

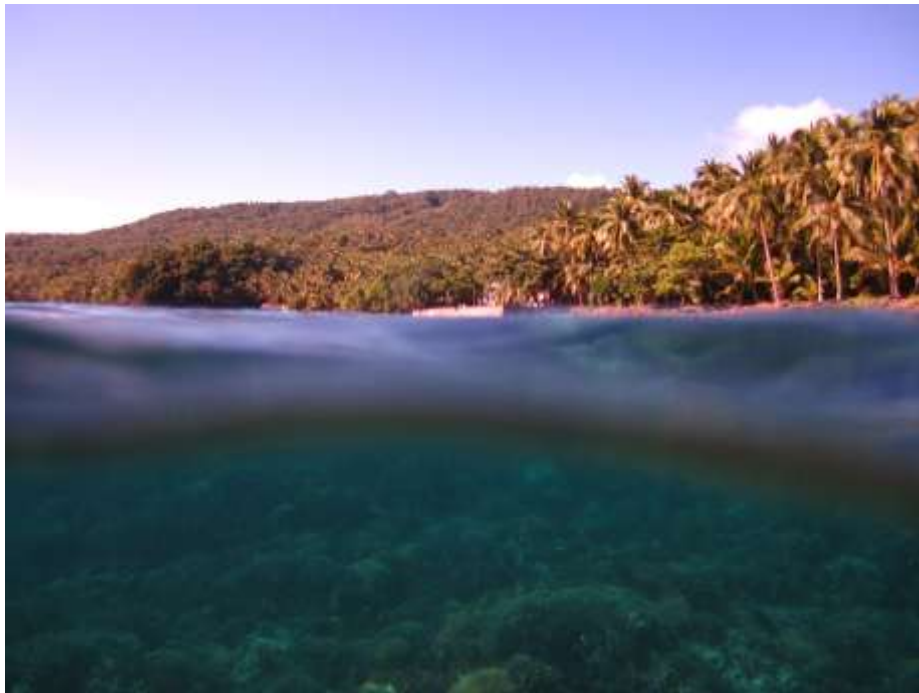


SOUTHERN LEYTE CORAL REEF CONSERVATION PROJECT

Summary Report

RESULTS OF COMMUNITY AND SCIENTIFIC WORK

AUGUST 2010 – JULY 2012



In partnership with:



The Provincial Government of Southern Leyte, Philippines

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Executive Summary

The Southern Leyte Coral Reef Conservation Project (SLCRCP) 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, Coral Cay Conservation (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 PGSL
- 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 2012. It also contains a synopsis of community work and capacity building activities undertaken between August 2012 and July 2012. Community and capacity building work undertaken prior to this have previously been presented in CCC summary reports.

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 24 months, CCC project staff and volunteers undertook 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 clean-ups and attendance at local fairs, symposia and workshops. The CCC Scholarship Programme provided 19 scholars with 4-week SCUBA dive and scientific survey training.

CCC survey teams have thus far produced a total of 2,055 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.

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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 1986, CCC is dedicated to 'providing resources to protect livelihoods and alleviate poverty through the protection, restoration and sustainable use of coral reefs and tropical forests'. 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 an innovative 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.

CCC has been successfully operating volunteer based conservation programmes in developing countries over the past 26 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 several no-take marine parks around Sogod Bay in the Philippines.

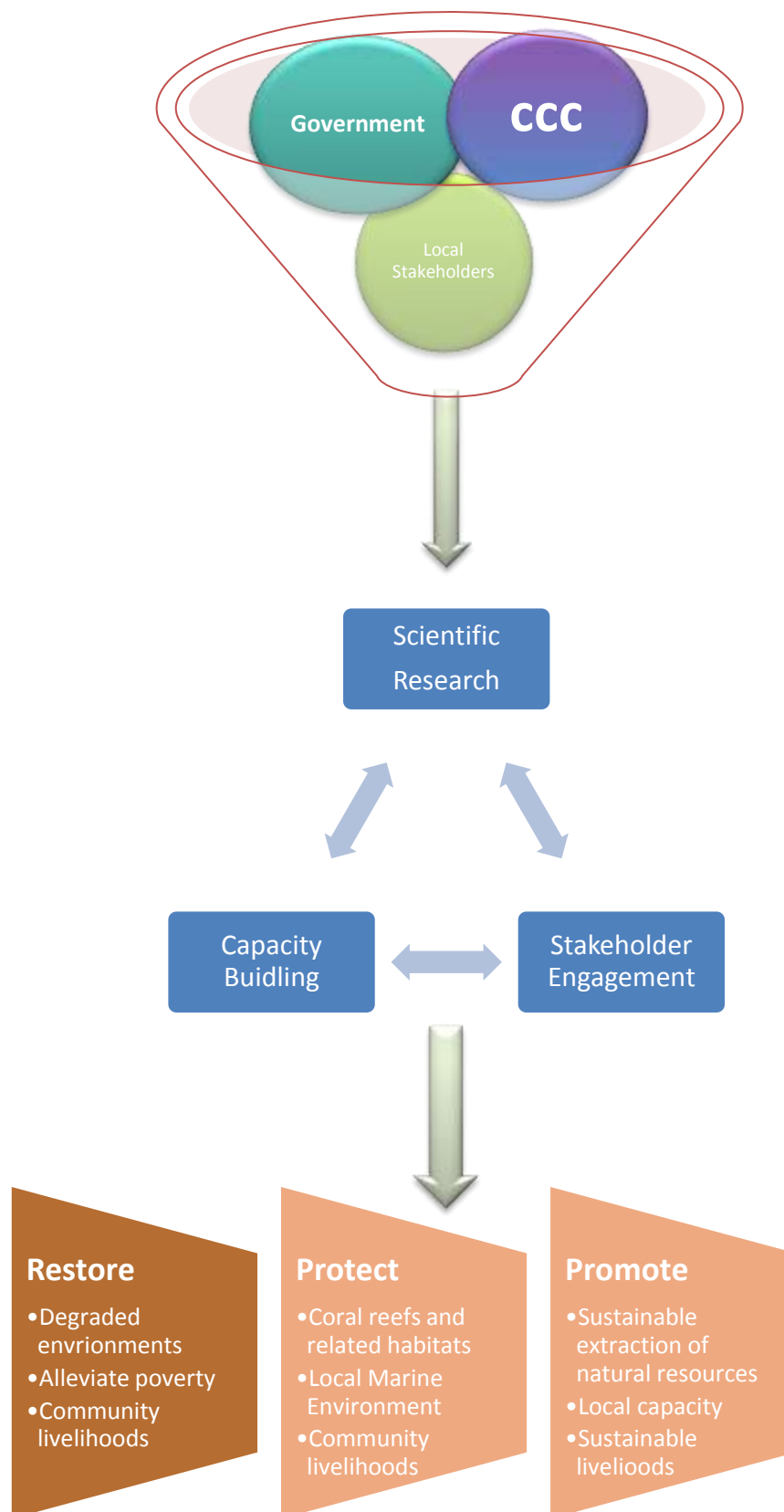


Figure 1 Flow process diagram of CCC's implementation strategy

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 in this region. 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, 25,000km² 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 95 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). The Global Coral Reef Monitoring Network (GCRMN) records 97% of reefs in the Philippines as 'at risk'.

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 coral reef habitats in the Philippines.

1.2 Southern Leyte



Figure 2 - 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 2) is bounded in the north by Leyte province, in the south by Mindanao Sea, in the east by the Pacific Ocean and in the west by the Canigao Channel. Sogod Bay (10° 12' N, 125° 12' E) is surrounded by 131.67 km of coastline and is 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 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 two metres per year (Calumpong *et al.*, 1994).

Southern Leyte is the second least populated area in Region VIII and, according to a 2010 census (census.gov.ph), the population is increasing at a rate of 1.08% per year. At the time of the 2010 census the population of Southern Leyte was 399,137 with a population density of 230/km². The low human population density is a factor that has contributed to the protection of coral reefs locally to date. However, increasing pressure is being put on marine resources as the population grows and, with this, a growing threat of marine habitat degradation which could result in 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

General reef Statistics	
Reef Area (km ²)	25,819
Overall Reef Condition (<i>arrows indicate direction of change since 2004</i>)	
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% ↓
Integrated threat index %	
Low	2
Medium	27
High	63
Very High	7
Threat Indicators	
Coastal Development	High
Marine-Based Pollution	High
Sedimentation	Low/Med
Over fishing	Med/High
Destructive fishing	Med/High
Marine Protection Status	
Total number of actively managed MPAs	339
Total number of MPAs with coral reefs	294
% of MPAs with good management ratings	20-30%

1.3.1 Global and Regional-Scale Threats and Impacts

Carbon Dioxide (CO₂) 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 CO₂ 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 majority 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, CO₂ 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 CO₂ produced by industry, causing a fall in pH of 0.1, which equates to a 30% increase in H⁺ 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.

1.3.2 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 corallivore, 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⁻¹), massive corals such as *Porites* spp. are also targeted during outbreaks and can suffer significant damage. Local extinction of these long-lived, architectural reef colonies could gradually extend the reefs recovery time, (Seymour & Bradbury, 1999). Lourey, (2000), found evidence that up to 25% of the reefs surveyed on the Great Barrier Reef may not recover, as outbreaks over the last thirty years have been occurring more frequently 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). COTs outbreaks in 2012 have posed a severe threat to the coral reefs in Sogod Bay and extraction programmes have taken place to remove them.

2. Community and Capacity Building Work

This section provides a review of the community educational work and capacity building work that Coral Cay has conducted in the Philippines between August 2010 and July 2012. Information regarding past community work can be viewed in previous project reports.

The purpose of the community work is two-fold: to raise awareness of environmental issues within the local community and to provide marine science training to local scholars whilst strengthening ties with local stakeholders and government bodies. The community educational aspects of the SLCRCP compliment the scientific survey effort and are key to the continued success of the project.

2.1 CCC scholarship Programme

One of the key objectives of the SLCRCP 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.

The scholarship programme run by CCC is an intensive four week course in which participants are certified to PADI Advanced Open Water Diver, as well as trained in the identification of over 300 marine life forms and in the methods for scientific surveying of coral reef ecosystems. In addition, further practical sessions and lectures provide the scholars with training in reef and MPA management and skills in managing, analysing and presenting data. The primary aim of the scholarship is to empower individuals to continue the conservation activities after CCC has moved on.

18 scholars from a variety of backgrounds and municipalities were trained between August 2010 and July 2012 (Table 2).

Table 2 – Scholarship participants

Month	Scholar name	Information
Aug 2010	Leonardo Monter	From Barangay Macrohon
Sept 2010	Lance Concepcion	Completed his scholarship and then stayed to undertake his PADI Dive Master Award.
Oct 2010	Lance Concepcion	
Nov 2010	Dinah Quiton	From Silago – Works for Ocean-Action Research Centre
Dec 2010	Kalen Manlangit	Works at the Sogod Bay Scuba Resort
Dec 2010	Eduardo Mira Jr.	Works at the Sogod Bay Scuba Resort
Dec 2010	Alfredo Esclamado	Works at the Sogod Bay Scuba Resort
Jan 2011	Karen Uy	From Silago – Works for Ocean-Action Research Centre.
Feb 2011	Karen Uy	Had already completed the scholarship programme but came back to undertake her PADI Dive Master award.

Mar 2011	Michael Estopin	From Ormoc City – Extended his stay to participate in
Apr 2011	Michael Estopin	further survey work
May 2011	Stephanie Arenas	From Manila
Jun 2011	Jerome Napala	From Malitbog
Jul 2011	Jerome Napala	
Nov 2011	Kristina Pahang	From Bohol
Jan 2012	Rodel Quilbio	Work for the Bureau of Fisheries and Aquatic Resources
Jan 2012	Matt Alcantara	for Region VIII
Mar 2012	Abegail Papong	Works for the Bureau of Fisheries and Aquatic Resources
		for Region VIII
Mar 2012	Marilou Bolina	
Mar 2012	Mary Prose O Cag-Ong	
Apr 2012	Hon Daisy Gamale	Board Member for the Provincial Government of
		Southern Leyte
May 2012	Janno Oben	Student at the University of Cebu
June 2012	Monty McGuire	Divemaster for Sogod Bay Scuba Resort

2.2 *Summary of Meetings and Community Activities*

In addition to the scientific survey work a major priority for the SLCRCP was to increase community awareness and knowledge of the marine environment. A variety of programmes and academic meetings have been conducted between August 2010 and July 2012 to fulfil these educational objectives and forge strong links with the community and local government. The section outlines some examples of the main meetings and events that CCC staff and volunteers have attended in the Philippines during this period. Information regarding past activities can be viewed in previous project reports.

August 2010

- Training in reef ecology, threats to coral reefs and the importance of MPAs was given to 32 teachers and District Supervisors from the Pintuyan and San Ricardo Municipalities.
- CCC held an open day on our project site for children from Bongawisan Elementary School. The day included learning about fish, corals, and invertebrates as well as a 'try SCUBA' dunk tank.
- 50 fisher folk from Limasawa took part in a Thresher Shark Workshop, aimed at teaching them how to collect an accurate sample for genetic testing.



Figure 3 – Children from Bongawisan Elementary School attend an open day at CCC's project site

September 2010

- CCC science staff presented lectures on marine Eco-tourism to Hotel, Restaurant and Tourism Management students of the Southern Leyte State University (SLSU).
- CCC staff assisted a Marine Wildlife camp on Danjugan Island, organised by the Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI).
- CCC staff attended the MPA Coastal Fisheries Resource Management (CFRM) networking meeting in Sogod.
- Beach clean-ups were undertaken in the municipality of Liloan, in addition to Talisay planting and blood donation activities at San Francisco as part of the Philippines Councillors League (PCL) week.



Figure 4 – SLSU Hotel, Restaurant and Tourism Management Students receive lectures from CCC staff

October 2010

- Representatives of the Dinagat Island Development Foundation (DIDF) a collection of 6 Barangays from the Dinagat Islands, visited CCC to learn about the implementation and management of MPAs
- CCC assisted in a reef education day run by the Ocean-Action Research Centre (ORC) in Silago. Staff gave lectures and organised marine themed activities to a group of school children. ORC was established by Grace Quiton a former scholar with CCC.
- CCC organised beach clean-ups on our local beach at Napantao.
- Two local government officials, Bandy Servando and Rodrigo Sajul, completed their PADI Rescue Diver qualification with CCC.

November 2010

- CCC staff and volunteers visited Napantao Elementary School to teach children about marine species using the 'Fred the Fish' puppet show.
- Nine classes at St Ignatius High School welcomed CCC staff to learn about coral biology and the work CCC conduct.



Figure 5 – 'Fred the Fish' at Napantao Elementary School

December 2010

- CCC was invited by Armon Gaviola at Provincial Environmental and Natural Resources Management Office (PENRMO) to a Crown of Thorne (CoT) removal in Sonuk.
- Staff presented guest lectures on Marine survey methods, data management and analysis to students on the Marine biology course at SLSU, Bontoc campus.
- CCC staff gave lectures to children, teachers and Barangay officials regarding coral reef biology and the implementation of a new MPA in Bahay on the Pacific side of Panaon Island.

January 2011

- CCC hosted 22 members of the US based NGO, RARE at our base in Napantao. Over 5 days they took part in a range of lectures and training in conjunction with CCC.
- CCC staff went to Napantao Elementary School to deliver a coral reef fish lectures to grades 5 and 6.
- CCC held an open day for children from Habay Elementary School who visited the site to learn about corals and invertebrates.



Figure 6 – Open day for Habay Elementary School students

February 2011

- CCC was invited to receive a Cultural Orientation Programme for foreign volunteers from students on the Hotel Restaurant and Tourism Management course at SLSU.
- CCC provided SCUBA equipment to assist with the setting up of marker buoys in the Santa Paz MPA.
- CCC assisted SLSU with an open day at Barangay Tampoong near Sogod. Staff and volunteers provided lectures and activities with a marine theme.
- CCC hosted a visit from a group of tourism officials from around Southern Leyte.
- CCC attended the MPA oversight committee meeting in San Francisco.



Figure 7 – CCC volunteers with children at Barangay Tampoong

March 2011

- Staff and volunteers travelled to Limasawa Island for the celebrations of the anniversary of the first Christian Mass in the Philippines.
- Tree planting in Napantao at the invitation of the Mayor of San Francisco, Hon. Samson Gumutan Jr.
- CCC science staff visited Barangay Santa Cruz to initiate an awareness programme regarding how MPAs function and how they can benefit the local community.

April 2011

- CCC staff organised a Crown of Thorns (CoT) removal day on Napantao reef in front of our base. A total of over 100 individuals were removed whilst leaving a healthy population.
- CCC assisted with the placement of marker buoys for the newly created MPA in Silago.
- CCC ran the Management Committee meeting for the newly created Punta Marine Protected Area (MPA), in collaboration with the Local Government Unit of San Francisco and Barangay officials from Punta.

May 2011

- In Liloan, CCC presented the results of the Liloan MPA surveys to Barangay officials and Tourism Council members.
- In preparation for the Fiesta celebrations CCC helped produce a new mural at a basketball court in Napantao.
- CCC staff and volunteers participated in a coastal clean-up in San Francisco organised by the Local Government Unit (LGU).



Figure 8 – CCC volunteers and staff with the new mural in Napantao

June 2011

- Children in grades 1-3 at Napantao Elementary school visited the CCC site for a marine awareness open day. The children enjoyed the marine themed games and activities and were delighted by the 'Fred the Fish' puppet show.

- The results of the Punta MPA biological assessment were presented by CCC staff to local government official and representatives from the Barangay. The MPA has been running since 2009 and this meeting summarised the biological and social survey results.
- CCC staff and volunteers organised a coastal clean-up, after storms at the end of May washed up large quantities of litter.

July 2011

- A workshop organised by the US NGO RARE discussed strategies to strengthen MPA management in the Philippines. At the culmination of the event officials signed on an agreement between RARE, the Municipality of San Francisco and CCC to pledge on-going support of the MPAs in the municipality.
- A Marine Fisheries Law Enforcement Team (MFLET) training workshop took place in San Francisco to develop a group of local marine wardens and establish an active enforcement presence within the MPA of the region.
- CCC staff and volunteers joined the local community in celebrating the Liloan Fiesta.

August 2011

- Painting an educational mural at Santa Paz High School. The marine themed mural depicted fish and coral commonly found on the reef. Each picture was labelled in order for the children to become familiar with species.
- CCC performed the 'Fred the Fish' puppet show to grades 1-6 at the San Francisco Elementary School.
- CCC science staff were invited to speak at a special lecture forum held at Southern Leyte State University (SLSU). The theme of the forum was 'the effect of human activity on marine resources and environment.'



Figure 9 – 'Fred the Fish' at San Francisco Elementary School

September 2011

- A lecture was given by CCC to 1,300 girls at the Provincial Girl Scout Encampment in Maasin, about coral reef ecology and marine species.
- CCC headed the launce of the RARE Pride Punta MPA. As part of two days of celebration and education CCC presented a number of lectures and talks on marine resources and the importance of MPA.
- CCC hosted children from Napantao Elementary School for a marine environment awareness day. The children learned about the threats to coral reefs and the measures to protect them.

October 2011

- Staff taught at a number of schools, to enforce the importance of MPA for marine conservation.
- As part of the monthly visit to SLSU Sogod Campus for the Philippine Cultural and Customs forum, CCC was invited to take part in the annual parade through the streets of Sogod. Two CCC representatives were asked to judge the two best dressed students.
- CCC presented a seminar on the effects of climate change to coral reefs at the 1st Municipal Climate Change Adaptation and Disaster Risk Reduction forum held in San Francisco.

November 2011

- CCC organised and hosted a marine education movie night aimed at enhancing the relationship between CCC and locals whilst providing education about coral reefs
- CCC's education officer and other CCC staff completed teaching in all San Francisco Elementary Schools.



Figure 10 – Teaching students from San Francisco Central School about coral reefs

December 2011

- CCC hosted a training day with Alternative Learning Systems (ALS) students teaching them coastal resource management. ALS is a newly developed adult education programme designed to up-skill high school dropouts and increase their job prospects.
- 30 nursing students from the College of Maasin visited the CCC site for an educational day learning about coral reef ecology and participating in a snorkel over the reef.

January 2012

- CCC helped organise a Crown of Thorn (CoT) extraction operation in Padre Burgos. More than 50,000 individuals were removed.
- As part of the schools Science and Environment month, CCC presented a series of lectures on marine ecology at St Thomas Aquinas College in Sogod.
- CCC volunteers went to Tabugon to plant mangroves. Around 150 mangrove plants were planted with the help of a large number of local children.



Figure 11 – CCC volunteers plant mangroves in Tabugon MPA

February 2012

- At the invitation of Macrohon Fisheries Technician Sir Nicanor Bendito, CCC volunteers joined a release of juvenile turtles at Macrohon MPA. Staff also gave lectures on turtle biology and the other conservation work carried out in the region.
- CCC took part in the Liloan Municipality Solid Waste Management Information Education Campaign, giving lectures across 16 Barangays regarding the effect of solid waste on the marine environment.
- CCC volunteers joined 100 students from the hospitality and tourism department of SLSU to clean waste from the coastline of San Jose, Sogod.
- CCC joined the local community from San Jose for a coastal clean-up.



Figure 12 – Fredo the clownfish helps at San Jose coastal clean-up

March 2012

- CCC were involved in the removal of Crown of Thorn starfish throughout Sogod Bay.
- After a personal request from Saint Thomas Aquinas College, Sogod, CCC staff taught students about marine conservation.
- CCC presented a lecture on coastal resource management to 40 lecturers from SLSU Bontoc Campus.
- A CCC representative joined with the fisheries and agriculture technician for the municipality of Liloan, Ms Benny Dipay, for the general assembly at Barangay Candayuman, regarding how to set up and manage an MPA.

April 2012

- CCC participated in Earth Day celebrations in Liloan, organised by local environmental group Igno. CCC presented a talk on coastal resource management. The aim was to provide information on protecting the Earth's resources. The volunteers also participated in an Earth Day parade which culminated in a large coastal clean-up.
- In Barangay Calian, CCC volunteers joined an environmental day organised by student leaders of the Barangay. The group conducted a beach clean-up and planted around 150 mangrove trees.



Figure 13 – CCC staff at the Earth Day parade in Liloan

May 2012

- At three sites across Southern Leyte CCC continued to help in the removal of CoTs from reefs. Over 900 were removed.
- Over 10 days CCC's Education Officer conducted training sessions on coral reef protection for students from Alternative Learning Systems (ALS). As a result of the training, officials in Barangay Gudan have started the development of an MPA.
- CCC joined the Southern Leyte Provincial Department of Environment and Natural resources (DENR) at Padre Burgos Tagkaan beach in celebration of international biodiversity day 2012.
- At the request of the environmental group Igno from the Liloan municipality, CCC conducted a 'Reef Scout' training session aimed at providing local volunteers with knowledge of corals, important invertebrates and how to recognise threats to coral reefs.

June 2012

- CCC staff joined honourable council members of Barangay Punta on a cross visit to the Macrohon, Molopolo and Santa Cruz Fish Sanctuaries. The visit provided the opportunity for the Punta council members to visit the very successful Molopolo MPA, learn from its success and develop the management practices on their own MPA.
- CCC hosted a second 'Reef Scout' training day in conjunction with volunteer environmental community group 'We Care Nature'.
- The CCC base welcomed representatives from Barangay Punta for Reef Monitor Training. The village of Punta has recently re-established their MPA with help from CCC.

July 2012

- CCC science staff were asked to assist with the necropsy of a Leatherback turtle which washed up on the shores of the town of Liloan. The results will be used to help educate the local community on the importance of marine protection.
- In conjunction with the environmental group 'Ignosa Panawi', CCC organised an Environmental Awareness day to coincide with the opening of the Liloan Municipality 192nd Founding Anniversary and Fiesta Celebrations. The event culminated in the planting of over 100 trees.
- CCC's education officer completed teaching in the Liloan Municipality schools and also taught at most of the schools in the Pintuyan district. The lessons focus on marine protection and the dangers of compressor fishing.



Figure 14 – CCC science staff prepare to perform a necropsy on a Leatherback turtle

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 coral reef 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 2012. 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.

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.

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



Figure 15 - Volunteers receive training in coral reef ecology, species ID and survey techniques from trained CCC staff

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.

Table 2 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+

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.

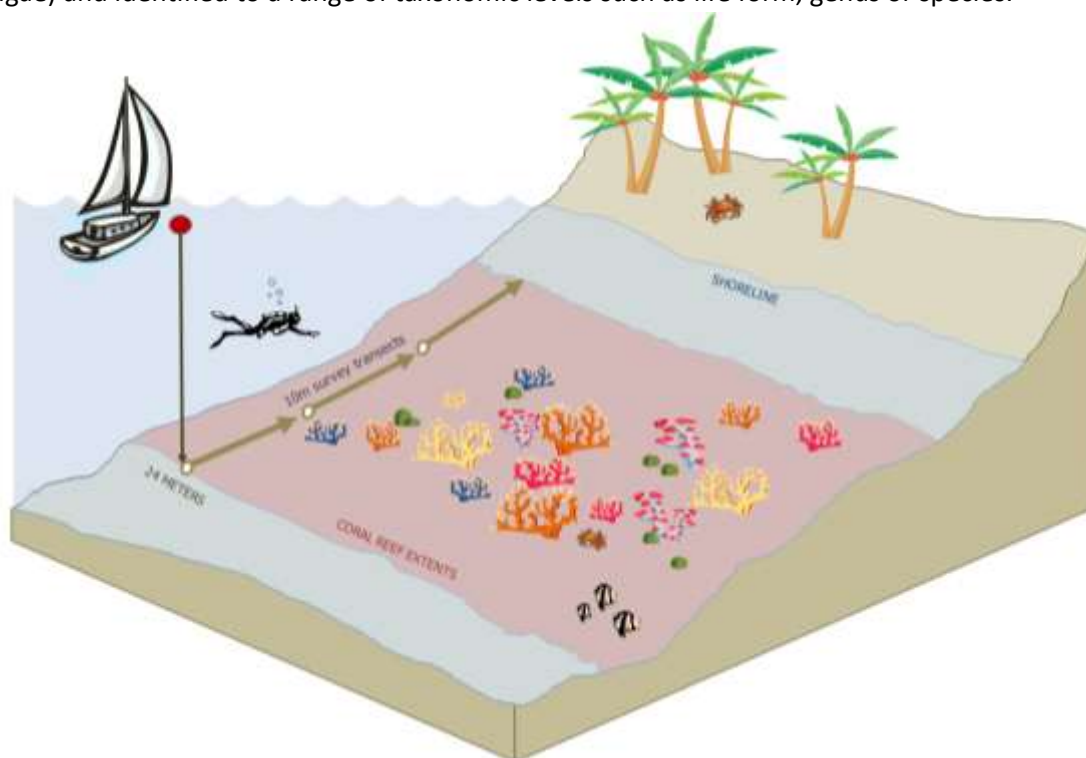
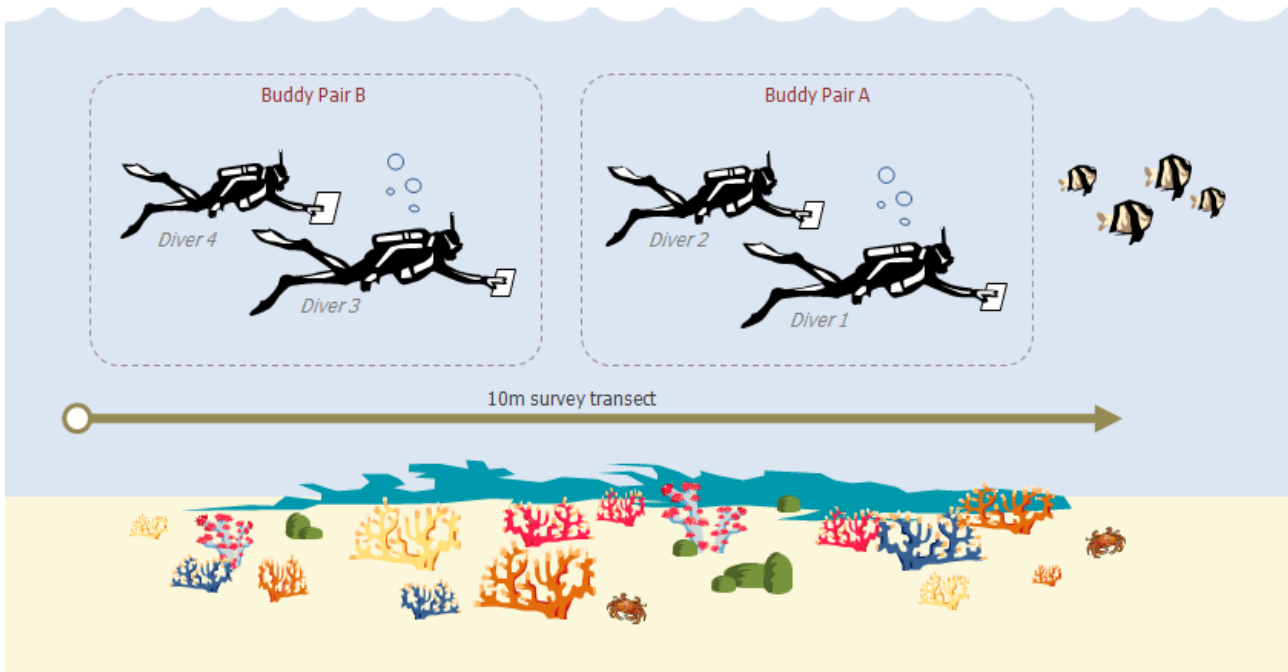


Figure 16 - Outline illustration of the CCC baseline survey methodology

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

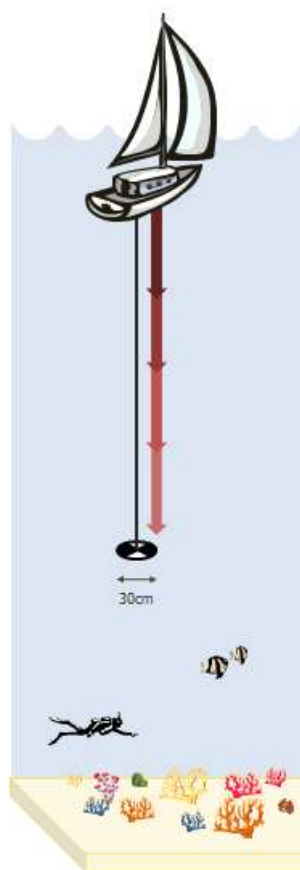
Diver 1: is responsible for leading the dive, taking a depth reading at the end of each 10m interval and documenting signs of anthropogenic impacts such as broken coral or fishing nets. Diver 1 also describes the substratum along the sub-transect by recording the presence of six substratum categories (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 27 - 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 17). 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 18). 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.

Figure 38 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.

Natural and anthropogenic impacts are assessed both at the surface from the survey boat and by divers during each survey. Surface impacts are classified as 'litter', 'sewage', 'driftwood', 'algae', 'fish nets' and 'other'. Sub-surface impacts are categorised as 'litter', 'sewage', 'coral damage', 'lines and nets', 'sedimentation', 'coral disease', 'coral bleaching', 'fish traps', 'dynamite fishing', 'cyanide fishing' and 'other'. All information is assessed as presence/absence and then converted to binary data for analysis. Any boats seen during a survey are recorded, along with information on the number of occupants and its activity. The activity of each boat is categorised as 'diving', 'fishing', 'pleasure' or 'commercial'.

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 2012, CCC survey teams produced 2,055 individual survey records around Sogod Bay (Figure 19). Although data from 2002 to 2010 have previously been presented (Harding et al., 2003; Taylor et al., 2004, van Bochove et al., 2007, 2009 and 2010), 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.

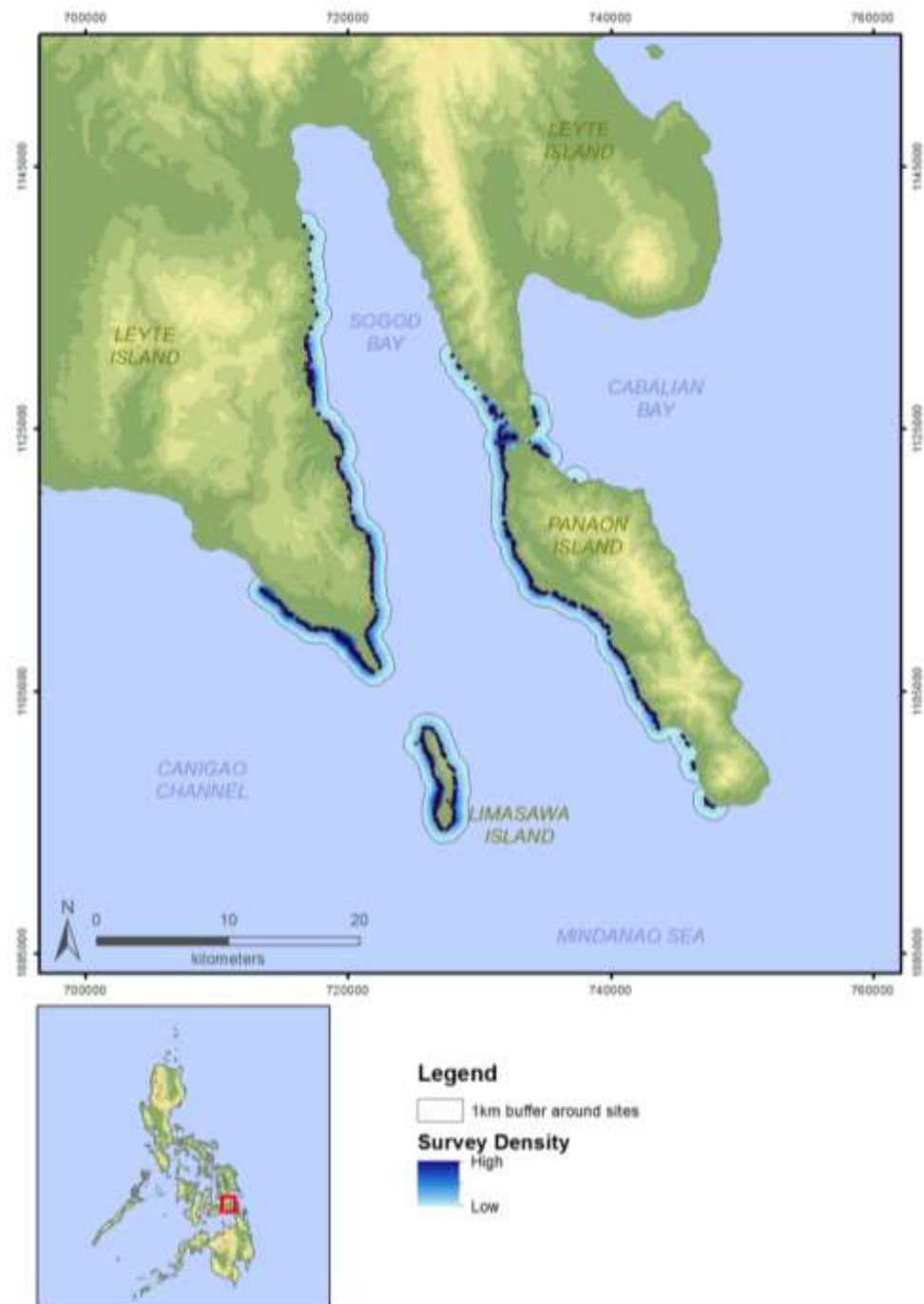


Figure 19 – Locations of 2,055 survey stations visited in Sogod Bay between September 2002 and July 2012

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 20).

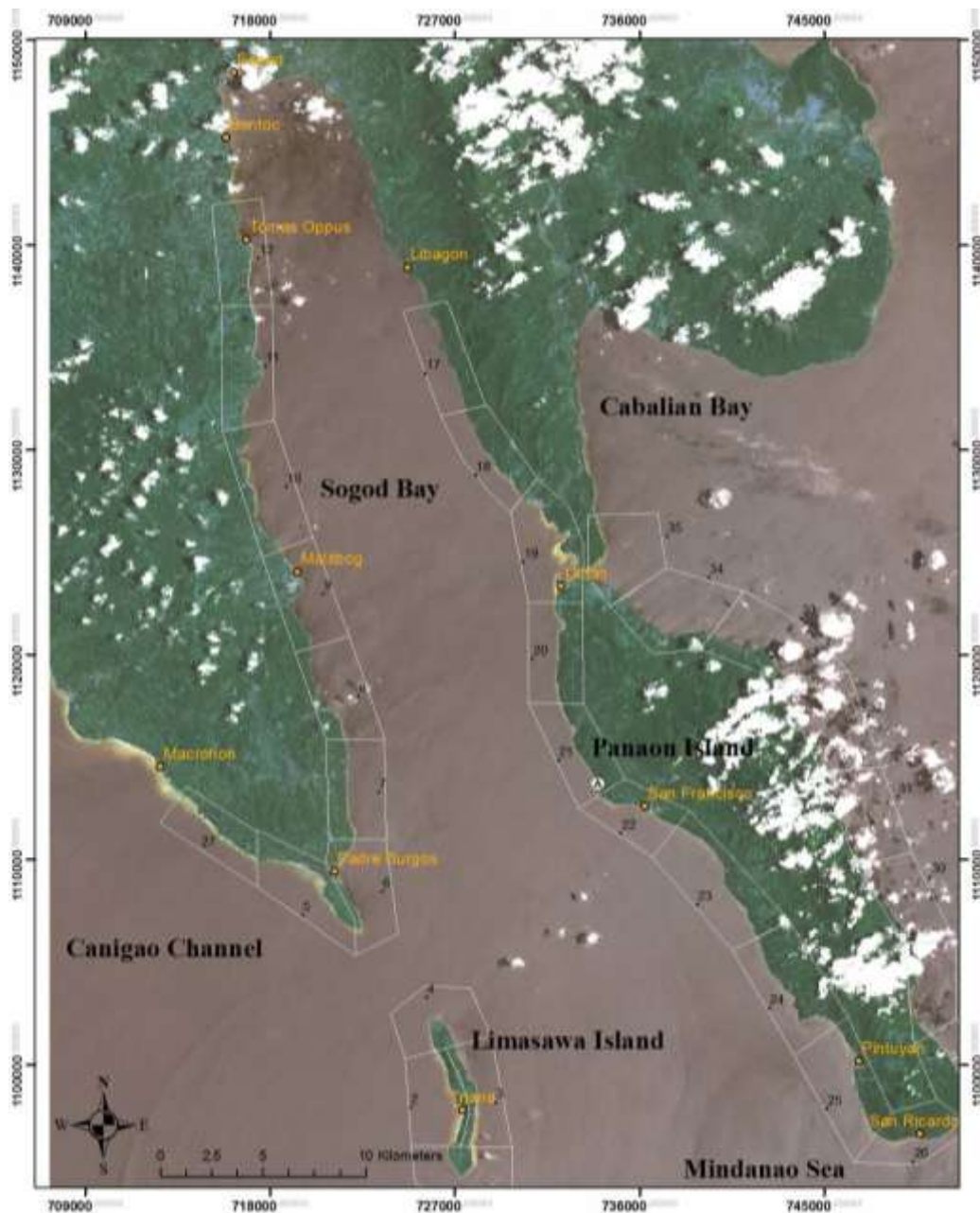


Figure 20 – Satellite image of Sogod Bay, Southern Leyte. The CCC survey sectors are presented in grey

In addition to the on-going 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). Examples are also available through the website (www.coralcay.org).

Table 3 – MPA sites established with the assistance of CCC

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

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 21). 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.

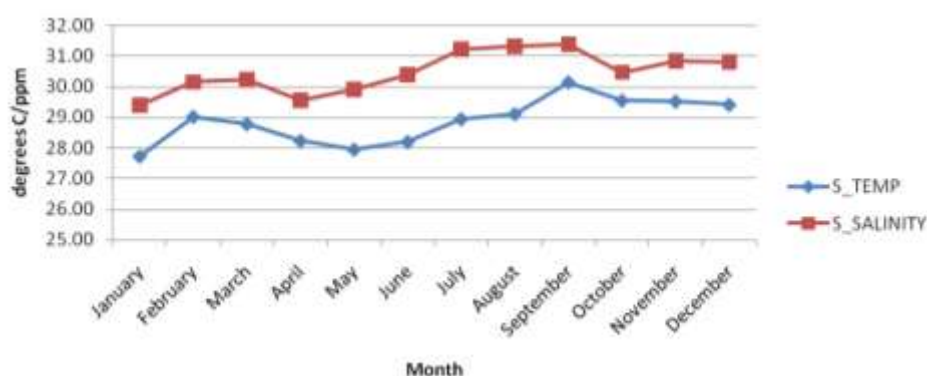


Figure 21 Average readings for sea surface temperature (°C) and surface salinity (ppm), taken over 5 years at all survey sites

Vertical Visibility

Vertical visibility of the water was taken using a Secchi disk (see section 3.2). Figure 22 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.

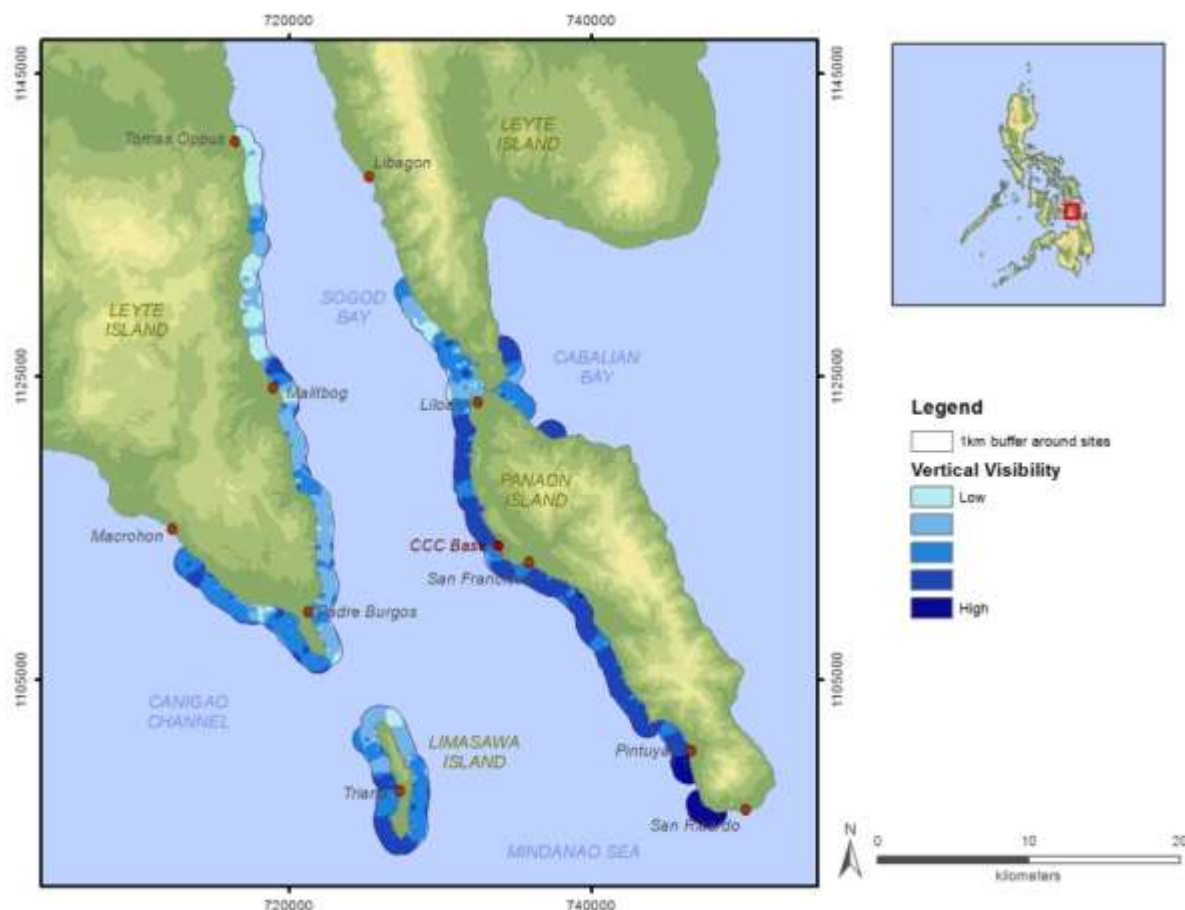


Figure 22 –4 Vertical visibility, expressed in metres around Sogod Bay, displayed as a colour ramp. Areas towards the dark blue end of the spectrum have the highest value (i.e. highest visibility).

Underwater Impacts

Direct underwater impacts such as litter, sedimentation and coral breakage due to anchors are presented in Figure 23. The overall impact rating per site was on a scale of low (0) to high (5). Although the level of underwater impacts was generally low 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.

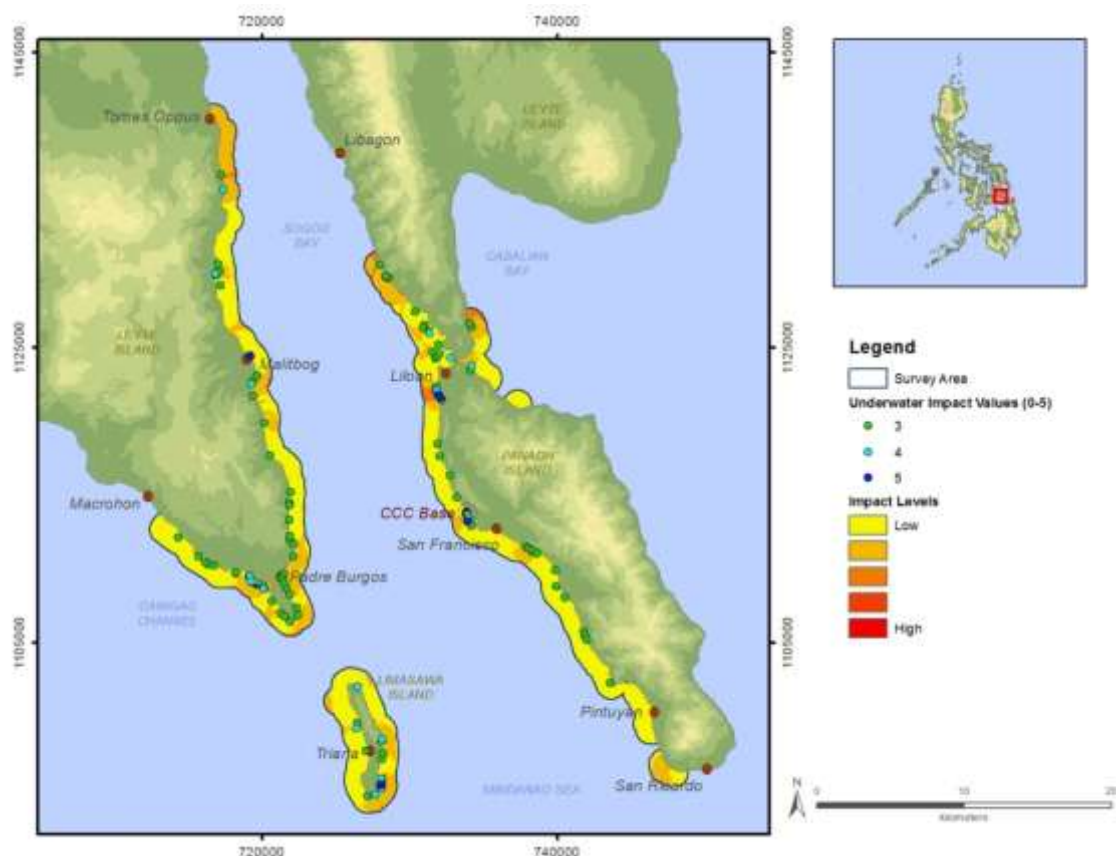


Figure 53 – Underwater impacts around Sogod Bay, displayed as a colour ramp. Areas towards the red end of the spectrum have the highest value (i.e. most heavily impacted). Sites marked on the map have high underwater impact values greater than 3.

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 also “transit”. The vast majority of boats observed during the survey programme were involved in fishing related activities (76%) – Figure 24. The next single greatest class was “pleasure” (14%), then “commercial” (5%).

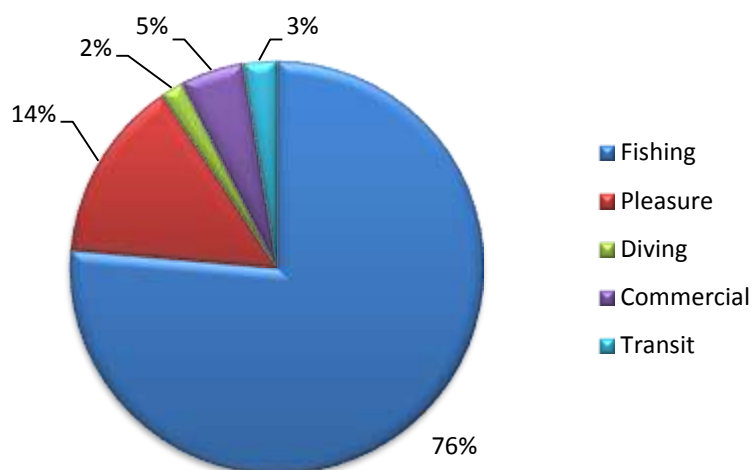


Figure 246 - Percentage of five different boat activities observed at all survey sites

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. 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 only 4% of surveys conducted (Figure 25). 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 11% of surveys. No significant variation was found for bleached or diseased corals between regions (see G.A. Smith, 2007 for further information). Further and on-going monitoring research is needed to gain a better understanding of coral disease and bleaching prevalence.

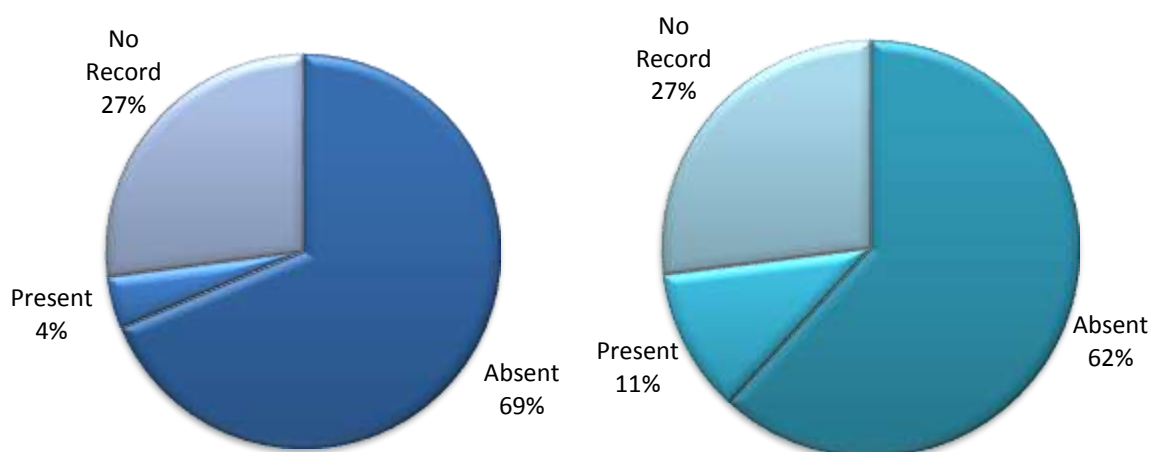


Figure 25 – Percentage of survey sites at which coral disease (left) and coral bleaching (right) were observed.

Site Impression

For each survey, a site impression was given by the survey team by the production of two 'scores'. One was given for the aesthetic value (visual appeal) of the area and one for the perceived biological value. The scores ranged from 'poor' (1) to 'excellent' (5). While subjective, these scores give a general impression of the overall quality of an area and can be used to determine the presence of particularly appealing or unappealing areas of reef.

A score of 'excellent' was only recorded at 2% of survey sites for both aesthetic and biological value (Figure 26). For aesthetic value the most commonly recorded score was 'poor' (31%) although 'average' and 'good' were also recorded in similar proportions (30% and 28% respectively). For biological value 'average' was the most commonly recorded score (34%), with 'good' also relatively high (28%) and poor slightly lower (24%). Scores of 'very good' and 'excellent' were comparatively low for both aesthetic and biological value.

For 70% of surveys, the perceived aesthetic and biological value were found to be closely linked. This high degree of similarity is unsurprising since it can be assumed that sites with a high aesthetic appeal (i.e. visual appeal) will be biologically rich, with a diverse range of species and therefore also have a high biological value.

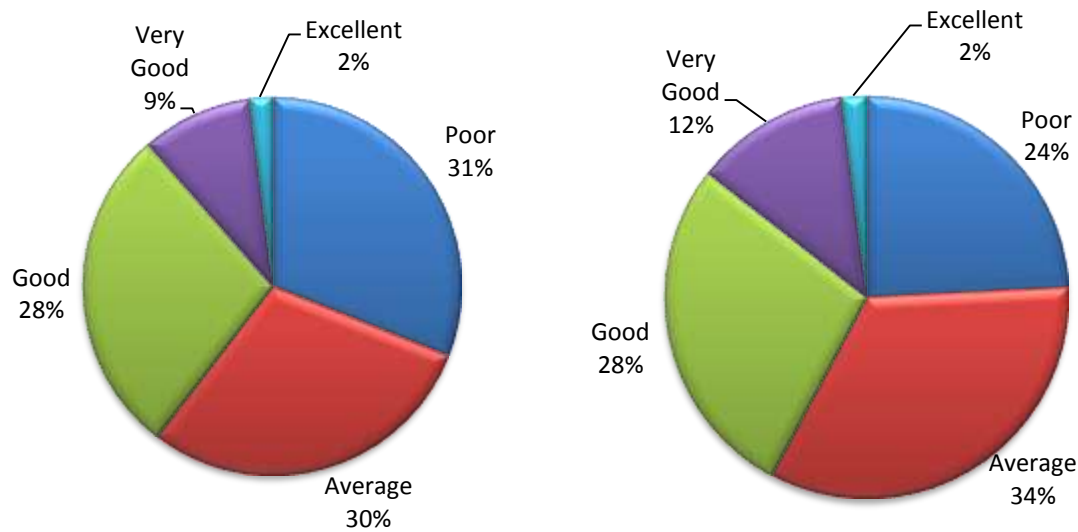


Figure 26 – Aesthetic value (left) and biological value (right) for all surveys combined, as a percentage of the total scores given.

Figures 27 and 28 display the biological and aesthetic values on a GIS map with values ranging from poor (1) to excellent (5).

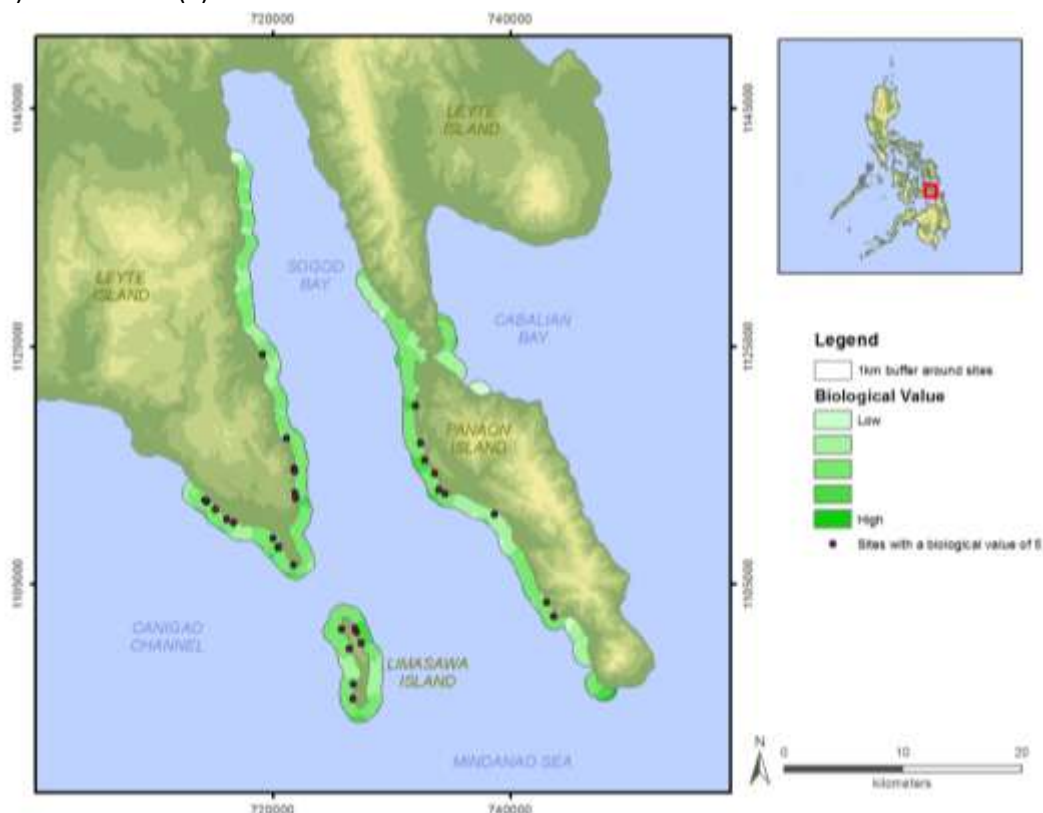


Figure 27 – Biological value of survey sites around Sogod Bay, displayed as a colour ramp. Areas towards the dark green end of the spectrum have the highest value. Sites designated with a circle were rated as having 'excellent' biological value.

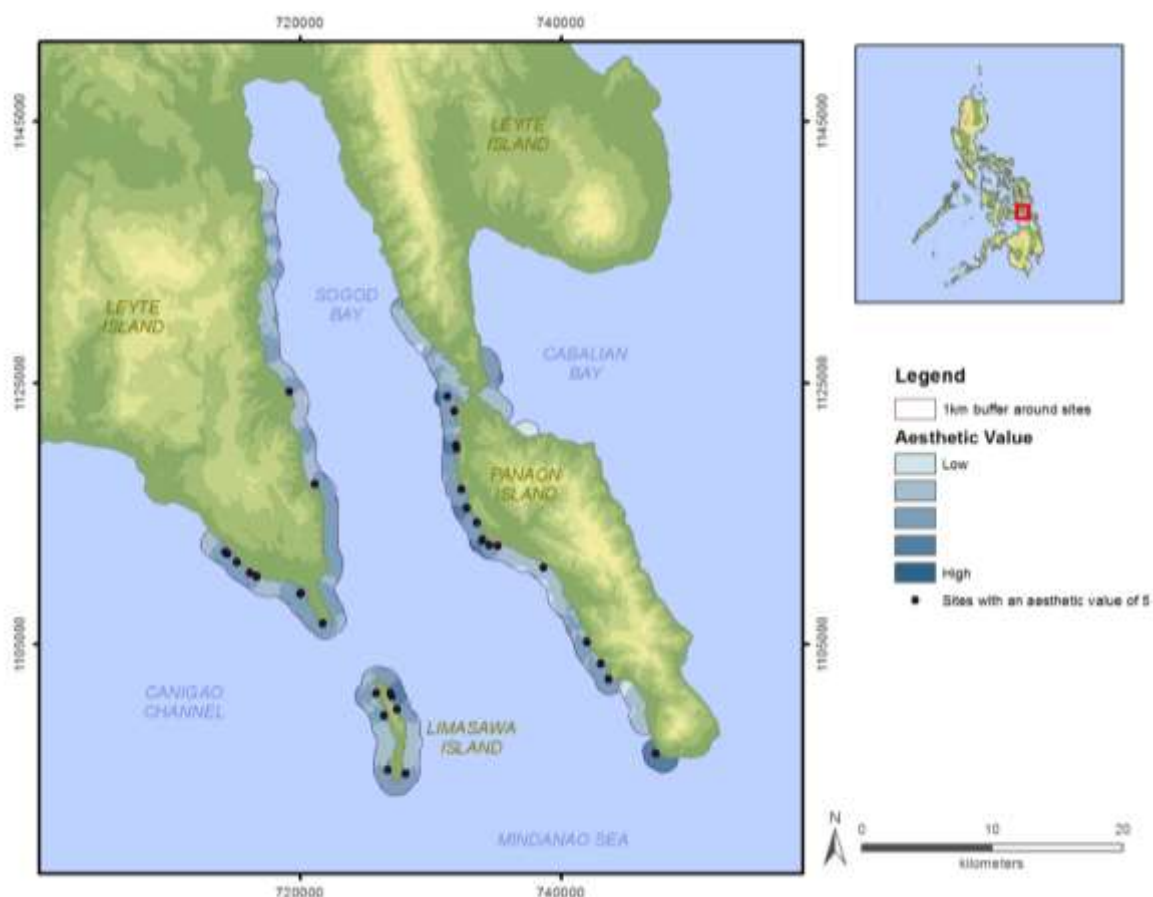


Figure 28 – Aesthetic value of survey sites around Sogod Bay, displayed as a colour ramp. Areas towards the dark blue end of the spectrum have the highest value. Sites designated with a circle were rated as having ‘excellent’ aesthetic value.

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), 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 29 shows this relationship for all the surveys analysed in this report. It can be seen that, in general, the more coral species present in an area, the more fish species there are.

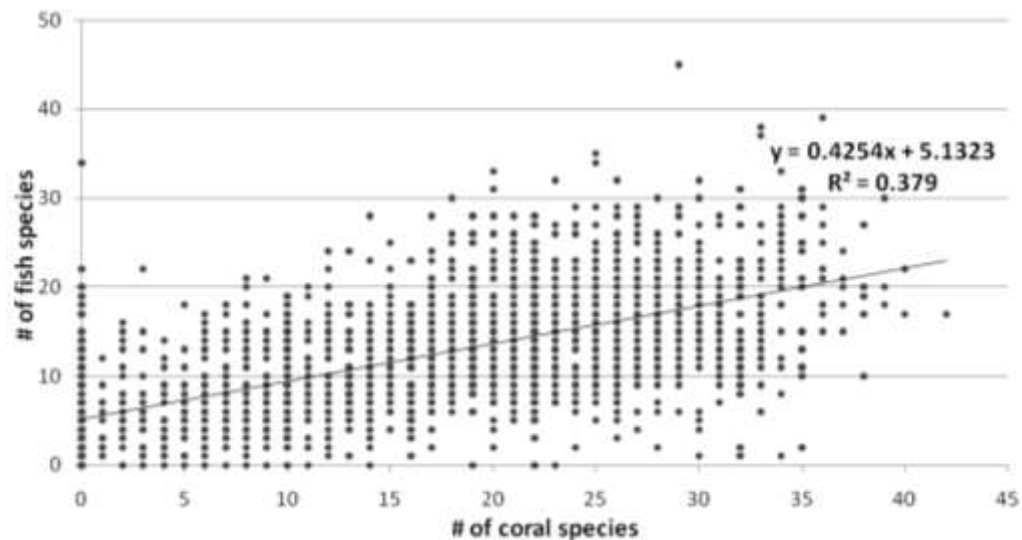


Figure 29 – Regression plot for the number of coral species vs. number of fish species for all survey sites ($R^2 = 0.379$, $p < 0.001$).

Figure 30 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.

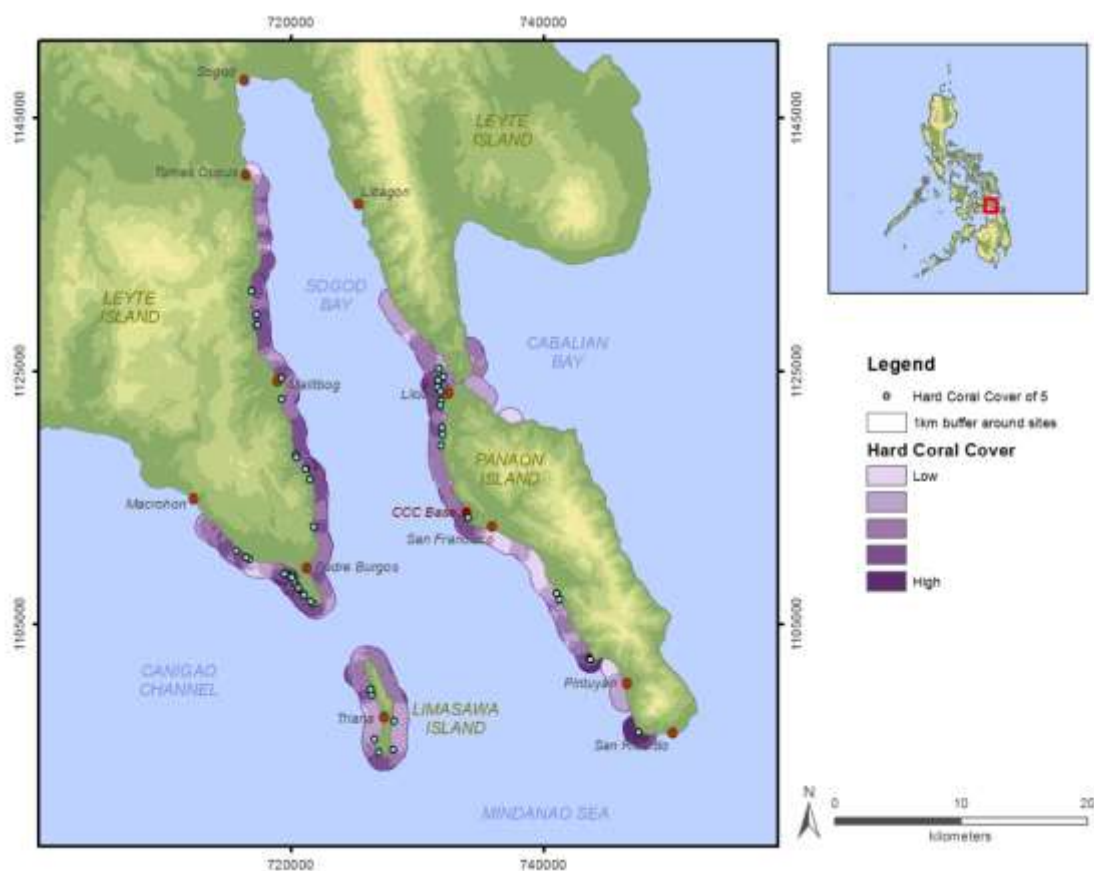


Figure 30 – Hard coral cover on a DAFOR scale, displayed as a colour ramp. Areas towards the darker end of the spectrum have the highest cover. Sites with a coral cover of 5 on the DAFOR scale are marked.

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 (75%, DAFOR 5). *Acropora* lifeforms (mainly 'branching' and 'tabulate') can dominate shallow-reef habitats and contribute significantly to overall hard coral cover. Rarer *Acropora* lifeforms (digitate and encrusting) were recorded on only 13% and 11% of the surveys respectively. The most common species recorded were *Favia* and *Favites* species which were present on over 70% of the surveys. Other common species include massive *Porites* species (66%), *Lobophyllia* species (62%) and *Galaxea* species (60%). *Pavona clavus* was the least abundant target coral species observed within the bay (6%, DAFOR 2).

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.

Table 4 – Most commonly recorded hard coral lifeforms (top) and target species (bottom) in Sogod Bay

Coral Lifeform	Proportion of surveys recorded (%)	Maximum DAFOR value
Non- <i>Acropora</i> submassive	75	5
Non- <i>Acropora</i> encrusting	69	4
Non- <i>Acropora</i> branching	67	4
Non- <i>Acropora</i> mushroom	66	4
Non- <i>Acropora</i> massive	66	4
<i>Acropora</i> branching	63	5
Non- <i>Acropora</i> foliose	56	5
<i>Acropora</i> tabulate	51	4
<i>Acropora</i> bottlebrush	39	5
<i>Acropora</i> submassive	13	4
<i>Acropora</i> digitate	13	3
<i>Acropora</i> encrusting	11	3
Coral Species		
<i>Favia</i> spp.	71	4
<i>Favites</i> spp.	70	4
Massive <i>Porites</i> spp.	66	5
<i>Lobophyllia</i> spp.	62	3
<i>Galaxea</i> spp.	60	3
<i>Seriatopora hystrix</i>	53	3
<i>Goniopora</i> / <i>Alveopora</i> spp.	52	5
<i>Pocillopora</i> (small)	40	3
Brain Coral (small)	40	3

<i>Diploastrea heliopora</i>	39	3
<i>Millepora</i> spp.	35	4
<i>Mycedium elephantotus</i>	35	4
<i>Pectinia lactuca</i>	34	3
<i>Echinopora</i> spp.	33	4
<i>Porites cylindrica</i>	32	4
<i>Pocillopora</i> spp. (medium)	31	3
<i>Herpolitha limax</i>	30	3
<i>Euphyllia</i> spp.	30	3
<i>Ctenactis echinata</i>	28	3
<i>Plerogyra</i>	28	3
Brain Coral (medium)	28	3
<i>Montipora</i> spp. (foliose)	28	3
<i>Porites nigrescens</i>	24	3
<i>Pachyseris speciosa</i>	23	3
<i>Pachyseris rugosa</i>	23	3
<i>Turbinaria</i> spp.	19	5
<i>Hydnophora</i> spp.	19	3
<i>Tubastrea micrantha</i>	19	3
Upsidedown bowl	18	3
Brain Coral (large)	18	3
<i>Tubipora</i> spp.	16	3
<i>Porites rus</i>	15	2
<i>Polyphyllia talpina</i>	13	2
<i>Heliopora</i> spp.	13	2
<i>Pocillopora</i> (Large)	10	2
<i>Pavona clavus</i>	6	2

Soft Corals

Figure 28 shows 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).

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 32). 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 these fish 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 can 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 33). A correlation was found between *Diadema* urchin density and coral reef cover.

Macro-algae

While algae are a normal component of a healthy reef, high abundances can be an indicator of increased nutrient levels in the water (often due to run off of fertilisers from land). An increase in algal growth can disrupt the ecological balance of a reef and there is potential for hard coral to be killed as algae overgrows and smothers it. In this analysis, emphasis has been placed on algae that are thought to be nutrient-indicators, such as brown “fleshy” algae. 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 58% of all transects. The next most common algae were *Dictyota* spp. (46%), green filamentous algae (29%), and *Padina* spp. (23%). Sites towards the north-western side of the bay had highest nutrient indicator abundance (Figure 34). This is likely due to the increased nutrient input from large population centres in this area.

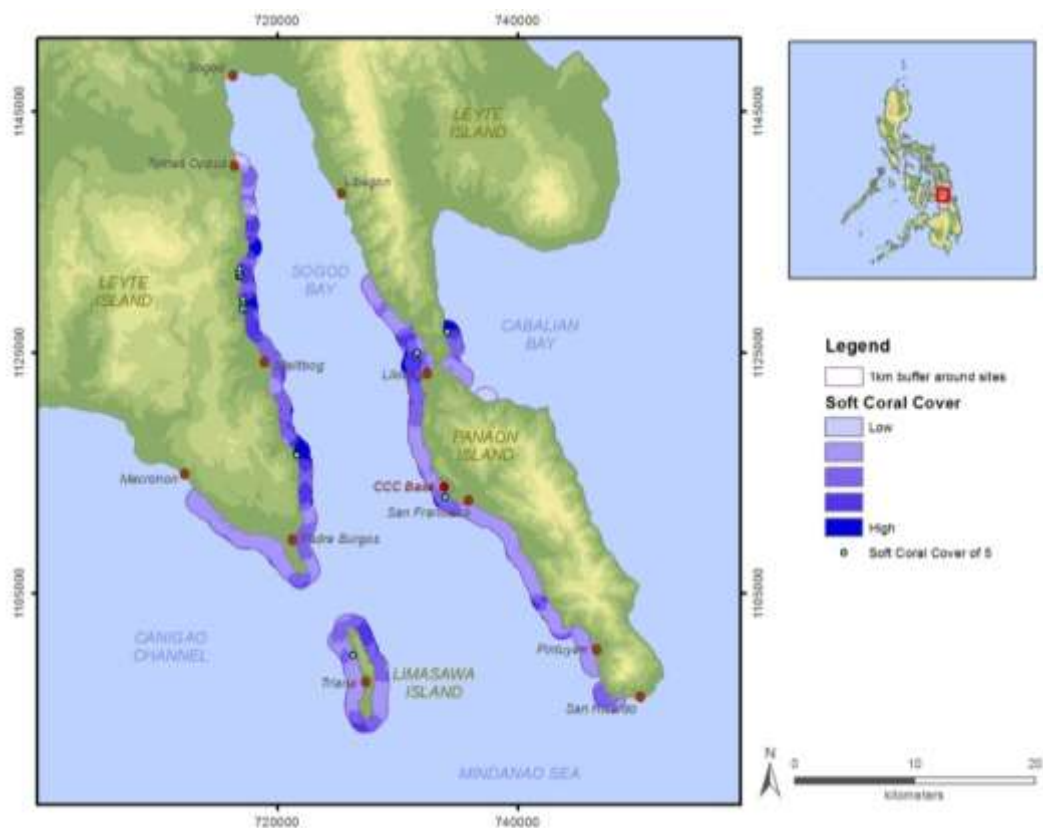


Figure 31 – Soft coral cover on a DAFOR scale, displayed as a colour ramp. Areas towards the darker end of the spectrum have the highest cover.

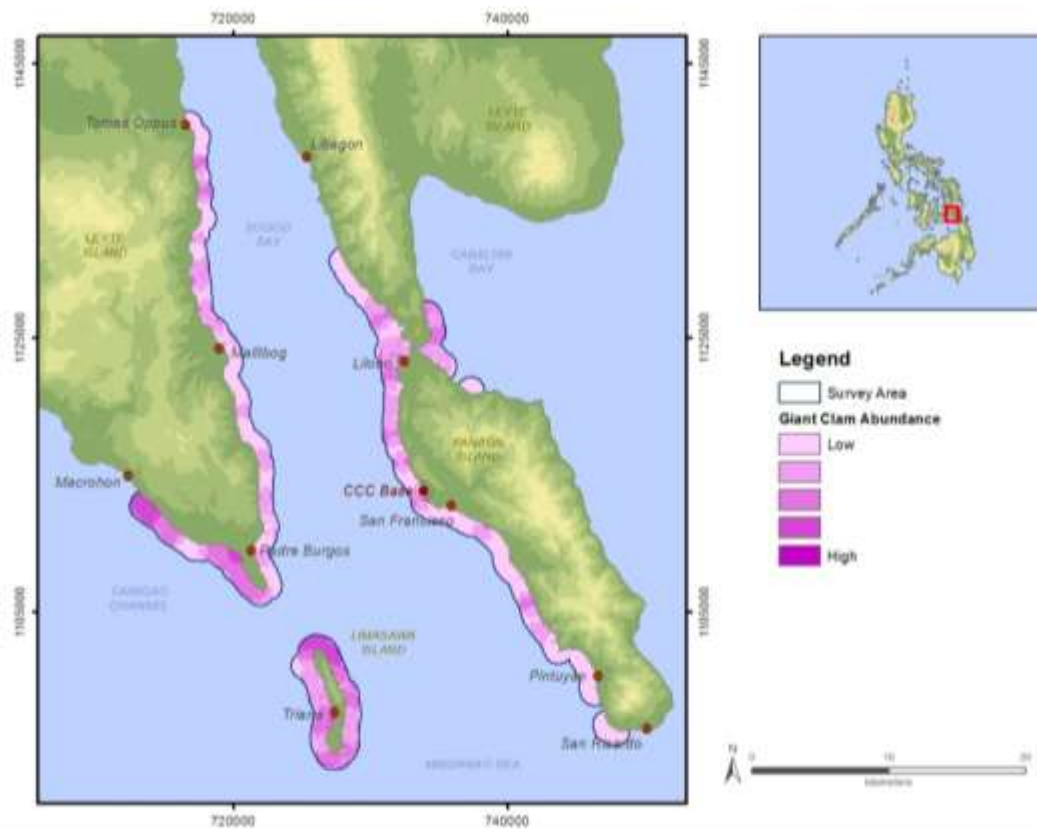


Figure 32 Giant clam (*Tridacna* sp.) abundance on a DAFOR scale, displayed as a colour ramp. Areas towards the darker end of the spectrum have the highest abundance.

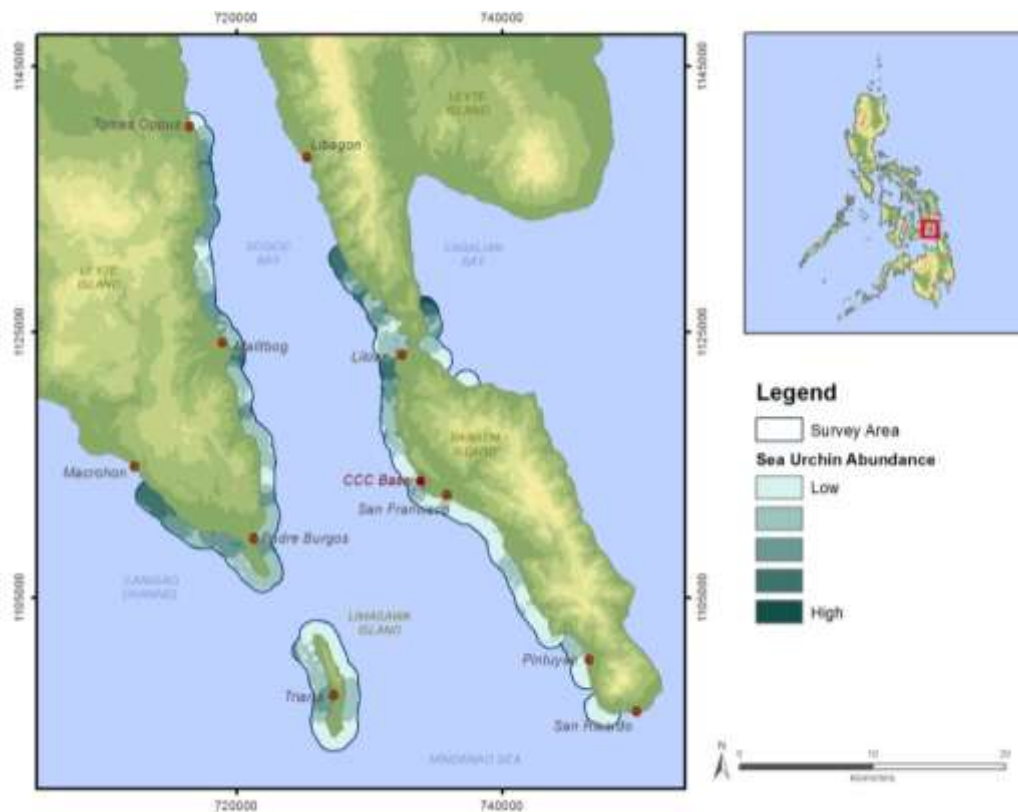


Figure 33 – Sea urchin (*Diadema* sp.) abundance on a DAFOR scale, displayed as a colour ramp. Areas towards the darker end of the spectrum have the highest abundance.

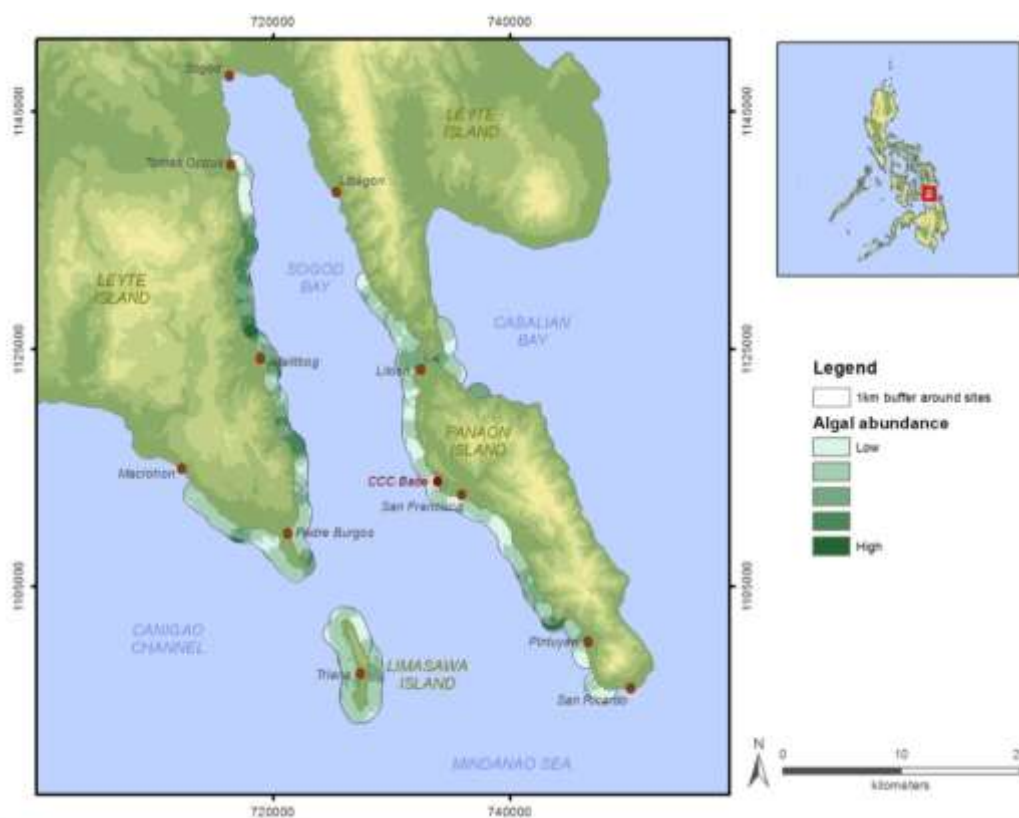


Figure 34 – Nutrient indicator algae abundance on a DAFOR scale, displayed as a colour ramp. Areas towards the darker end of the spectrum have the highest abundance.

4.3 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. Areas on the eastern side of Sogod Bay, particularly Napantao, northern San Francisco and areas of Liloan saw a relatively high abundance of Butterflyfish (Figure 35). 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 strategy enables greater numbers of individuals within a population, compared to the large carnivores, such as groupers.

Figure 36 displays the abundance of Parrotfish around the bay. Parrotfish abundance was generally low throughout the bay. The highest numbers were recorded around Limasawa island, Napantao, Liloan and western Padre Burgos.

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 community 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 aquaculture.

Grouper sightings were extremely low on reefs throughout Sogod Bay (<5% of all surveys). They were rarely observed on transects 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 37). 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 38).

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 not very common in Sogod Bay, being recorded on less than 4% of surveys. The highest abundances were recorded in northern Liloan and around Pintuyan (Figure 39). There were also higher populations around Limasawa, Padre Burgos and Napantao. Sweetlips distribution was very similar to that of Snappers.

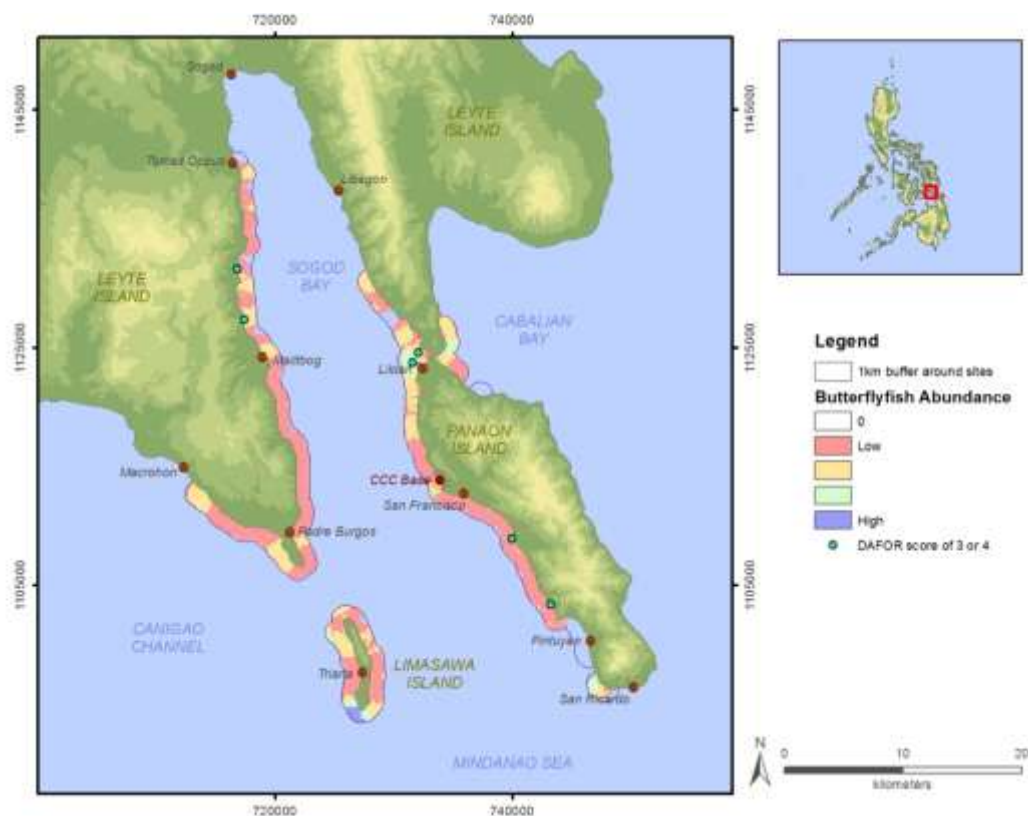


Figure 35 –7 Abundance of Butterflyfish, displayed as a colour ramp. Areas towards the blue end of the spectrum have the highest abundance. Survey sites with DAFOR values over 3 are marked on the map.

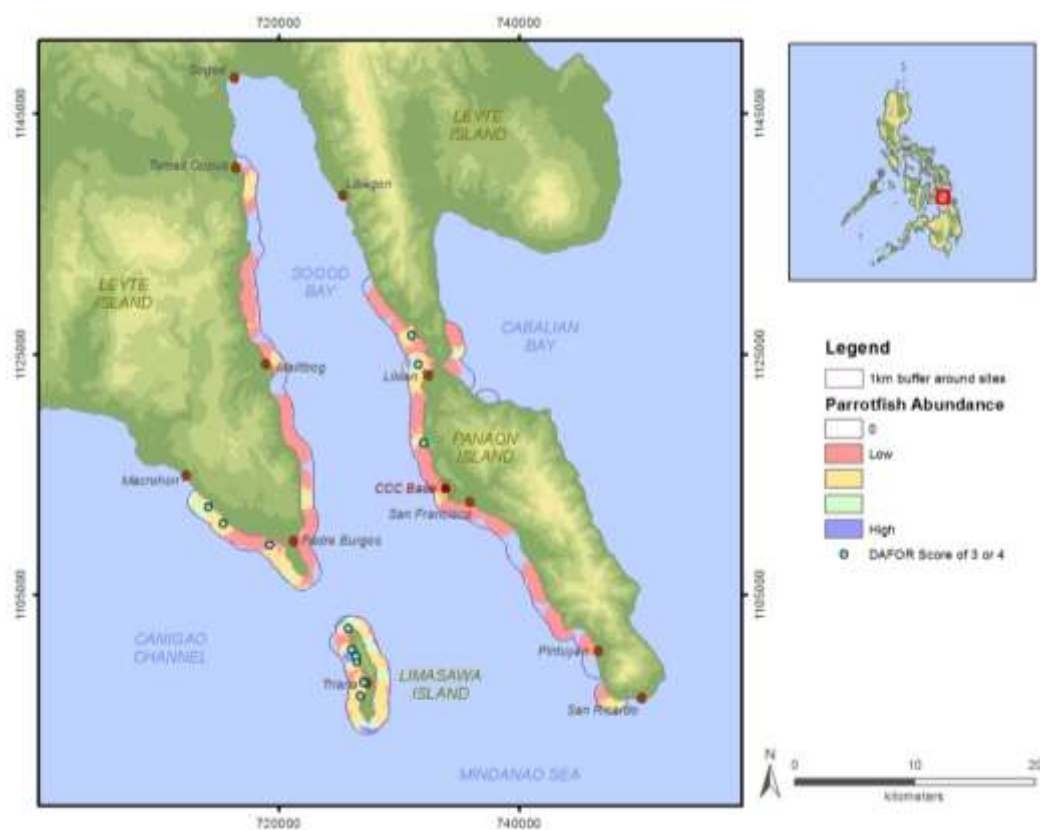


Figure 36 - Abundance of Parrotfish, displayed as a colour ramp. Areas towards the blue end of the spectrum have the highest abundance. Survey sites with DAFOR values of over 3 are marked on the map.

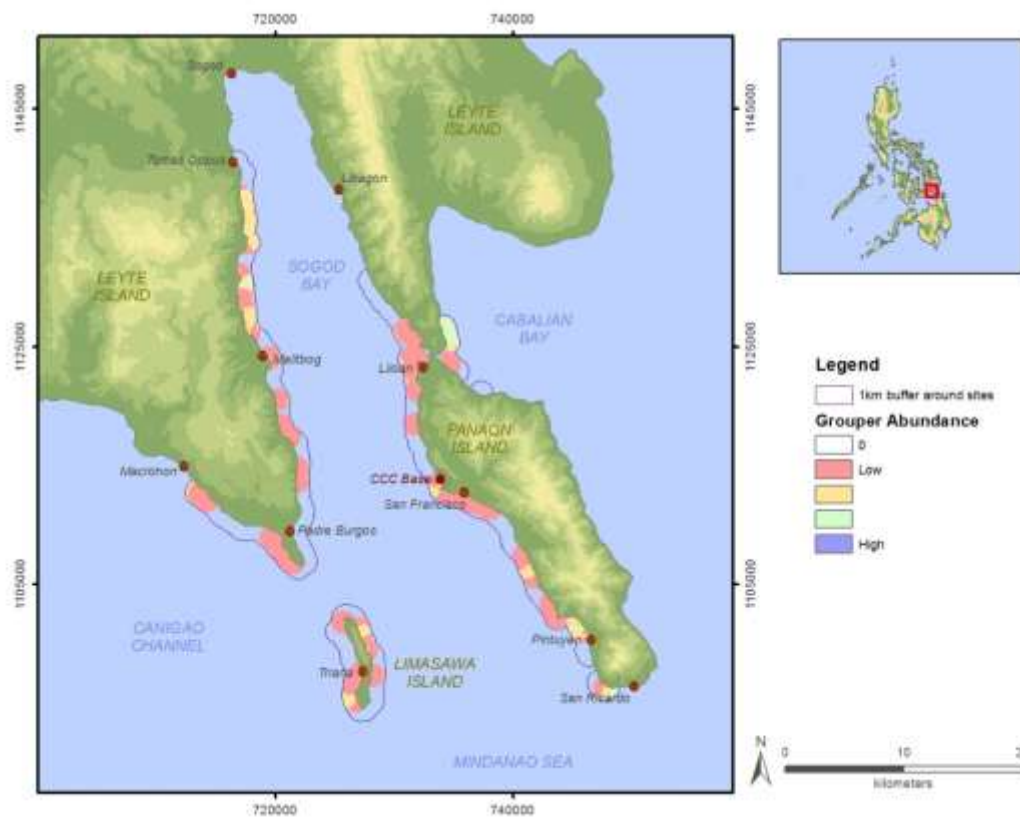


Figure 37 – Abundance of Groupers, displayed as a colour ramp. Areas towards the blue end of the spectrum have the highest abundance.

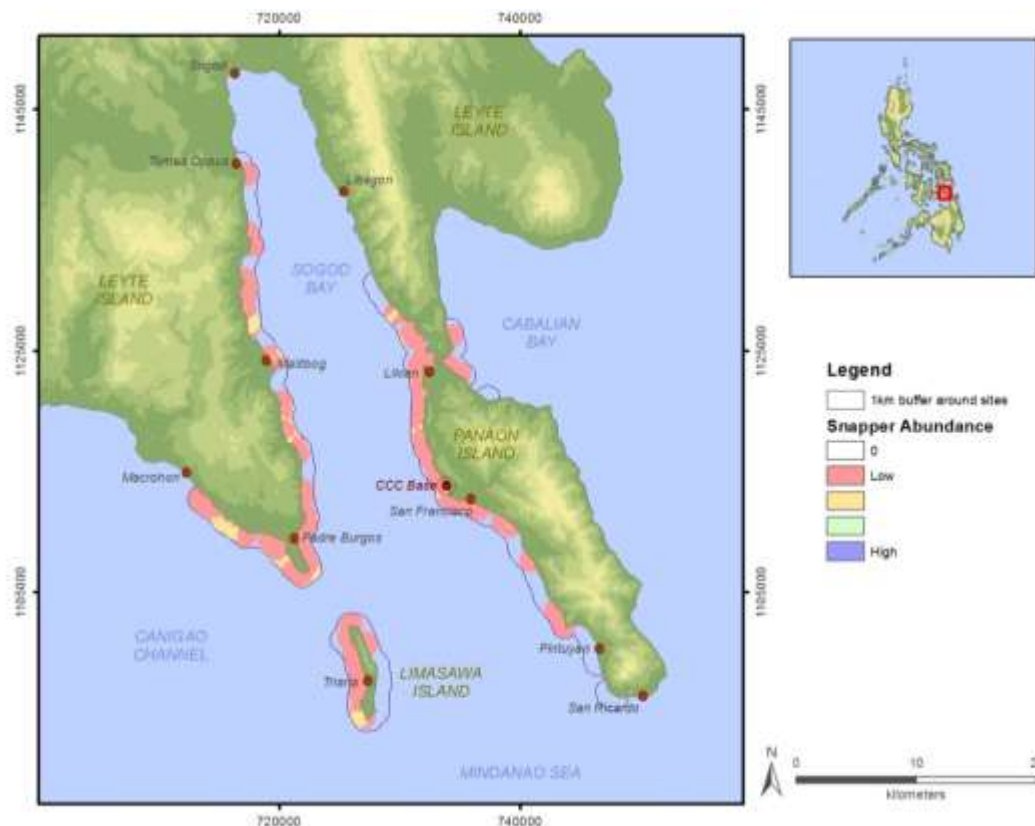


Figure 38 – Abundance of Snappers, displayed as a colour ramp. Areas towards the blue end of the spectrum have the highest abundance.

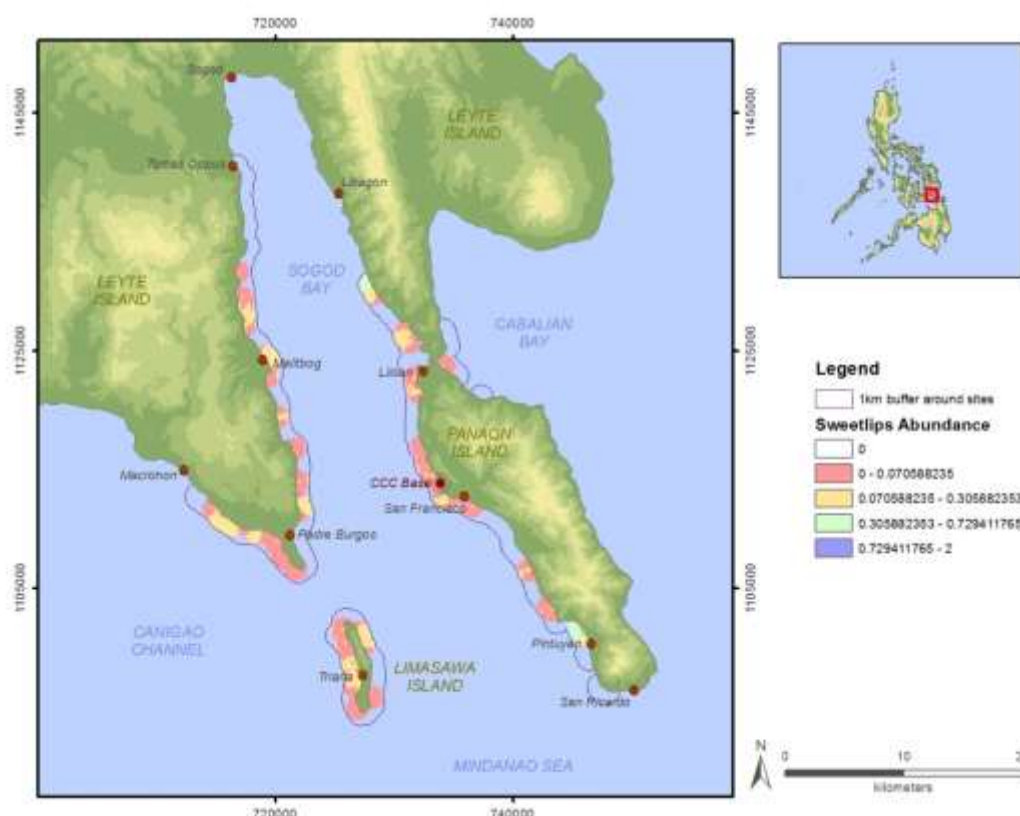


Figure 39 – Abundance of Sweetlips, displayed as a colour ramp. Areas towards the blue end of the spectrum have the highest abundance.

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, and 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, San Francisco and San Ricardo (Figure 40). These results closely correlate with coral cover and commercial fish abundances.

[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.]

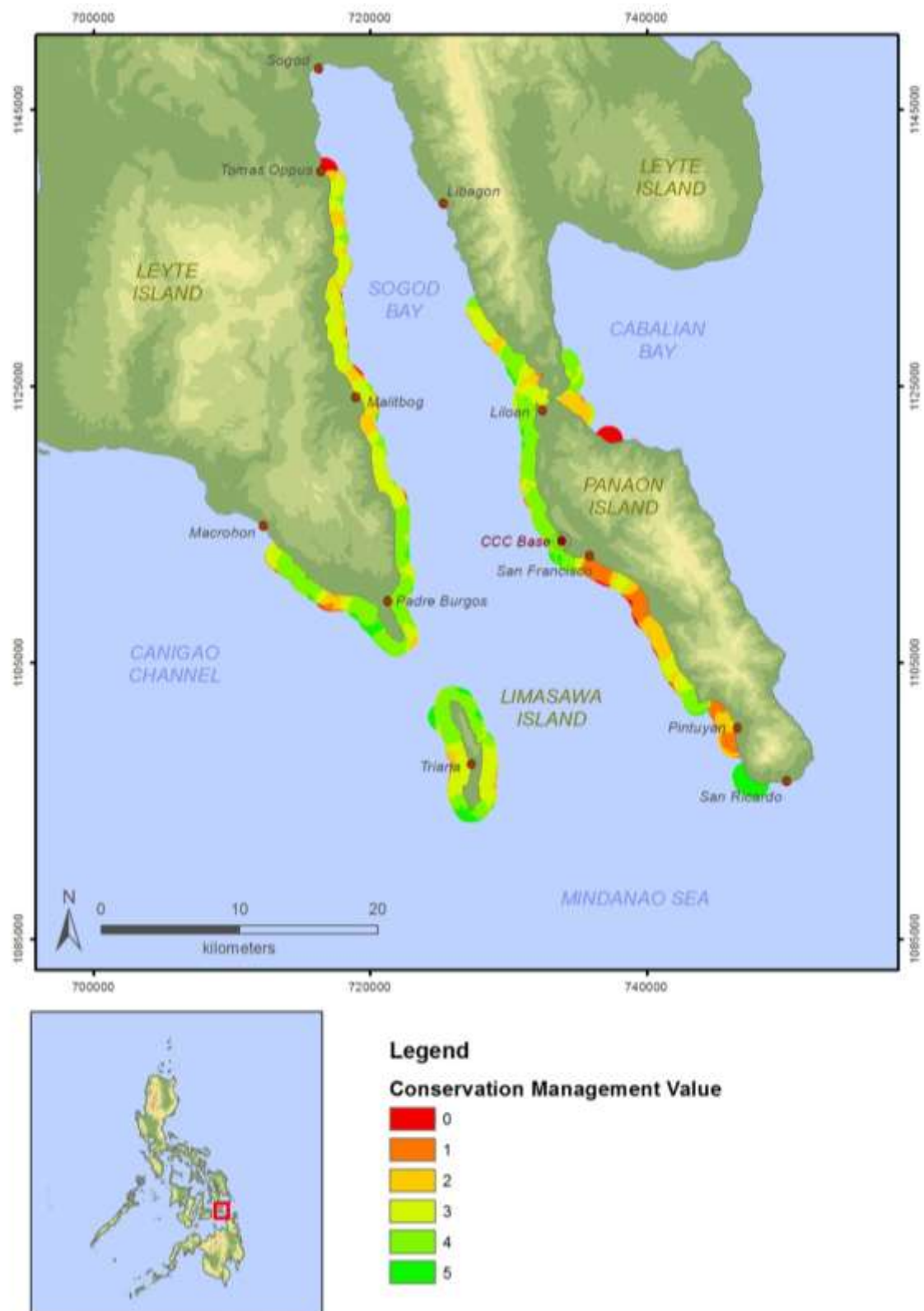


Figure 40 - Conservation Management Values (CMVs) displayed as a colour ramp. Areas towards the green end of the spectrum have the highest CMVs.

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, Marine Protected 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 40) indicates that areas of moderate to high ecological value 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.

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 on-going 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 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 on-going 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.

6. The Future of the SLCRCP

Baseline survey work has been on-going in Sogod Bay for ten years, since the inception of the SLCRCP in September 2002. This report is a summary of all baseline data collected to date and it is important to bear this in mind when interpreting the data presented. The information presented within this report gives a good general overview of the status of the marine resources within Sogod Bay. However, the baseline surveys cannot continue indefinitely since data collected from certain regions towards the beginning of the project (e.g. Malitbog and areas of Padre Burgos and Limasawa) would become out of date and unreliable. It is necessary, at certain intervals, for CCC to re-evaluate the approach which it takes in its scientific work and now is the time to do this.

Since the establishment of the SLCRCP, a huge amount of work has been done both at community, Municipal and Provincial Government level on developing tools and strategies for effective coastal resource management. To this end, a number of marine protected areas have been established within the bay over the years. In addition to conducting baseline surveys, as part of their conservation effort, CCC has conducted assessments of several of the MPAs in the region both before and after establishment and produced scientific reports based on these. This process of on-going monitoring is essential to the effective management of these MPAs. The success of an MPA can be established by comparing monitoring data over the course of years and this information is essential in informing management decisions.

As such, it is considered that it would be useful for CCC to move away from conducting baseline surveys and move towards establishing a comprehensive and on-going monitoring scheme for MPAs. In the coming months, a programme of work will be developed in collaboration with Municipal and Provincial government employees. CCC is looking forward to starting this exciting new phase of the SLCRCP.

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Appendix A: Baseline survey forms

TRANCODE		TRANSECT/PHYSICAL FORM			
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	Description
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

DATABASE INFO

ENTERED BY

DATE

LOGGED?

CHECKED BY

DATE

SPECIES ABUNDANCE		Rating	Abundance Scale (coral, substratum, algae)	Numbers (Fish/ Inverts)
N.B. ALL CORAL AND FISH TARGET SPECIES MUST ALSO BE COUNTED IN THE APPROPRIATE FAMILY OR LIFEFORM		0	None	0
		1	Rare	1-5
		2	Occasional	6-20
		3	Frequent	21-50
		4	Abundant	51-250
		5	Dominant	250+

MICRO-ALGAE		MARINE PLANTS		Mollusca:	
Cyano-Bacteria: Blue-Green	1	(Angiospermophyta)		Gastropods:	
MACRO-ALGAE		Sea Grass	102	Abalone	390
<i>Chlorophyta</i> : Green		<i>Thalassia</i> sp.	108	<i>Murex</i> sp.	394
Green Filamentous	39	<i>Halophila</i> sp.	105	Conch	398
<i>Chaetomorpha</i> sp.	15	Other:		Cowrie	402
Marble (<i>Valonia ventricosa</i>)	36	Mangroves	114	Triton	406
<i>Bornetella</i> sp.	10	TOTAL PLANTS		Cone Shell	408
<i>Neomeris</i> sp.	29	(Not Including Algae)		<i>Drupella</i> sp.	419
<i>Codium</i> sp.	18	TARGET INVERTEBRATES		Limpet	445
<i>Caulerpa</i> sp.	12	<i>Porifera</i> : Sponges		Topshell	404
<i>Halimeda</i> sp.	24	Tube	126	Nudibranch	448
<i>Tydemania</i> sp.	33	Barrel	146	Other	389
Further Green Algae:		Elephant Ear	128	Oyster	426
		Branching	143	Giant Clam	438
		Encrusting	130	Other Clam	443
TOTAL GREEN ALGAE		Lumpy	145	Other	425
		Rope	144	Chiton	442
		Vase	125	Cephalopods:	
<i>Phaeophyta</i> : Brown				Cuttlefish	469
<i>Dictyota</i> sp. (Flat-Branched)	44	<i>Octocorallia</i> : Soft Coral Forms		Squid	470
<i>Padina</i> sp. (Fan Blade)	50	Deadman's Fingers	275	Octopus	468
<i>Lobophora</i> sp. (Blade/Ruffle)	49	Leather	277	Echinodermata:	
<i>Hydroclathrus</i> sp.	48	Tree	278	Sea Stars:	
<i>Turbinaria</i> sp. (Pyramid)	55	Pulsing	295	<i>Acanthaster planci</i> (COT)	472
Brown Filamentous	42	Sea Fan	280	<i>Linkia laevigata</i> (Blue)	478
<i>Sargassum</i> sp. (Bladder)	53	Sea Whip	281	<i>Nardoa</i> sp. (Brown)	479
Further Brown Algae:		Bamboo	283	<i>Culcita novaeguineae</i>	474
		Flower	294	<i>Protoreaster nodosus</i>	482
		Sea pen	338	<i>Choriaster granulatus</i>	473
		Other Cnidarians		Other	471
TOTAL BROWN ALGAE		Black Coral	303	Brittle Star	483
		Anemone (Sea and tube)	306	Feather Star	489
<i>Rhodophyta</i> : Red		Zoanthid	315	Basket Star	495
Encrusting coralline algae	70	Jellyfish (Medusa)	327	Sea Urchin:	
<i>Galaxaura</i> sp.	73	Hydroid	333	Short Spine	502
<i>Amphiroa</i> sp.	63	Corallimorph	320	Long Spine	503
<i>Jania</i> sp.	83	Annelid Worms		Sea Cucumber: Synaptid	515
Red Filamentous	60	Segmented Worms	348	Other	520
Sheet	80	Feather Duster	349	Tunicate (Phylum Chordata)	529
<i>Actinotrichia</i> - spikeweed	61	Christmas Tree	350	Bryozoan (Phylum Bryozoa)	526
Wiry branched (<i>Gelidiella</i> sp.)	74	Flatworms	341	FURTHER SPECIES:	
Further Red Algae		<i>Arthropoda</i> : Crustacea			
		Shrimps	361		
		Rock lobster (<i>Panulirus</i> spp.)	366		
TOTAL RED ALGAE		Crab	381	TOTAL INVERTEBRATES	
				(including tunicates and bryozoans)	

