

SOUTHERN LEYTE
CORAL REEF CONSERVATION PROJECT

Annual Report
**RESULTS OF COMMUNITY AND
SCIENTIFIC WORK**
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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 a pioneering volunteer participatory scheme whereby international volunteers are given the opportunity to join a phase of each project in return for a financial contribution towards the project costs. Upon arrival at a project site, volunteers undergo a training programme in marine life identification and underwater survey techniques, under the guidance of qualified marine scientists, prior to assisting in the acquisition of data. Finances generated from the volunteer programme allow CCC to provide a range of services, including data acquisition, assimilation and synthesis, conservation education, technical skills training and other capacity building programmes. CCC is associated with the Coral Cay Conservation Trust (the only British-based charity dedicated to protecting coral reefs).

CCC has been successfully running volunteer based conservation programmes in developing countries over the past 23 years with notable conservation successes in Belize (formation of the Belize Reef Marine Park and World Heritage Site) and the Philippines (creation of the Danjungan Island Marine Reserve in Negros Occidental).

Executive Summary

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

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

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

From September 2002 to April 2004, the SLCRCP was based near the town of Malitbog, from where CCC dive teams assessed the northeastern and northwestern 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 southeastern 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 December 2008. It also contains a synopsis of community work and capacity building activities undertaken between August 2007 and December 2008. Community and capacity building work undertaken prior to December 2005 have previously been presented in Taylor et al (2004), O'Farrell et al (2006) and van Bochove et al. (2007).

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 17 months, CCC project staff and volunteers undertook an extensive community education programme. In excess of 1500 students from the schools and colleges of Southern Leyte had the opportunity to learn about their reef resources, through a variety of community projects and initiatives, some of which are outlined below.

- Alternative livelihood development programmes such as eco-tourism (whale watching and dive guides) and handicraft manufacturing.
- Signing of a contract between the Southern Leyte State University and CCC in order to allow students to partake in regular scholarship programmes at the expedition site.
- Development and provision of school marine educational materials (lesson plans, games, CDs, posters etc.)

- Teacher training workshops in collaboration with the Southern Leyte Department of Education.
- Open days for local schools to teach children about coral reefs, their importance and current threats, all presented in a fun and interactive manner.
- School visits where marine education and awareness lectures are given to students of all ages.
- Creation of information leaflets, signs, posters and murals to inform the community of their marine resources, local MPA rules and regulations, code of conduct.
- Beach and Reef cleanups with partner NGO's (e.g. Dive into Earth Day) and LGU's (e.g. Youth Catholic Movement)
- Training of students in the highly successful 'Reef Ranger' programme in which the students monitor the state of their local reef and present the results to their school. Reef Rangers are provided with their own snorkel gear and survey equipment by CCC.
- Mangrove and forest replantation schemes as part of coastal resource management initiatives.

CCC survey teams conducted 1257 survey dives, producing a total of 1481 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.

From these data, a total of 9 benthic habitats were identified within Sogod Bay. 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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Introduction

1.1 *The Philippines*

The Philippine archipelago of approximately 7100 islands forms part of the Wallacea triangle, an area renowned for its high terrestrial and marine biodiversity. Some 499 hard coral species (Chou, 1998) and more than 2500 fish species (Lieske and Myers, 2001), have been identified. This is a higher concentration of fish species per unit area than anywhere else in the world (Carpenter and Springer, 2005). The Philippines has 36,289km of coastline, 25,000km² of which are fringed with coral reefs (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 90 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. 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.

1.2 Southern Leyte

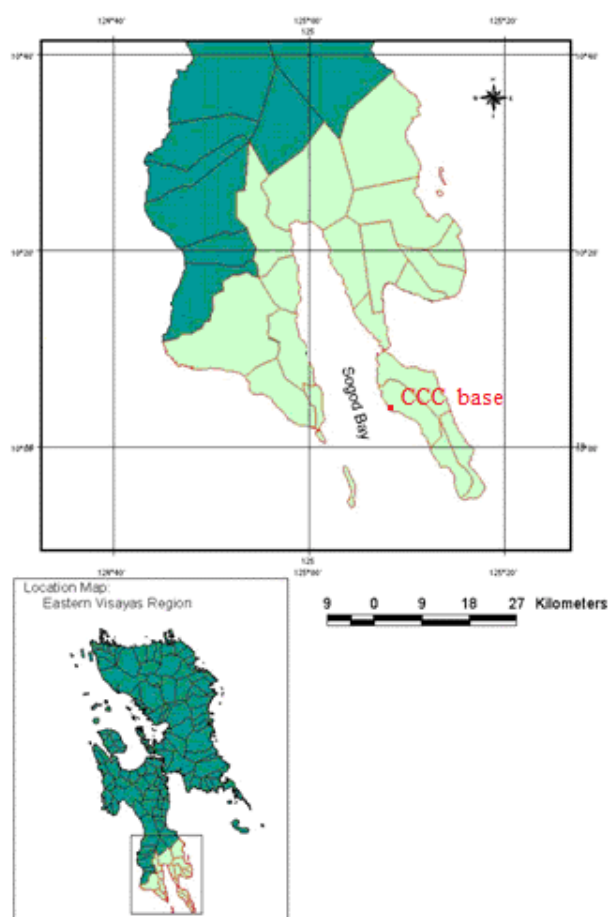


Figure 2 Map of the Eastern Visayas with the province of Southern Leyte in light green. The black lines indicate municipal boundaries. Napantao Dive Resort (marked) is where the current CCC base is located. Source: DENR and SLSU, Southern Leyte.

Southern Leyte, one of the six provinces of Eastern Visayas (Figure 1) is bounded in the north by Leyte province, in the south by Mindanao Sea, in the east by the Pacific Ocean and in the west by the Canigao Channel. Sogod Bay (10° 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 (Calumpang *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 (Calumpang *et al.*, 1994).

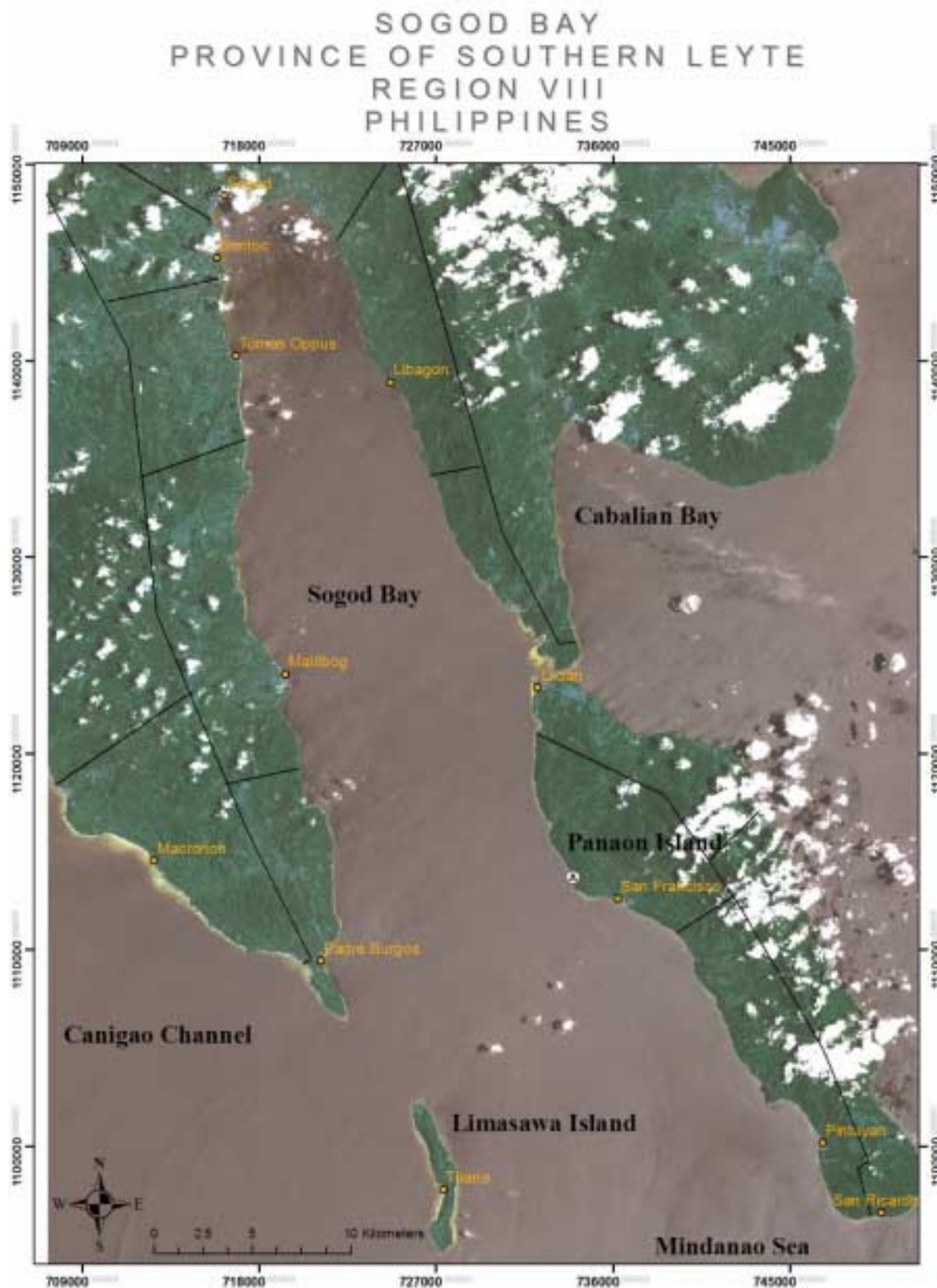


Figure 3 Satellite image of Sogod Bay. The borders of the coastal municipalities presented in black with its main town in orange.

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

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

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

The population in the province has recently started to increase again since 2000 at 1.13% per year according to a 2007 census. It stands at 390,847 with a population density of 217.5/km². The low human population density is a factor that has contributed to the protection of coral reefs locally to date. However, a further rise in population and subsequent pressure on all marine resources could result in marine habitat degradation and consequently the loss of income or whole livelihoods. The ecosystem diversity in Sogod Bay is limited and the processes of degradation are prevailing (Calumpong *et al.*, 1994).

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

Silliman University undertook an assessment of the natural resources and coastal ecology in Sogod Bay in 1993/1994 and again in 2001/2002 and more recently in 2007. During the 1993/1994 surveys, water quality and fisheries were assessed and an ecological study of the bay was carried out. The extent and condition of the coral reef resources was assessed

using manta tow surveys and quadrat sampling methods. To date, no comprehensive work has been carried out on the deeper parts of the reefs in Sogod Bay.

1.3 Threats to the coral reefs of Sogod Bay

The Philippines is the most highly threatened center of endemism (Roberts et al. 1998). It has been predicted that 90% of the reefs across the Philippines are at risk (Wilkinson, 2008). A variety of factors, exacerbated by an expanding population, have caused serious degradation of the coral reefs. The main regional and local, anthropogenic impacts are described below.

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 bulk of the coral's nutrition via photosynthesis. If a coral colony is not able to regain its population of symbiotic algae, it will starve.

Although there have been records of coral bleaching since 1870 (Glynn, 1993), extensive or regional bleaching appears to be a relatively new phenomenon, with a significant increase in the levels and extent of bleaching recorded in the past 20 years or so (Winter et al, 1998). Recent examples of corals reefs' responses to elevated sea surface temperatures in the

Indo-Pacific were demonstrated in 1998 when bleaching due to the *El Niño* Southern Oscillation (ENSO) event effectively killed 16% of the world's coral reefs. Such events are expected to become bi-annual within the next 20-50 years if drastic measures are not taken to reduce carbon emissions (IPCC, 2007).

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

Ocean Acidification

In addition to rising sea surface temperatures, another phenomenon is expected to affect the very structure and growth capabilities of hard corals through a process known as oceanic acidification. As the oceans soak up more carbon dioxide, the marine chemistry of the ocean 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 also 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 both stronger and more unpredictable (Webster 2005). Healthy reefs can recover from infrequent damage caused by tropical storms but already weakened and stressed reefs may be further degraded with little opportunity for recovery.

Intermediate and Local-Scale Threats and Impacts

Although climate change is now considered to be the overarching threat to tropical marine ecosystems, impacts to coral reefs are exacerbated by local, anthropogenic events. To maintain hard coral populations on reef systems around the world it will be necessary to carefully manage direct pressures such as pollution, sedimentation, overfishing and coastal development, and hope that some coral species are able to adapt to the warmer environment (Wilkinson and Souter, 2008). Studies conducted on relatively undisturbed coral reefs in the absence of direct human pressures have indicated that these 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). This effect 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 the growth of marine algae, 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 easily be 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 remains 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 Calumpang *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 (Calumpang *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 stresses 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 as they inadvertently cause 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 the some of the sanctuaries still occurs, with fishers using 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 assisted in 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. This is believed to have helped in the success of the sanctuaries over the last 2 years.

Crown-of-thorns Outbreaks

The Crown-of-thorns sea-star (*Acanthaster planci*) is a corralivore, feeding on the lipid palmatate reserves of hard corals. Under normal conditions, it is thought to be a rare echinoderm inhabiting deeper parts of sheltered reefs throughout the Indo-Pacific region. 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.

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 rate corals can grow, 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 and preventing full regeneration of coral cover.

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

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

2. Community Work

One of the key objectives of the Southern Leyte Coral Reef Conservation Project is to assist the Province in strengthening its human resources. This is achieved by the training of host country counterparts, educators, LGU employees, and students. The nature of the training varies with the needs of the trainees, ranging from simple coral reef appreciation for young children, to technical scientific training for Provincial Government employees and school teachers. This section summarises the extensive community work undertaken by CCC from August 2007 to December 2008.

August

- 10th Beach cleanup at the CCC project site, filling 10 bins of trash washed up on the shore
- 14th School visit to Malitbog Central School for lectures and a puppet show.
- 18th Visit to Ichon Convent to present lectures and puppet show to over 200 children
- 19th Reef Rangers trained by CCC conduct surveys inside and outside their local fish sanctuaries
- 22nd CCC hosts the Padre Burgos Marine Protected Area (MPA) Oversight Committee meeting at its project base.

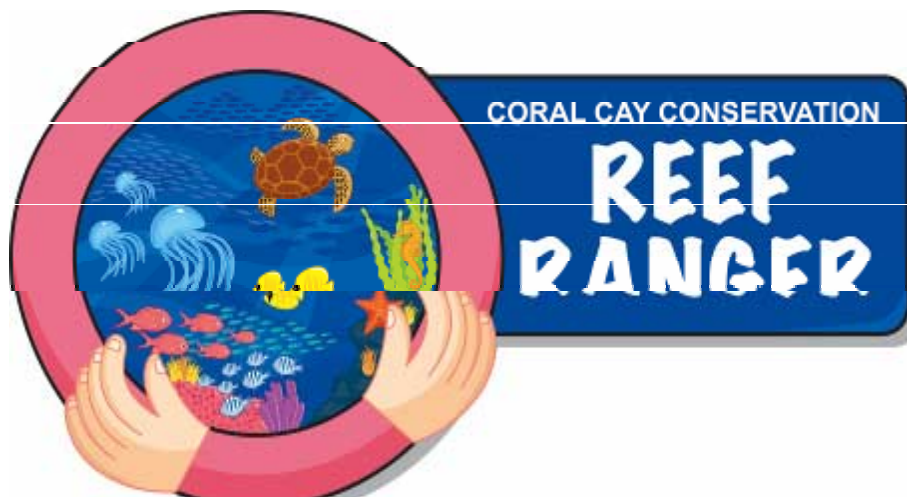


Figure 4 The official CCC Reef Ranger logo

September

- 7th Tangka'an Elementary School visits the CCC base for an Open Day
- 11th CCC was invited by the Provincial Board Member, Hon Daisy Gamale to partake in a massive beach cleanup in Sogod. The CCC Project Scientist also gave a radio interview to talk about the importance of proper waste management.
- 13th Inauguration of the Padre Burgos Fish Sanctuary Patrol Boat. This patrol boat was paid for and donated to the Municipality by the Federation of Omega Beneficiaries (FOBI),

CCC and the Municipality of Padre Burgos. Financial support for fuel and boat maintenance was generously being provided by the local dive centres of Padre Burgos



Figure 5 Official christening of the Padre Burgos MPA Patrol Boat

14th CCC attended the Panaon Coastal Resources Summit to discuss the future management of the island.

21st CCC and Sogod Bay Divers joined up to conduct a beach cleanup in Barangay Lungsodaan, Padre Burgos.

27th CCC met with the fisherfolk of barangay Bunga, Padre Burgos, to discuss the possibility of establishing an MPA along their coastline.



Figure 6 CCC volunteers and Sogod Bay SCUBA Resort staff display the result of their efforts to clean the beach and reef inside the Lungsodaan MPA, Padre Burgos.

October

4th CCC attended the Waste Management Forum for Southern Leyte in Maasin, hosted by the Provincial and Environmental Resource Management Office (PENRMO).

6th CCC launches an inter-school poster competition in Padre Burgos, advocating good waste management practices under the theme 'Reduce, Reuse & Recycle'. The eighteen posters were displayed at the 50th anniversary fiesta of Padre Burgos on the 22nd of October. The winning posters were displayed around Padre Burgos.

25th CCC attended the Annual Tourism Workshop in Hinunangan on the Pacific side of Southern Leyte. Whilst in Hinunangan, CCC scientists conducted several rapid reef assessments around the remote island of San Pedro, off the coast of Hinunangan.

28th CCC scientists and local scholars conduct the first socio-economic surveys with the fisher folk of barangay Bunga, Padre Burgos.

November

4th Children from the Kinderhilfe orphanage attended an Open Day at the CCC expedition site.

24th Governor Damien Mercado's 53rd birthday in Maasin. CCC was invited to join the celebrations.

December

22nd CCC staff and volunteers assisted the community of barangay Buenavista, Padre Burgos with the planting of some 2000 mangrove seedlings within their MPA.

27th-29th CCC attended the 'Children's forum on Environmental Awareness and Coastal Cleanup' in Liloan where the project scientists were involved in the coastal cleanups and presented several lectures on coral reef conservation and solid waste management.

January

26th-27th CCC held a 'Reef Ranger' weekend for 10 students from the St. James' High School Scholar Club in Padre Burgos. The students followed an intense course, learning about coral reef ecology, reef creature identification and basic survey methods which can be used to monitor the health of their local reef.

28th CCC initiates talks with the Provincial Environmental and Natural Resource Management Office and GTZ to discuss the feasibility of installing a large-scale MPA along Limasawa's north-eastern coast. CCC survey results indicate this area to have a high biodiversity of reef organisms, making it a priority site for protection.

February

23rd-24th CCC trained the Barangay Captains of Buenavista, Lungsodan and Sta. Sofia as well as their council members and constituents in marine species identification. Snorkel survey techniques were also taught to aid them in the monitoring of their respective MPAs.

10th-17th A small satellite expedition set up camp on San Pedro Island, Hinunangan to assess the state of their coral reefs and help develop their coastal resource management program. The expedition also included education components for the island's youths.

March

10th-11th CCC participated in the PCRA and CFRM planning workshops on Limasawa Island. The two-day event involved members from all six of Limasawa's barangays and CCC introduced the stakeholders to the proposed MPA site.

15th CCC visited the Southern Leyte State University in Bontoc, attending the graduation ceremony of the marine fisheries students and signing a memorandum of agreement between the university and CCC. The agreement allows a number of SLSU students to undertake in CCC's 4-week dive and science program.

22nd A meeting was held between CCC and other members of the MPA Oversight Committee (MPAOC) in the Mayors office, Padre Burgos. CCC donated flashlights to each of the 4 barangays which have MPAs installed in order for them to patrol the MPA at night.

30th CCC moves to the new expedition base in Barangay Napantao, Municipality of San Francisco, Panaon Island. The base is located on the eastern side of the bay and allows the project to complete its baseline survey assessment of Sogod Bay.

April

9th-10th CCC returned to Limasawa for the second instalment of the PCRA and CFRM Planning workshop. Habitat destruction, fisheries, and waste management issues were discussed with the various stakeholders as was the proposal for the creation of an MPA on the island.

22nd Earth Day. CCC presented to a number of students and barangay members on waste management and coral reefs.

27th Barangay Napantao community members visited CCC's new project base for an Open Day. It was a chance to get to know the project and learn about what CCC is doing to help the community.

22nd CCC presented the results of the underwater visual census (UVC) reef assessment data of barangay Bunga. This was coupled with the findings from the fisher folk interviews. The information was presented to the Barangay Captain, Council Members, President and Vice President of the Fisherfolk association and the fisherfolk themselves.



Figure 7 CCC Project Scientists discussing the MPA proposal with community representatives from barangay Bunga.

May (Ocean Month)

3rd CCC celebrated Earth Day by joining up with the Maasin Youth organisation for a coastal cleanup in Maasin city.

14th CCC takes part in the municipality of San Francisco parade to celebrate the town's fiesta.

22nd The CCC Project Scientist and Community Liaison Officer met with representatives from barangays San Agustin and Lugsongan on Limasawa Island to discuss the proposed establishment of a MPA on the island. The workshop was conducted in collaboration with the Provincial Environmental and Natural Resources Management Office and both barangays were visited in turn for presentations and open discussions with local stakeholders.

23rd Representatives from Limasawa Island visit the CCC project site to listen to testimonies and share ideas with MPA managers and barangay Captains from Sonok and Hinunangan. There was also a chance to learn about coral reef biology and threats to the reef.

25th An Open Day was held for the youth of barangay Napantao at CCC's base

June

3rd Local Stakeholders convened at CCC's project site for the Napantao Fish Sanctuary Action Planning Workshop. This resulted in the establishment of the Napantao Fish Sanctuary Management Committee.

9th Three scholars from Southern Leyte State University (SLSU) completed their scholarship training, making the first students to complete this 4-week training as part of an agreement between CCC and SLSU.



Figure 8 SLSU students surfacing from a successful science dive

July

13th Captains from all 22 of the Barangays in San Francisco attended a workshop on coral reef management at CCC's project base.

19th CCC provided lectures on mangroves and marine conservation at Southern Leyte State University to help celebrate its Marine Biology Day

21st CCC and the Bureau of Fisheries and Aquatic Resources (BFAR) discussed management of the Napantao Fish Sanctuary.

27th Children of barangay Bungawisan visited for an Open Day to try snorkelling and learn about the marine environment.

CCC attended the 48th Anniversary of the Southern Leyte capital in Maasin, and received an award from the governor for its continued partnership with the Provincial Government of Southern Leyte in the field of Marine Protection & Preservation.

CCC continued holding discussion groups in Napantao and Anislagon. These give further insights into the management and efficiency of existing MPAs from the local community's perspective.

August

12th Napantao Fish Sanctuary Oversight Committee (NFSOC) invited CCC to a workshop to specify the policies regarding the Napantao Fish Sanctuary.

20th CCC gave an introductory lecture about CCC and coral reefs to year 2 students at Santa Paz High School.

22nd CCC gave a lecture about conducting socio-economic research to year 4 students at Santa Paz High School.

23rd-24th Sixteen students from Santa Paz High School visited for a Reef Rangers Weekend, learning about the marine environment and how to monitor coral reefs using snorkelling gear.

26th Jack Petchey volunteers and the local kids all joined hands to paint marine creatures on the wall of the Napantao Elementary School.

CCC welcomed 20 Jack Petchey volunteers from the UK in August. The foundation was established in 1999 by Jack Petchey and focuses on projects and programmes that benefit 11–25 year olds. The main area of operation is the London boroughs and Essex, where it currently operates in 1600 secondary schools and youth clubs.

September

Three officials from the Bureau of Fisheries and Aquatic Resources (BFAR) of Tacloban partook in the counterpart training programme. During their four week stay at the CCC base, they received dive training up to PADI AOW and learned about coral reef ecology and species identification. This knowledge was then incorporated in practicing MPA surveying techniques. The skills acquired to BFAR at no cost will enable them to carry out valuable MPA monitoring surveys.

2nd CCC and the Jack Petchey volunteers presented a 'Fred the Fish' puppet show and painted the water tank together with the children of Napantao.

8th Results from the marine surveys conducted in February were presented to the Mayor and board members of Hinunangan and to the council members of the remote island of San Pedro.

10th CCC helped organise an orientation day about community-based ecotourism in Napantao.

20th International Coastal Cleanup Day was celebrated with a beach cleanup in barangay Tabugon, Liloan, together with the Igno sa Panawi (a local organisation protecting nature).

23rd CCC Education Officers completed their tour of San Francisco, presenting lectures in all schools in San Francisco Municipality

26th CCC Project Scientist provided a lecture to the Municipal Fisheries Agriculture Resources Management Council.

28th Bongbong Elementary School visited CCC base for an Open Day.

CCC introduced the recording of fish catch diversity and weight around Napantao in order to monitor trends in fisheries. Sixteen fishermen followed training and began recording their fish catch on each fishing trip. Beginning as a small-scale pilot project, the aim is to extend this initiative all over the coastal Barangays of San Francisco. Once the monitoring is structured, CCC will be able to train the municipal department of fisheries and enable them to monitor their fish stock independently from external institutions, which is one of their principal needs.



Figure 9 Introduction to CCC lesson at Pinamudlan Elementary School

October

3rd-8th CCC was invited to provide coral reef awareness classes at all six schools on Limasawa Island; Triana, Magallanes, Lugsongan, San Bernado and San Agustin Elementary Schools and Limasawa National High School.

5th CCC invited pupils of Habay Elementary School and their parents and teachers to an Open Day at the expedition base in Napantao.

Mid-Oct The project scientist gave lectures on environmental awareness and threats to coral reefs at seminars in Liloan and San Francisco organised by the Local Governmental Unit and the Department of Education. This seminar was held for organisations concerned with out-of-school youth.

18th On invitation, CCC provided information and suggestions for effective waste management for the barangay at the General Assembly in Napantao.

25th CCC presented lectures on coral reef ecology to approximately 600 Girl Scouts in Maasin.

The development of sustainable, community-based ecotourism in Napantao moved another step forward. The national training agencies Technical Skills Development Authority

(TESDA) and Department of Trade and Industry (DTI) presented their proposals for souvenir making and management training. Interesting suggestions were offered for the People's Organisations of Napantao for skills training and management training regarding determining a business plan and the costs, prices and quality of products. Much of these initiatives have transpired thanks to the hard work of CCC's local and international Community Liaison Officers and Project Scientists.



Figure 10 Meeting with community members to discuss the potentials of developing ecotourism in Barangay Napantao

November

Throughout November, CCC was able to visit all the 23 schools in the Municipality of Liloan and provide reef awareness lectures at each school. A hugely successful undertaking, school visits throughout Panaon Island have provided hundreds of children with a basic awareness and appreciation of coral reef ecology and its importance to their future livelihoods.

17th The Municipality of Limasawa celebrated the opening of their MPA in the northeast of the island. The MPA covers a large area of diverse coral reefs along the Barangays of San Agustin and Lugsongan. Covering a 26 hectare area with a 40 hectare buffer zone, it is one of the largest no-take zones in the Philippines and marks a major milestone in the development of a network of MPAs along Southern Leyte's coastline.

23rd CCC organised a teacher training day for all the schools in Municipality San Francisco. 25 teachers from 8 different schools attended and gained knowledge on coral ecology, coral biology, and threats to reefs, MPAs and waste management. A snorkel session at the end of the day was hugely appreciated. They were furthermore provided with lesson resources.

26th CCC invited the national training agency Technical Skills Development Authority (TESDA) to provide a three-day training to the Napantao community for making novelty items from coconut shells and placemats and photo frames from coconut twigs. These items are to be sold to visiting (dive) tourists.

27th The Small and Medium Enterprise Development Council (SMEDC) of Southern Leyte held an investment forum in Cebu City. The CCC Expedition Leader presented an

introduction to CCC's activities and evidence of the high marine diversity found in Sogod Bay. He also discussed various potential tourism activities which could be developed in Sogod Bay.

CCC volunteers and staff completed the biannual MPA survey period along the permanent transects in Napantao. Two of the five permanent transects are located inside the fish sanctuary and the other three are located outside the sanctuary. The aim is to perform MPA surveys at regular, biannual intervals and monitor and compare commercial fish biomass and coral health on these transects. Reports on the MPA monitoring programme can be found on the Coral Cay website.

December

9th CCC attended the annual Provincial Coastal Resource Management Meeting of Southern Leyte.

13th CCC staff and volunteers were lucky to see a Whale Shark (*Rhincodon typus*) off the coast of San Ricardo, the Municipality at the Southern tip of Panaon Island in Southern Leyte. It was the first of many sightings! The Whale Sharks normally arrive around November time and leave mysteriously in March. CCC has been monitoring the migration of individuals to the bay and sharing this imagery with the Shark Trust.

14th CCC held an Open Day for over 60 students of Calian Elementary School of Municipality Liloan.

26th CCC helped paint the wall at Bong Bong Elementary School with an underwater seascape.



Figure 11 The beautiful and mysterious Whale Shark seen off the coast of San Ricardo. Photo by Chris Veazey-Doucet

Scientific Methods

3.1 Background

One of the key objectives of the SLCRCP is to survey the coral reefs of Sogod Bay, in order to provide data for the assessment of the nature and status of the reefal resources. As well as providing a 'snapshot' of the reefs at this point in time, these data are used to highlight spatial variation and trends which can be used to make recommendations for management action by the Provincial Coastal 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 December 2008. These data and those subsequently gathered by the project will be made freely available to any interested parties who may have use of them.

3.2 Methodology

Developed for the assessment of biological and physical characteristics of reef communities by trained volunteer divers, the CCC Baseline Survey Technique has been continuously refined and improved since 1990. Following an intensive training programme, CCC's techniques have been shown to generate precise and consistent data appropriate for baseline mapping (Mumby et al., 1995). The survey programme is coordinated by the onsite marine science staff to ensure accurate and efficient data collection.



Figure 12 Volunteers learning coral reef species identification under guidance of science staff.

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

The CCC Baseline Survey Technique utilises a series of plot-less transects, perpendicular to the reef, starting from the 24m contour and terminating at the reef crest or in very shallow water (0.5m). 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.

During the course of each sub-transect survey, divers may have traversed two or more apparently discrete habitat types, based upon obvious gross geomorphologic (e.g. forereef, escarpment or lagoon) or biological differences. Data gathered from each habitat type are recorded separately for subsequent analysis. Each species, life form or substratum category within each habitat type encountered is assigned an abundance rating from the DAFOR scale, as shown in Table 1.

Table 1 The ordinal scale assigned to life forms and target species during CCC Reef Surveys

Abundance rating	Corals, other colonial invertebrates and macroalgae	Fish and invertebrates (number of individuals)
0	None	0
1	Rare	1-5
2	Occasional	6-20
3	Frequent	21-50
4	Abundant	51-250
5	Dominant	250+

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.

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).

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.

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 12). 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

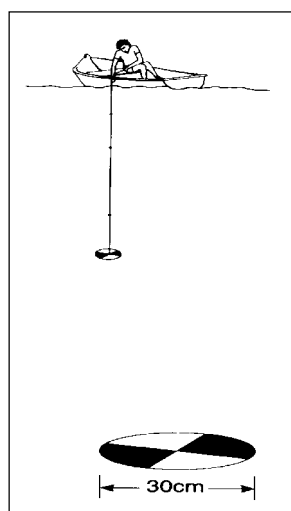


Figure 13 The use of a Secchi disc to assess vertical water clarity. The Secchi disc is lowered into the water until the black and white quarters are no longer distinguishable. The length of rope from the surveyor to the disc is then recorded. Source: English et al

the wind at each survey site. Direction is recorded as one of eight compass points (direction wind was blowing from) and strength is assessed using the Beaufort scale.

Natural and anthropogenic impacts are assessed both at the surface from the survey boat and by divers during each survey. Surface impacts are classified as 'litter', 'sewage', 'driftwood', 'algae', 'fish nets' and 'other'. Sub-surface impacts are categorised as 'litter', 'sewage', 'coral damage', 'lines and nets', 'sedimentation', 'coral disease', 'coral bleaching', 'fish traps', 'dynamite fishing', 'cyanide 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 9.2 (ESRI software).

3. Results

It is not possible (nor necessarily useful) within this report to undertake an exhaustive analysis of all of the data gathered during the reporting period. A more thorough analysis will be made when all the baseline surveys within the bay have been completed and comparison can be made between all sites, producing a clearer picture of the state of Sogod Bay's marine resources. All the data are made freely available in a GIS compatible meta-database, allowing interested parties to undertake further analysis of any particular dataset.

Between September 2002 and December 2008, CCC survey teams produced 1481 individual survey records from 1257 survey dives around Sogod Bay (Figure 14). Although data from 2002 to 2007 have previously been presented (Harding et al., 2003; Taylor et al., 2004, van Bochove et al., 2007), it is considered appropriate to include these data in this analysis, to allow for comparisons to be made throughout the bay region.

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 very 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.

During the survey programme, the bay was divided into 27 geographically distinct survey sectors (Figure 13) for the purposes of this analysis, the surveys have been recombined into 8 geographical regions (Table 2), the borders of which follow the Municipal boundaries around the bay.

Although surveys have been conducted at a number of sites adjacent to the 8 geographical regions, analysis of the data for these reefs will not be conducted until a complete dataset has been compiled.

In addition to the ongoing baseline survey program, several Marine Protected Areas have been monitored and evaluated over the past years in order to allow for continued management of these sanctuaries. The sanctuaries include Santa Sofia, Lungsodaan, Tangkaan, Buenavista (all Padre Burgos), Napantao (San Francisco) and Esperanza (San Ricardo). On the request of local communities, we have also assessed the suitability of several proposed sites. These include Bunga (Padre Burgos), Molopolo (Liloan), San Pedro (Hinunangan), Molopolo/Santa Cruz (Marcohon) and Biasong (Libagon). 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.info@coralcay.org).

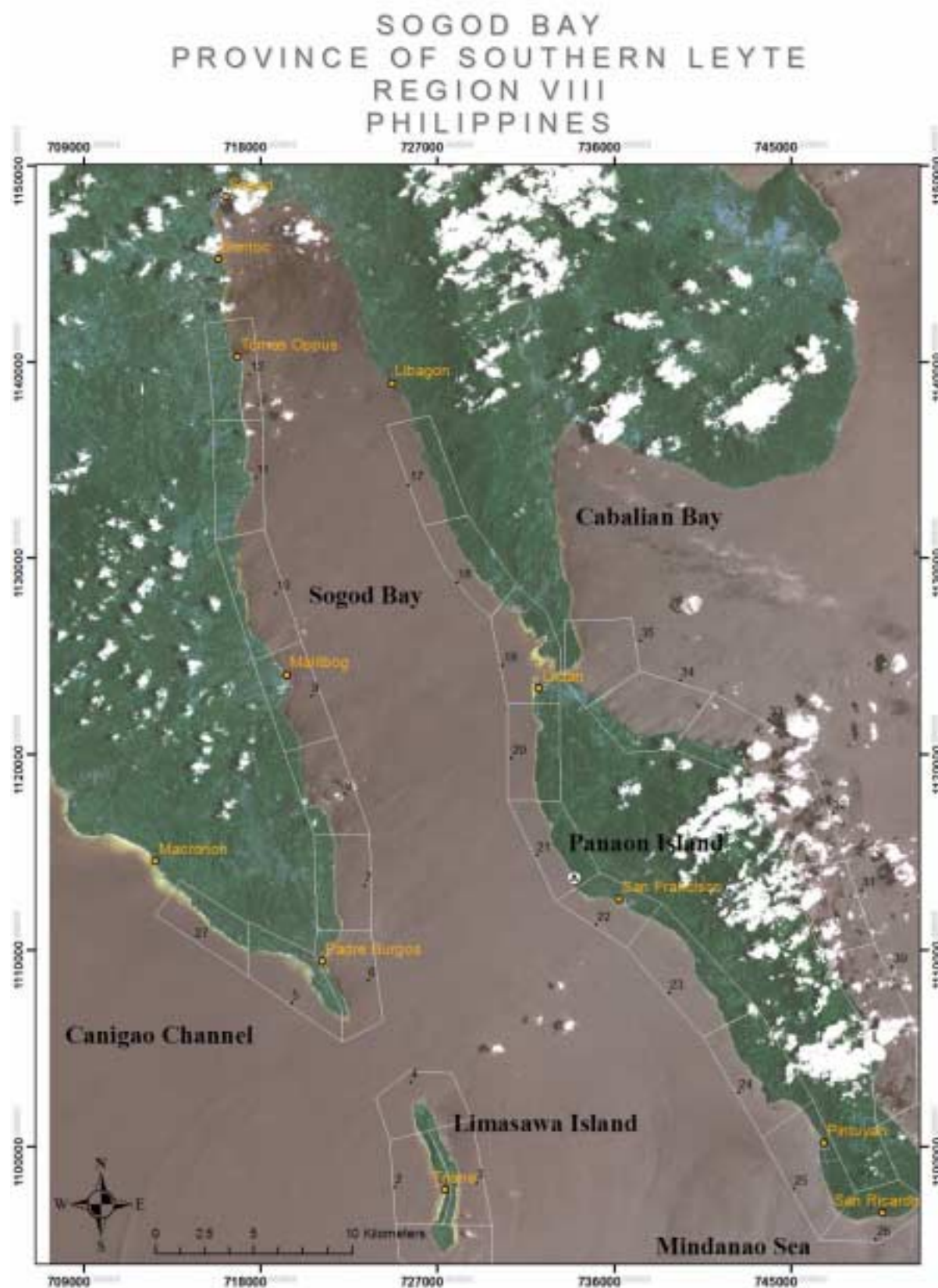


Figure 14 Satellite image of Sogod Bay. The CCC survey sectors are presented in gray.

Table 2 Survey sectors analysed in this report, represented by 8 regions. Survey sectors were grouped to approximate coastal municipalities.

Region	Survey Sectors	Municipalities
1	11 and 12	Bontoc
2	10	Tomas Oppus
3	8 and 9	North Padre Burgos and Malitbog
4	6 and 7	East Padre Burgos
5	5 and 27	West Padre Burgos and San Roque
6	18, 19 and 20	Liloan and Libagon
7	21 and 22	San Francisco
8	1,2,3 and 4	Limasawa Island

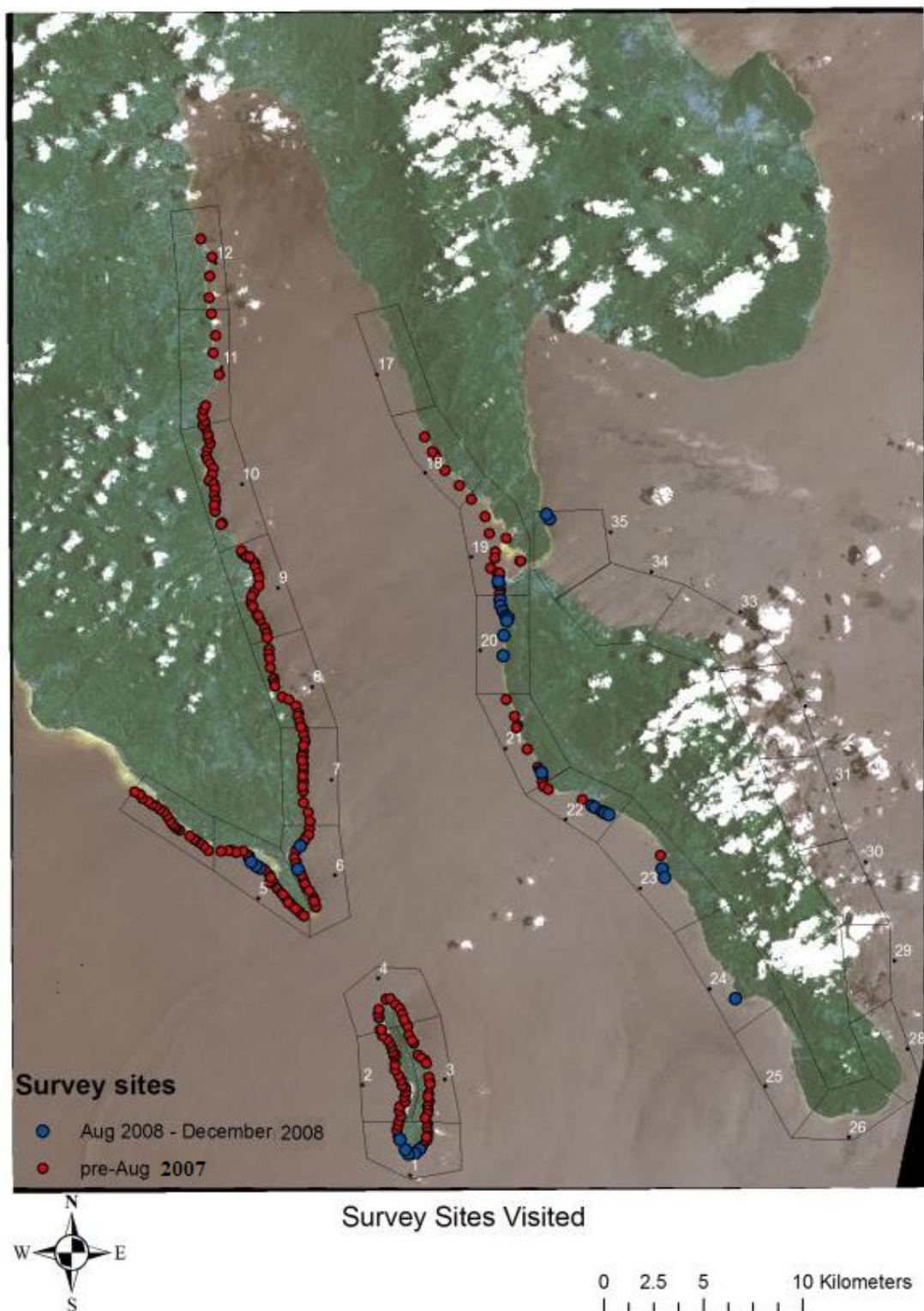


Figure 15 Locations of survey stations visited in Sogod Bay between November 2002 and December 2008. Red dots represent sites surveyed before august 2007 and blue dots represent sites surveyed between August 2007 and December 2008

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

- Results from oceanographic and anthropogenic impact data (4.1)
- Results from biological indicators. Benthic (4.2) and Reef Fish Families (4.3)
- Definition of ecologically distinct marine habitats (4.4)
- Generation of management ratings (Conservation Management Value) for each survey site (4.5)

4.1 Results from Oceanic and Impact Data

Surface Temperature and Salinity

The data for mean sea surface temperatures and salinities are displayed in Figure 15. Data were collected over a 7-year period. Sea surface temperatures reflect seasonal fluctuations in air temperature and solar irradiance, with the highest mean temperatures recorded in June and July. Surface salinity follows the same trend with the highest reading recorded in June. Surface salinity is affected by the amount of rainfall. This explains the low surface salinity during the rainy season between November and March.

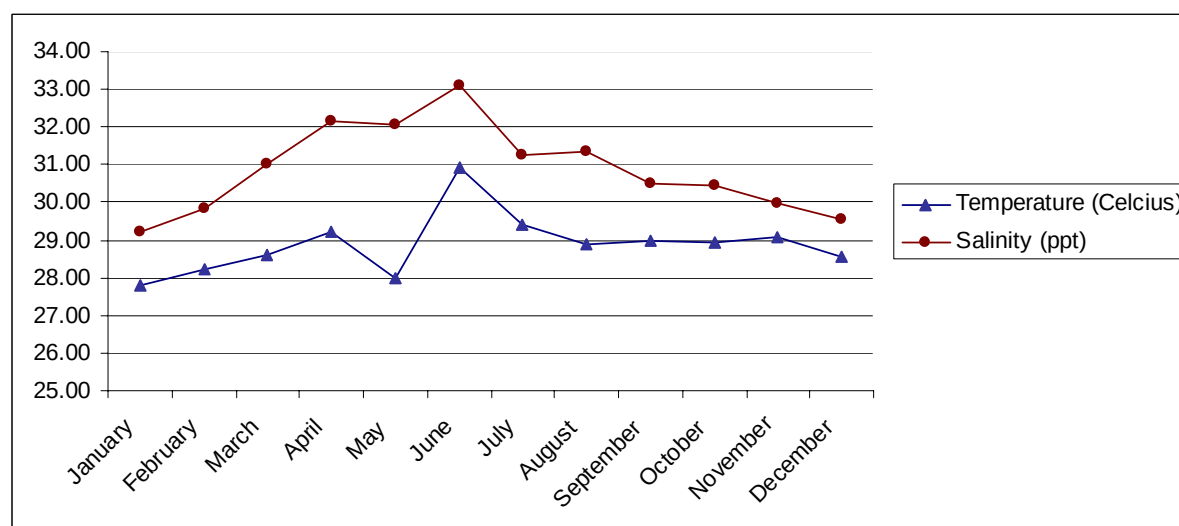


Figure 16 Annual fluctuations in surface salinity and temperature in Sogod Bay.

Boat Frequency and Activity

Boats that were observed during surveys were recorded in 4 activity classes, namely “fishing”, “diving”, “commercial” (such as ferries or cargo vessels) and “pleasure”. The vast majority of boats observed during the survey programme were involved in fishing (78%) – Figure 16. The next single greatest class was “pleasure” (13%), then “commercial” (6%). Two percent of the observations made were of dive boats within the area.

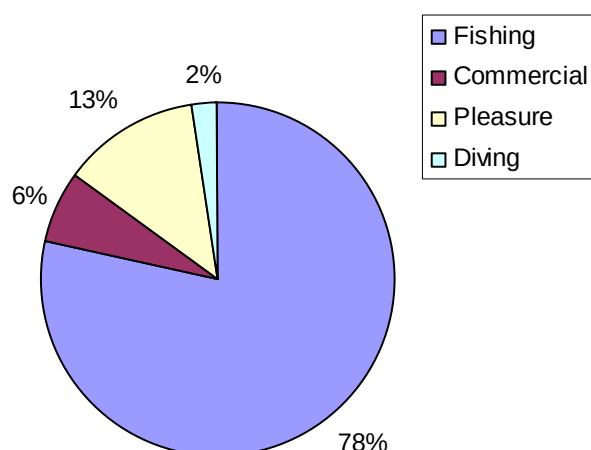


Figure 17 Boat activity by class, as a percentage of total boat observations

Fishing Pressure

The estimated fishing pressure for a particular site was determined by the amount of fishing boats present in addition to any underwater survey evidence of fishing recorded such as fish traps, discarded nets and fishing lines. By tallying these factors on a nominal scale, a total fishing pressure value of between 0 and 5 was obtained which is displayed on a GIS map in figure 17.

Fishing pressure was generally highest on reefs adjacent to population centres such as Padre Burgos, Liloan and Malitbog. Discarded nets and fish lines were a common sighting around Padre Burgos town where shore-based net and hook and line fishing in addition to the usage of fish traps are popular.

Some areas are known to be important fishing grounds such as the reefs around the north of Limasawa and around Padre Burgos. Fishing pressure seems to increase to the north of Sogod Bay, most likely due to the increase in number of people living along the coast rather than a higher abundance of commercially targeted fish.

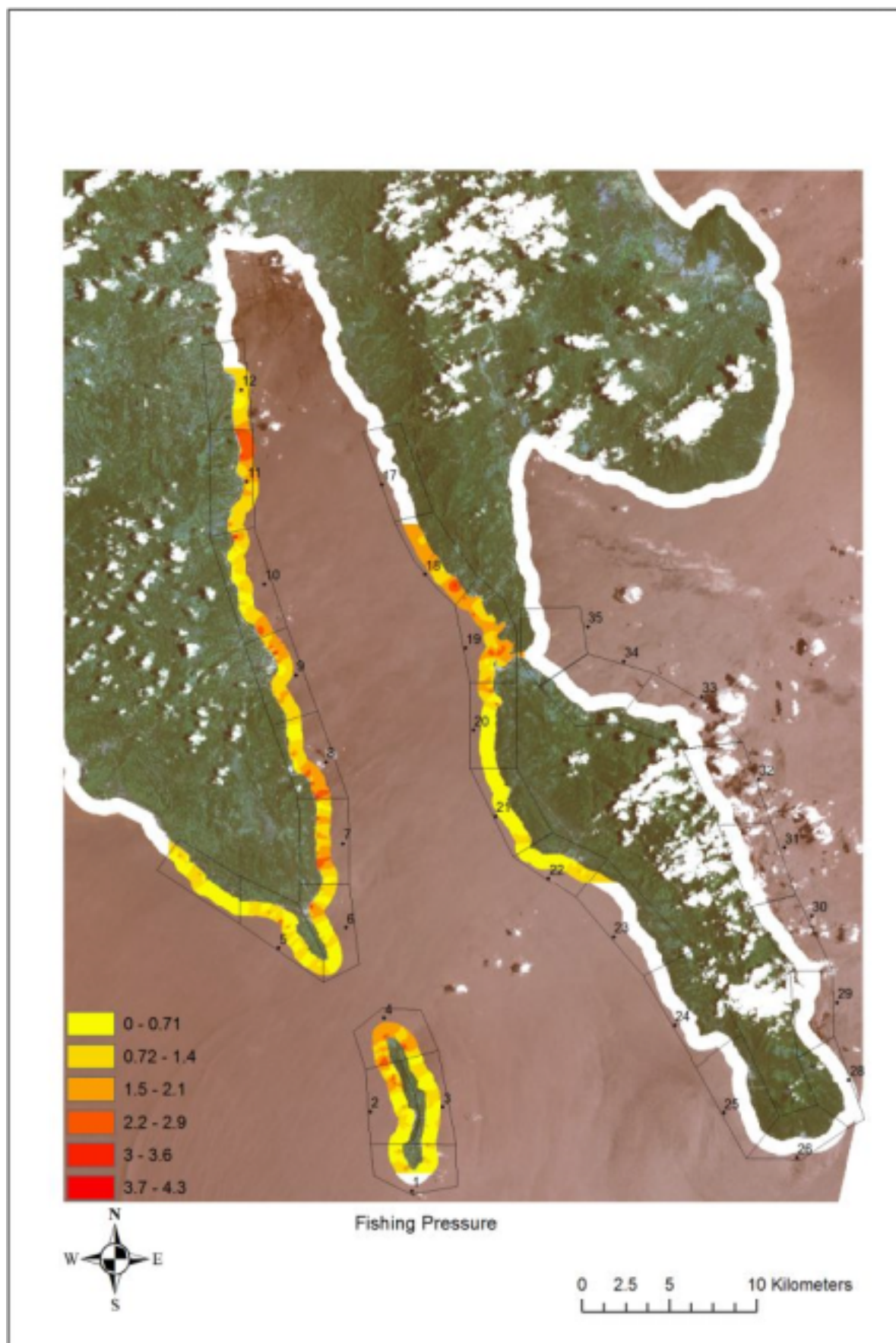


Figure 18 Fishing pressure around Sogod Bay, displayed as a colour ramp. Areas towards the red end of the spectrum have the highest value (i.e. highest fishing pressure).

Underwater Impacts

Direct underwater impacts such as litter, sedimentation and coral breakage due to anchors are presented in Figure 18. The overall impact rating per site was on a scale of 0-5.

Litter was dominant in the northern end of the bay at Bontoc and was seen on over a third of the surveys conducted there. Litter from the whole bay tends to collect in the closed end of the bay through the combined action of wind, tides and currents. Litter is also a serious problem around the towns of Padre Burgos and Liloan.

Recordings of coral damage were generally highest where high population densities were located nearby areas of extensive reefs (Malitbog, Liloan and Padre Burgos). Boats frequently anchor in these areas, particularly so during the southwest monsoon (*Habagat*) when these natural harbours protect the boats from storms.

Heavy sedimentation is one of the factors responsible for the lack of extensive reefs in the north of Sogod Bay. Here, several river systems discharge into the bay, releasing large amounts of sediment transported from upland areas. Sedimentation was also high in the Liloan area where high sediment loads are carried in and out of the bay through the narrow passage between the mainland and Panaon Island. Another contributing factor may be the impacts of landslides that occurred in this area just prior to the surveys. Very little sedimentation was observed around Limasawa Island where strong currents prevent it from settling.

Dead coral and algae-covered coral coverage was estimated at each survey site. This allows for comparisons to be made between sites in order to get an indication which reefs have undergone recent degradation by Crown of Thorns starfish, coral disease or bleaching or any other of the impacts. Recently killed coral typically gets covered with filamentous algae over a few weeks. The colony structure will then become degraded and break down into rubble over a period of about a year. Therefore, any areas where the coral structure is still intact but covered in algae are indicative of reefs that have died recently. Particular macro-algae thrive in polluted, nutrient rich waters where they out-compete the corals for light and space. When this happens a phase shift from a coral to an algae dominated community may occur. Areas with high algae coverage over a past coral substrate are a good indication of severe eutrophication or sedimentation within that area.

Figure 19 displays the coral reef areas within Sogod Bay that have been heavily impacted by direct or indirect human impacts. Most of the reefs highlighted are found in areas where human presence is high. Other reefs such as those around Limasawa Island may have been degraded by plagues of Crown of Thorn starfish.

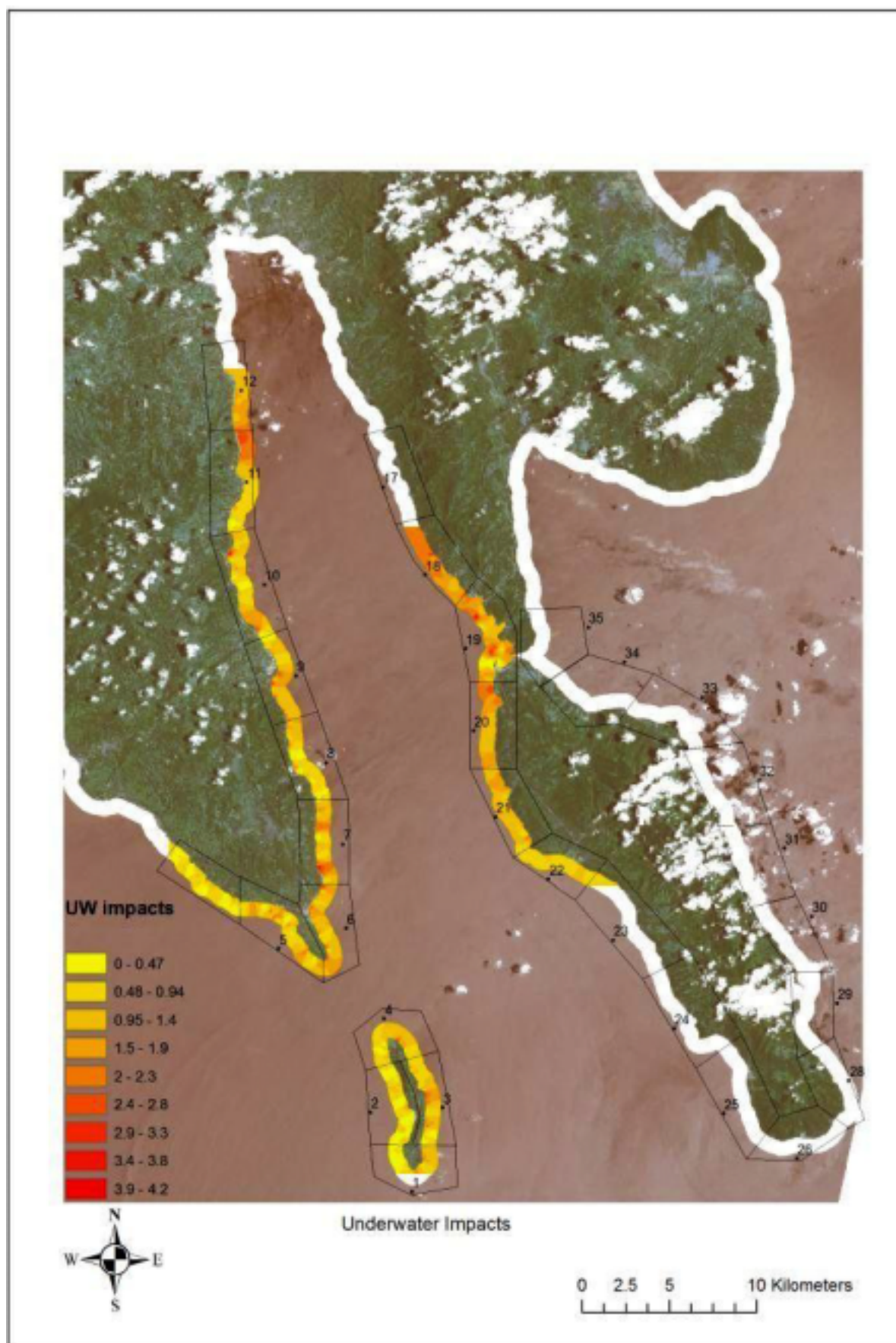


Figure 19 Underwater impacts around Sogod Bay, displayed as a colour ramp. Areas towards the red end of the spectrum have the highest value (i.e. most heavily impacted).

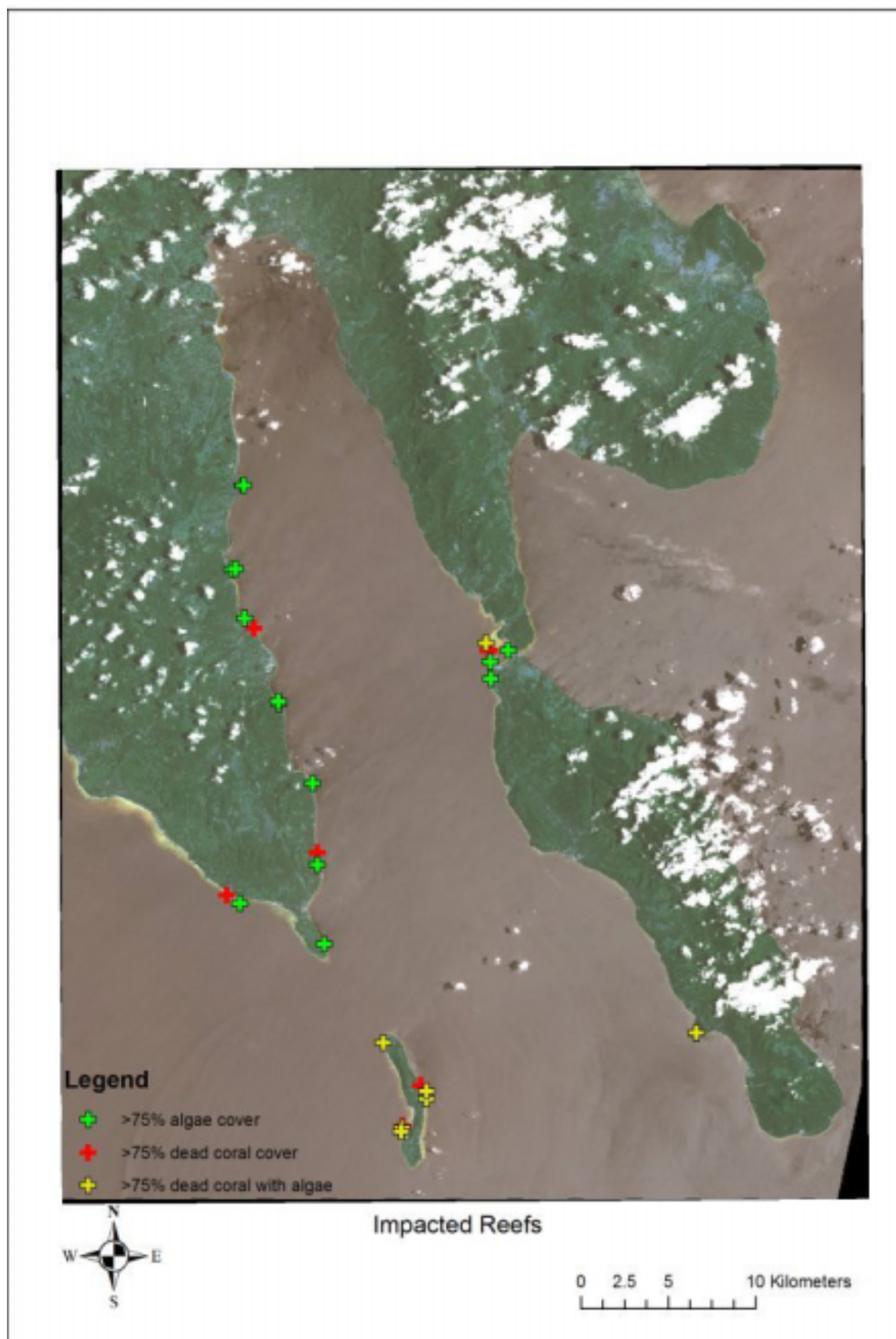


Figure 20 Survey sites that had significant coral damage and/or algae over-growth. Sites designated with a red, green or yellow cross had over 75% coverage of algae, dead coral or dead coral with algae resp.

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. However, little research has been conducted on the prevalence of coral diseases in this region. Therefore, CCC is currently monitoring the prevalence of two of the main coral diseases impacting reefs in Sogod Bay, Black Band Disease and White Syndrome. Results from these surveys will be presented in the next report.

Reliable and sufficient data for coral diseases was only available for regions 4, 5 and 8 (Figure 20) in this study. The same holds true for coral bleaching which poses a potentially far greater threat and has previously affected much of the Philippines' coral reefs, namely during the ENSO event of 1998 where severe coral bleaching was documented throughout the region. In Sogod Bay, coral diseases were generally uncommon, being observed on less than 6.3% of surveys conducted. 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 14-21% of surveys. No significant variation was found for bleached or diseased corals between regions (see G.A. Smith, 2007 for further information).

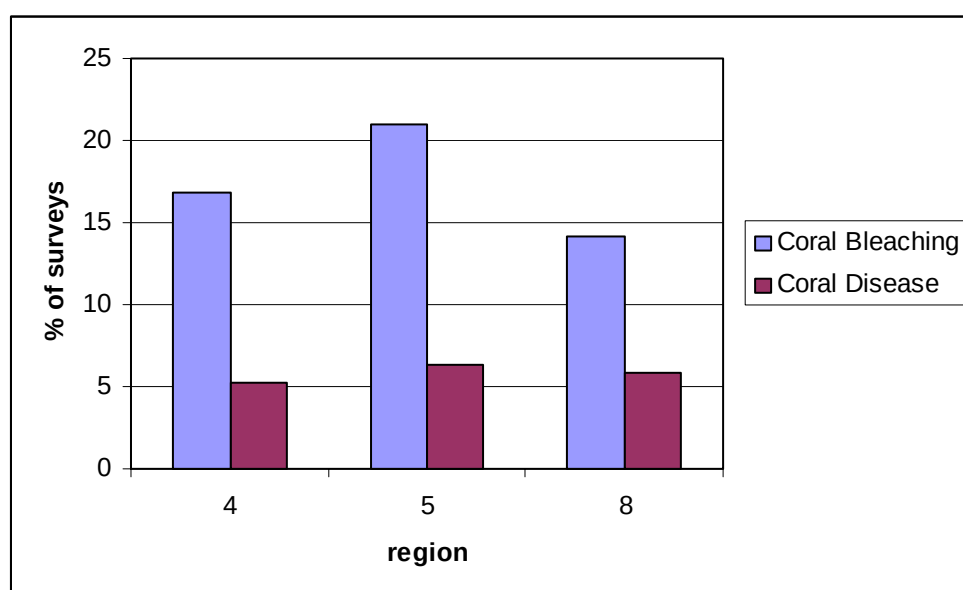


Figure 21 Coral disease and bleaching occurrences observed on surveys for 4 selected regions. Results given as a percentage of the surveys on which they were observed.

Site Impression

After each survey, a site impression was given, based on two arbitrary scores that were given to that particular reef. One was given for the aesthetic value of the area and one for the perceived biological value. The scores ranged from 'poor' to 'excellent'.

Two percent of the surveys found 'excellent' biological and aesthetic value on that particular site (Figure 21). Most sites were found to be 'average' (36 and 37% resp.). 29% of sites were found to be of poor aesthetic value. 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.

Figure 22 displays the biological value on a GIS map with values ranging from poor (0) to Excellent (5).

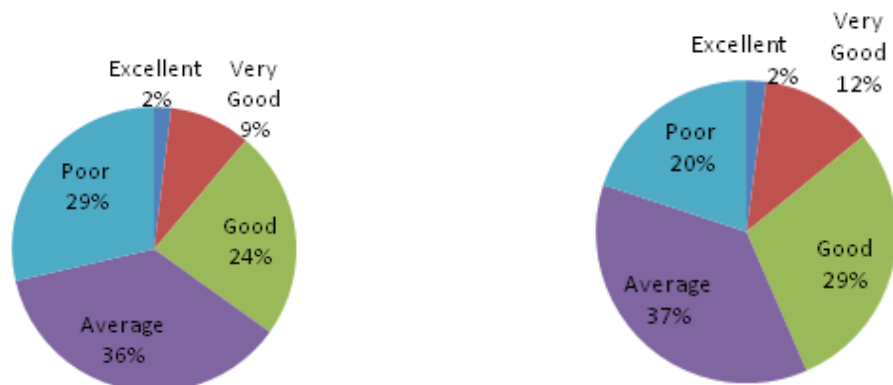


Figure 22 Biological value (above) and aesthetic value (below) for all surveys combined, as a percentage of the total scores given.

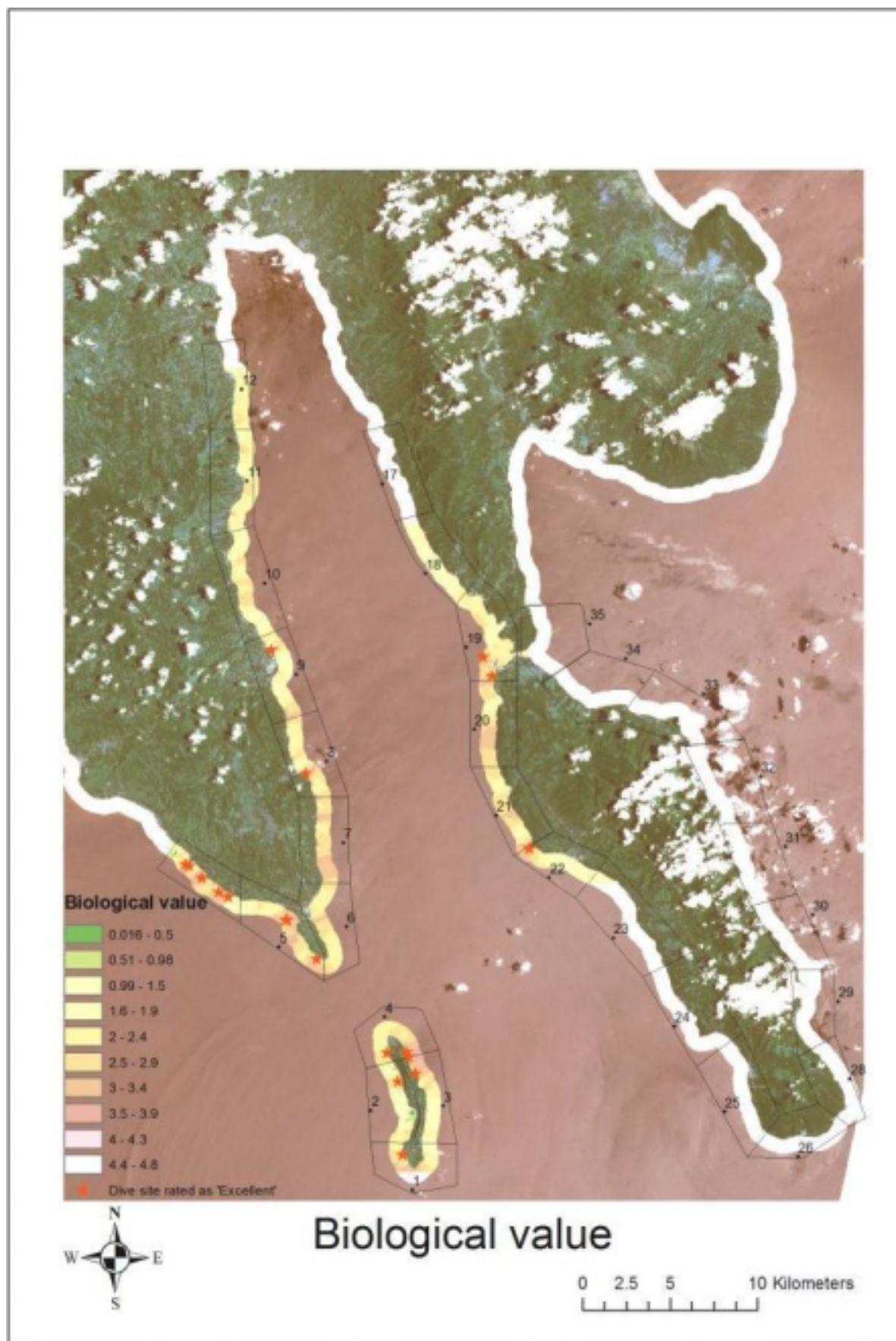


Figure 23 Biological value of survey sites around Sogod Bay, displayed as a colour ramp. Areas towards the lighter end of the spectrum have the highest value. Sites designated with a red star were rated as having 'excellent' aesthetic value.

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 23 shows this relationship for all the surveys analysed in this report.

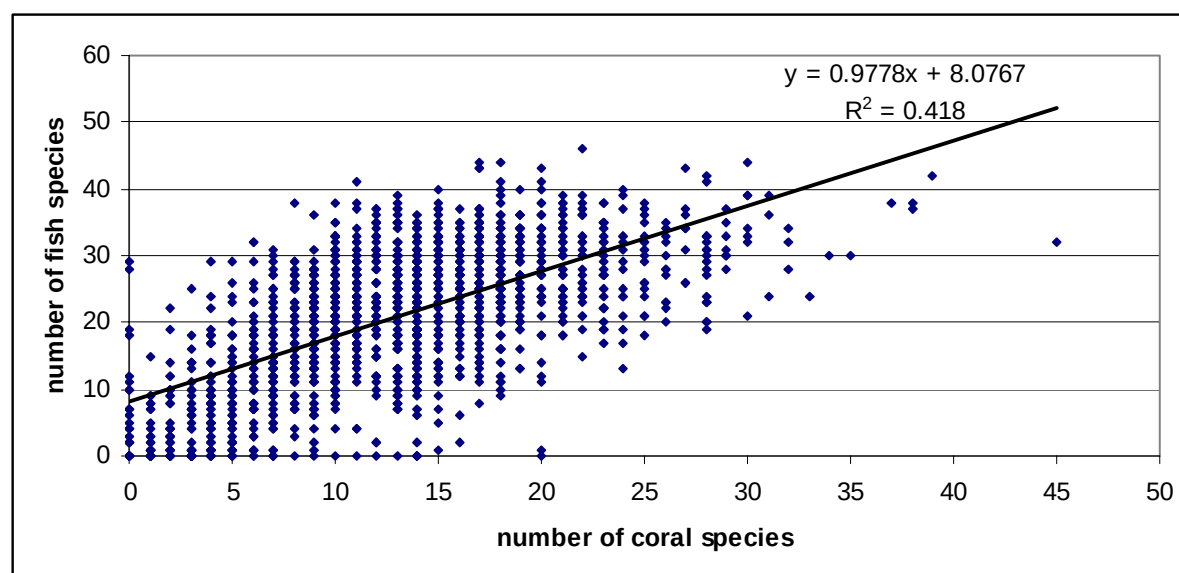


Figure 24 Regression plot for the number of coral species vs. number of fish species for all survey sites ($R^2 = 0.418$, $p < 0.000$).

Figure 24 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 and Padre Burgos harbour reefs with particularly high coral cover. Coral cover generally decreased towards the north of the bay.

Figure 25 displays soft coral cover around the bay on a GIS map. Soft corals are generally more abundant in the northern half of the bay 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 northeastern 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).

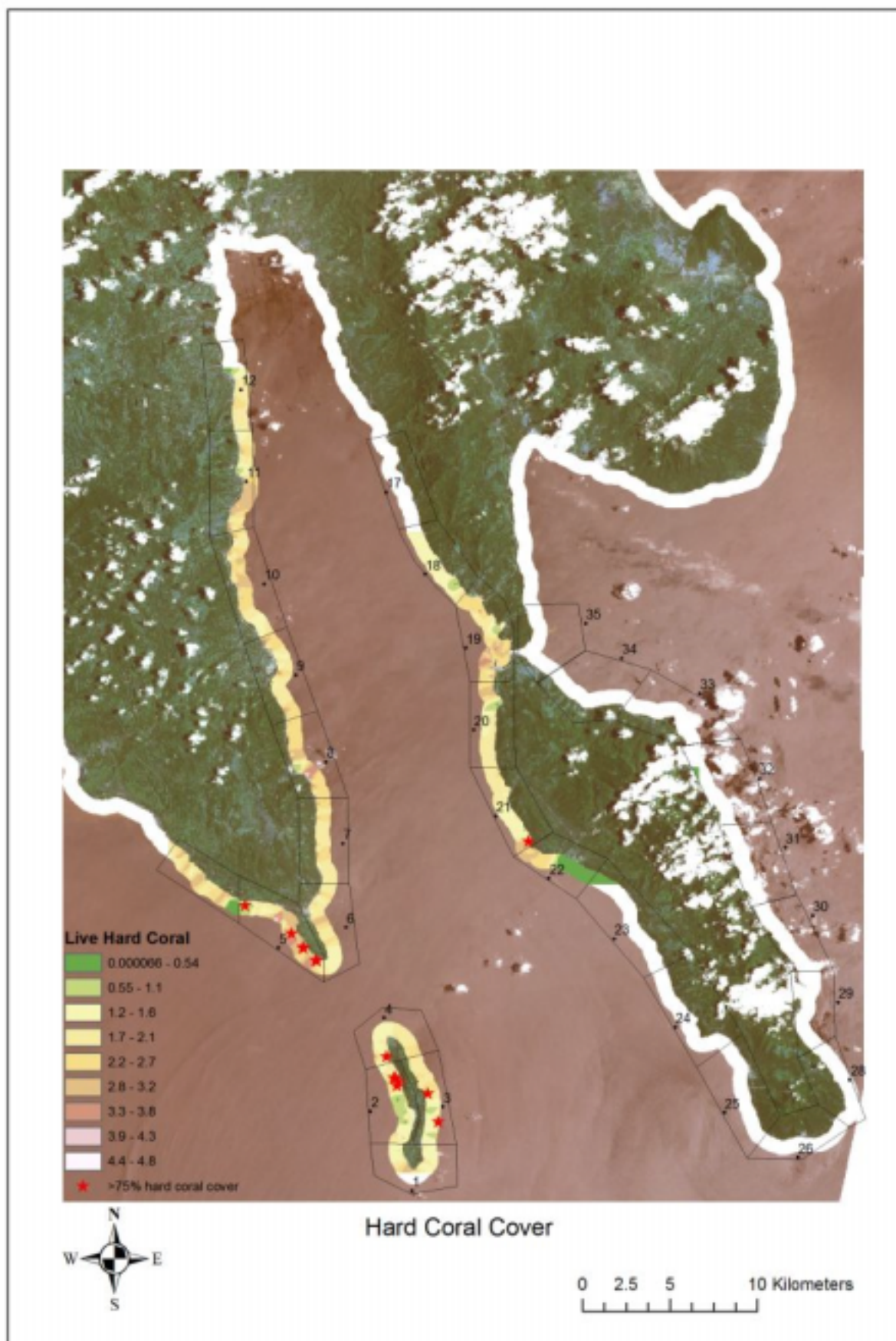


Figure 25 Hard coral cover on a DAFOR scale, displayed as a colour ramp. Areas towards the lighter end of the spectrum have the highest cover. Sites marked with a star had over 75% hard coral cover

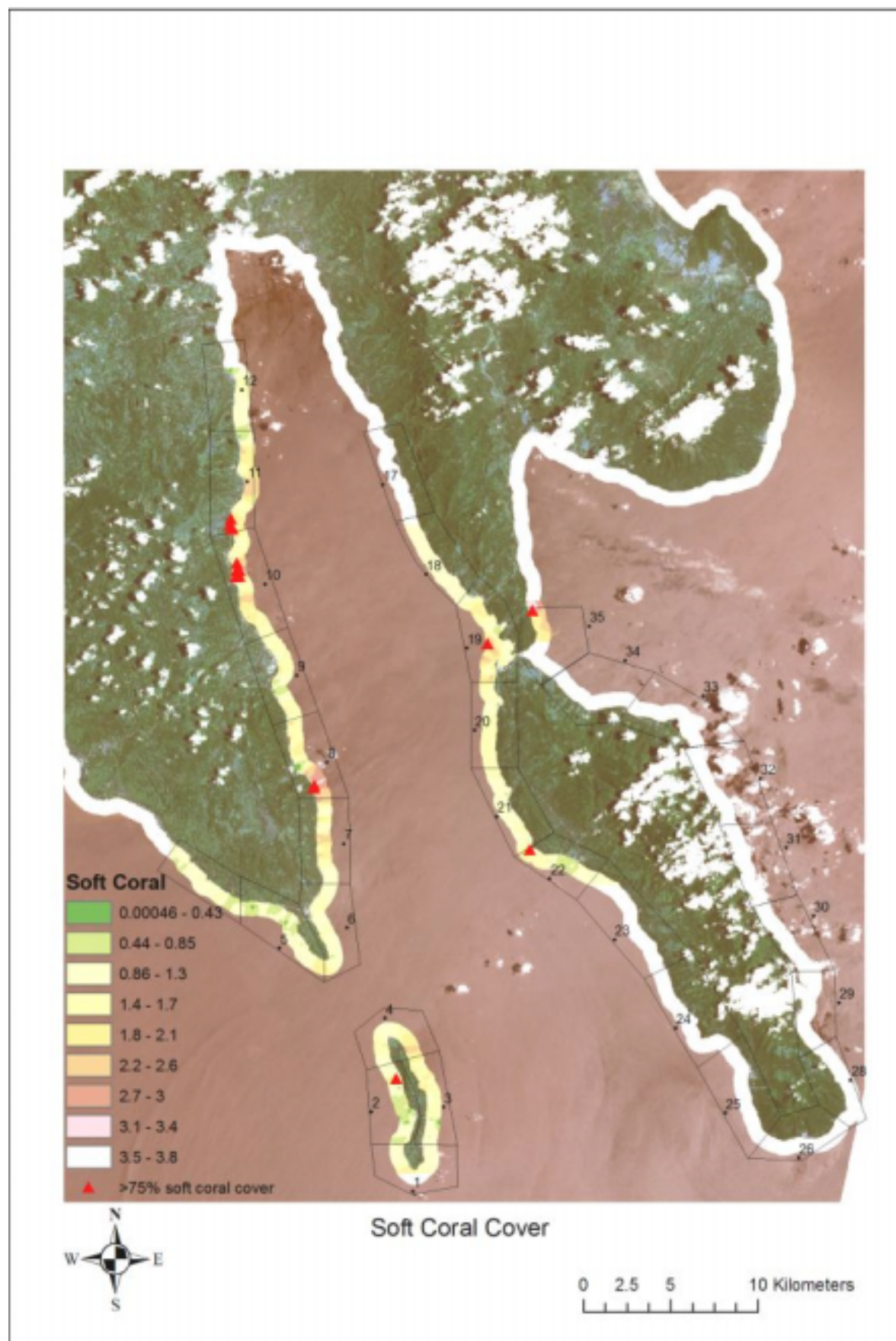


Figure 26 Soft coral cover on a DAFOR scale, displayed as a colour ramp. Areas towards the lighter end of the spectrum have the highest cover. Sites presented by a red triangle had over 75% soft coral cover.

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 (Tables 3 and 4 respectively). 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 54% 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 (78%, DAFOR 5). *Acropora* lifeforms (mainly 'branching' and 'tabulate') can dominate shallow-reef habitats and contribute significantly to overall hard coral cover. Rarer *Acropora* lifeforms (encrusting and digitate) were recorded on only 11% of the surveys. *Favia*, *Favites* and Massive *Porites* were recorded on over 70% of the surveys. *Pavona clavus* was the least abundant target coral species observed within the bay (4%, DAFOR 1).

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

Table 3 Most commonly recorded hard coral lifeforms in Sogod Bay

Coral Lifeform	Proportion of surveys recorded (%)	Maximum DAFOR value
Non-Acropora submassive	78	5
Non-Acropora encrusting	73	4
Non-Acropora branching	72	4
Acropora branching	70	5
Non-Acropora mushroom	70	4
Non-Acropora massive	69	5
Non-Acropora foliose	57	5
Acropora tabulate	52	4
Acropora bottlebrush	38	5
Acropora submassive	14	4
Acropora encrusting	11	3
Acropora digitate	11	3

Table 4 Most commonly recorded coral targets in Sogod Bay

Coral Species	Proportion of surveys recorded (%)	Maximum DAFOR value
<i>Favia spp.</i>	74	4
<i>Favites spp.</i>	72	4
<i>Porites spp.</i> (massive)	71	5
<i>Lobophyllia spp.</i>	67	3
<i>Galaxea spp.</i>	65	3
<i>Goniopora / Alveopora spp.</i>	58	5
<i>Seriatopora hystrix</i>	54	3
<i>Pocillopora damicornis</i>	44	3
Brain Coral (small)	42	3
<i>Diploastrea heliophora</i>	36	3
<i>Pocillopora spp.</i> (medium)	36	3
<i>Euphyllia spp.</i>	36	3
<i>Millepora spp.</i>	35	4
<i>Pectinia lactuca</i>	35	3
<i>Mycedium elephantotus</i>	34	3
<i>Echinopora spp.</i>	33	4
<i>Porites cylindrica</i>	33	4
<i>Herpolitha limax</i>	32	3
<i>Plerogyra</i>	31	3
Brain Coral (medium)	29	3
<i>Ctenactis echinata</i>	27	3
<i>Montipora spp.</i> (foliose)	27	3
<i>Pachyseris speciosa</i>	24	3
<i>Pachyseris rugosa</i>	23	3
<i>Porites nigrescens</i>	22	3
<i>Tubastrea micrantha</i>	18	3
Upsidedown bowl	18	3
<i>Hydnophora spp.</i>	17	3
<i>Turbinaria spp.</i>	16	3
Brain Coral (large)	15	3
<i>Porites rus</i>	15	2
<i>Tubipora spp.</i>	15	3
<i>Polyphyllia talpina</i>	11	2
<i>Pocillopora</i> (Large)	9	2
<i>Heliophora spp.</i>	9	2
<i>Pavona clavus</i>	4	1

Giant Clams (*Tridacna* spp.)

Giant clams (*Tridacna* spp.) are an important local food source and have been traditionally harvested for centuries. They are important reef filter feeders that contribute to the reef structure and rugosity. Populations of giant clams were highest outside of Sogod Bay in region 5 (Figure 26) where they were recorded on 21% of surveys. Limasawa Island (region 8) 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 (regions 3 and 4).

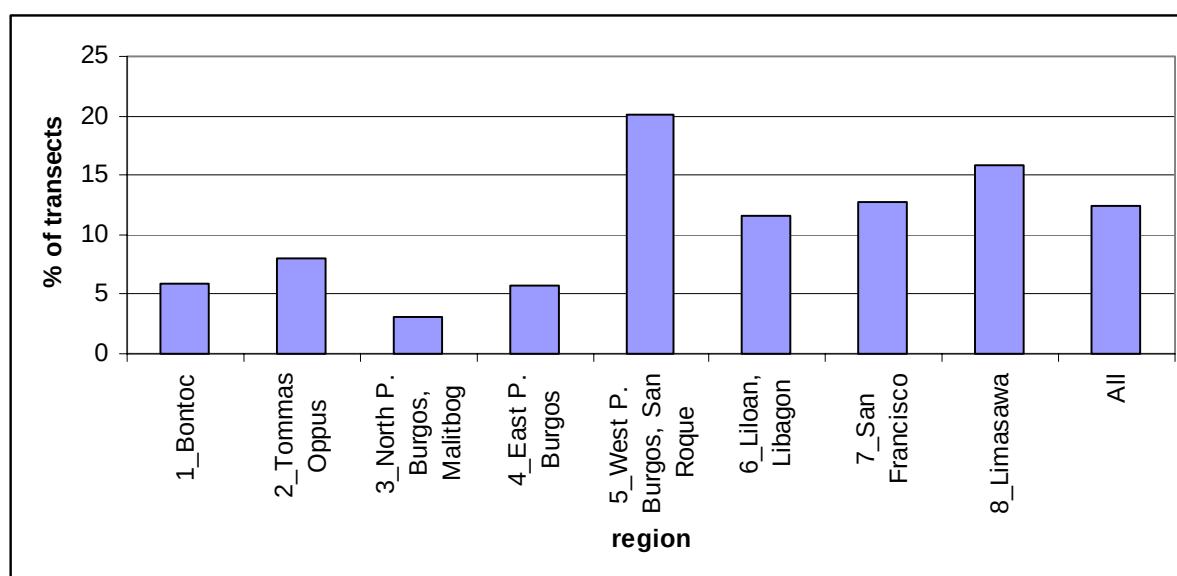


Figure 27 Giant clam (*Tridacna* spp.) abundance by region, expressed as a percentage of the number of transects in each region on which they were recorded. The last column shows the average for all regions.

Sea Urchins

Sea urchins were recorded in two categories, namely “short-spined” and “long-spined” (*Diadema* spp.). The latter is often used as an ecological indicator, with major population changes possibly highlighting shifts in the ecological balance of the ecosystem. Certain reef fish species (e.g. triggerfish) are known to feed on *Diadema* spp., which in turn graze on algae. Reduced populations of triggerfish may result in increased urchin populations and a shift in the ecological balance of the reef as algae becomes increasingly grazed. Likewise, a sudden decrease in *Diadema* populations may result in overgrowth by algae, outcompeting corals for light and space on the reef. *Diadema* urchins have been documented to aggregate in exposed or recently disturbed locations and as such, higher abundances of *Diadema* urchins may be indicative of reduced coral cover. Populations of *Diadema* urchins were found to be higher than other urchins in all regions (Figure 27), with the most frequent observations of both categories found in regions 1 (Bontoc) and 6 (Liloan/Libagon).

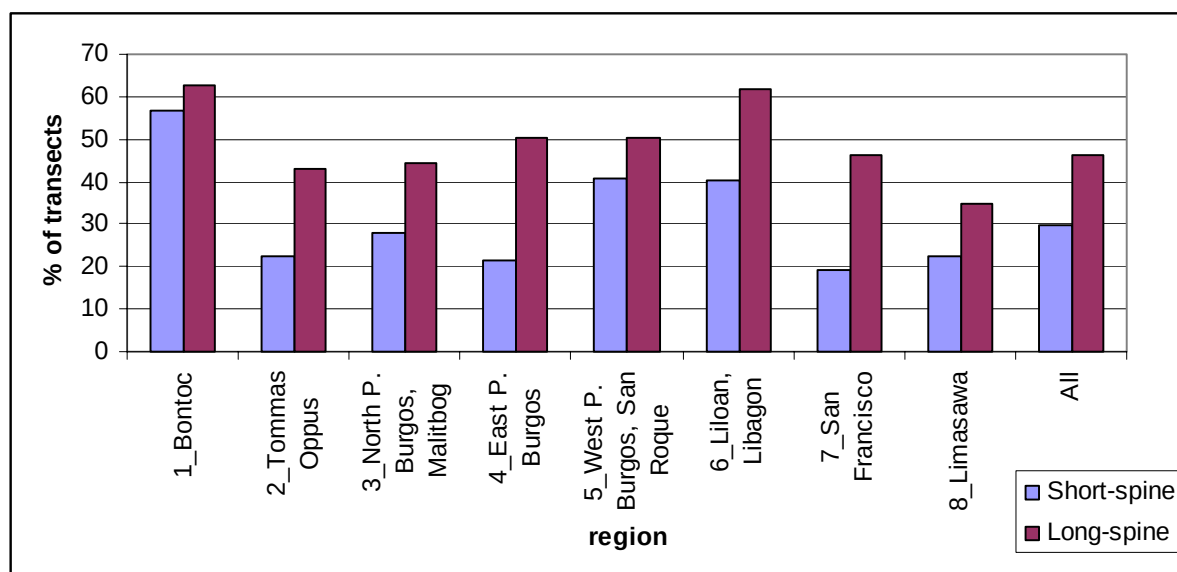


Figure 28 Sea urchin abundance by region, expressed as a percentage of the number of transects where they were recorded. The last two columns show the average for all regions.

Reef Gastropods

Certain gastropods are good indicators of reef health and are often overharvested by the curio trade. Conch shells and Cowries have been severely depleted throughout the world and were rarely encountered on surveys (Figure 28, <5% and <15% resp.). *Drupella* spp. feed on live hard coral and, together with Crown of Thorns starfish, can form a major threat to coral reefs when they reach unusually high numbers. *Drupella* spp. were a common sighting throughout region 5, observed on over 50% of surveys. The high presence of *Drupella* shells is likely to be related to the high coral cover within this region. They may be having a significant impact on coral reef health (G.A. Smith, 2007).

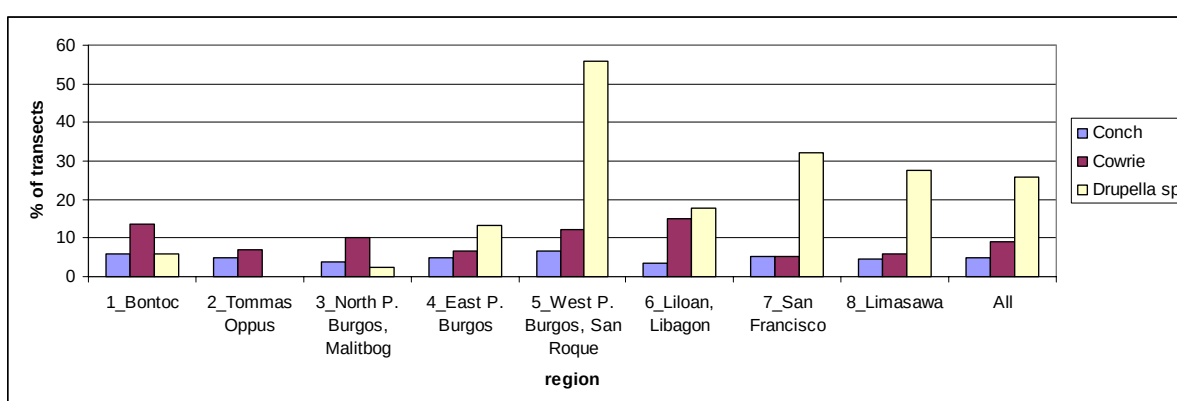


Figure 29 Abundance of three selected gastropods by region. The last column shows the average for all regions.

Macro-algae

In this analysis, emphasis has been placed on algae that are thought to be nutrient-indicators, such as brown “fleshy” algae. *Halimeda* spp. are an exception as they have a calcareous structure which helps to ‘cement’ the reef. Although not actually algae, cyanobacteria (a.k.a. blue-green ‘algae’) have been included in this section, as most of them

respond in a similar manner to macroalgae in terms of environmental conditions that promote/inhibit their growth. Cyanobacteria were the most commonly encountered taxon in this group, recorded on 64% of all transects (Figure 29). The next most common algae were *Dictyota* spp. (45%), green filamentous algae (33%), and *Padina* spp. (22%). All survey regions displayed high levels of nutrient indicator algae.

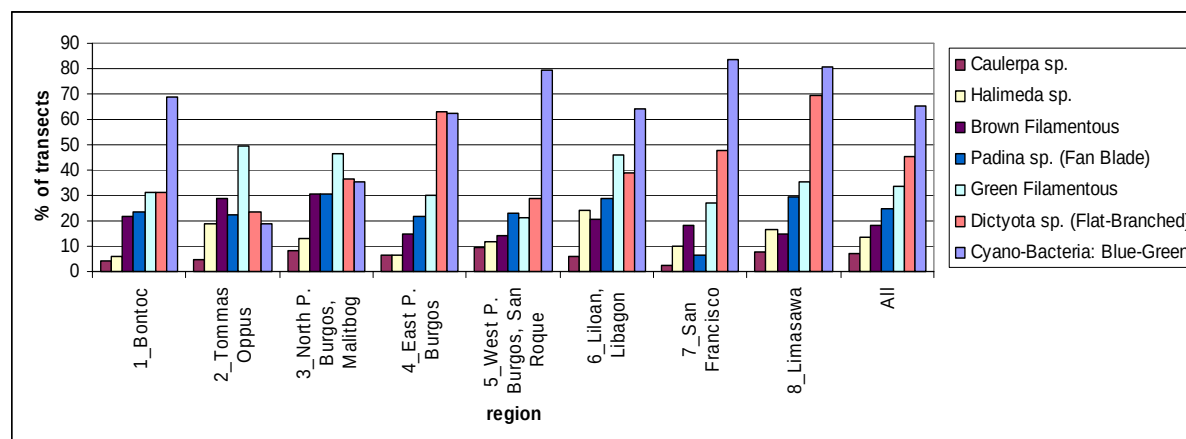


Figure 30 Abundance of selected macro-algae by region. The last column shows the average for all regions.

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. Commercially targeted families such as Snappers (Lutjanidae), Groupers (Serranidae) 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.

Butterflyfish (Chaetodontidae)

Butterflyfish are obligate corallivores, making them good indicators of reef health. A high abundance and diversity of Butterflyfish species is usually associated with a diverse reef. The eastern side of Sogod Bay and Limasawa saw a relatively high abundance of Butterflyfish (Figure 30). Over 50% of the surveys conducted around Liloan and Libagon (region 6) and 38% and 36% of the surveys in San Francisco and Limasawa (region 7 and 8 resp.) found this family present within the survey area. The abundance of Butterflyfish in these areas is more likely to be an indicator of lower pressure from small-scale, artisanal fisheries rather than better reef health. Figure 31 shows a GIS map of Butterflyfish density

throughout Sogod Bay. Butterflyfish density was found to be closely related to coral cover.

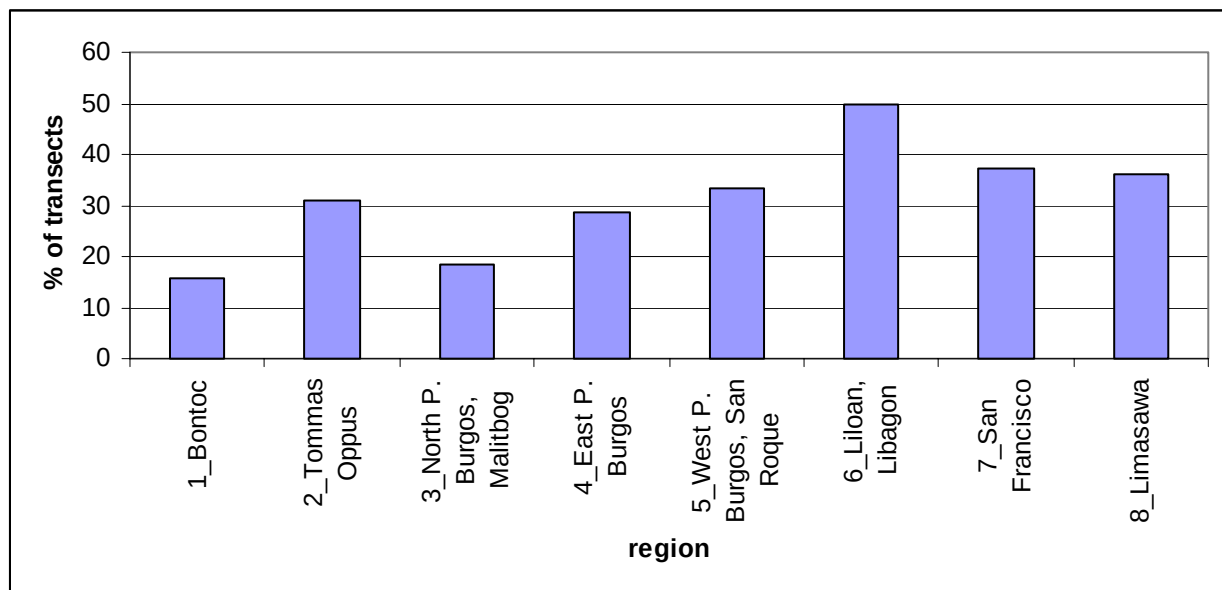


Figure 31 Abundance of Butterflyfish, expressed as a percentage of the number of transects in each region on which they were recorded

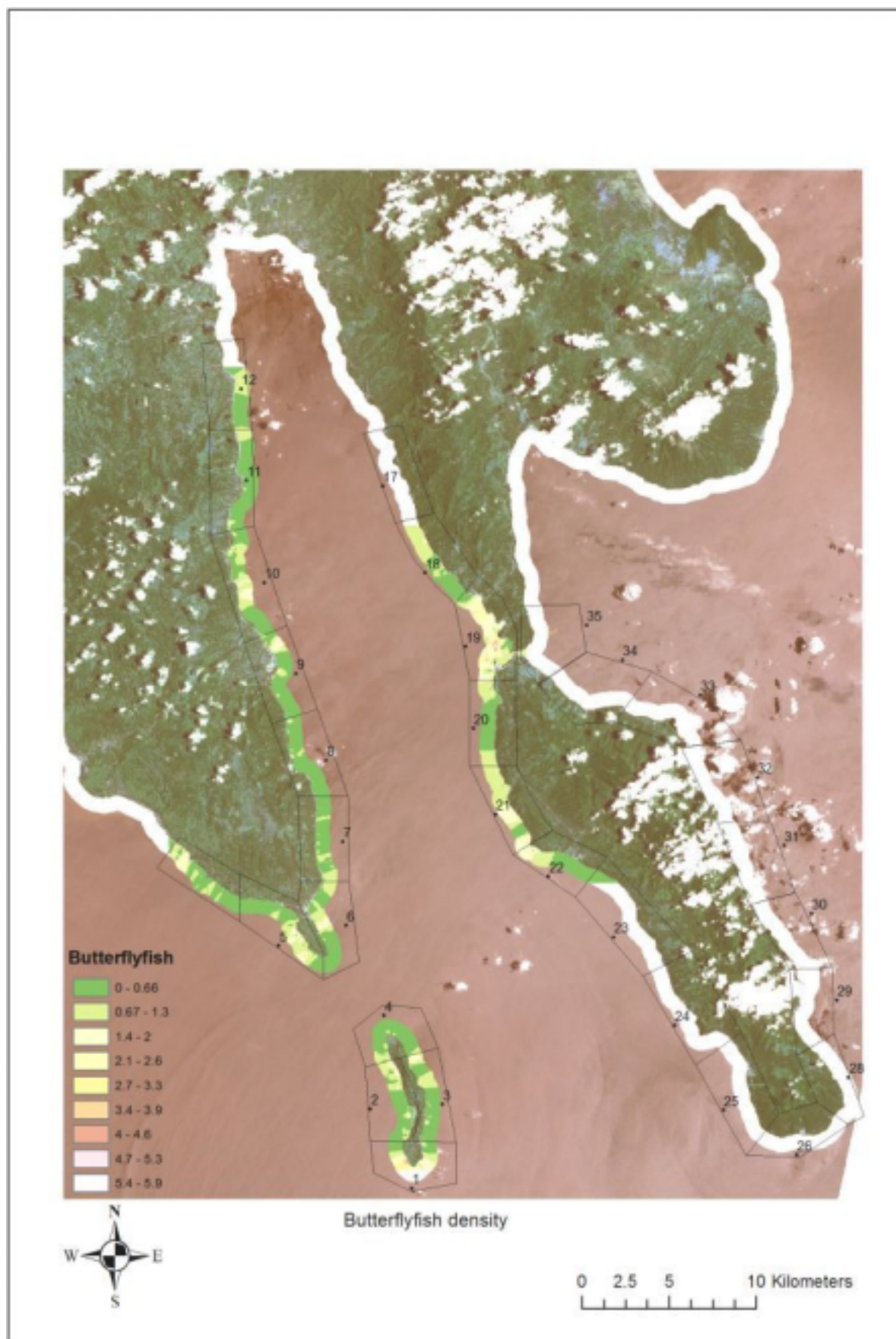


Figure 32 Abundance of Butterflyfish on a DAFOR scale, displayed as a colour ramp. Areas towards the lighter end of the spectrum have the highest abundance.

Groupers (Serranidae)

Groupers are commercially important and very popular food fish all over the world. At a late age (5-7 years), they spawn in aggregations and are extremely vulnerable to over-exploitation. Spawning occurs in large aggregations in order to optimize fertilisation, minimise egg predation, facilitate dispersal and maximise recruitment. The effects of fishing tend to reduce the abundance of the target species, lower their average size and modify their species composition (Van't Hof, 2001) by selectively removing larger individuals due to an ever-increasing requirement for the export of these fish. Many researchers believe that it is not possible to fish for Grouper at a rate that is both ecologically sustainable and commercially viable, although some successes have been achieved in by aquaculture. Grouper sightings were extremely low on reefs throughout Sogod Bay. They were rarely observed on transects area and are known to be wary of divers, hiding in the reef or swimming away. Records of groupers were generally low across all regions and habitats. Surprisingly, survey regions in the north of Sogod Bay had the highest recorded densities of groupers (Figure 32). 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.

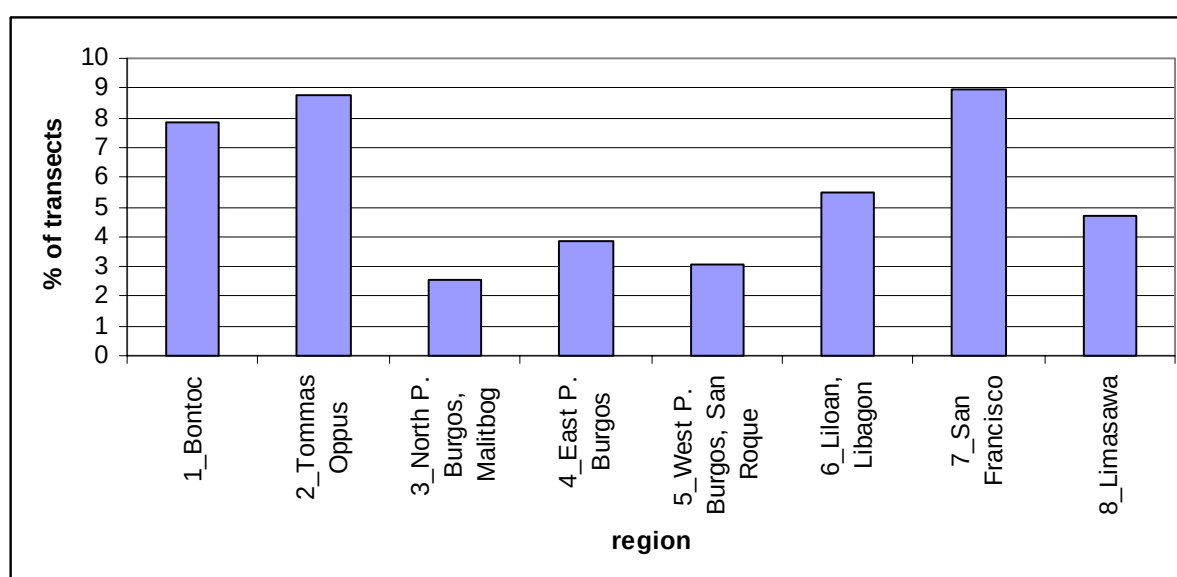


Figure 33 Abundance of Groupers, expressed as a percentage of the number of transects in each region on which they were recorded

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%), but sightings were especially low in Bontoc (region 1, 4%). They were most abundant around Ampo and San Roque (region 5) and San Francisco (region 7) where they were sighted on 13 and 14% of surveys respectively (Figure 33).

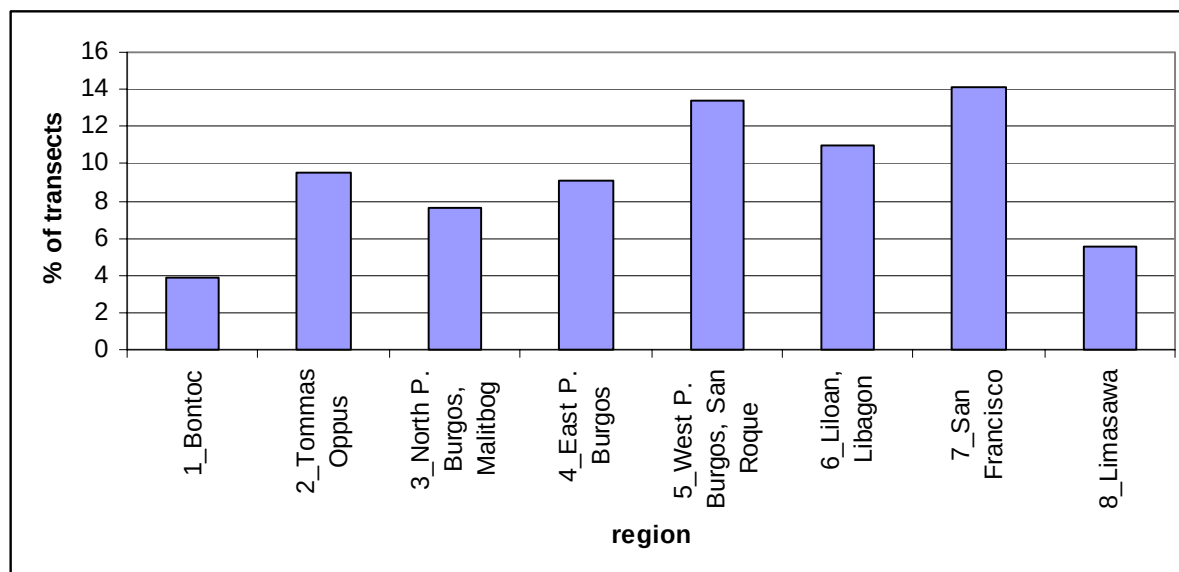


Figure 34 Abundance of Snappers, expressed as a percentage of the number of transects in each region on which they were recorded

Figure 34 displays the abundance of commercially targeted predatory fish (Snappers, Groupers, Jacks/Trevally, Emperors, Mackerel and Barracuda) around the bay on a GIS map using a colour ramp. Predatory fish are most commonly found near or inside MPAs (Lungsodaan, Napantao and Liloan, Bontoc, Tommas Oppus) and areas of high coral cover (San Roque, Limasawa and Bunga).

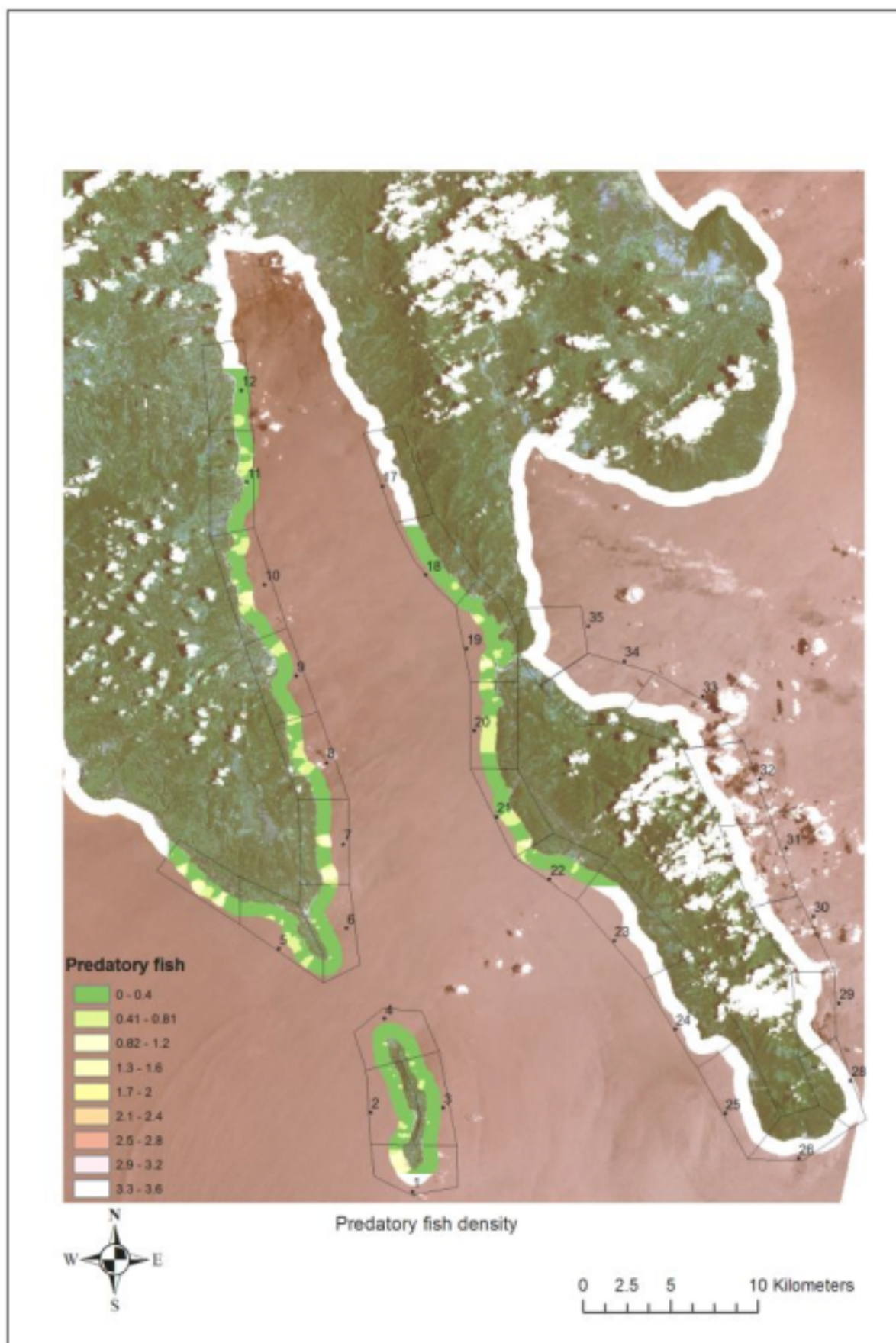


Figure 35 Abundance of predatory fish on a DAFOR scale, displayed as a colour ramp. Areas towards the lighter end of the spectrum have the highest abundance.

Parrotfish (Scaridae)

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

Limasawa (region 8) had a relatively high abundance of Parrotfish with individuals recorded on 33% of transects surveyed (Figure 35). Surveys completed around Padre Burgos (regions 5 and 6) where coral cover was generally highest in the bay also revealed a higher abundance of Parrotfish. The regions in the north of the bay had considerably lower abundance with Parrotfish, recorded on less than 10% of the transects.

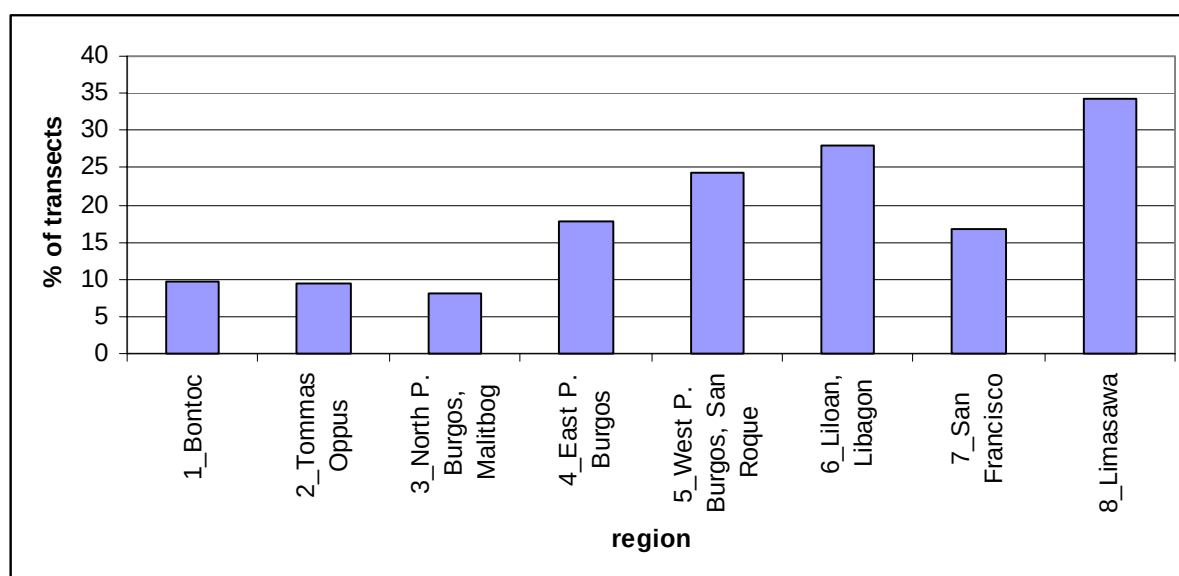


Figure 36 Abundance of Parrotfish, expressed as a percentage of the number of transects in each region on which they were recorded

Figure 36 displays the abundance of herbivorous fish (Parrotfish and Surgeonfish, *Acanthuridae*) around the bay on a GIS map using a colour ramp. Herbivorous fish are most commonly found in varying numbers throughout the bay and are relatively more abundant around Liloan and the south of the bay, particularly so in San Roque, Burgos and Limasawa Island.

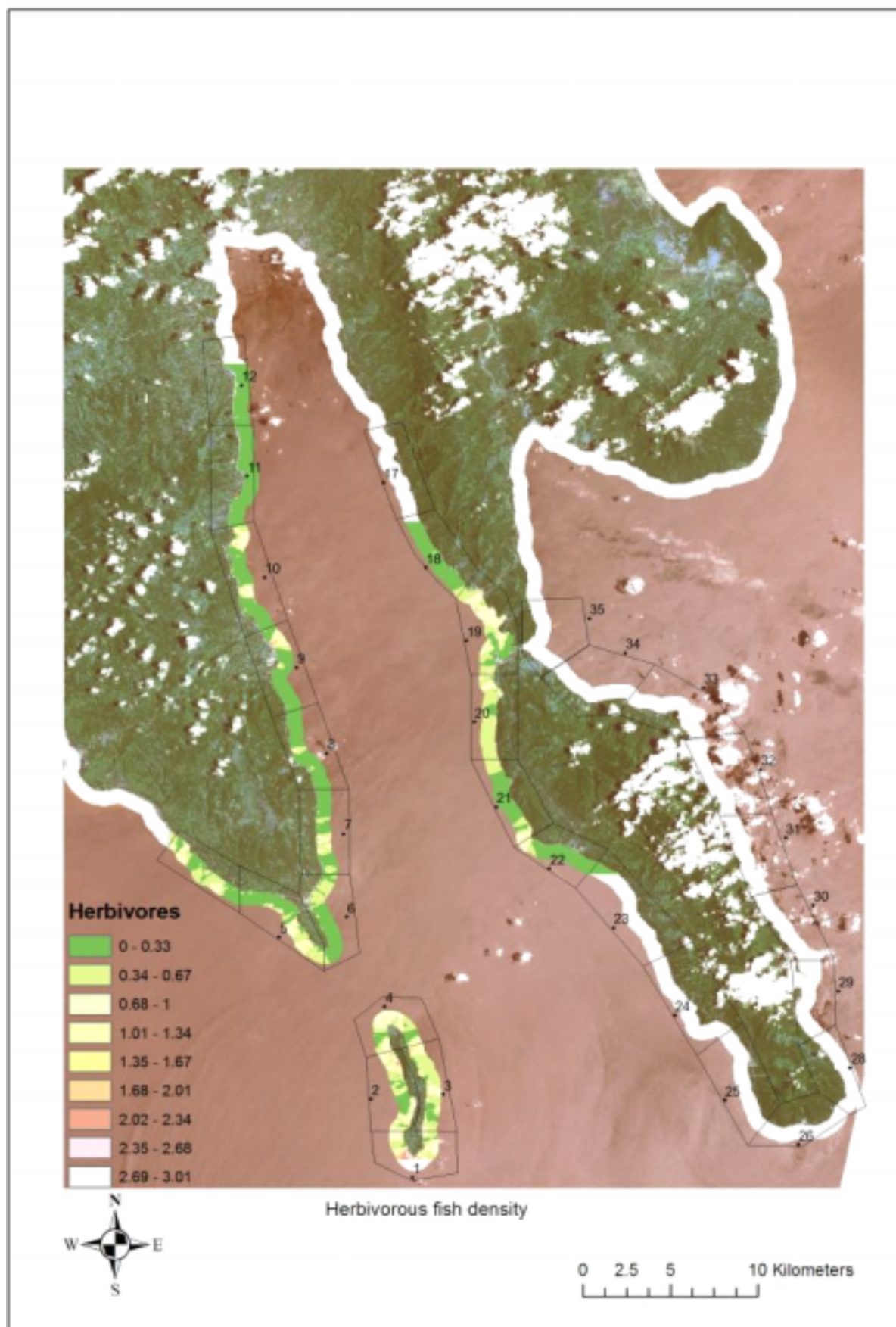


Figure 37 Abundance of herbivorous fish on a DAFOR scale, displayed as a colour ramp. Areas towards the lighter end of the spectrum have the highest abundance.

4.4 *Habitat Classification*

In order to allow for further comparison of survey sites, they must first be classified into distinct ecological units, or 'habitats'. Each variable in each survey record (the data from each site) is compared statistically against the same variable in every other survey record and the similarity between any two records is calculated using the Bray-Curtis Similarity Coefficient. This similarity is expressed as a percentage. Using the ecological analysis package, PRIMER (Plymouth Routines in Multivariate Ecological Research), the survey records are then ranked by these similarities to produce natural groupings or 'clusters' from the data (Table 5). SIMPER is then used to define the key characteristics of each cluster. To date, 9 discrete ecological habitats have been defined for the Sogod Bay area. A summary of these is presented in Table 6.

Table 5 PRIMER Hierarchical Cluster Analysis output, coloured to show the discreet ecological habitat clusters, as defined from a random sample (n=300) of the survey data. Each vertical line within each cluster represents an individual survey site

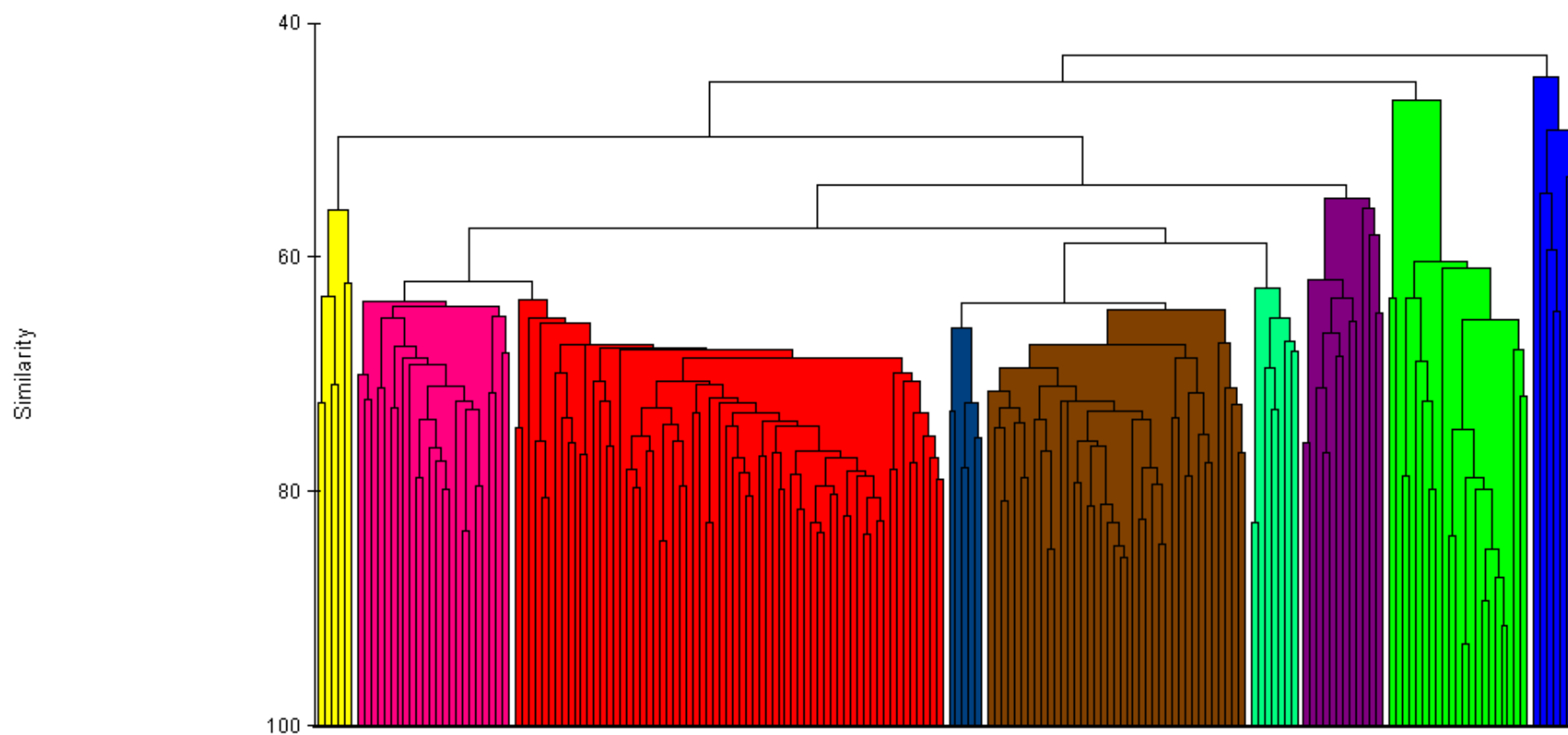


Table 6 Major characteristics of the benthic classes defined from baseline data collected in shallow coastal waters of Sogod Bay. Figures in parentheses indicate average abundances in accordance with DAFOR ratings assigned during surveys.

Habitat	No of Site Records	Average Depth (m)	Dominant Substrata	Hard Corals	Soft Corals	Sponge	Algae / Seagrass	Avg No of Benthic Spp	Avg no of Fish Spp	Avg Shannon Weiner Diversity Index (Benthic)	Avg Shannon Weiner Diversity Index (Fish)
Deep reefs with mixed biotic communities	40	17	Hard coral (3.5), Sand (3.0), Soft Coral, Sponge, Algae (2.0)	*A Branching (2.5), A Bottlebrush (2.0), NA Encrusting, NA Mushroom (2.0)	Pulsing, Tree, Flower Leather (1.0)	Encrusting (1.5)	Algae (2.0), Dictyota (1.0)	60	23	3.35	2.40
Deep patch reefs	342	19	Hard Coral (2.0), Sand (3.0)	NA Massive, NA Encrusting (1.0), Favia, Favites (1.0)	Total (1.0)	Total (1.0) Encrusting (1.0)	Algae (1.0) Cyanobacteria (1.0)	40	20	3.42	2.28
Mid-depth patch reef with mixed biotic communities	78	14	Sand (3.5), Hard Coral, Soft Coral (2.0)	A Branching (1.0), NA Massive, Branching, Sub-massive (1.0), Massive Porites (1.0)	Leather, Tree Coral (1.0)	Total (1.5)	Algae (1.5)	45	21	3.39	2.19
Deep sparse patch reef	222	19	Sand (3.5), Algae (1.5)	Total (1.5)	Total (1.0)	Total (1.0)	Encrusting Coralline (0.5), Dictyota (0.5)	23	13	2.64	1.72
Mid-depth dense reef	430	9	Hard Coral (3.0)	A Branching, A Tabulate (1.0), Massive Porites, Favia, Favites, Lobophyllia, Galaxea (1.0)	Total (1.5) Tree, Pulsing (1.0)	Total (1.0) Encrusting, Lumpy (1.0)	Total (1.5) Encrusting Coralline, Cyanobacteria (1.0), Dictyota (0.5)	58	29	3.77	2.58

Shallow sparse patch reef and bedrock	215	6	Sand (2.0), Bedrock (2.0), Hard Coral (2.0)	NA Encrusting, NA Sub-massive (1.0), Massive Porites (1.0)	Total (1.0)	Total (1.0) Encrusting (1.0)	Algae (1.5) Cyanobacteri a (1.0)	48	26	3.58	2.46
Shallow dense reef	14	7	Hard Coral, Sand (3.0)	A Tabulate, A Branching (1.0), NA Sub-massive (2.0), Massive Porites (2.0)	Total (1.5)	Total (1.5)	Total (2.0) Padina (1.0) Algae (1.5)	54	27	3.30	2.33
Sand and mud bottom	73	10	Sand (3.0), Mud (2.0)	Total (1.0)	Total (1.0)	Total (0.5)	Cyanobacteri a (1.0) Seagrass (0.5)	20	10	2.34	1.36
Shallow sand and seagrass beds	67	3	Algae, Sand, Mud (2.0)	Total (1.5)	Total (1.0)	Total (1.0)	Seagrass (1.0)	28	14	2.84	1.78
*A = Acropora corals, NA = Non-acropora corals											

4.5 Conservation Management Values

Using five ecological indices, comparisons between site records can now be made in order to highlight key areas of ecological importance. The indices used are the site record values for live hard coral cover, the total number of benthic targets (not including algae), total number of reef fish targets, the Shannon-Weiner Biodiversity Indices for both benthic and reef fish targets.

Firstly, an inter-habitat analysis is made to determine the ecological 'value' of each habitat relative to the others. To do this, the average value for each of the 5 indices is calculated for each habitat, and these values are then used to determine the overall averages for each index across all habitats. The habitats are then compared against these overall averages to determine the number of indices in which each habitat is above or below the overall average. If, for example, a habitat 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).

Secondly, an intra-habitat analysis is conducted. Each site record in each habitat is compared against the other site records within that habitat, to determine which sites are the most ecologically 'valuable' examples for their particular habitat. The same system is used to calculate this, with site records scoring values of 0-5. To calculate the Conservation Management Value (CMV) of each site, the inter-habitat value is multiplied by the intra-habitat value, producing scores on a scale of 0 to 25. For example, a poor site record (e.g. one that scored a 2) from a good habitat type (e.g. one that scored a 5) would score an overall CMV of 10, whereas an excellent site record (e.g. one that scored a 5) from that habitat would score an overall CMV of 25.

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. In the GIS output (Figure 37), the colour green represents areas where lower CMVs are dominant; areas towards the lighter end of the spectrum represent areas where higher CMVs are dominant. Survey sectors 22 and 23 have relatively low CMV values due to the limited number of surveys conducted there thus far. As more surveys are conducted in these regions, a more accurate picture of the CMV's will develop.

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

Figure 38 displays MPAs which have been installed along the southern end of Sogod Bay and Limasawa Island. Ideally, additional MPAs need to be placed in areas that have high CMVs as well as protecting a variety of different habitats.

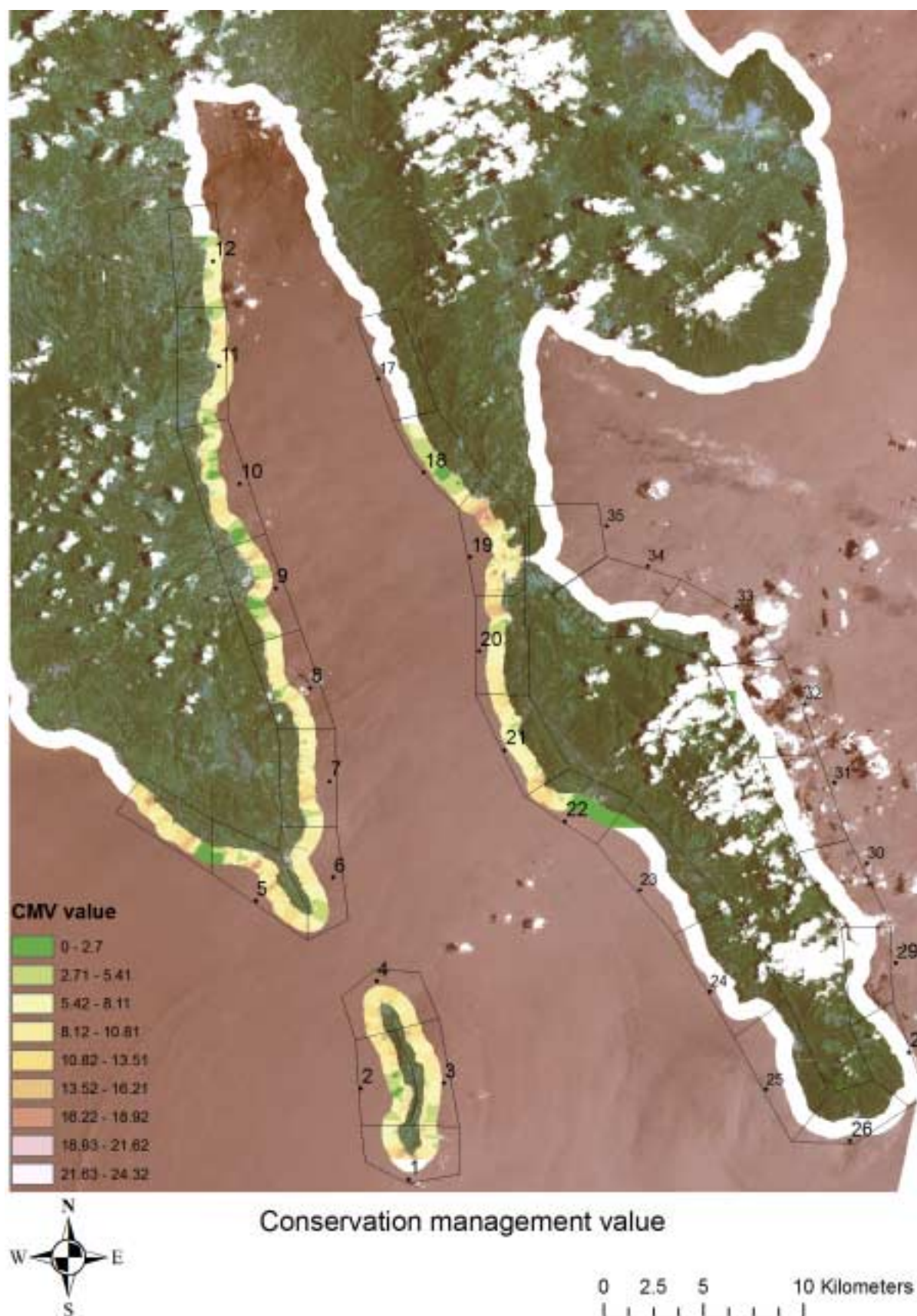


Figure 38 Conservation Management Values (CMVs) displayed as a colour ramp. Areas towards the lighter end of the spectrum have the highest CMVs.

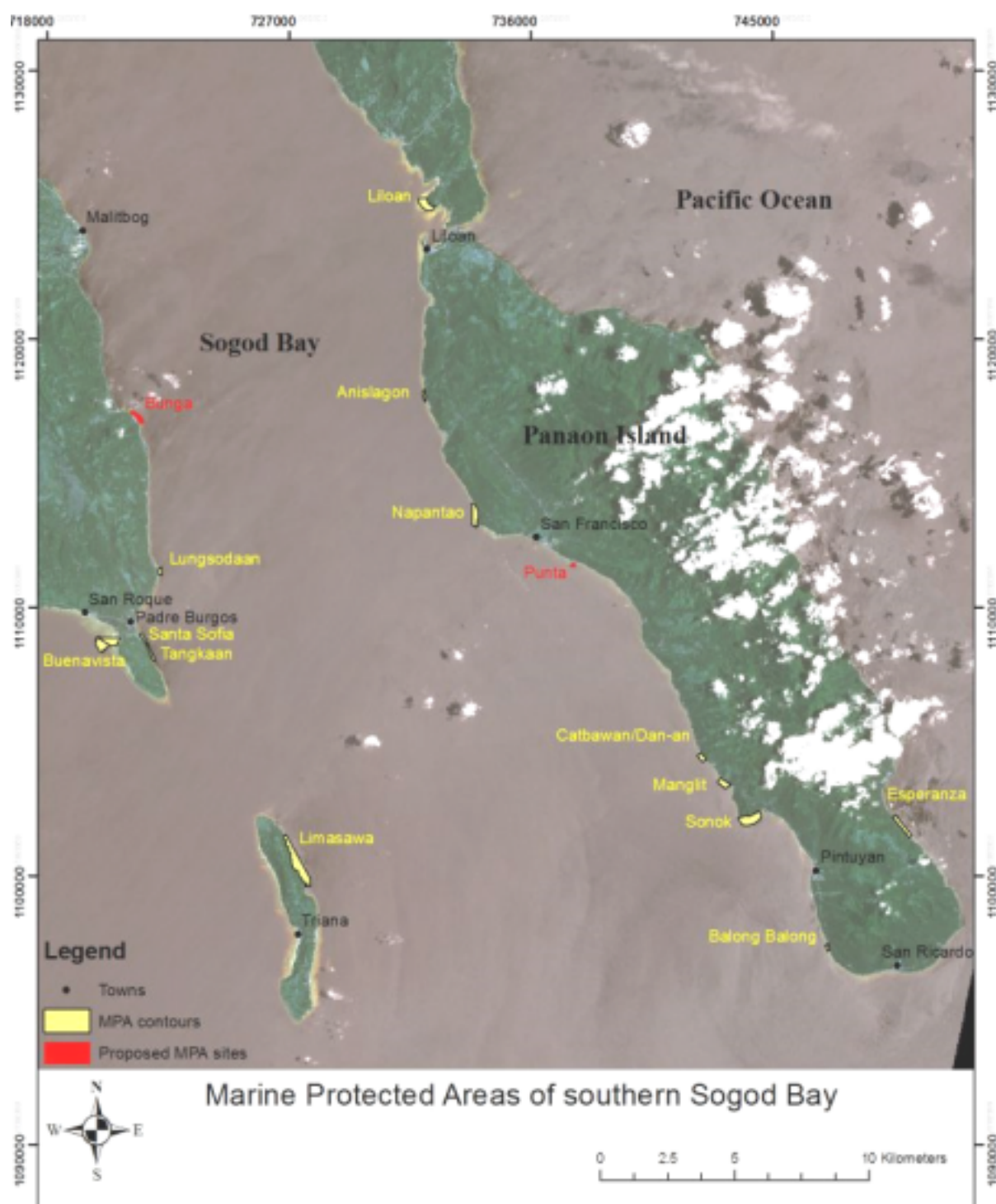


Figure 39 GIS map of current and proposed MPA locations in southern Sogod Bay.

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. 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.

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 barangay system means large MPAs would almost certainly be trans-boundary, leading to considerable political challenges in the management of such reserves. A notable and recent exception has been the installation of the Limawasa Island Marine Reserve that protects the coastal zone of two barangays. Regardless, the creation of a network of smaller MPAs throughout the bay is more appropriate ecologically and more achievable politically.

The map of CMVs (Figure 38) indicates that areas of moderate to high ecological value (light colours) are dispersed throughout the coastal zone of the bay. These areas are linked by larval dispersal for coral reef organisms, with water currents within the bay transporting larvae between healthy reef patches.

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

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.

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

The map of CMVs (Figure 37) indicates 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.

It was clear from conversations with the fisherfolk during the creation of the MPAs in Padre Burgos that most of the fisherfolk seem to feel that fish catches have dropped as a result of an unsustainable level of historical fishing. Indeed, most fisherfolk are dependent on other sources of income in addition to fishing in order to take care of their families (Heuër, A. 2008).

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 of its people.

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 upland agricultural and urban development must be managed if reefs are to retain their resilience and ability to absorb impacts of regional stressors. Sedimentation from land runoff can have devastating impacts to the health of fringing coral reefs that line the bay. The recent increase in coral disease prevalence is likely to be related to human-induced impacts from the land. It is 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.

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Appendix

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	
☐	Lagoon
☐	Backreef
☐	Reef Crest
☐	Forereef
☐	* Reef Front
☐	* Upper Reef Slope
☐	* Lower Reef Slope
☐	Escarpment ("wall")
☐	Dense Patch Reef
☐	Diffuse Patch Reef

UNDERWATER IMPACTS		IMPRESSION OF THE SITE	
LITTER	AESTHETIC	POOR	AVERAGE
SEWAGE	BIOLOGICAL	POOR	AVERAGE
CORAL DAMAGE			GOOD
LINES/ NETS			V. GOOD
FISH TRAPS			EXCELLENT
SEDIMENTATION			
DISEASE			
BLEACHING			
DYNAMITE			
OTHER			

GENERAL LOCATION
(SHORE REFERENCE)

TOPOGRAPHY

LOW	MEDIUM	HIGH
-----	--------	------

MAIN HABITATS

ORIENTATION

DISTANCE TRAVELLED m

APPROX DISTANCE REMAINING m

LATITUDE START:	07	LATITUDE END	07
LONGITUDE START:	1	LONGITUDE END	1

CURRENT STRENGTH	NONE	WEAK	MEDIUM	STRONG	WIND STRENGTH (BEAUFORT)	
CURRENT DIR (wards)	(N,NW etc.)				WIND DIR (deg)	
TEMPERATURE	AT DEPTH OF				SURFACE TEMPERATURE	
SALINITY	AT DEPTH OF				SURFACE SALINITY	
SECCHI						

SURFACE ACTIVITY

OCCUPANTS	PROXIMITY	ACTIVITY*

*FISHING
DIVING
PLEASURE
(COMMERCIAL)

SURFACE IMPACTS

LITTER
ALGAE
SEWAGE
NETS
DRIFTWOOD
OTHER

PHYSICAL	FIRST NAME	SURNAME	NO. SURVEYS
FISH			
CORAL			
ALGAE/INVS			

DATABASE INFO

ENTERED BY	
DATE	
LOGGED?	
CHECKED BY	
DATE	

HABITAT FORM

HABITATE CODE		TOTAL HABITATS		DIVEDATE	
HABITAT NO		HABITAT COVERAGE (%)		START TIME	
				END TIME	

START DEPTH	
END DEPTH	
HORIZONTAL VISIBILITY	

Geomorphical Classes

Remember: each new zone is a new habitat, so requires a new biological recording form for each.

tick

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

SUBSTRATUM COVER

BEDROCK		Any exposed area of hard, bare substratum without visible corallite structures
DEAD CORAL WITH ALGAE		Dead coral with visible corallite structures and/or lifeform covered in algae
DEAD CORAL		Bare dead coral with visible corallite structures and/or lifeform not covered in algae
RUBBLE		Any area of unconsolidated, loose bedrock or hard substratum (eg. Old coral fragments)
SAND		Coarse sediment (diameter >1mm). "Grainy" when disturbed
MUD		Fine sediment (diameter <1mm). "Milky" when disturbed

BIOLOGICAL COVER

LIVE HARD CORAL		Total hard corals, including both target and non-target lifeforms
SOFT CORAL		
SPONGES		
OTHER INVERTEBRATES		Other Cnidarians, Arthropods, Molluscs, Annelids, Echinoderms
ALGAE		Green, Brown, and Red algae, not including blue/green 'algae'
SEAGRASS		
MANGROVES		

SUBSTRATE TYPES**COMMENTS**

(coral,fish,invs,algae)

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

TARGET FISH								
<u>Butterflyfish</u>	540	☐	<u>Wrasse</u>	598	☐	<u>Rabbitfish</u>	579	☐
(Big) Long-Nosed	752	☐	Diana's hogfish	931	☐	Foxface	757	☐
Klein's	651	☐	Mesothorax hogfish	611	☐	Virgate	630	☐
Vagabond	541	☐	Humphead	600	☐			
Pyramid	750	☐	Red-banded	932	☐	<u>Dartfish</u>	774	☐
Eastern Triangle	783	☐	Checkerboard	725	☐	Blackfin	695	☐
Latticed	681	☐	Twotone	768	☐			
Redfin	760	☐	Crescent	647	☐	<u>Cardinalfish</u>	621	☐
Orange-banded Coral fish	923	☐	Cigar	685	☐	Pajama	917	☐
Copper-banded	947	☐	Bird	610	☐			
Humphead Bannerfish	669	☐	Cleaner	605	☐	<u>Puffer</u>	635	☐
						Blackspotted	652	☐
<u>Angelfish</u>	544	☐	<u>Goatfish</u>	615	☐			
Regal	663	☐	Half-and-half	648	☐	<u>Goby</u>	749	☐
Bicolour	673	☐	Dash-and-dot	781	☐	Sphynx	954	☐
Pearlscale	545	☐	Blackstriped	616	☐	Brownbarred	955	☐
Emperor	756	☐						
Blue-girdled	937	☐	<u>Triggerfish</u>	624	☐	OTHER MAJOR FAMILIES		
			Orangestriped	625	☐	Anthias	642	☐
<u>Surgeonfish</u>	546	☐	Clown	626	☐	Jack / Trevally	553	☐
Convict	547	☐	Blackbelly Picassofish	927	☐	Sweetlips	577	☐
Ringtail' spp.	548	☐	Scythe	692	☐	Barracuda	560	☐
Brushtail tang	638	☐	Picasso	628	☐	Moorish Idol	551	☐
Unicorn spp.	550	☐	Moustache / Titan	623	☐	Emperor	924	☐
			<u>Groupers</u>	583	☐	Spadefish / Batfish	595	☐
<u>Tuna/ Mackerel</u>	940	☐	Flagtail	682	☐	Porcupine	634	☐
Narrow-banded king mackere	558	☐	Peacock	935	☐	Toby	636	☐
			Humpback	936	☐	Trunk / Box / Cowfish	640	☐
<u>Fusilier</u>	571	☐	"Honeycomb" sp.	586	☐	Blenny	926	☐
"Blue and yellow" sp.	929	☐	Lyretail	946	☐	Sweeper	689	☐
Bluestreak	930	☐				Squirrelfish / Soldierfish	619	☐
			<u>Parrot Fish</u>	613	☐	Filefish	629	☐
<u>Damselfish</u>	589	☐	Bumphead	933	☐	Lionfish	631	☐
Blue-Green Chromis	596	☐				Scorpionfish / Stonefish	632	☐
Black Bar Chromis	646	☐	<u>Spinecheek</u>	581	☐	Lizardfish	643	☐
Other "Chromis" sp.	590	☐	Twoline	582	☐	Hawkfish	902	☐
Threespot dascyllus	671	☐	Pearly	659	☐	Sandperch	675	☐
Humbug dascyllus	767	☐				Sharksucker	787	☐
Reticulated dascyllus	771	☐	<u>Snapper</u>	565	☐	Needlefish	562	☐
Whitebelly	654	☐	Two-spot	753	☐	Pipefish	911	☐
Staghorn	745	☐	Black-and-white	569	☐	Shrimp fish	790	☐
Alexanders	764	☐	Chequered	665	☐	Trumpetfish	664	☐
"Anemone fish" sp.	591	☐				Moray Eel	637	☐
"Sergeant" sp.	656	☐						
						FURTHER SPECIES		
						_____	☐	
						_____	☐	
						_____	☐	
						_____	☐	
						_____	☐	
						_____	☐	
						TOTAL FISH	☐	

[illegible]