in which participants were certified to PADI Advanced Open Water Diver, trained in the identification of target marine life forms and trained in Reef Check and MPA monitoring survey techniques.
- **Reef Conservation Scuba Award:** An intensive four-weeks in which participants were certified to PADI Advanced Open Water Diver, trained in the identification of over 300 marine life forms and in a variety of methods for scientific surveying of coral reef ecosystems.

17 scholars from different backgrounds and municipalities were trained between January 2009 and July 2010 (Table 1).

**Table 2 2 and 4-week scholarships awarded**

| Month      | Scholar name            | LGU/NGO/University               |
|------------|-------------------------|----------------------------------|
| Jan 2009   | Welvin Gultiano         | SLSU Bontoc                      |
| Jan 2009   | Darwin Alba             | SLSU Bontoc                      |
| Jan 2009   | Dick Francis Lampong    | SLSU Bontoc                      |
| May 2009   | Marlon Raules           | SLSU Bontoc                      |
| May 2009   | Emmanual Intong         | SLSU Bontoc                      |
| Jul 2009   | Jessy Tinapay           | Brgy. Napantao                   |
| Jul 2009   | Jose L. Ydel JR         | Brgy. Napantao                   |
| Jul 2009   | Servando Cagigas Tio JR | Municipal Council, San Francisco |
| Sep 2009   | Ryan Tomol              | ORC, Silago                      |
| Jan 2010   | Rodrigo Baluran         | Brgy. Sta Paz Sur                |
| Jan 2010   | Carlito R. Mosot        | Brgy. Son-ok                     |
| Mar 2010   | Hazel Soriano           | ORC, Silago                      |
| Mar 2010   | Marlon Lopez            | ORC, Silago                      |
| Mar 2010   | Karen Uy                | UP Marine Science Institute      |
| April 2010 | Lorina Toyhacao         | ORC, Silago                      |
| April 2010 | Rey Valerio             | ORC, Silago                      |
| July 2010  | Leonardo Monter         | Brgy. Marcohon                   |

In addition to this, CCC provides a wide range of community educational and awareness activities in support of its scientific work. The nature of the training varies according to the needs of the trainees, ranging from simple coral reef appreciation for young children to 2-day training Reef Ranger and teacher training workshops for local schools.

The section below provides an overview of the wide range of community work undertaken by CCC between January of 2009 and July of 2010.

#### JANUARY 2009

- ◆ The Vice-Governor of the Provincial Government of Southern Leyte, Hon. Miguel Maamo, invited CCC to the State of City Address (SOCA), where The City Mayor Hon. Maloney L. Samaco, the Congressman Hon. Roger G. Mercado, the Governor Hon. Damian G. Mercado and all Barangay Captains of the districts concerned were present.
- ◆ Children from the Kinderhilfe Orphanage in Padre Burgos were taken on a day trip to the beach where they were taught about coral reefs and conducted a beach clean up.
- ◆ CCC hosted a Reef Rangers weekend at their base in Napantao. The 18 pupils from third year Santa Paz High School were invited to spend 2 days learning about the variety of fish, coral, invertebrates, sponges and algae in the sea. They were also trained in snorkel survey techniques which provided them with the skills needed to monitor their own local area.
- ◆ The CCC Education Officer taught waste management lessons in Napantao village and informed children at the Elementary school of the impact litter can have on the environment.

#### FEBRUARY 2009

- ◆ CCC attended a meeting with the Southern Leyte Education department, where project staff met with the superintendant of schools, Hon. Violeta Merin-Alocija to discuss the implementation of more coral reef related material into the school curriculum.
- ◆ A business skills training session was held in Napantao in partnership with DENR. The aim of the training was to follow up on skills training which the women of the Napantao Community Association (NACOA) livelihood project had previously received.
- ◆ CCC organised for a mural to be painted at the basketball court in Napantao village. In addition, focusing on the rural schools in the Municipality of Liloan, the education team continued teaching students about coral reefs.
- ◆ CCC facilitated a lecture on coral reef conservation at a youth conference, organised by people from the Mambajao Youth Association (MYA) and Sanggun-an kabata-an (SK), held in Maasin.
- ◆ The Philippines Country Environmental Profile was updated with CCC's help. The information provided in this document reflects the changes in the state of the

environment during the last few years and makes suggestions for further implementation of the environmental programme in the Philippines during the period 2010 to 2013.



Figure 2 Naomi Billingham, Educational Coordinator, teaching children from Tabugon Elementary School about corals.

#### *MARCH 2009*

---

- ◆ CCC hosted an open day for marine biology students from Southern Leyte State University (SLSU) and high school pupils from Limasawa where they learned about coral reef ecology and conservation.
- ◆ CCC gave a lecture on waste management at a coastal clean up day in the municipality of San Juan.
- ◆ CCC conducted a rapid reef assessment in the municipality of Punta so as to advise the municipality on the potential establishment of an MPA.
- ◆ CCC attended an economic development workshop presented by the Department of Trade and Industry (DTI). The purpose of the meeting was to inform and teach people from the community of Napantao about local economic development.
- ◆ Fish catch survey forms were collected for analysis for the first time, and good results were received from the fisheries survey programme.



Figure 3 Third year marine biology students from SLSU being given an advanced science lecture (left). Limasawa kids enjoying a snorkel (right).

#### APRIL 2009

- ◆ Two important meetings took place in April, the first with the Marine Protected Area Oversight Committee meeting in Padre Burgos on the 2nd of April. The second, on the 7th of April, was with the Barangay council of Punta. In the meeting it was established that the Barangay council would like to have a MPA and we agreed on an area that could be set aside for protection.
- ◆ CCC participated in the Annual Earth Day celebrations in Maasin, where there was a parade and series of presentations at St Joseph's College that addressed the negative impacts of humans on the environment. A lecture on the connectivity of rivers and the ocean was also given.



Figure 4 Parade and Presentation during the Annual Earth Day in Maasin.

#### MAY 2009

- ◆ CCC was invited to attend the first Ocean Action Resource Centre and SIDLAK (teachers association) conference in Silago. CCC presented a talk that highlighted the wealth and uniqueness of the Philippines marine resources.

- ◆ Community members from the municipality of Padre Burgos joined CCC for a Marine Protected Area (MPA) monitoring training weekend at the CCC base in Napantao. The barangays represented included Tangkaan, Lungsodaan and Sta Sofia, all of which have MPAs.
- ◆ Representatives from the municipalities of Padre Burgos and San Francisco travelled to Apo Island, situated just offshore from the city of Dumaguete in the Province of Negros Oriental. The main purpose of the excursion was to investigate how the Apo Island sanctuary started, how it's managed and why it has been so successful.



Figure 5 Grace Quiton at the first ORC conference (left) and the 18 delegates at Apo island (right).

#### *JUNE 2009*

---

- ◆ A second wall paint and an open day, which started with an information session followed by a beach cleanup, were arranged at the Napantao Elementary School.
- ◆ CCC and women NACOA attended the Agriculture and Fish Fair in Maasin during the Independence Celebrations of Southern Leyte.

#### *JULY 2009*

---

- ◆ CCC attended both the Champions of the Sea Award in Maasin, and the Punta Council meeting to assist in establishing the management of their new MPA.
- ◆ CCC was present at the NFSOC (Napantao Fish Sanctuary Oversight Committee) meeting in Napantao, the Anislagon Council meeting and the CRM (Coastal Resource Management) network meeting in Sogod, where improved networking between stakeholders was one of the major topics addressed.
- ◆ There was a meeting between CCC, the municipality of Pintuyan and the KASAKA (Kapunungan sa mga Son-okanon Alang sa Kalamboan) organisation to establish ways in which CCC Conservation could assist in training and information sessions. It was decided that CCC would hold a seminar for tour guides and spotters to extend their knowledge in whale shark biology, research and current status.

- ◆ CCC and the President of NACOA travelled to Padre Burgos to display additional material in the dive centres and to introduce dive centre contacts to the President of the organisation.

#### AUGUST 2009

- ◆ A lecture was held for the KASAKA organisation and officials from the municipality of Pintuyan to increase their knowledge of whale shark biology and ecology; an interest in collecting data during the coming season was shown.
- ◆ CCC Conservation attended a meeting in Macrohon regarding provincial orientation and consultation on LGU coastal alliance. The overall objective of the meeting was to discuss how effective alliances could be established in Southern Leyte.
- ◆ The first session of the teacher training programme for school teachers from Silago was held; the aim of the programme is to educate teachers in the importance of marine biology and enable them to fully appreciate their local resources.

#### SEPTEMBER 2009

- ◆ The final day of the teacher training program for the teachers from Silago took place. The founder of the ORC organisation, Grace Quiton, also came to the CCC project site in Napantao. In a separate event over 200 head teachers attended the Head teacher's Conference for the San Juan District, during which CCC gave an introduction to its conservation work.
- ◆ Educational work with students from Napantao Elementary School continues. Furthermore, CCC taught 360 children about coral reefs at Pintuyan Central School.
- ◆ The Bureau of Fisheries and Aquatic Resources (BFAR) hosted a workshop in Barangay Punta for the finalisation of the establishment of a marine protected area.
- ◆ CCC Conservation attended a seminar and workshop in Tacloban on small-scale fisheries management. The workshop was hosted by WORLD FISH centre and was aimed at five chosen municipalities around Sogod Bay.
- ◆ CCC, along with the Mayor of San Francisco, attended an evening of entertainment, lectures and presentations on climate change at the San Francisco Environmental Event.

#### OCTOBER 2009

- ◆ Open Day for the Santa Paz Sur Elementary School and trips to several other elementary schools in Pintuyan and in Habay. CCC volunteers gave lessons in coral reef conservation, presented a puppet show helped create an underwater mural at Pintuyan High School.
- ◆ CCC was invited to the Marine Education Celebration Days in Silago. The elementary school teachers together with the Ocean Action Resource Centre (ORC) organised the

event involving: a number of beach clean ups, tree planting events and two mangrove plantings in Silago and Pintuyan Municipalities.

- ◆ Twelve high school children from Napantao arrived to take part in the Reef Ranger training programme.



Figure 6 A Coral Cay Reef Ranger recording information about the coral reef on his slate while snorkeling (left). Mangrove planting in Silago (right).

#### NOVEMBER 2009

---

- ◆ Twelve more high school children arrived at the CCC base for a Reef Ranger training weekend.
- ◆ Fifteen new MPA Biophysical Assessment trainers left the CCC base after three days of intense studying and training
- ◆ CCC staff and volunteers went to Silago for a day of mangrove planting, where Willy O. Reyta from the Department of Environment and Natural Resources (DENR) gave a short lecture on the importance of replanting mangroves. Three CCC staff members helped replant mangroves that were once found in Maasin, thanks to an invitation from the Legacy of the Independent Volunteers for the Environment (LIVE) and Restore Green Movement (RGM) Youth Alliance.
- ◆ CCC staffs were invited to the birthday celebration of the Governor of Southern Leyte.
- ◆ The Negros Forest and Ecological Foundation Inc. (NFEFI) celebrated the Negros Wildlife Month. Activities included: storytelling about wildlife conservation in Bacolod City and a colourful parade mimicking the endemic and threatened species of Negros.



Figure 7 Coral Cay pose with the new MPA assessment trainers, fisheries technicians from all over the province.

### DECEMBER 2009

---

- ◆ Elementary and High School teachers from the Pintuyan District visited the CCC base in Napantao for a day of teacher training. CCC provided lectures on Reef Ecology, Coastal Ecosystems, Threats to Coral Reefs, Fisheries Regulations and Waste Management.
- ◆ The 15th Annual Girl Scout Junior and Senior Encampment took place in Maasin City; CCC assisted by providing lectures to over 500 Scouts on the threats to coral reefs from human activities and the benefits of Marine Protected Areas.
- ◆ Rodrigo Baluran, the Barangay Captain of Santa Paz Sud, graduated from our marine scholarship programme and has already organized a public talk about his diving and surveying experiences.
- ◆ OCR considered taking over the responsibility of rare sperm whale bones in Silago, Southern Leyte. This was due to concern over the proper care and maintenance of the bones, said to be the only complete set in the Philippines, and among one of the only four throughout the world.

### JANUARY 2010

---

- ◆ Additional teacher training for teachers from Pintuyan district.
- ◆ Over a three day period, all the coastal schools in San Ricardo were visited by the Education Officer who taught about corals reefs, threats to the reefs and how marine protected areas work. All coastal schools on Panoan Island have now received lectures on coral reefs.
- ◆ Twelve new Reef Rangers from San Francisco graduated. In addition, twelve children and two teachers from Santa Paz High School came to CCC base to attend the first two days of their Reef Ranger training.
- ◆ A group of children and some Barangay officials from Santa Paz Sur attended a CCC open day on the 24<sup>th</sup> January.
- ◆ A unique project focusing on thresher shark conservation commenced on Limasawa Island. After learning of a large thresher shark (*Alopias spp.*) fishery from

communications from Nestor Rin, the local Agricultural Technician, discussions were held with Hon. Melchor Petracorta, Mayor of Limasawa. Following this, CCC devised a project to help alleviate the fishing pressure on Limasawa's sharks whilst shifting the dependence on the sharks to an alternative, more sustainable, tourist based income.

#### **FEBRUARY 2010**

---

- ◆ CCC completed the Reef Ranger training for the high school children of Sta. Paz.
- ◆ Marine biology students from Southern Leyte State University (SLSU), Bontoc campus visited the CCC site for instruction in coral reef assessment.
- ◆ CCC attended a seminar on eco-tourism entitled "Attracting and Building Marine Eco-tourism" for the students studying Hotel, Restaurant and Tourism Management at SLSU's Sogod campus.
- ◆ CCC visited Limasawa Island for the second phase of the Thresher Shark Project. Lessons were given by CCC to all five elementary schools across the island.
- ◆ Coral Cay visited the Youth Catholic Group in Sogod to discuss ideas for events the group could organize related to marine conservation.



Figure 8 Students of Hotel, Restaurant, and Tourism Management from SLSU Sogod pose for photos with Coral Cay staff after the eco-tourism seminar.

#### **MARCH 2010**

---

- ◆ Coral Cay hosted a number of open days for the Department of Tourism from Maasin as well as a number of participants from Flordelize.
- ◆ CCC held an open day for 40 children from Habay.
- ◆ Together, the Thresher Shark Research Project (TSRP) and CCC gave talks to the Macrohon and Padre Burgos council members, Provincial Environmental and Natural Resource Management Office (PENRMO). The main topics covered were the Thresher Shark Project and ideas for potential eco-tourism ventures.
- ◆ CCC had the opportunity to work with Elson, a whale shark expert from the WWF.

- ◆ On Limasawa, CCC gave whale shark talks to the local schools and barangay officials and set up Thresher Shark Sampling Stations.



Figure 9 CCC members and Habay children painting marine life on a school wall (left). CCC and TSRP with the local fishermen from Limasawa(right).

#### APRIL 2010

---

- ◆ Earth Week (April 16-22) in Maasin City was a huge community event and CCC staff and volunteers were very visible in their involvement.
- ◆ Reef and Beach Clean in Padre Burgos to celebrate Earth Day (22nd April).
- ◆ Thirteen students from Santa Paz National High School attended an intensive three-day Reef Ranger training program at the CCC base in Napantao
- ◆ CCC assisted the Liloan's Young Hearts' Club annual Summer League which has a lot of community support. Among the activities were: coastal cleanup, whale shark painting and talks on coral ecology.

#### MAY 2010

---

- ◆ Official Month of the Ocean: CCC teamed up with the Department of Agriculture of Maasin and held a number of seminars for the fisher folk from the barangay of Manhilo. CCC Project Scientist gave a number of talks on Coral Reef Ecology and the benefits of MPA's.
- ◆ CCC was invited by the Provincial Environmental and Natural Resource Management Office (PENRMO) to assist with a COTs removal in the 3 barangays of Padre Burgos.
- ◆ CCC, PLAN International and the Local Government Unit of San Francisco held a number of talks and demonstrations for the 4 barangays of Gabi, Santa Paz North and South and Cahayag.

- ◆ Five teachers from Napantao High School attended a 2 day training course at CCC base in Napantao. The teachers were given a number of lectures followed by a snorkel in Napantao Fish Sanctuary.

### *JUNE 2010*

---

- ◆ CCC assisted with maintenance work at San Francisco Central School to prepare for the new school year.
- ◆ Community Liason Officer, Dag Navarette, visited the Thresher Shark Research and Conservation Project (TSRCP) based in Malapascua and spent one week helping the project's educational work.
- ◆ On the 12th June 2010, 30 active members from the Couples for Christ (CFC) Organisation based in Maasin city attended a seminar on "Marine Biodiversity Conservation" held at CCC base in Napantao.
- ◆ PLAN International visited CCC's base. Both organisations are currently working in partnership on a Disaster Risk Management (DRM) project. PLAN International gave the volunteers several talks about the projects they carry out in the Philippines.
- ◆ CCC's Head of Marine Science, Jan-Willem van Bochove attended the 2nd Asia Pacific Coral Reef Symposium in Phuket, Thailand, between the 20th and 24th of June 2010. The theme this year was 'collaboration for coral reef conservation in a changing climate' and brought together top coral reef scientists working in the Indo-Pacific. Jan-Willem gave a presentation on the development of community-based MPAs in Sogod Bay.

### *JULY 2010*

---

- ◆ During the 50<sup>th</sup> Anniversary celebrations of Southern Leyte the CCC Project Scientist was asked to judge a competition organised by the Provincial Environmental and Natural Resource Management Office (PENRMO). A number of barangays from Southern Leyte had produced a brochure containing information about their Marine Protected Areas (MPA) and their future aims
- ◆ After months of planning and preparation, CCC completed training for 40 local barangay officials in Emergency First Response (EFR).
- ◆ CCC was invited to attend a parade in the nutrition month celebrated by the Republic of the Philippines and the Province of Southern Leyte.
- ◆ CCC and Municipal Fisheries Agriculture Resources Management Councils (MFARMC) joined forces as part of the Liloan Ocean Festival. CCC volunteers made a poster displaying a number of facts about the Philippines and the ocean.
- ◆ CCC leant a hand in beach cleans at Napantao and helped Napantao Day Care Centre carry out some maintenance work.

### 3. Scientific Methods

#### 3.1 Background

One of the key objectives of the SLCRCP is to survey the coral reefs of Sogod Bay, in order to provide data for the assessment of the nature and status of the reefal resources. As well as providing a 'snapshot' of the reefs at this point in time, these data are used to highlight spatial variation and trends which can be used to make recommendations for management action by the Provincial Environmental and Natural Resources Management Office and other LGUs, such as the most appropriate siting of Marine Protected Areas. The analysis presented herein has been undertaken using all of the data gathered from September 2002 (the inception of the SLCRCP) until July 2010. These data and those subsequently gathered by the project will be made freely available to any interested parties who may have use of them.

#### 3.2 Methodology

Developed for the assessment of biological and physical characteristics of reef communities by trained volunteer divers, the CCC Baseline Survey Technique has been continuously refined and improved since 1990. 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). The survey programme is coordinated by the onsite marine science staff to ensure accurate and efficient data collection.



Figure 10 Volunteers learning coral reef species identification under guidance of science staff.

Each survey provides one or more biological record forms which are effectively snapshots of the biological communities (benthic and reef fish) found within any particular reef zone. These data are complimented by basic physical and oceanographic information (see Appendix for examples of the survey forms).

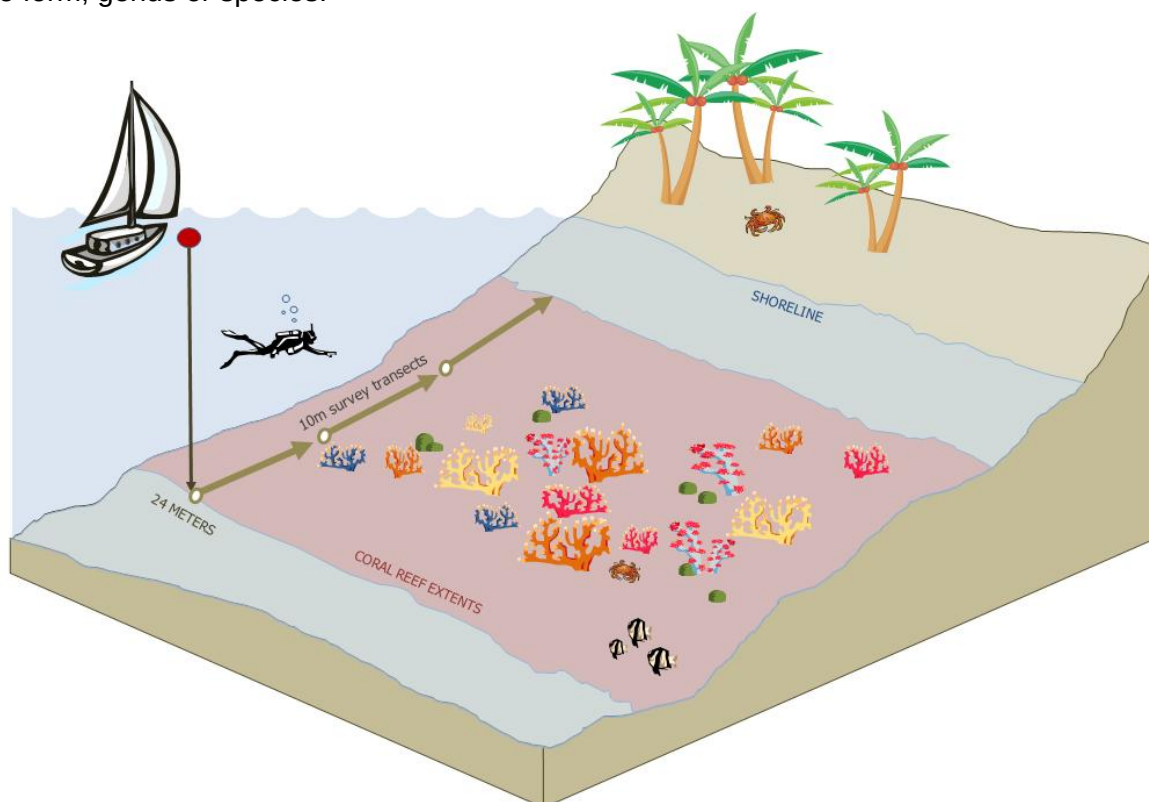
The CCC Baseline Survey Technique utilises a series of plot-less transects, perpendicular to the reef, starting from the 24m contour and terminating at the reef crest or in very shallow water (figure 11) Benthic and reef fish surveys are focused on life forms or families along with a pre-selected number of target species that are abundant, easily identifiable or ecologically or commercially important. Full species lists can be found in the appendix.

**Table 3 The ordinal 'DAFOR' scale assigned to life forms and target species during CCC Reef Surveys**

| Abundance rating | Corals, colonial invertebrates and macroalgae (% cover) | Fish and invertebrates (# of individuals) |
|------------------|---------------------------------------------------------|-------------------------------------------|
| 0                | None (0%)                                               | 0                                         |
| 1                | Rare (0-10%)                                            | 1-5                                       |
| 2                | Occasional (11-30%)                                     | 6-20                                      |
| 3                | Frequent (31-50%)                                       | 21-50                                     |
| 4                | Abundant (51-75%)                                       | 51-250                                    |
| 5                | Dominant (76-100%)                                      | 250+                                      |

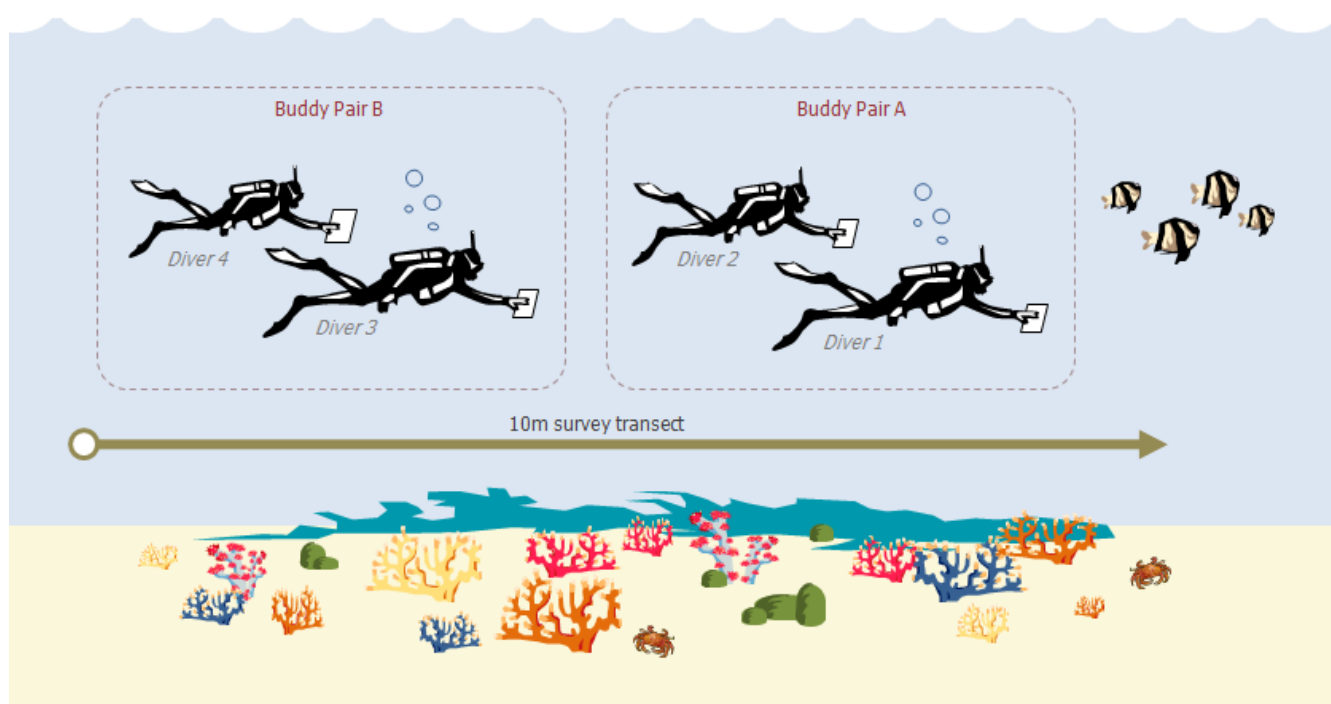
During the course of each sub-transect survey, divers may have traversed two or more apparently discrete habitat types, based upon obvious gross geomorphologic (e.g. forereef, escarpment or lagoon) or biological differences. Data gathered from each habitat type are recorded separately for subsequent analysis. Each species, life form or substratum category within each habitat type encountered is assigned an abundance rating from the DAFOR scale, as shown in Table 2.

Hard corals are recorded as life forms as described by English et al. (1997) and 36 target corals are identified to genus or species level. Reef fish are generally identified to family level (45 families) but in addition, 104 important target species are identified. Sponges and octocorals are recorded in various life form categories. Macroalgae are classified into three groups (green, red and brown algae) and identified to a range of taxonomic levels such as life form, genus or species.



**Figure 11 Outline illustration of the CCC baseline survey methodology.**

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



#### LAYING DOWN THE TRANSECT

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 the reef slope on a predetermined compass bearing until the 10m line connecting Diver 1 and 3 becomes taut.

Buddy Pair A then remains stationary whilst Buddy Pair B swims towards them. This process is repeated until the end of the planned dive profile, when a surface marker buoy (SMB) carried by Diver 2 is deployed to mark the end of that sub-transect. The SMB acts as the start point for the next survey team and this process is repeated until the entire transect is completed. The positions of the SMB at the start and end of each dive are fixed using a Global Positioning System (GPS).

#### RESPONSIBILITIES

**Diver 1:** is responsible for leading the dive, taking a depth reading at the end of each 10m interval and documenting signs of anthropogenic impacts such as broken coral or fishing nets. Diver 1 also describes the substratum along the sub-transect by recording the presence of six substratum categories (dead coral, dead coral with algae, bedrock, rubble, sand and mud).

**Divers 2, 3 and 4:** survey reef fish, hard corals, and other invertebrates plus algae respectively. Diver 3 surveys an area of approximately 1 metre to each side of the transect line whilst Divers 1, 2 and 4 survey an area of approximately 2.5 metres to either side of the line.

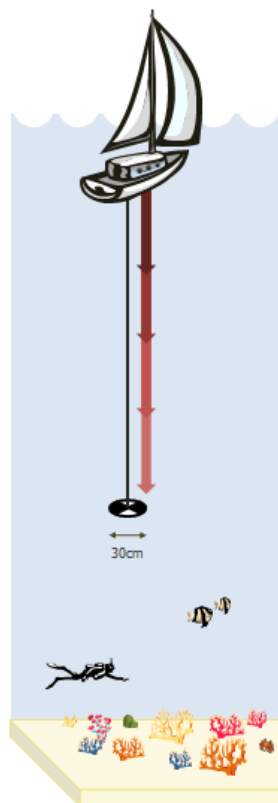
Figure 12 Description of specific diver roles within the survey teams

Diver 1 is responsible for leading the dive, taking a depth reading at the end of each 10m interval and documenting signs of anthropogenic impacts such as broken coral or fishing nets (figure 12). Diver 1 also describes the substratum along the sub-transect by recording the presence of six substratum categories (dead coral, dead coral with algae, bedrock, rubble, sand and mud). Divers 2, 3 and 4 survey reef fish, hard corals, and other invertebrates plus algae respectively. Diver 3 surveys an area of approximately 1 metre to each side of the transect line whilst Divers 1, 2 and 4 survey an area of approximately 2.5 metres to either side of the line.

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

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

Salinity is measured from water samples taken from both the surface and the maximum survey depth using a hydrometer. Water visibility, a surrogate of turbidity (sediment load), is recorded both vertically and horizontally. A Secchi disc is used to measure vertical visibility through the water column (Figure 13). Secchi disc readings are not taken where the water is too shallow to obtain a true reading. Horizontal visibility through the water column is measured by divers' estimates while underwater.



Survey divers qualitatively assess the strength and direction of the current at each survey site. Direction is recorded as one of eight compass points (direction current was flowing towards) and strength is assessed as being 'None', 'Weak', 'Medium' or 'Strong'. Similarly, the boat marshal on the support vessel qualitatively assesses the strength and direction of the wind at each survey site. Direction is recorded as one of eight compass points (direction wind was blowing from) and strength is assessed using the Beaufort scale.

Natural and anthropogenic impacts are assessed both at the surface from the survey boat and by divers during each survey. Surface impacts are classified as 'litter', 'sewage', 'driftwood', 'algae', 'fish nets' and 'other'. Sub-surface impacts are categorised as 'litter', 'sewage', 'coral damage', 'lines and nets', 'sedimentation', 'coral disease', 'coral bleaching', 'fish traps', 'dynamite fishing', 'cyanide

**Figure 13** The use of a Secchi disc to assess vertical water clarity. The Secchi disc is lowered into the water until the black and white quarters are no longer distinguishable. The length of rope from the surveyor to the disc is then recorded. Source: English et al.

fishing' and 'other'. All information is assessed as presence/absence and then converted to binary data for analysis. Any boats seen during a survey are recorded, along with

information on the number of occupants and its activity. The activity of each boat is categorised as 'diving', 'fishing', 'pleasure' or 'commercial'.

Data collected from each sub-transect survey are transferred to recording forms prior to incorporation into CCC's database, which is compatible with a range of Geographic Information System (GIS) software used for spatial analysis.

### **3.3 Geographic Information System**

In a similar way to how extensive geographical data can be 'simplified' to produce a topographical map, the development of GIS software and techniques allows marine ecological data to be manipulated in multi-dimensional space. Once appropriate analysis techniques have been applied, managers and decision makers can use the final product to make informed judgements concerning coastal zone management. The visual nature of GIS outputs facilitates the interpretation of such data by non-technical persons who may nonetheless be key decision makers. Because all CCC teams record the location of each survey on a handheld GPS unit, this allows the surveys to be 'placed' relative to each other on a map. Relationships between the data from the various survey sites can then be explored to highlight geographical regions of key interest.

Information can be represented in many ways in a GIS, from simple placement techniques ("this was found here") to more intricate mapping techniques such as data contouring ("this area is 'better' than that area"). It is important to bear in mind that the outputs are produced from the data themselves; the maps are not merely 'coloured in' at particular places. This is because the GIS links the map and the database intrinsically, and any data that are required for visual examination can be 'called up' on the screen. GIS is therefore not just a mapmaker; it is a tool that allows ongoing interaction between the decision-maker and the data. When further geographic/ ecological data are gathered in the future, they can be added to the GIS, making a custom-built instrument for visual interpretation of any data that can be represented at any point on Earth, above or below the sea.

The GIS map of Conservation Management Values contained in this report was created using the Inverse Distance Weighted function in the Spatial Analyst of ArcView 9.3 (ESRI software). Further details on GIS parameters can be found in appendix C

## 4 Scientific Results

Between September 2002 and July 2010, CCC survey teams produced 1911 individual survey records from 1654 survey dives around Sogod Bay (Figures 15 and 16). Although data from 2002 to 2009 have previously been presented (Harding et al., 2003; Taylor et al., 2004, van Bochove et al., 2007 and 2009), it is considered appropriate to include these data in this analysis, to allow for comparisons to be made throughout the bay region. All the data are made freely available in a GIS compatible meta-database, allowing interested parties to undertake further analysis of any particular dataset.

Initial rapid assessments of the reefs in the most northerly part of the bay in 2002 indicated that the fringing reefs in this region were heavily silted, caused by the influx of large quantities of terrigenous sediment via the rivers entering the bay at, or near Sogod town. Fringing reefs were either buried under sediment or were very heavily affected and in poor condition. It was therefore considered more appropriate for CCC teams to concentrate the surveying effort on the more southerly reefs of the bay, which were likely to be less affected by sedimentation. The westerly coastal zones of the Municipalities of San Roque and Padre Burgos which are located just outside the south-western side of the bay were also included as these areas generally had very good coral cover and diversity. Additionally, some sites on the Pacific side of the Province, outside of Sogod Bay were also included.

During the survey programme, the bay was divided into 35 geographically distinct survey sectors (Figure 14).

In addition to the ongoing baseline survey program, several Marine Protected Areas have been monitored and evaluated over the past years in order to allow for continued management of these sanctuaries. The results of these scientific assessments have been written up and presented to the local communities and stakeholders. Reports can be obtained from CCC on request ([science@coralcay.org](mailto:science@coralcay.org)). Examples are also available through the website ([www.coralcay.org](http://www.coralcay.org)).

**Table 4 MPA sites established with the assistance of CCC**

| MPAs established with CCC's support |                     |                                            |               |
|-------------------------------------|---------------------|--------------------------------------------|---------------|
| Barangay (MPA)                      | Municipality        | Esperanza II                               | San Ricardo   |
| Santa Sofia                         | Bunga               | Santa Paz                                  | San Francisco |
| Lungsodaan                          | Molopolo            | Sonok                                      |               |
| Tangkaan                            | San Pedro           | Potential MPA assessments conducted by CCC |               |
| Buenavista                          | Molopolo/Santa Cruz | Bunga                                      | Padre Burgos  |
| Limasawa                            | Biasong             | Molopolo                                   | Liloan        |
| Napantao                            | San Francisco       | San Pedro                                  | Hinunangan    |
| Punta                               | San Francisco       | Molopolo/Santa Cruz                        | Macrohon      |
| Liloan                              | Liloan              | Biasong                                    | Libagon       |

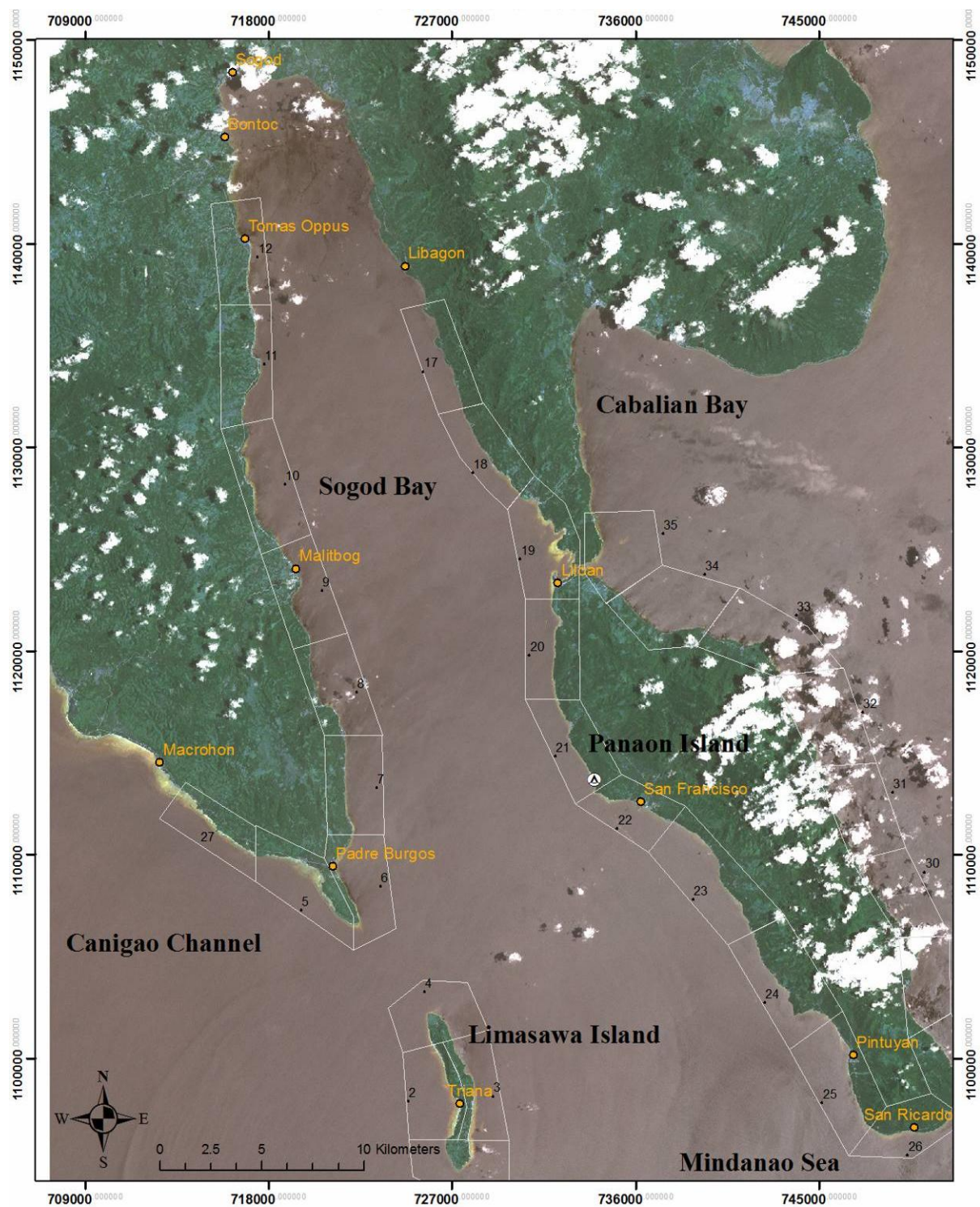


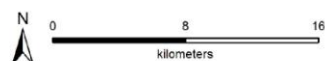
Figure 14 Satellite image of Sogod Bay, Southern Leyte. The CCC survey sectors are presented in gray.

Leyte Island: 2010 Base Data Outputs  
Survey site location density



**Legend**

- Site locations
- 1km buffer around sites
- High
- Low



Coral Cay Conservation © 11 November 2010  
WGS84 UTM Zone 51N © 1: 250, 000



Figure 15 (above) Locations of 1911 survey stations visited in Sogod Bay between November 2002 and July 2010. The darkness of red represents survey intensity along the coastline

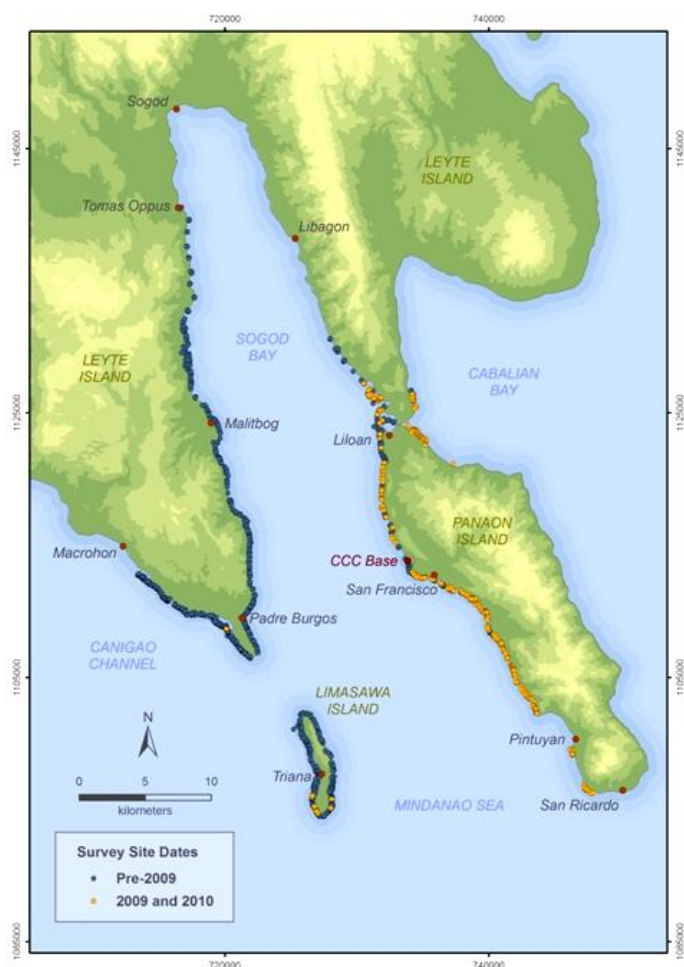


Figure 16 (left) Surveys conducted previously to this report (blue) and more recently, between 2009 and 2010 (gold)

The survey data are presented in a number of ways, namely:

- Results from oceanographic and anthropogenic impact data (4.1)
- Results from biological indicators. Benthic (4.2) and reef fish families (4.3)
- Generation of management ratings (Conservation Management Value) for each survey site (4.4)

## 4.1 Results from oceanographic and anthropogenic impact data

### Surface Temperature and Salinity

Sea surface temperatures reflect seasonal fluctuations in air temperature and solar irradiance, with the highest mean temperatures recorded in June - August. Average monthly sea surface temperatures, taken from 5 years, varied between 27.9 – 30.1°C with peak temperatures occurring during September (figure 17). Surface salinity varied between 29.4 – 31.3 ppm, closely following sea surface temperatures. Salinity was heavily affected by seasonal changes in rainfall which was particularly high in May - July for most survey years, resulting in lower salinities.

Vertical visibility of the water was taken using a Secchi disk. Figure 18 presents a GIS map of visibility throughout the bay. Visibility generally increased towards the mouth of the bay and was particularly good along the western coast of Panaon Island.

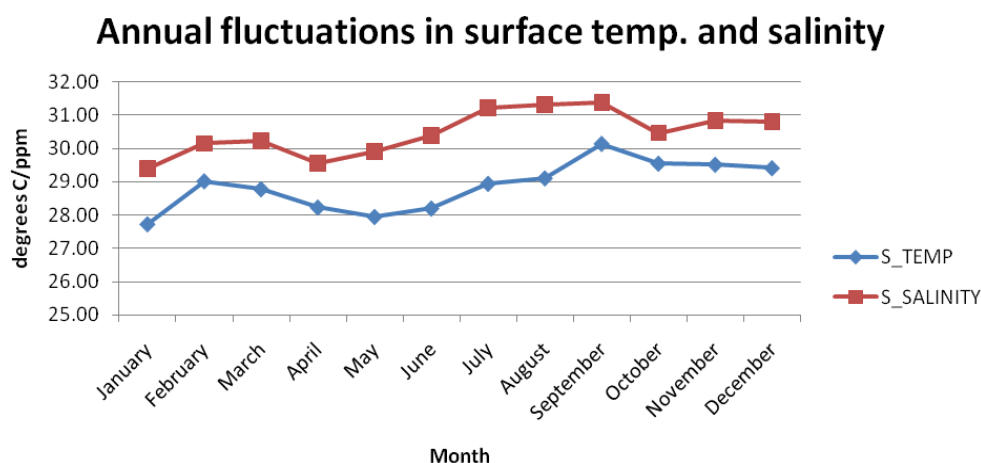
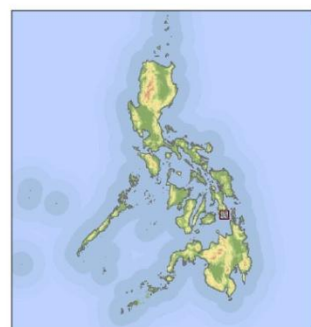


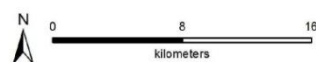
Figure 17 Average readings for sea surface temperature (°C) and surface salinity (ppm), taken over 6 years at all survey sites

Leyte Island: 2010 Base Data Outputs  
Physical Visibility Values (via Secchi)



#### Legend

- 1km buffer around sites
- IDW: 100/1000
- High : 30
- Low : 0



Coral Cay Conservation o 7 June 2011  
WGS84 UTM Zone 51N o 1: 250, 000

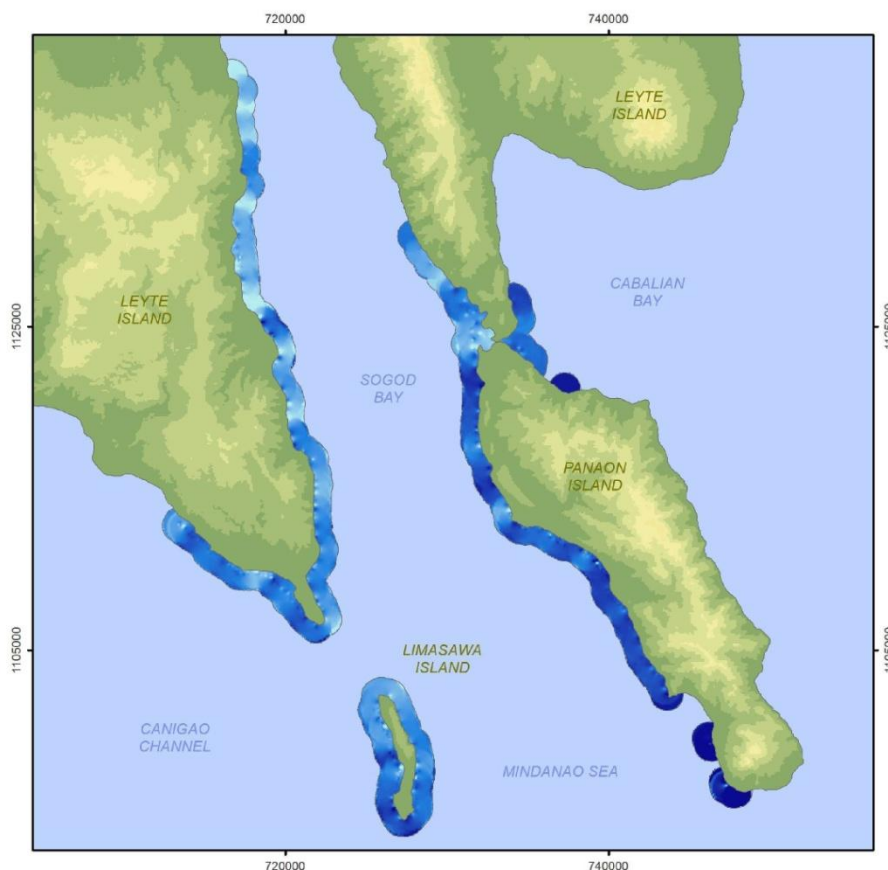


Figure 18 Vertical visibility, expressed in metres around Sogod Bay, displayed as a colour ramp. Areas towards the dark blue end of the spectrum have the highest value (i.e. highest visibility).

## Boat Frequency and Activity

Boats that were observed during surveys were recorded in 4 activity classes, namely “fishing”, “pleasure”, “diving”, “commercial” (such as ferries or cargo vessels) and “transit”. The vast majority of boats observed during the survey programme were involved in fishing related activities (77%) – Figure 19. The next single greatest class was “pleasure” (13%), then “commercial” (5%).

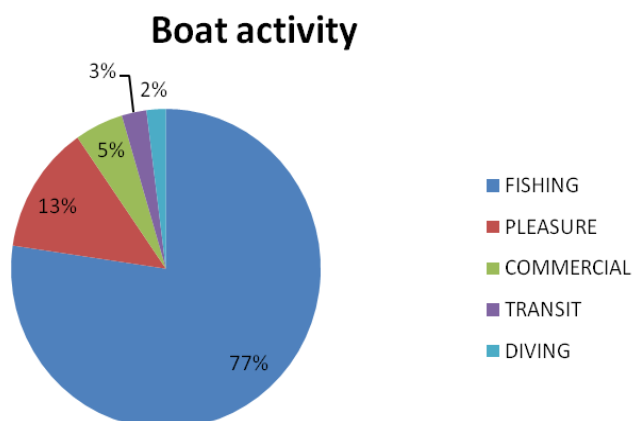


Figure 19 Percentage of 5 different boat activities observed at all survey sites

## Fishing Pressure

The estimated fishing pressure for a particular site was determined by the amount of fishing boats present in addition to any underwater survey evidence of fishing recorded such as fish traps, discarded nets and fishing lines. By tallying these factors on a nominal scale, a total fishing pressure value of between 0 and 5 was obtained which is displayed on a GIS map in figure 20.

Fishing pressure was generally highest on reefs adjacent to population centres such as Padre Burgos, Liloan and Malitbog. Discarded nets and fish lines were a common sighting around Padre Burgos town where shore-based net and hook and line fishing in addition to the usage of fish traps are popular. Some areas are known to be important fishing grounds such as the reefs around the north of Limasawa and around Padre Burgos. Fishing pressure seems to increase to the north of Sogod Bay, most likely due to the increase in number of people living along the coast rather than a higher abundance of commercially targeted fish.

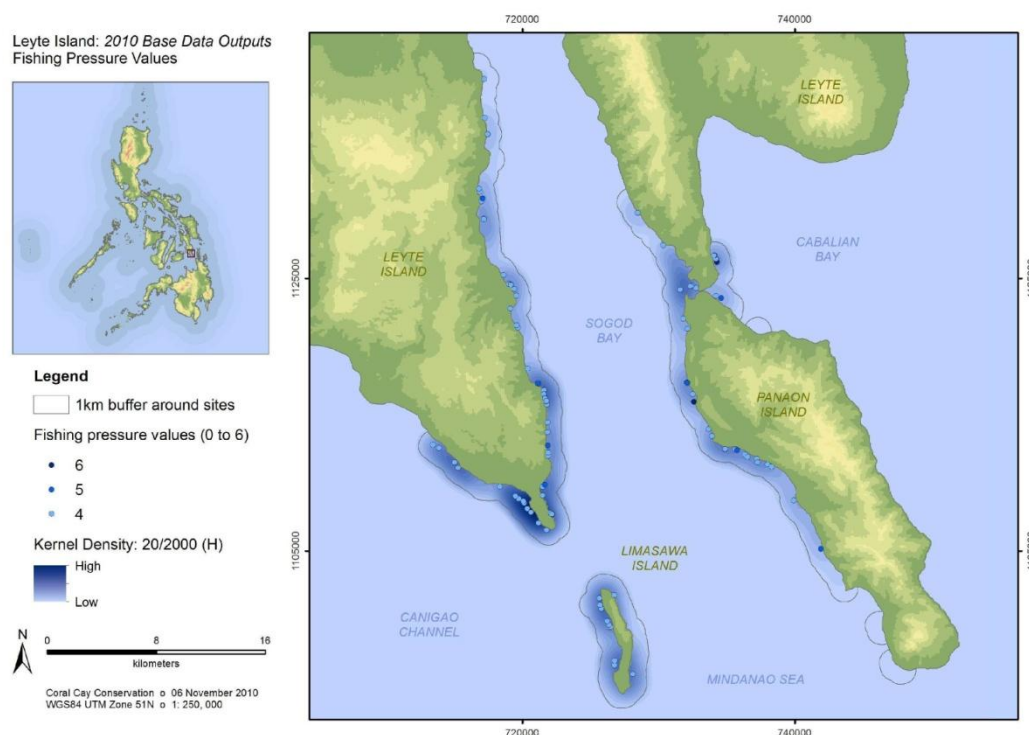
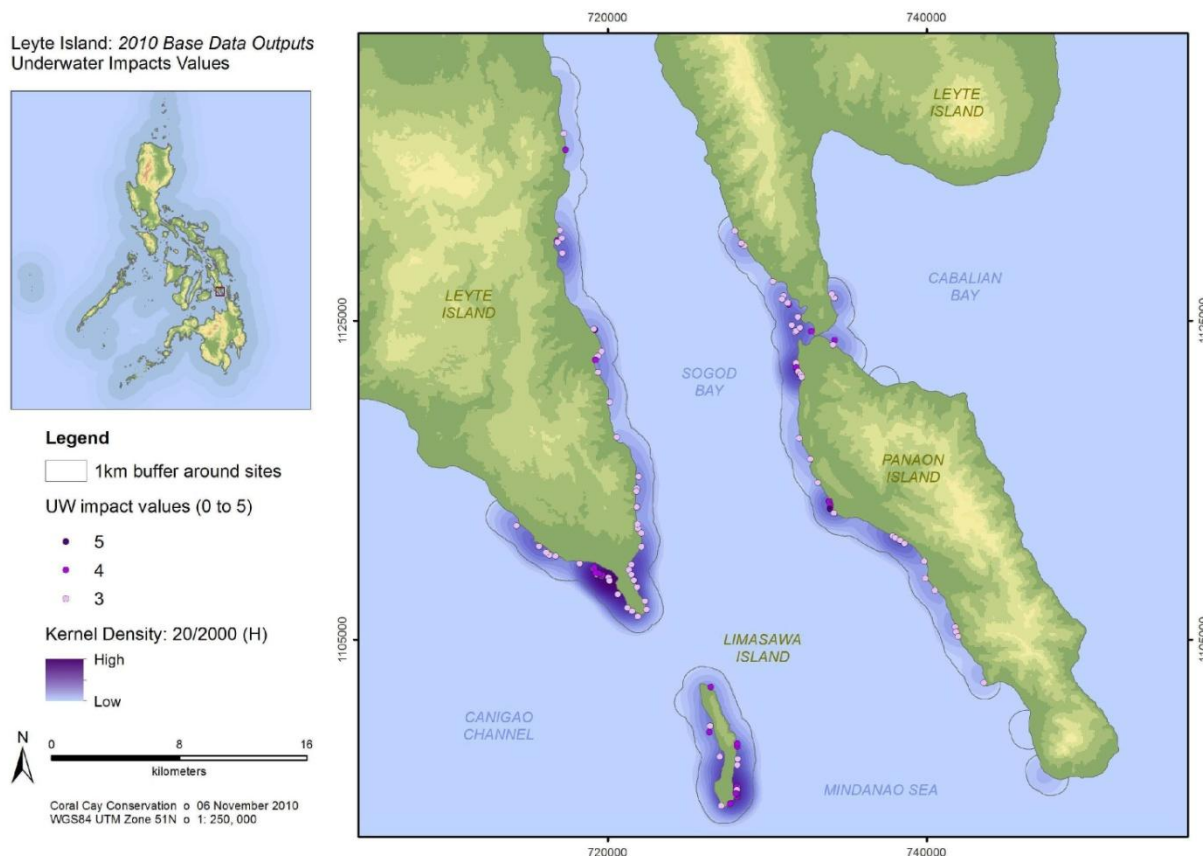


Figure 20 Fishing pressure around Sogod Bay, displayed as a colour ramp. Areas towards the dark blue end of the spectrum have the highest value (i.e. highest fishing pressure). Sites marked on the map have high fishing pressure values of <4.

## Underwater Impacts

Direct underwater impacts such as litter, sedimentation and coral breakage due to anchors are presented in Figure 21. The overall impact rating per site was on a scale of 0-5. Although there were sites with high levels of underwater impacts throughout Sogod Bay, some sites displayed particularly high numbers of surveys with impact values of 4 and 5. These included the reefs around Tangkaan peninsula on the south-western tip of Sogod Bay and the reefs around the south-eastern side of Limasawa Island. The coastal towns of Malitbog, Liloan and San Francisco were all found to have high impact ratings.



**Figure 21 Underwater impacts around Sogod Bay, displayed as a colour ramp. Areas towards the dark purple end of the spectrum have the highest value (i.e. most heavily impacted). Sites marked on the map have high underwater impact values of <3.**

## Coral Bleaching and Disease

Coral diseases have had a devastating impact on Caribbean reefs (see Introduction). Fortunately, the coral reefs of the Indo-Pacific have been largely spared from disease impacts thus far although there are indications that coral disease incidence is increasing. However, little research has been conducted on the prevalence of coral diseases in this region. CCC is monitoring the prevalence of the main coral diseases that may impact the reefs in Sogod Bay. Results from these surveys will be presented in a separate report.

Coral bleaching continues to pose a significant threat to the reefs of Sogod Bay and has previously affected much of the Philippines' coral reefs, namely during the ENSO event of

1998 where severe coral bleaching was documented throughout the region. In Sogod Bay, coral diseases were generally uncommon, being observed on less than 3% of surveys conducted (figure 22). This is probably an underestimate of prevalence as coral disease identification was not part of the CCC science training for volunteers for all surveys conducted. Coral bleaching was recorded more often and observed on 10% of surveys. No significant variation was found for bleached or diseased corals between regions (see G.A. Smith, 2007 for further information). Further and ongoing monitoring research is needed to gain a better understanding of coral disease and bleaching prevalence.

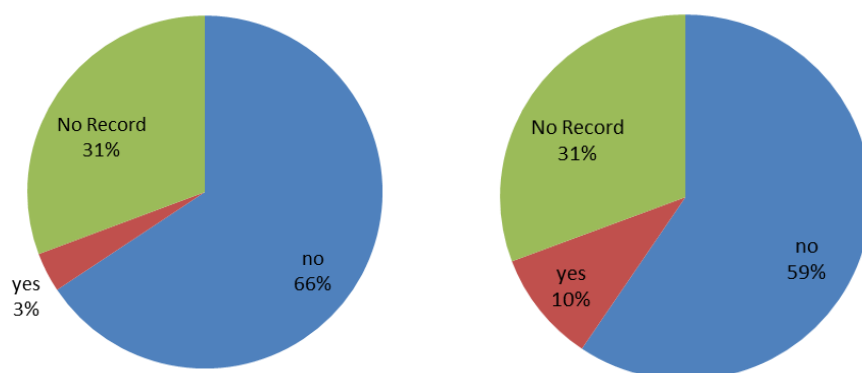


Figure 22: Percentage of total survey sites at which coral disease (left) and coral bleaching (right) were observed.

## Site Impression

After each survey, a site impression was given, based on two arbitrary scores that were given to that particular reef. One was given for the aesthetic value (visual appeal) of the area and one for the perceived biological value. The scores ranged from 'poor' to 'excellent'. Two percent of the surveys found 'excellent' biological and aesthetic value on that particular site (Figure 23). Most sites were found to be 'average' (36 and 37% resp.). 29% of sites were found to be of poor aesthetic value. For 68% of surveys, aesthetic and biological site impression were found to be closely linked, sites with a high aesthetic appeal were assumed to have a high biological value. Figures 24 and 25 displays the biological and aesthetic values on a GIS map with values ranging from poor (0) to Excellent (5).

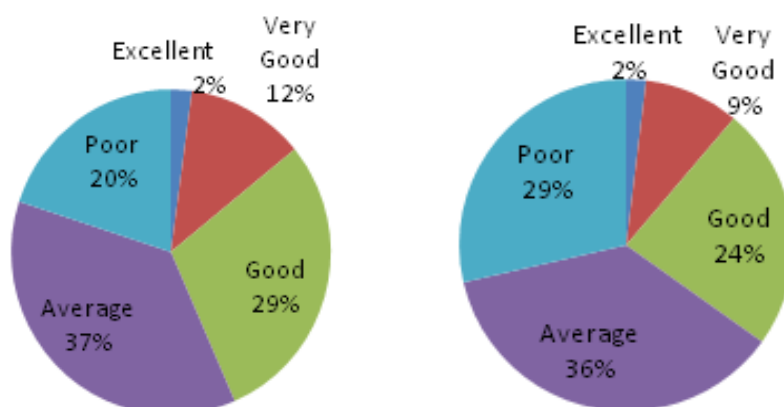


Figure 23 Aesthetic value (left) and Biological value (right) for all surveys combined, as a percentage of the total scores given.

Leyte Island: 2010 Base Data Outputs  
Biological Values



**Legend**

- 1km buffer around sites
- Biological quality (individual sites)
  - Excellent
- Kernel Density: 20/2000 (H)
- Biological value
  - High
  - Low

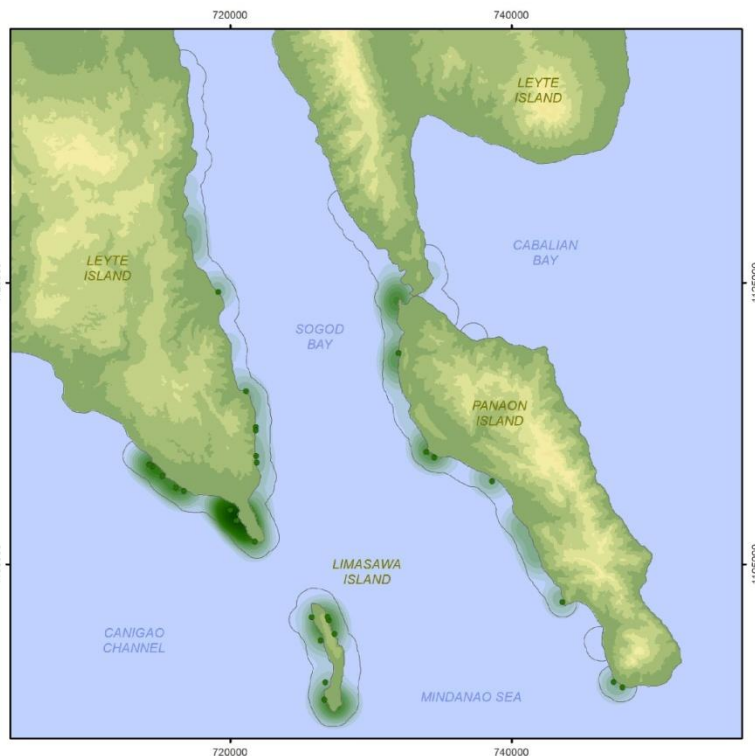
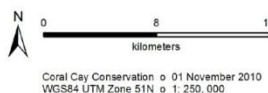
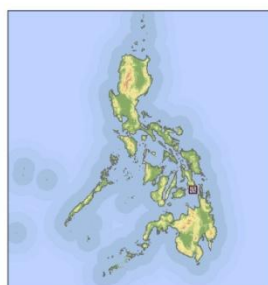


Figure 24 Biological value of survey sites around Sogod Bay, displayed as a colour ramp. Areas towards the dark green end of the spectrum have the highest value. Sites designated with a circle were rated as having 'excellent' biological value.

Leyte Island: 2010 Base Data Outputs  
Aesthetic Values



**Legend**

- 1km buffer around sites
- Aesthetic quality (individual sites)
  - Excellent
- Kernel Density: 20/2000 (H)
- Aesthetic value
  - Higher
  - Lower

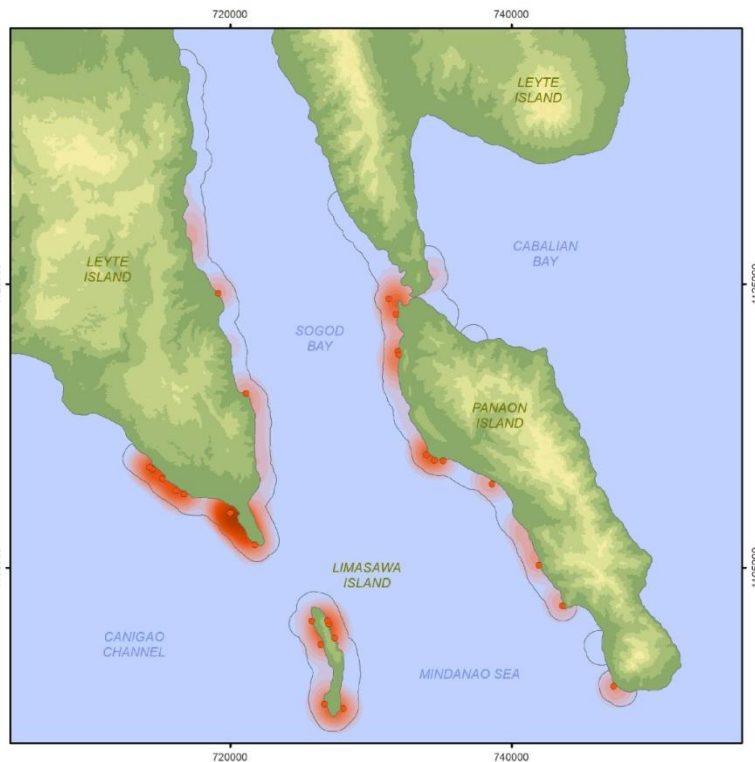
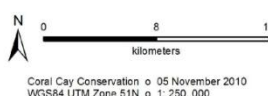


Figure 25 Aesthetic value of survey sites around Sogod Bay, displayed as a colour ramp. Areas towards the dark orange end of the spectrum have the highest value. Sites designated with a circle were rated as having 'excellent' aesthetic value.

## 4.2 Results from Benthic Indicators

Certain species have been shown to be effective indicators of overall reef health (Hodgson, 1999). Depending on the particular species, they can indicate histories of overfishing, nutrient pollution, destructive fishing practices and the removal of organisms for the curio or aquarium trade. In this analysis, the indicator organisms have been adapted from those defined by the Reef Check Foundation ([www.reefcheck.org](http://www.reefcheck.org)), which are recognised as robust gauges of general reef health.

### Scleractinian corals

Hard (Scleractinian) coral cover is a useful indicator of general reef health. It is generally accepted that reef fish species diversity is directly related to hard coral cover and diversity (Taylor et al., 2004). Figure 26 shows this relationship for all the surveys analysed in this report.

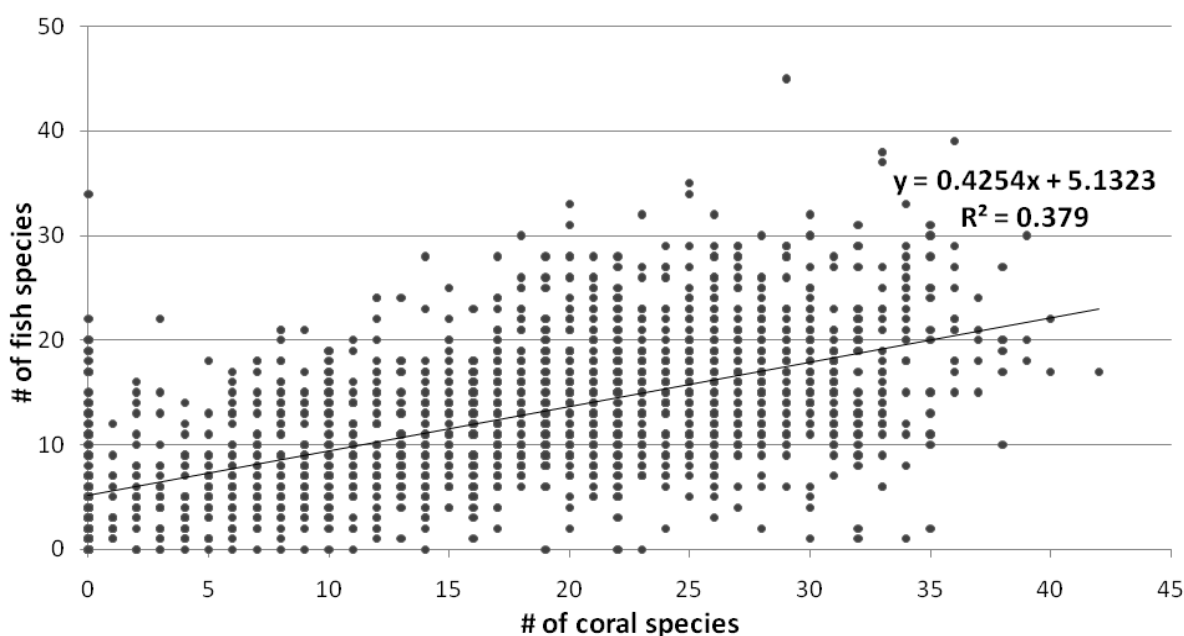


Figure 26 Regression plot for the number of coral species vs. number of fish species for all survey sites ( $R^2 = 0.379$ ,  $p < 0.000$ ).

Figure 27 displays hard coral cover around the bay on a GIS map using a colour ramp. Areas of high hard coral cover were found in all regions. The reefs around Limasawa Island, San Francisco (Napantao), Liloan and Padre Burgos harbour reefs with particularly high coral cover. Coral cover generally decreased towards the north of the bay.

Figure 28 displays soft coral cover around the bay on a GIS map. Soft corals are generally more abundant in the northern half of the bay, particularly in Liloan and Malitbog which may indicate a phase shift from a hard coral dominated state after an impact such as dynamite fishing or a Crown of Thorns starfish outbreak. The results of this can be seen at the popular dive site of Gunther's Wall on the north-eastern side of Limasawa where a Crown of Thorns outbreak killed much of the hard coral colonies in 2004. Soft corals now dominate this particular area. Some soft corals are naturally abundant however. For example, some of the

reefs around barangay Santa Sofia in Padre Burgos house a thriving community of soft corals, some estimated to be between 50 to a 100 years old (D. Fenner, 2007).

A total of 257 hard coral species including some rare species have been identified in Sogod Bay thus far, over 141 of which were recorded on a single dive (Fenner, 2007). This number is likely to be an underestimate and the true number much higher. The most commonly occurring hard coral lifeforms and target species were ranked according to the proportion of transects on which they were recorded (Table 3). This provides a more accurate reflection of coral diversity than using the DAFOR values alone. For example, *Seriatopora hystrix* forms small colonies, and thus would be very far down the table in terms of area cover, yet it was recorded on 53% of all of the surveys and can therefore be considered widely distributed on the reefs.

Of the 15 coral lifeforms recorded, non-*Acropora* lifeforms were the most abundant, particularly submassive colonies (76%, DAFOR 5). *Acropora* lifeforms (mainly 'branching' and 'tabulate') can dominate shallow-reef habitats and contribute significantly to overall hard coral cover. Rarer *Acropora* lifeforms (encrusting and digitate) were recorded on only 11% of the surveys. *Favia*, *Favites* species were recorded on over 70% of the surveys with massive *Porites* species recorded on 69% of all surveys. *Pavona clavus* was the least abundant target coral species observed within the bay (4%, DAFOR 1).

For more details on the diversity of scleractinian diversity in Sogod Bay, particularly rarer species, please consult previous reports by Dr. Fenner which can be downloaded from the Coral Cay website.

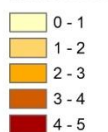
Leyte Island: 2010 Base Data Outputs  
Hard coral cover



**Legend**

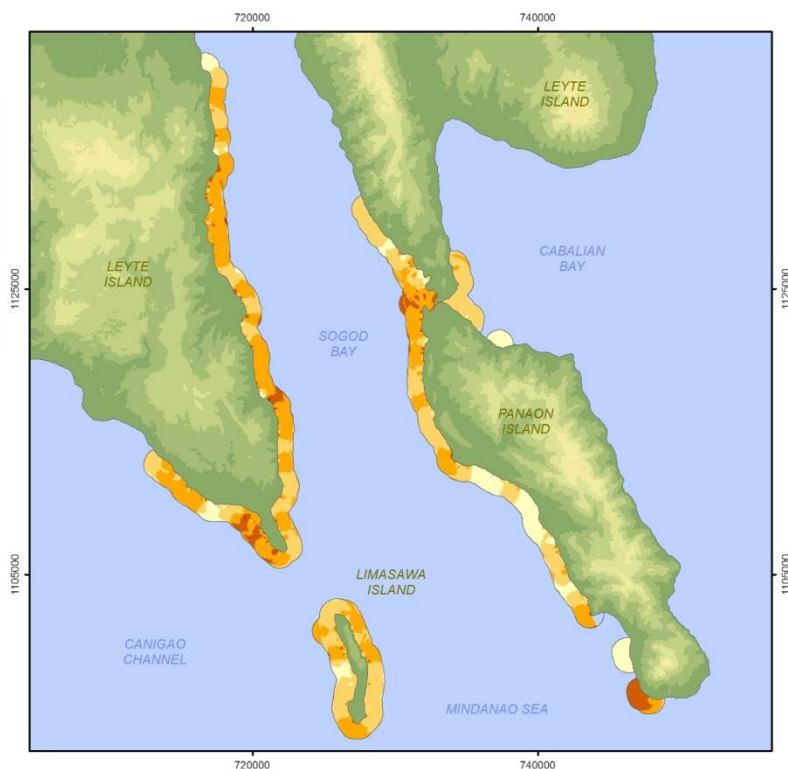
1km buffer around sites

IDW: 20/1000



0 8 16  
kilometers

Coral Cay Conservation 12 November 2010  
WGS84 UTM Zone 51N 1: 250, 000



Leyte Island: 2010 Base Data Outputs  
Hard coral cover



**Legend**

Hard coral top values



1km buffer around sites

Kernel Density: 20/2000 (H)



0 8 16  
kilometers

Coral Cay Conservation 06 November 2010  
WGS84 UTM Zone 51N 1: 250, 000

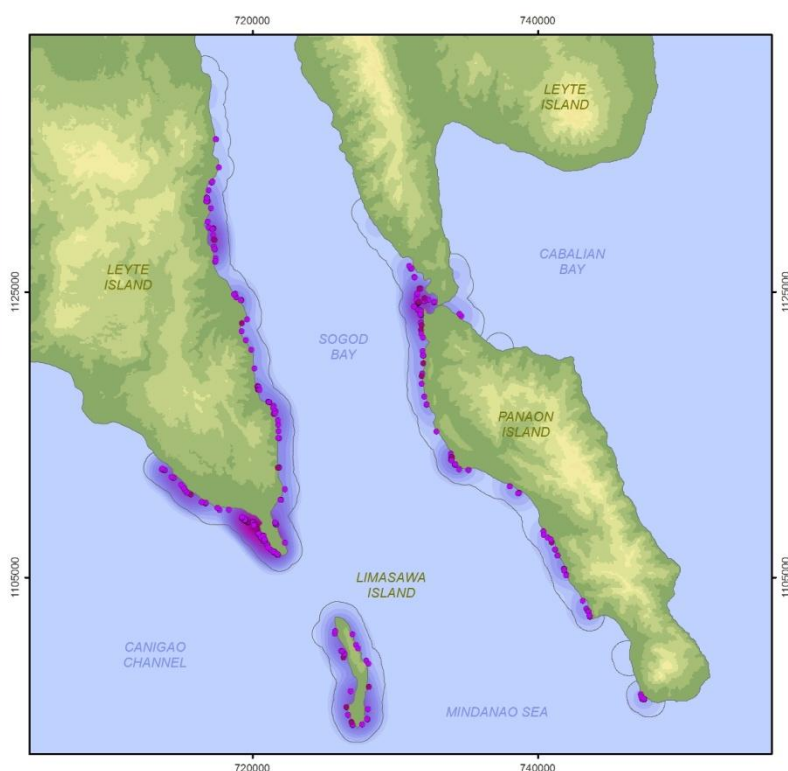


Figure 27 Top - Hard coral cover on a DAFOR scale, displayed as a colour ramp. Areas towards the lighter end of the spectrum have the highest cover.  
Bottom – Hard coral cover for only the highest values (bottom). Sites marked on the bottom map have hard coral cover values of <4 (51-100%)

Leyte Island: 2010 Base Data Outputs  
Soft coral cover



**Legend**

1km buffer around sites

IDW: 20/1000

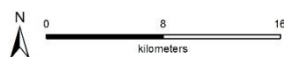
0 - 1

1 - 2

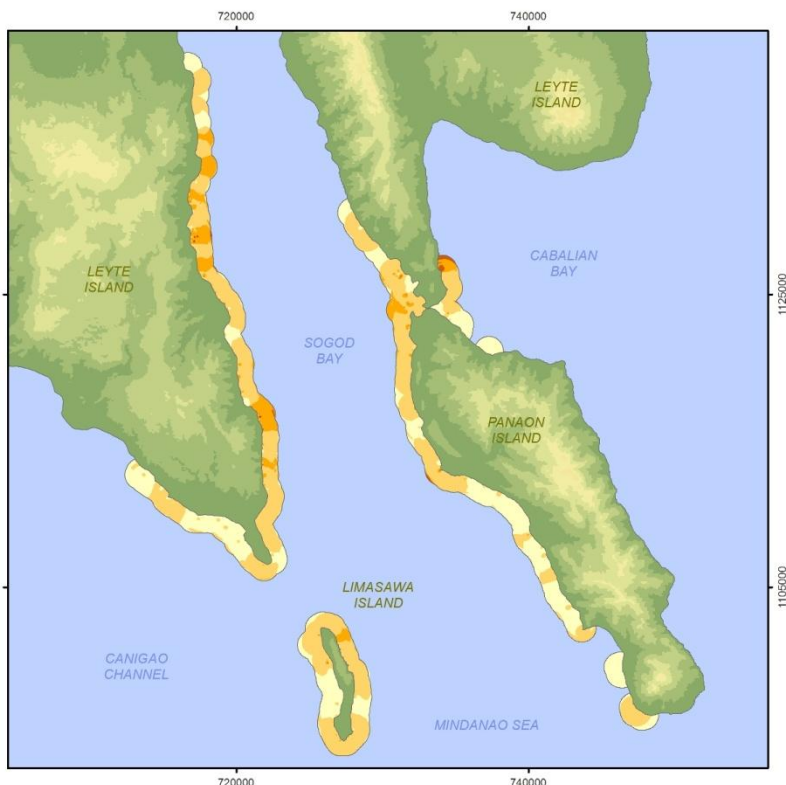
2 - 3

3 - 4

4 - 5



Coral Cay Conservation o 12 November 2010  
WGS84 UTM Zone 51N o 1: 250, 000



Leyte Island: 2010 Base Data Outputs  
Soft coral cover



**Legend**

Soft coral top values

5

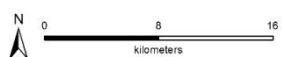
4

1km buffer around sites

Kernel Density: 20/2000 (H)

High

Low



Coral Cay Conservation o 06 November 2010  
WGS84 UTM Zone 51N o 1: 250, 000

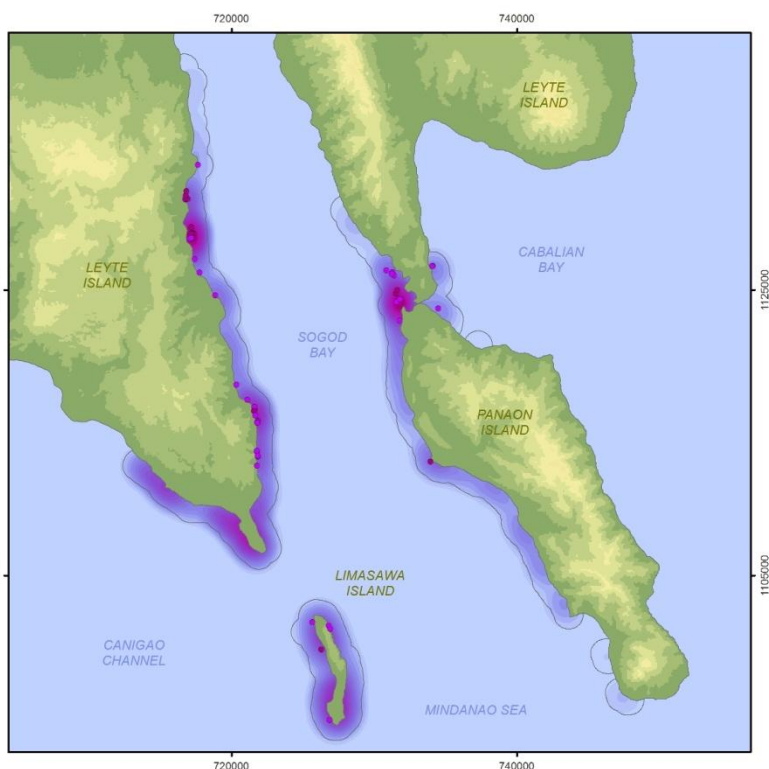


Figure 28 Top - Soft coral cover on a DAFOR scale, displayed as a colour ramp. Areas towards the lighter end of the spectrum have the highest cover.  
Bottom - Soft coral cover for only the highest values (bottom). Sites marked on the bottom map have soft coral cover values of <4 (51-100%)

**Table 5 Most commonly recorded hard coral lifeforms (top) and target species (bottom) in Sogod Bay**

| Coral Lifeform                    | Proportion of surveys recorded (%) | Maximum DAFOR value |
|-----------------------------------|------------------------------------|---------------------|
| Non-Acropora submassive           | 76                                 | 5                   |
| Non-Acropora encrusting           | 72                                 | 4                   |
| Non-Acropora branching            | 69                                 | 4                   |
| Acropora branching                | 69                                 | 5                   |
| Non-Acropora mushroom             | 69                                 | 4                   |
| Non-Acropora massive              | 67                                 | 4                   |
| Non-Acropora foliose              | 56                                 | 5                   |
| Acropora tabulate                 | 51                                 | 4                   |
| Acropora bottlebrush              | 38                                 | 5                   |
| Acropora submassive               | 13                                 | 4                   |
| Acropora encrusting               | 11                                 | 3                   |
| Acropora digitate                 | 10                                 | 3                   |
| <b>Coral Species</b>              |                                    |                     |
| <i>Favia spp.</i>                 | 73                                 | 4                   |
| <i>Favites spp.</i>               | 71                                 | 4                   |
| <i>Porites spp.</i> (massive)     | 69                                 | 5                   |
| <i>Lobophyllia spp.</i>           | 65                                 | 3                   |
| <i>Galaxea spp.</i>               | 63                                 | 3                   |
| <i>Goniopora / Alveopora spp.</i> | 55                                 | 5                   |
| <i>Seriatopora hystrix</i>        | 53                                 | 3                   |
| <i>Pocillopora damicornis</i>     | 42                                 | 3                   |
| Brain Coral (small)               | 40                                 | 3                   |
| <i>Diploastrea heliopora</i>      | 36                                 | 3                   |
| <i>Millepora spp.</i>             | 35                                 | 4                   |
| <i>Pectinia lactuca</i>           | 35                                 | 3                   |
| <i>Pocillopora spp.</i> (medium)  | 34                                 | 3                   |
| <i>Euphyllia spp.</i>             | 34                                 | 3                   |
| <i>Mycedium elephantotus</i>      | 34                                 | 3                   |
| <i>Echinopora spp.</i>            | 33                                 | 4                   |
| <i>Porites cylindrica</i>         | 33                                 | 4                   |
| <i>Herpolitha limax</i>           | 31                                 | 3                   |
| <i>Plerogyra</i>                  | 29                                 | 3                   |
| Brain Coral (medium)              | 28                                 | 3                   |
| <i>Ctenactis echinata</i>         | 27                                 | 3                   |
| <i>Montipora spp.</i> (foliose)   | 26                                 | 3                   |
| <i>Pachyseris speciosa</i>        | 23                                 | 3                   |
| <i>Porites nigrescens</i>         | 23                                 | 3                   |
| <i>Pachyseris rugosa</i>          | 22                                 | 3                   |
| <i>Tubastrea micrantha</i>        | 18                                 | 3                   |
| Upsidedown bowl                   | 17                                 | 3                   |
| <i>Hydnophora spp.</i>            | 17                                 | 3                   |
| <i>Turbinaria spp.</i>            | 16                                 | 3                   |
| <i>Porites rus</i>                | 15                                 | 2                   |
| Brain Coral (large)               | 15                                 | 3                   |
| <i>Tubipora spp.</i>              | 14                                 | 3                   |
| <i>Polyphyllia talpina</i>        | 11                                 | 2                   |
| <i>Heliopora spp.</i>             | 10                                 | 2                   |
| <i>Pocillopora</i> (Large)        | 9                                  | 2                   |
| <i>Pavona clavus</i>              | 4                                  | 1                   |

## Giant Clams (*Tridacna* spp.)

Giant clams (*Tridacna* spp.) are an important local food source and have been traditionally harvested for centuries. They are important reef filter feeders that contribute to the reef structure and rugosity. Populations of giant clams were highest outside of Sogod Bay (figure 29). Limasawa Island also had higher than average numbers of Giant Clams, likely due to its remoteness from population centres. Clams were uncommon in areas of urbanisation despite high coral cover which can be attributed to severe overharvesting in these areas.

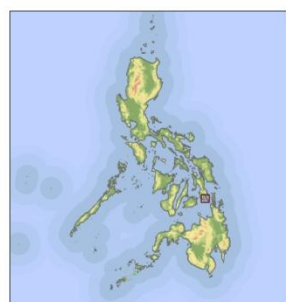
## Sea Urchins (*Diadema* spp.)

Sea urchins were recorded in two categories, namely “short-spined” and “long-spined” (*Diadema* spp.). The latter is often used as an ecological indicator, with major population changes possibly highlighting shifts in the ecological balance of the ecosystem. Certain reef fish species (e.g. triggerfish) are known to feed on *Diadema* spp., which in turn graze on algae. Reduced populations of triggerfish may result in increased urchin populations and a shift in the ecological balance of the reef as algae becomes increasingly grazed. Likewise, a sudden decrease in *Diadema* populations may result in overgrowth by algae, outcompeting corals for light and space on the reef. *Diadema* urchins have been documented to aggregate in exposed or recently disturbed locations and as such, higher abundances of *Diadema* urchins may be indicative of reduced coral cover. Populations of *Diadema* urchins were found to be higher than other urchins in all regions, with the most frequent observations of both categories found around Bontoc, Padre Burgos, San Roque and Liloan/Libagon (Figure 30). A correlation was found between *Diadema* urchin density and coral reef cover.

## Macro-algae

In this analysis, emphasis has been placed on algae that are thought to be nutrient-indicators, such as brown “fleshy” algae. *Halimeda* spp. are an exception as they have a calcareous structure which helps to ‘cement’ the reef. Although not actually algae, cyanobacteria (a.k.a. blue-green ‘algae’) have been included in this section, as most of them respond in a similar manner to macroalgae in terms of environmental conditions that promote/inhibit their growth. Cyanobacteria were the most commonly encountered taxon in this group, recorded on 64% of all transects. The next most common algae were *Dictyota* spp. (45%), green filamentous algae (33%), and *Padina* spp. (22%). All survey regions displayed high levels of nutrient indicator algae. Sites towards the north-western end of the bay had highest nutrient indicator abundance (Figure 31).

Leyte Island: 2010 Base Data Outputs  
Giant Clam density



**Legend**

1km buffer around sites

IDW: 20/1000

High : 1.53

Low : 0



0 8 16  
kilometers

Coral Cay Conservation o 27 June 2011  
WGS84 UTM Zone 51N o 1: 250, 000

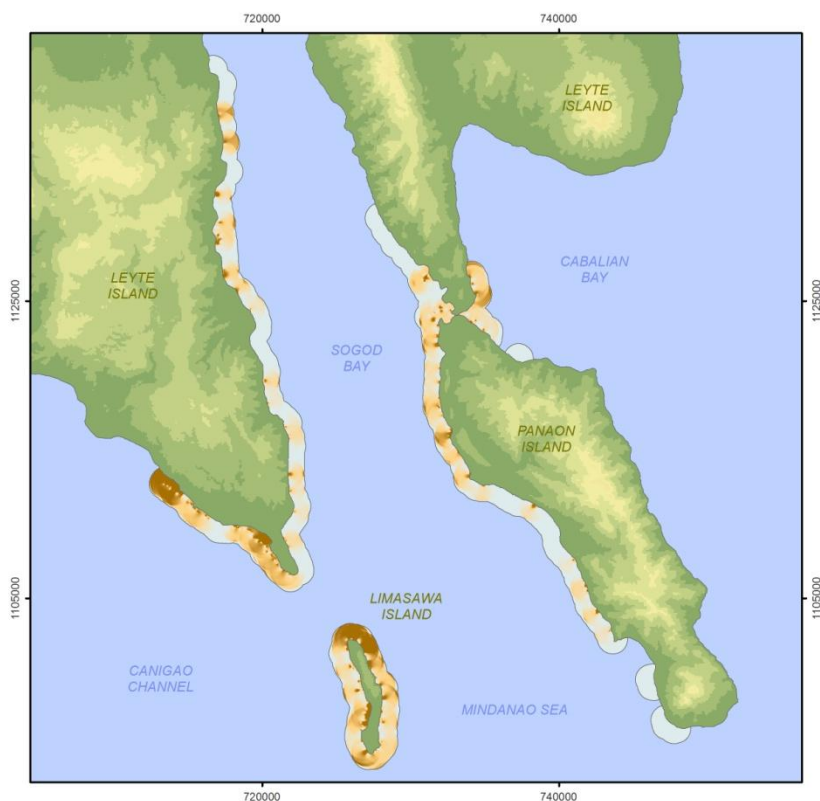


Figure 29 Giant clam (*Tridacna*) abundance on a DAFOR scale, displayed as a colour ramp. Areas towards the darker end of the spectrum have the highest abundance.

Leyte Island: 2010 Base Data Outputs  
Diadem Sea Urchin density



**Legend**

1km buffer around sites

IDW: 20/1000

High : 5

Low : 0



0 8 16  
kilometers

Coral Cay Conservation o 27 June 2011  
WGS84 UTM Zone 51N o 1: 250, 000

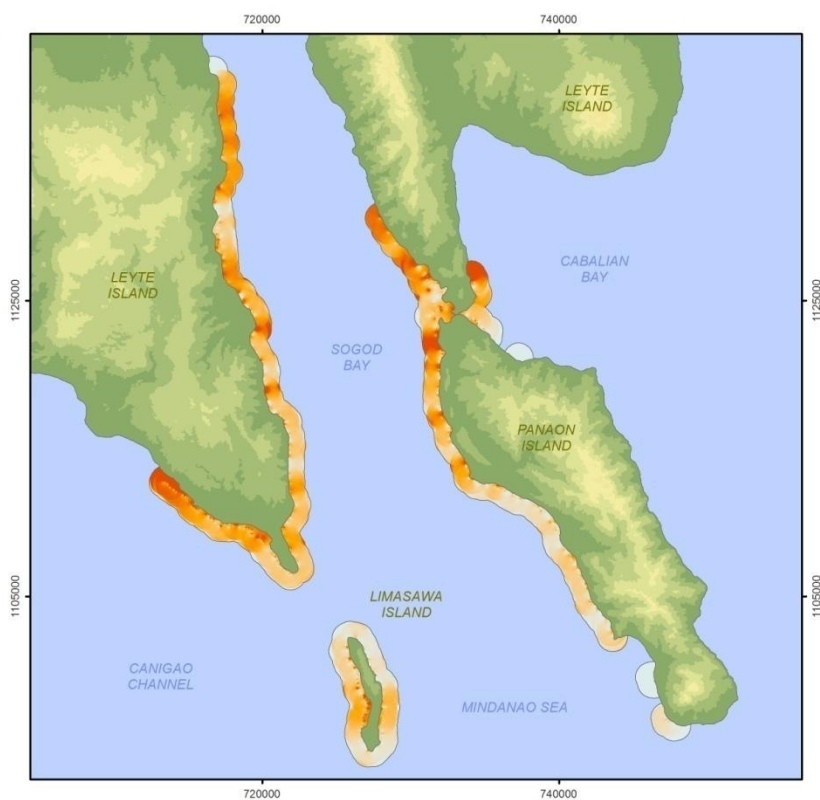


Figure 30 Sea urchin (*Diadema*) abundance on a DAFOR scale, displayed as a colour ramp. Areas towards the darker end of the spectrum have the highest abundance.

Leyte Island: 2010 Base Data Outputs  
Nutrient Indicator Algae density



**Legend**

1km buffer around sites

IDW: 20/1000

High : 5

Low : 0



0 8 16  
kilometers

Coral Cay Conservation o 27 June 2011  
WGS84 UTM Zone 51N o 1: 250, 000

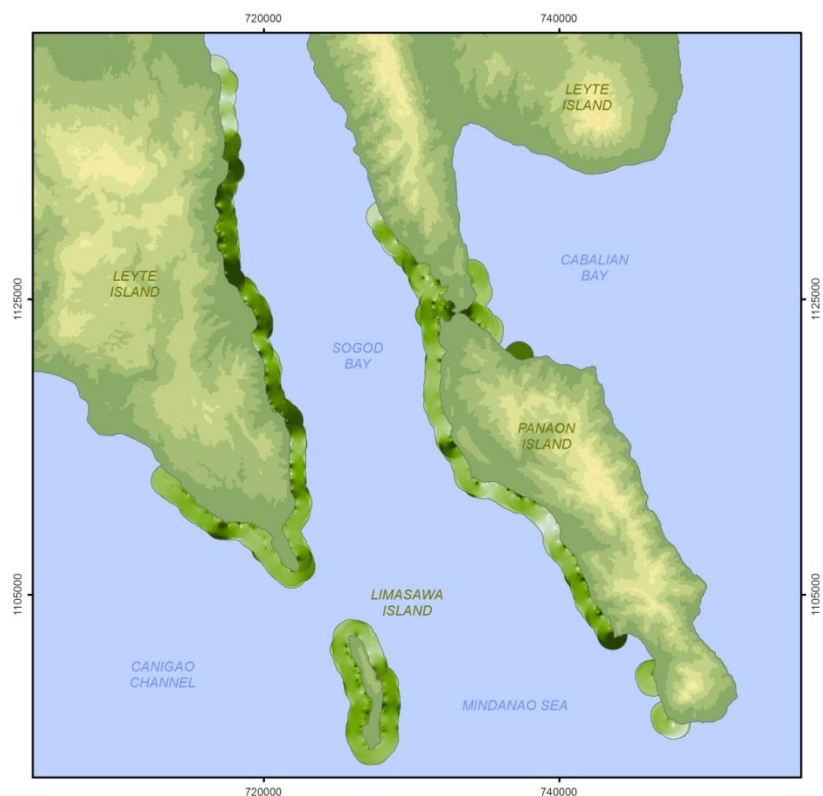


Figure 31 Nutrient Indicator Algae abundance on a DAFOR scale, displayed as a colour ramp. Areas towards the darker end of the spectrum have the highest abundance.

## 4.2 Results from Fish Families

The presence or absence of certain reef fish families is an important indicator of overfishing or coral reef health. Some families such as Butterflyfish (Chaetodontidae) can be indicative of coral diversity and cover whilst commercially targeted families such as Snappers (Lutjanidae), Groupers (Serranidae), Sweetlips (Plectorhinchus) and Parrotfish (Scaridae) form an important part of the reef ecosystem and are often the first to suffer severe population declines in overfished areas. These families were generally quite low in abundance and although not expressed here, their sizes were rarely that of a mature individual. If allowed to grow to adult size, many reef fish will produce considerably more offspring. A 12.5kg snapper for example, will produce as many offspring as 212 snappers weighing 1.1kg each (Bohnsack, 1990). This section looks more closely at fish families that are good indicators of fisheries trends and reef health throughout Sogod Bay. It should be noted that some of the data used in this analysis is more than 5 years old and it is likely that fish densities for areas that include Liloan and the north of Sogod Bay (Bontoc) will have seen reductions since the time of surveying.

### Butterflyfish (Chaetodontidae)

Butterflyfish are obligate corallivores, making them good indicators of reef health. A high abundance and diversity of Butterflyfish species is usually associated with a diverse reef. The eastern side of Sogod Bay and Limasawa saw a relatively high abundance of Butterflyfish (Figure 32). Over 50% of the surveys conducted around Liloan and Libagon and 38% and 36% of the surveys in San Francisco and Limasawa found this family present within the survey area. Butterflyfish density was found to be closely related to coral cover and diversity.

### Parrotfish (Scaridae)

Parrotfish are indicators of reef health as well as being targeted by artisanal fisheries. They are important herbivores, grazing on the reef and help to keep macroalgae in check. Furthermore, some species feed on live hard corals and by doing so, help to maintain coral diversity. Within the classical trophic chain, their herbivorous lifestyle strategy enables greater numbers of individuals within a population, compared to the large carnivores, such as groupers.

Figure 33 displays the abundance of Parrotfish around the bay. Parrotfish were most commonly found in varying numbers throughout the bay and are relatively more abundant around Liloan and the south of the bay, particularly so in San Roque, Burgos and Limasawa Island.

### Groupers (Serranidae)

Groupers are commercially important and very popular food fish all over the world. At a late age (5-7 years), they spawn in aggregations and are extremely vulnerable to over-exploitation. Spawning occurs in large aggregations in order to optimize fertilisation, minimise egg predation, facilitate dispersal and maximise recruitment. The effects of fishing tend to reduce the abundance of the target species, lower their average size and modify

their species composition (Van't Hof, 2001) by selectively removing larger individuals due to an ever-increasing requirement for the export of these fish. Many researchers believe that it is not possible to fish for Grouper at a rate that is both ecologically sustainable and commercially viable, although some successes have been achieved in by aquaculture. Grouper sightings were extremely low on reefs throughout Sogod Bay. They were rarely observed on transect area and are known to be wary of divers, hiding in the reef or swimming away. Records of groupers were generally low across all regions and habitats. Surprisingly, survey regions in the north of Sogod Bay had the highest recorded densities of groupers (Figure 34). This may be partly due to the long-established MPAs in Napantao (San Francisco), Bontoc and Timba (Tommas Oppus). Most of the surveys conducted in Bontoc were done before 2005, which indicates that groupers were more abundant back then.

### **Snappers (Lutjanidae)**

Like Groupers, Snappers are medium to large sized predatory fish and are important targets for artisanal reef-associated fisheries. Depletion in their stocks can indicate overfishing over the whole range of commercially targeted fishes. Snappers were uncommon in all of Sogod Bay (>10% of surveys), but sightings were especially low towards the north of the bay (Bontoc). They were most abundant around Padre Burgos, San Roque and San Francisco where they were sighted on approximately 15% of surveys (Figure 35).

### **Sweetlips (Plectorhinchus)**

These predatory fish feed mainly at night and like Groupers and Snappers, are targeted by local, artisanal and commercial fisheries. Although not as common as Snappers, their presence or absence is not only indicative of fishing pressure but also of coral reef health and diversity as they share a habitat with a wide diversity of prey upon which they feed.

Sweetlips were most abundant around the Padre Burgos peninsula, particularly along the south-western coastline up to and including the Municipality of San Roque (figure 36). There were also higher populations around Limasawa and Liloan. Sweetlips densities were very similar to that of Snappers.

Leyte Island: 2010 Base Data Outputs  
Butterfly Fish density



**Legend**

1km buffer around sites

Butterfly Fish top density values

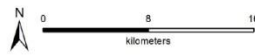
4

3

Kernel Density: 20/2000 (H)

High

Low



Coral Cay Conservation 06 November 2010

WGS84 UTM Zone 51N 1: 250, 000



Figure 32 Abundance of Butterflyfish, displayed as a colour ramp. Areas towards the darker, red end of the spectrum have the highest abundance. Survey sites with DAFOR values of 3 and 4 (21-50 and 51-250 individuals respectively) are marked on the map.

Leyte Island: 2010 Base Data Outputs  
Parrot Fish density



**Legend**

1km buffer around sites

Parrot Fish top density value

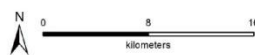
4

3

Kernel Density: 20/2000 (H)

High

Low



Coral Cay Conservation 06 November 2010

WGS84 UTM Zone 51N 1: 250, 000

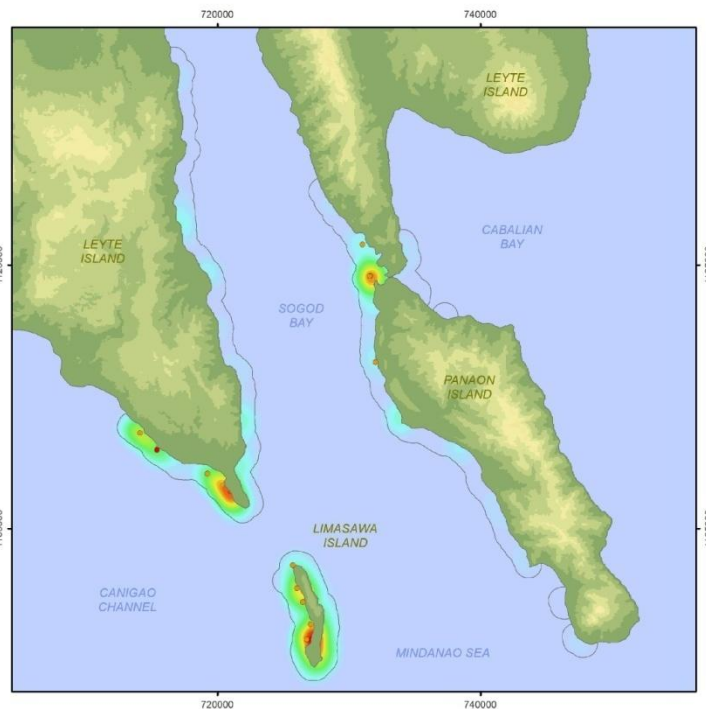


Figure 33 Abundance of Parrotfish, displayed as a colour ramp. Areas towards the darker, red end of the spectrum have the highest abundance. Survey sites with DAFOR values of 3 and 4 (21-50 and 51-250 individuals respectively) are marked on the map.

Leyte Island: 2010 Base Data Outputs  
Grouper density



**Legend**

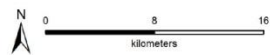
Grouper top density value

3

1km buffer around sites

Kernel Density: 20/2000 (H)

High  
Low



Coral Cay Conservation 06 November 2010  
WGS84 UTM Zone 51N 1: 250, 000

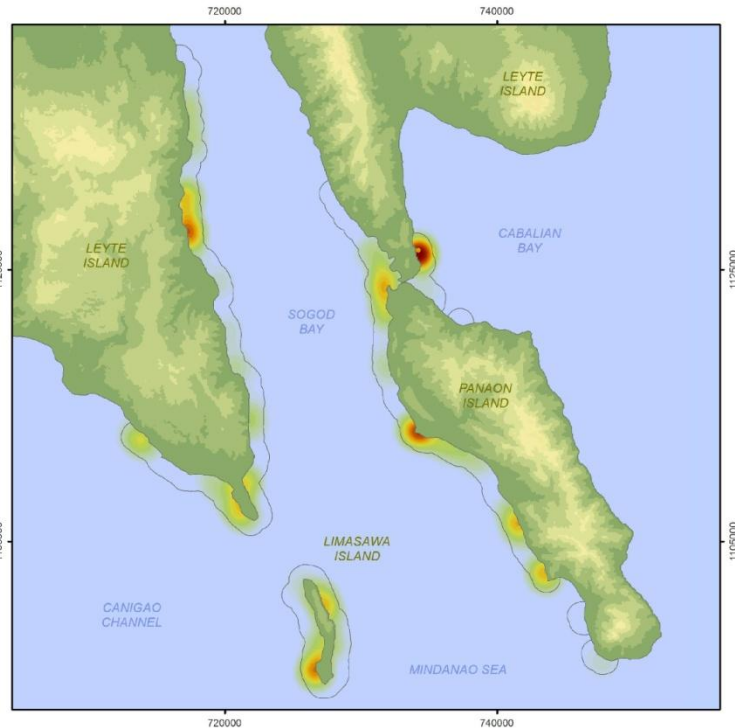


Figure 34 Abundance of Groupers, displayed as a colour ramp. Areas towards the darker, red end of the spectrum have the highest abundance. Survey sites with a DAFOR value of 3 (21-50 individuals) are marked on the map.

Leyte Island: 2010 Base Data Outputs  
Snapper density



**Legend**

1km buffer around sites

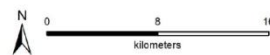
Snapper top density values

4

3

Kernel Density: 20/2000 (H)

High  
Low



Coral Cay Conservation 06 November 2010  
WGS84 UTM Zone 51N 1: 250, 000

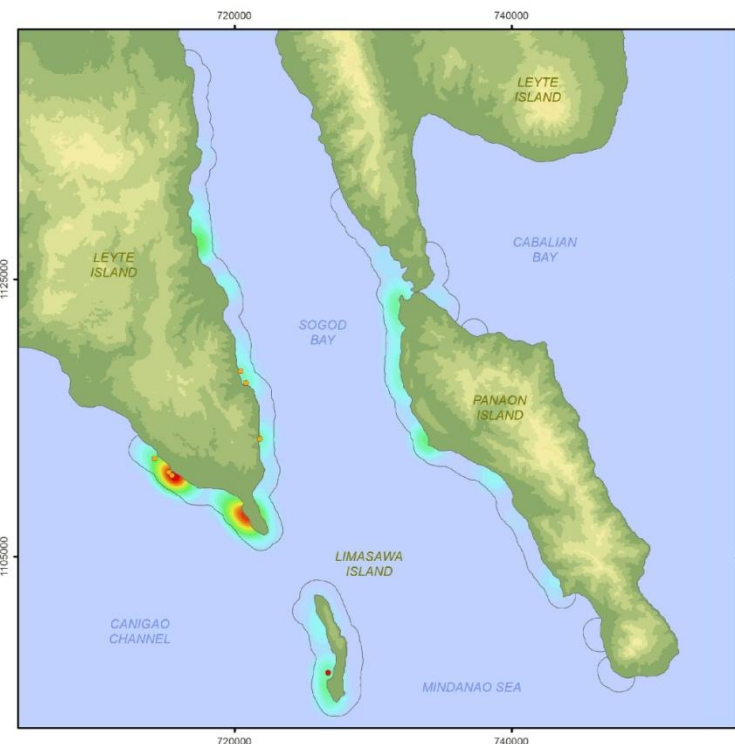


Figure 35 Abundance of Snappers, displayed as a colour ramp. Areas towards the darker, red end of the spectrum have the highest abundance. Survey sites with DAFOR values of 3 and 4 (21-50 and 51-250 individuals respectively) are marked on the map.

Leyte Island: 2010 Base Data Outputs  
Sweetlips density



**Legend**

1km buffer around sites

Sweetlips top density value

2

Kernel Density: 20/2000 (H)

High  
Low



0 8 16  
kilometers

Coral Cay Conservation © 06 November 2010  
WGS84 UTM Zone 51N © 1: 250, 000

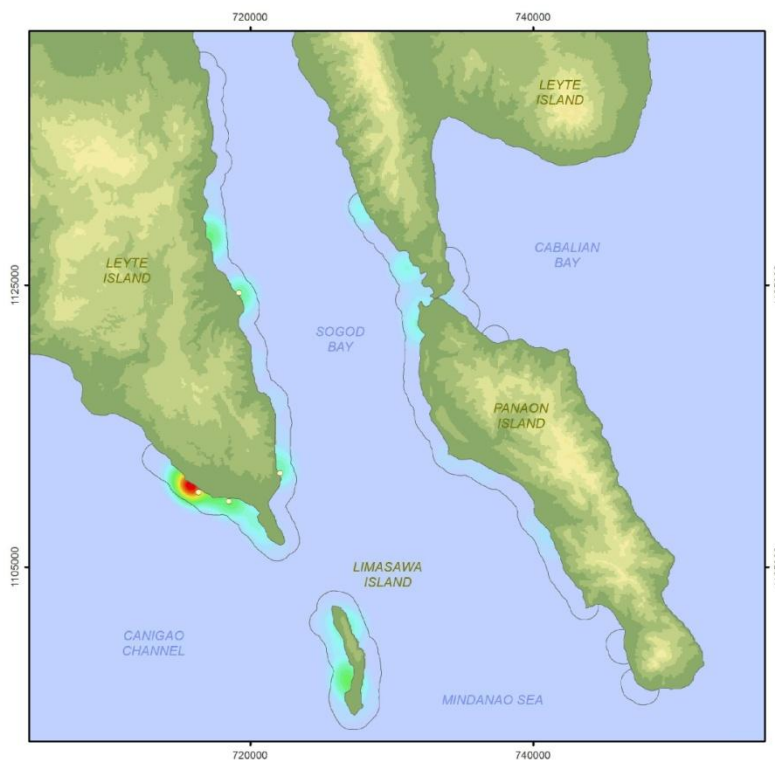


Figure 36 Abundance of Sweetlips, displayed as a colour ramp. Areas towards the darker, red end of the spectrum have the highest abundance. Survey sites with a DAFOR value of 2 (6-20 individuals) are marked on the map.

## 4.4 Conservation Management Values

Using five ecological indices, comparisons between site records can now be made in order to highlight key areas of ecological importance. The indices used are the site record values for live hard coral cover, the total number of benthic targets (not including algae), total number of reef fish targets, the Shannon-Weiner Biodiversity Indices for both benthic and reef fish targets. If, for example, a survey site is below average in all 5 indices, it would score a value of 0; if it was above average in only 1 index, it would score a value of 1, and so on up to a maximum value of 5 (above average in all 5 indices).

Because the location of each survey has been recorded with a GPS unit, the CMVs can be imported into a Geographic Information System (GIS) to enable spatial analysis. The density function in the Spatial Analyst of ArcView (ESRI software) can then be used to highlight areas displaying a particularly high or low density of the various CMVs. These values can be represented on a colour ramp to facilitate visual interpretation.

High CMV values were dispersed throughout the survey area although most high CMV values were found towards the southern end of Sogod Bay, including Limasawa Island, Padre Burgos, San Roque and San Francisco. These results closely correlate with coral cover and commercial fish abundances.

Some survey sectors along Panaon Island have relatively low CMV values due to the limited number of surveys conducted there thus far. As more surveys are conducted in these regions, a more accurate picture of the CMV's will develop.

[Note: This technique compares each site against the other sites within a region, and thus it is a *relative value* for that region only. The fact that a site is displayed as a low CMV does not necessarily mean it is biologically 'poor', but simply that there are biologically 'richer' areas in the same region.]

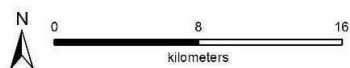
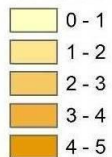
Leyte Island: 2010 Base Data Outputs  
Conservation Management Values



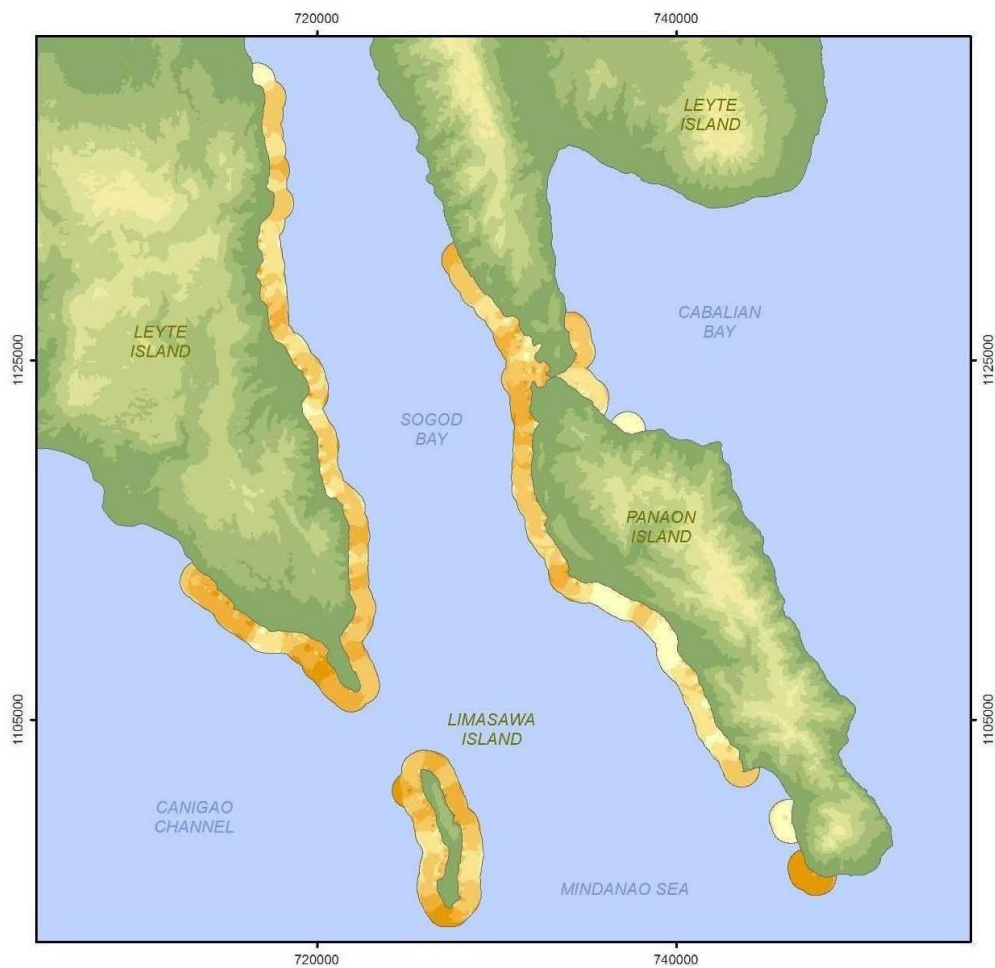
**Legend**

1km buffer around sites

**CM Values**



Coral Cay Conservation o 12 November 2010  
WGS84 UTM Zone 51N o 1: 250, 000



**Figure 37 Conservation Management Values (CMVs) displayed as a colour ramp. Areas towards the darker end of the spectrum have the highest CMVs.**

## 5. Discussion

The general demise of coral reef ecosystems has been well documented with many anthropogenic factors contributing both directly and indirectly to this global phenomenon. The undeniable evidence now supporting the serious threat posed by climate change, coupled with regional and local level impacts will continue to put a tremendous amount of stress on the reefs of the Philippines. The lack of long term data sets and monitoring programmes makes quantification of these processes difficult, but it is likely that no 'pristine' reefs remain anywhere in the world (Wilkinson et al, 2008). Despite this stark appraisal, the reefs of Sogod Bay are, in many places, exceptionally good. This is partly attributable to the efforts of the LGUs and fisherfolk of the Province in enforcing or respecting national legislation governing the use of appropriate fishing gears and methods. Furthermore, no mass-bleaching events have been recorded within the bay, adding to its value as a resilient reef system that may play a crucial role in helping to reseed and restore adjacent reefs in the region. These observations underline its high value, both for the local communities dependent on it as well as for the future food security and biodiversity conservation of the Philippines.

CCC baseline survey data confirms that, in general, target reef fish populations are present at low abundance levels throughout the bay, although a lack of historical data makes it impossible to accurately quantify any long-term temporal changes. However, it is hoped that the major efforts by the various LGUs and NGOs working with the fishing communities of Sogod Bay will help to slow any such decline before species preservation becomes a real scenario, and will ultimately contribute to the development of a sustainable artisanal fishery, which will help to safeguard the coral reefs of the Province, and thus the food-security needs of its people.

Aesthetic and Biological site impression were found to be closely linked, sites with a high aesthetic appeal were assumed to have a high biological value. This is why dive-related eco-tourism and fisheries management can be mutually beneficial. In overfished areas, MPAs are ideally located in areas that have healthy reefs to maximize fish spawning and recovery. These areas are generally appealing to divers as well, allowing local communities to ask divers to pay a fee in order to dive inside the MPA.

The map of CMVs (Figure 38) indicates that areas of moderate to high ecological value (light colours) are dispersed throughout the coastal zone of the bay. Currents circulating around the bay are likely to provide larval dispersal routes for coral reef organisms, with water currents within the bay transporting larvae between healthy and degraded reef patches.

The map also shows that the ecological health of the reefs tends to improve with proximity to the mouth of the bay. This may be partly attributable to the influx of clean oceanic water, which is likely to dilute the level of dissolved nutrients and terrigenous sediment entering from the land. Furthermore, the majority of sediment arrives from the extensive river systems entering at the apex of the bay near Sogod town leading to high levels of sediment deposition smothering corals and lower levels of hard substrate available for coral settlement. Sedimentation from land runoff can have devastating impacts to the health of

fringing coral reefs that line the bay. The recent increase in coral disease prevalence is likely to be related to human-induced impacts from the land.

It is encouraging that Barangays are taking the initiative to approach NGOs such as CCC and government departments such as the PENRMO to ask for their assistance in safeguarding their coastal resources. Evidence of this has been seen by the numerous invitations from barangays for CCC to carry out monitoring work in order to establish ideal MPA placement. In this regard, the ongoing capacity building and community education and awareness programmes are crucial and will continue to be a vital tool to help ensure the sustainable management of Sogod Bay's marine resources. Several scholars from the province, trained by CCC through its capacity building programmes, are now actively engaged in marine conservation and management at various levels. The further expansion of these scholarship programmes will continue to play an important role in the success of the SLCRP.

In many countries, Coastal Resources Management strategies have concentrated on the creation of a small number of very large MPAs (>50 hectares). The reefs of the Sogod Bay however, tend to drop away steeply, with a short backreef area, and thus in most areas, the installation of very large MPAs would likely encompass more deep water than coral reef area. Furthermore, the nature of the local legislative system means large MPAs would almost certainly be trans-boundary, leading to considerable political challenges in the management of such reserves. A notable and recent exception has been the installation of the Limawasa Island Marine Reserve that protects the coastal zone of two barangays. Regardless, the creation of a network of smaller MPAs throughout the bay is more appropriate ecologically and more achievable politically. It is therefore recommended that further and ongoing support is provided to communities in order to facilitate the expansion of a network of locally-led, community-supported MPAs throughout Southern Leyte. CCC can continue to assist the Provincial Government of Southern Leyte and the LGUs with this campaign.

Dive related tourism can be an effective means to create alternative livelihoods and alleviate fishing pressure in coastal waters. Popular and rare mega-fauna such as the Whale Sharks have attracted thousands of tourists to Donsol in Luzon. There is no reason why a similar eco-tourism destination could not be set up in Sogod Bay although limitations must be placed on the number of snorkelers allowed to watch the Whale Sharks at any one time. In addition to Whale Shark watching, the diverse and often spectacular reefs of Sogod Bay remain one of the most valuable assets in terms of attracting tourists to the province, making a strong case for protecting these sites before they become severely degraded.

The implementation of a holistic management approach to the successful preservation of Sogod Bay's marine habitats in the face of human-induced climate change is essential. Upland deforestation, land-based pollution and agricultural and urban development must be managed if reefs are to retain their resilience and ability to absorb impacts of regional stressors. It is only through the effective management and conservation of healthy reef systems that they can continue to provide crucial ecological, financial and social services. It is only through a complete 'ridge to reef' approach that coral reefs of Sogod Bay can be secured for the future benefit and enjoyment of the people of Southern Leyte. Coral Cay looks forward to continue to work closely with its partners to make this a reality.

## Bibliography

Aeby, G.S. (2007) Coral disease on reefs in Sogod Bay, Southern Leyte in July 2007. A preliminary study for Coral Cay Conservation. Coral Cay Conservation, London, UK

van Bochove, J., Harding, S., Raines, P. (2007) Southern Leyte Coral Reef Conservation Project – Results of Scientific and Community Work. Coral Cay Conservation, London, UK.

Bohnsack, J.A. (1990). The potential of marine fishery reserves for reef fish management in the U.S. Southern Atlantic. NOAA Technical Memorandum NMFS-SEFC-261, Miami, USA

Buddemeier, R., Kleypas, J., Aronson, R. (2004). Coral Reefs and Global Climate Change – Potential Contributions of Climate Change to Stresses on Coral Reef Ecosystems. Pew Center on Global Climate Change, Arlington USA.

Calumpong H.P., L.J. Raymundo, E.P. Solis- Duran, M.N.R. Alava and R.O. de Leon (Eds.). (1994). Resource and Ecological Assessment of Sogod Bay, Leyte, Philippines- Final Report.

Carpenter, K.E., Springer, V. (2005) The center of the center of marine shore fish biodiversity: the Philippine Islands.

Cervino, J.M., Hayes, R.L., Polson, S.W., Polson, S.C., Goreau, T.J., Martinez R.J. and Smith, G.W. (2004) Relationship of *Vibrio* Species Infection and Elevated Temperatures to Yellow Blotch/Band Disease in Caribbean Corals. *Applied and Environmental Microbiology*, p. 6855–6864

Chou, LM (1998). Status of Southeast Asian coral reefs. In: Wilkinson CR (Ed.) Status of coral reefs of the world: 1998. Australian Institute of Marine Science.

Courtney, CA, Atchue JA, Carreon, M, White, AT, Pestano-Smith, R, Deguit, E, Sievert, R, Navarro, R, (Ed.) (1999). In Coastal Resource Management Programme for Food Security, Cebu City, Philippines. 27 pages.

Darwall, W.R.T. and N.K. Dulvy. (1996). An evaluation of the suitability of non-specialist volunteer researchers for coral reef fish surveys. Mafia Island, Tanzania – A case study. *Biological Conservation* 78: 223-231.

Department of Environmental and Natural Resources, Bureau of Fisheries and Aquatic Resources of the Department of Agriculture, and the Department of Interior and Local Government. (2001). Philippines Coastal Management Guidebook No. 1: Coastal Management Orientation and Overview. Coastal Management Resource Project of the Department of Environmental and Natural Resource Department, Cebu City, Philippines, 58pp

Erdmann, M.V., A. Mehta, H. Newman and Sukarno. (1997). Operation Wallacea: Low-cost reef assessment using volunteer divers. *Proceedings of the 8<sup>th</sup> International Coral Reef Symposium* 2: 1515-1520.

- Glynn, P. (1993). Coral reef bleaching ecological perspectives. *Coral Reefs* 12: 1-17.
- Hay, M.E. (1996). Marine chemical ecology: what is known and what is next? *J. Exp. Mar. Biol. Ecol.* 200, 103-134.
- Heuër, A., Navarette, D., Chaigneau, T., van Bochove, J., Harding, S., Raines, P. (2008). Socio-Economic Study: Local Livelihoods, Use and Management of Coastal Resources and Efficiency of Marine Protected Area's in Panaon Island. Coral Cay Conservation, London, UK.
- Hodgson G. (1999). A global assessment of human effects on coral reefs. *Marine Pollution Bulletin* 38: 345-355
- Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, and D. Xiaosu (eds.) (2001). IPCC Third Assessment Report: Climate Change 2001: The Scientific Basis. Cambridge University Press, Cambridge, UK, 944 pp.
- Hughes, T. et al. (2003). Climate change, human impacts, and the resilience of coral reefs. *Science* 301: 929–933.
- Hunter, C. and J. Maragos. (1992). Methodology for involving recreational divers in long-term monitoring of coral reefs. *Pacific Science* 46: 381-382.
- IPCC (2007). The Physical Science Basis. Summary for Policymakers. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. 18 pp.
- Jacinto G.L., Alino P.M., Villanoy C.L., Talaue-McManus L. and E.D. Gomez (2000). The Philippines. In *Seas of the Millennium: An environmental evaluation*. C. Sheppard (Ed.), Elsevier Science, chapter 79, 405-423.
- Kinsey, D.W. (1988). Coral reef system response to some natural and anthropogenic stresses. *Galaxea* 7: 113-128.
- Koch, S.L. (1993). A survey of the marine resources of Southern Leyte. R.A.N.A Consultancy Inc.
- Lieske E and Myers R (2001) *Coral reef fishes: Indo Pacific and Caribbean*. Harper Collins London.
- Lourey, M.J., Ryan, D.A.J., Miller, I.R., (2000). Rates of decline and recovery of coral cover on reefs impacted by, recovering from and unaffected by crown-of-thorns starfish, *Acanthaster planci*: a regional perspective of the Great Barrier Reef. *Mar. Ecol. Prog. Ser.* 196, pp. 179-186.
- McCook, L.J. (1999). Macroalgae, nutrients and phase shifts on coral reefs: Scientific issues and management consequences for the Great Barrier Reef. *Coral Reefs* 18: 357-367.
- Moran, P.J., (1986). The *Acanthaster* Phenomenon. *Oceanographic Marine Biology Annual Review* 24, pp. 379-480.

Mumby, P.J., A.R. Harborne, P.S. Raines and J.M. Ridley. (1995). A critical assessment of data derived from Coral Cay Conservation volunteers. *Bulletin of Marine Science* 56: 737-751.

O'Farrell, S., van Bochove, J.H., Bodley, H., Fenner, D., Raines, P. (2006) Southern Leyte Coral Reef Conservation Project – Results of Scientific and Community Work. Coral Cay Conservation, London, UK.

Orr, J. et al. (2005). Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. *Nature* 437 (29): 681-686.

Roberts, C.M., C.J. Mclean, J.E.N. Veron, J.P. Hawkins, G.R. Allen, D.E. McAllister, C.G. Mittermeier, F.W. Schueler, M. Spalding, F. Wells, C. Vynne & T.B. Werner. (2002). Marine biodiversity hotspots and conservation priorities for tropical reefs. *Science* 295: 1280-1284

Royal Society. (2005). Ocean Acidification Due to Increasing Atmospheric Carbon Dioxide. The Royal Society, London, UK [<http://www.royalsoc.ac.uk/displaypagedoc.asp?id513539> accessed 19 July, 2008].

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

Sheppard, C.R.C., Harris, A. and Sheppard, A.L.S. (2008). Archipelago-wide coral recovery patterns since 1998 in the Chagos Archipelago, central Indian Ocean. *Marine Ecology Progress Series* 362: 109-117.

Smith, G., Ives, L., Nagelkerken, I and Ritchie, k. (1996). Aspergilliosis associated with Caribbean sea fan mortalities. *Nature* 382:487

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

Taylor, J., O'Farrell, S., Walker, R., Fenner, D. and Raines, P. (2004) Southern Leyte Coral Reef Conservation Project – Second Year Report and Coral Species List For Sogod Bay. Coral Cay Conservation, London, UK.

Van't Hof, T. (2001). Tourism Impacts on Coral Reefs: Increasing Awareness in the Tourism Sector. UNEP Publication.

Voss, J., Richardson, L. (2006). Nutrient enrichment enhances black band disease progression in corals. *Coral Reefs* 25: 569–576

Wells, S.M. (1995). Reef assessment and monitoring using volunteers and non-professionals. University of Miami.

Wilkinson, C., Souter, D. (2008). Status of Caribbean coral reefs after bleaching and hurricanes in 2005. Global Coral Reef Monitoring Network, and Reef and Rainforest Research Centre, Townsville, 152 p.

Wilkinson, C. (2008). Status of coral reefs of the world: 2008. Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre, Townsville, Australia, 296 p.

Webster, P., Holland G., Curry, A., Chang, H. (2005). Changes in tropical cyclone number, duration, and intensity in a warming environment. *Science* 309: 1844-1846.

Winter, A., Appeldoorn, R., Bruckner, A., Williams, E. and Goenaga, C. (1998). Sea surface temperatures and coral reef bleaching off La Parguera, Puerto Rico. *Coral Reefs* 17: 377-382

Wolanski, E., Richmond, R., McCook, L. and Sweatman, H. (2003). Mud, marine snow, and coral reefs. *American Scientist* 91: 44-51.

## Appendix A: Baseline survey forms

|                 |  |                               |  |                     |  |
|-----------------|--|-------------------------------|--|---------------------|--|
| <b>TRANCODE</b> |  | <b>TRANSECT/PHYSICAL FORM</b> |  |                     |  |
| SURVEY DATE:    |  |                               |  |                     |  |
| START TIME:     |  | END TIME:                     |  | FISH BOUY DEPTH:    |  |
| END DEPTH:      |  | START DEPTH:                  |  | REPEAT VISIT: (Y/N) |  |

Geomorphical Classes Surveyed during entire Dive (ONLY 1 REQD PER SURVEY)  
Remember: each new zone is a new habitat, so requires a new biological recording form for each.

|                     | tick |                                                                |
|---------------------|------|----------------------------------------------------------------|
| Lagoon              |      | Shallow zone between backreef and land. Soft substratum        |
| Backreef            |      | Shallow zone between reef crest and lagoon.                    |
| Reef Crest          |      | Shallowest (often emergent zone); separates fore from backreef |
| Forereef            |      | Sloping face of reef unto 45 degrees                           |
| * Reef Front        |      | Forereef slope from 3-10m                                      |
| * Upper Reef Slope  |      | Forereef slope from 10-20m                                     |
| * Lower Reef Slope  |      | Forereef slope from 20-30m                                     |
| Escarpment ("wall") |      | Any area of reef whose slope is greater than 45 degrees        |
| Dense Patch Reef    |      | Area of coral 'bommies' >70% hard coral, often sand between    |
| Diffuse Patch Reef  |      | Area of coral 'bommies' <70% hard coral, often sand between    |

**UNDERWATER IMPACTS**

|               |
|---------------|
| LITTER        |
| SEWAGE        |
| CORAL DAMAGE  |
| LINES/ NETS   |
| FISH TRAPS    |
| SEDIMENTATION |
| DISEASE       |
| BLEACHING     |
| DYNAMITE      |
| OTHER         |

**IMPRESSION OF THE SITE**

|            |      |         |      |         |           |
|------------|------|---------|------|---------|-----------|
| AESTHETIC  | POOR | AVERAGE | GOOD | V. GOOD | EXCELLENT |
| BIOLOGICAL | POOR | AVERAGE | GOOD | V. GOOD | EXCELLENT |

**GENERAL LOCATION**  
(SHORE REFERENCE)

|               |     |        |      |
|---------------|-----|--------|------|
| TOPOGRAPHY    | LOW | MEDIUM | HIGH |
| MAIN HABITATS |     |        |      |

**ORIENTATION**

|                           |   |
|---------------------------|---|
| DISTANCE TRAVELLED        | m |
| APPROX DISTANCE REMAINING | m |

LATITUDE START: 07

LONGITUDE START: 1

LATITUDE END: 07

LONGITUDE END: 1

CURRENT STRENGTH

|      |      |        |        |
|------|------|--------|--------|
| NONE | WEAK | MEDIUM | STRONG |
|------|------|--------|--------|

CURRENT DIR (towards) (N,NW etc.)

TEMPERATURE AT DEPTH OF

SALINITY AT DEPTH OF

SECCHI

WIND STRENGTH (BEAUFORT)

WIND DIR (from)

SURFACE TEMPERATURE

SURFACE SALINITY

**SURFACE ACTIVITY**

| OCCUPANTS | PROXIMITY | ACTIVITY* |
|-----------|-----------|-----------|
|           |           |           |
|           |           |           |
|           |           |           |
|           |           |           |
|           |           |           |
|           |           |           |

\*(FISHING DIVING PLEASURE COMMERCIAL)

**SURFACE IMPACTS**

|           |
|-----------|
| LITTER    |
| ALGAE     |
| SEWAGE    |
| NETS      |
| DRIFTWOOD |
| OTHER     |

**PHYSICAL**

|            | FIRST NAME | SURNAME | NO. SURVEYS |
|------------|------------|---------|-------------|
| FISH       |            |         |             |
| CORAL      |            |         |             |
| ALGAE/INVS |            |         |             |

**DATABASE INFO**

|            |
|------------|
| ENTERED BY |
| DATE       |
| LOGGED?    |
| CHECKED BY |
| DATE       |

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



## Appendix B: Science Development Programme training schedule

| CCC Skills Development Programme (SDP)                                                                                                                                                           |                                                                                                                                                                                                                                                  |                                                                                                                                                                                 |                                                                                                                     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| Philippines Southern Leyte Reef Conservation Project                                                                                                                                             |                                                                                                                                                                                                                                                  |                                                                                                                                                                                 |                                                                                                                     |
| EL = Expedition Leader                      SI = Scuba Instructor<br>CLO = Community Liaison Officer<br>PS = Project Scientist                      MO = Medical Officer<br>SO = Science Officer |                                                                                                                                                                                                                                                  |                                                                                                                                                                                 |                                                                                                                     |
| <b>Pointies, validations and other in-water activities are represented in blue</b><br><b>Computer tests are represented in red</b><br><b>Reef Check activities are represented in green</b>      |                                                                                                                                                                                                                                                  |                                                                                                                                                                                 |                                                                                                                     |
| Day                                                                                                                                                                                              | Morning                                                                                                                                                                                                                                          | Afternoon                                                                                                                                                                       | Evening                                                                                                             |
| Thursday<br>(SDP Day 1)                                                                                                                                                                          | 0700 – Welcome and tour of facilities <b>(EL)</b><br>0800 – Medical briefing <b>(MO)</b><br>0830 – Medical interview <b>(MO)</b><br>0900 – Dangerous marine animals lecture <b>(SO)</b><br>0930 – CCC dive standards and boat safety <b>(SI)</b> | 1300 – Dive briefing <b>(SI)</b><br>1330 – Check dive <b>(SI)</b><br>1430 – Check dive debrief <b>(SI)</b><br>1500 – Introduction to Coral Reef Ecology and Biology <b>(PS)</b> | 1900 – Introduction to CCC in the Philippines <b>(PS)</b><br>1945 – Philippines Customs and Culture <b>(PS/CLO)</b> |
| Friday<br>(SDP Day2)                                                                                                                                                                             | 0700 – Introduction to Cnidarian Taxonomy <b>(PS)</b><br>0800 – Hard Coral Biology and Lifeforms <b>(PS)</b><br>0930 – Hard Coral Lifeforms Pointy                                                                                               | 1300 – Substrates and Habitats <b>(SO)</b><br>1300 – Hard Coral Species I <b>(SO)</b><br>1500 – Hard Coral Species Pointy I                                                     | 1900 – Community Education lecture <b>(EO/CLO)</b><br>2000 – Blue Planet DVD                                        |
| Saturday<br>(SDP Day 3)                                                                                                                                                                          | 0700 – Hard Coral Species II <b>(SO)</b><br>0800 – Hard Coral Species Pointy II                                                                                                                                                                  | 1300 – Inverts and Sponges <b>(SO)</b><br>1400 – Inverts and Sponges Pointy                                                                                                     |                                                                                                                     |
| Sunday<br><b>No dive day</b>                                                                                                                                                                     |                                                                                                                                                                                                                                                  | 1300 – Marine Plants and Algae <b>(SO)</b><br>1400 – Marine Plants and Algae Pointy (Snorkel)                                                                                   | 1900 – Hard Coral Computer Test                                                                                     |

|                          |                                                                                                                                                   |                                                                                                                                                                                                         |                                                                             |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| (SDP Day 4)              |                                                                                                                                                   | 1530 – Shore Marshal/Boat Marshal lecture, Boat Box and Oxygen Administration <b>(EL/MO)</b>                                                                                                            |                                                                             |
| Monday<br>(SDP Day 5)    | 0700 – Fish Biology and Fish Families I <b>(PS/SO)</b><br><br>0800 – Fish Families Pointy I                                                       | 1300 – Fish Families II <b>(SO)</b><br><br>1400 – Fish Families Pointy II                                                                                                                               | 1900 – Inverts and Sponges Computer Test                                    |
| Tuesday<br>(SDP Day 6)   | 0700 – Fish Species I <b>(SO)</b><br><br>0800 – Fish Species Pointy I                                                                             | 1300 – Fish Species II <b>(SO)</b><br><br>1400 – Fish Species Pointy II                                                                                                                                 | 1900 – Marine Plants and Algae Computer Test                                |
| Wednesday<br>(SDP Day 7) | 0830 – Coral Pointy Test                                                                                                                          | 1400 – Coral Trail Test (Validation)                                                                                                                                                                    | 1900 – Fish Computer Test<br><br>2030 – Test re-takes                       |
| Thursday<br>(SDP Day 8)  | 0830 – Inverts and Algae Pointy Test                                                                                                              | 1400 – Invert and Algae Trail Test (Validation)                                                                                                                                                         |                                                                             |
| Friday<br>(SDP Day 9)    | 0700 – Fish Validation I<br><br>0830 – Fish Validation I Debrief                                                                                  | 1300 – Fish Validation II<br><br>1430 – Fish Validation II Debrief                                                                                                                                      |                                                                             |
| Saturday<br>(SDP Day 10) | Recreational Diving or Validation Retakes                                                                                                         | Recreational Diving or Validation Retakes                                                                                                                                                               |                                                                             |
| Sunday<br>(SDP Day 11)   |                                                                                                                                                   | 1300 – Reef Check EcoDiver Registration and Introduction <b>(SO/PS)</b><br><br>1430 – Reef Check DVD<br><br>1530 – Reef Check: Fish, Substrate, Invertebrates and Impacts Identification <b>(SO/PS)</b> | 1900 – Reef Check Fish, Substrate, Invertebrates and Impacts Computer Tests |
| Monday<br>(SDP Day 12)   | 0700 – Reef Check EcoDiver Data Entry <b>(SO/PS)</b><br><br>0800 – Reef Check EcoDiver Pointy and Identification Test                             | 1300 – Reef Check EcoDiver Survey Methods and Dry Run <b>(SO/PS)</b><br><br>1430 – Reef Check EcoDiver Practice Survey                                                                                  | 2000 – Reef Check EcoDiver Certification                                    |
| Tuesday<br>(SDP Day 13)  | 0700 – Introduction to Baseline Survey Techniques <b>(SO)</b><br><br>0800 – Dry Run Practice Survey I <b>(SO)</b><br><br>0900 – Practice Survey I | 1300 – Form Filling, GPS and Knots <b>(SO)</b><br><br>1400 – Dry Run Practice Survey II <b>(SO)</b><br><br>1500 – Practice Survey II                                                                    |                                                                             |

## Appendix C: GIS Outputs

**Kernel Density** Calculates a magnitude per unit area from point or polyline features using a kernel function to fit a smoothly tapered surface to each point or polyline.

You can calculate density using simple or kernel calculations. In a simple density calculation, points or lines that fall within the search area are summed, and then divided by the search area size to get each cell's density value.

In kernel density, the values associated with each point are spread from the point location to the specified radius. The density is greatest at the point location and diminishes to zero at the specified radius. The sum of the intersecting spreads is calculated for each output cell. The result is a smoother distribution of values than with simple density.

**Inverse Distance Weighted (IDW)** Interpolates a surface from points using an inverse distance weighted (IDW) technique. IDW is a method of interpolation that estimates cell values by averaging the values of sample data points in the neighbourhood of each processing cell. The closer a point is to the center of the cell being estimated, the more influence, or weight, it has in the averaging process.

| Output Map                               | Spatial Analyst function | Population field        | Output value           | Cell size | Search Radius |
|------------------------------------------|--------------------------|-------------------------|------------------------|-----------|---------------|
| Perceived aesthetic and biological value | <i>Kemel Density</i>     | <i>Aesthetic value</i>  | <i>Qualitive scale</i> | 20        | 2000          |
| Vertical visibility                      | <i>Kernel Density</i>    | <i>Secchi</i>           | <i>Depth</i>           | 20        | 1000          |
| Hard and soft coral cover                | <i>Kemel Density</i>     | <i>HC or SC CONV</i>    | <i>DAFOR</i>           | 20        | 2000          |
| Hard and soft coral cover                | <i>IDW</i>               | <i>HC or SC CONV</i>    | <i>DAFOR</i>           | 20        | 1000          |
| Sea urchin ( <i>Diadema</i> )            | <i>IDW</i>               | <i>Sea Urchin</i>       | <i>DAFOR</i>           | 20        | 1000          |
| Giant clam ( <i>Tridacna</i> )           | <i>IDW</i>               | <i>Clams</i>            | <i>DAFOR</i>           | 20        | 1000          |
| Nutrient indicator algae                 | <i>IDW</i>               | <i>NIA</i>              | <i>DAFOR</i>           | 20        | 1000          |
| Fish families                            | <i>Kemel Density</i>     | <i>Biological value</i> | <i>DAFOR</i>           | 20        | 2000          |
| Fishing pressure                         | <i>Kemel Density</i>     | <i>FP_XX</i>            | <i>Qualitive scale</i> | 20        | 2000          |
| Underwater impacts                       | <i>Kemel Density</i>     | <i>UWI_XX</i>           | <i>Qualitive scale</i> | 20        | 2000          |
| CMV                                      | <i>IDW</i>               | <i>CMV</i>              | <i>CMV</i>             | 20        | 1000          |