Marine Protected Area Surveys of the Central Visayas, Philippines – 2007

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Summary Report

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Submitted to:

Barangays of Panglao, Bohol; Mactan, Cebu; Olango, Cebu; Moalboal, Cebu; Badjian, Cebu; and Dauin, Negros Oriental

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I. Introduction and Background

In 2006, the Coral Disease Working Group (CDWG) of the Global Environment Facility-World Bank Coral Reef Targeted Research Program initiated a project to examine coral reef health inside and outside of Marine Protected Areas in the Central Philippines. The work was designed and conducted by CDWG member, Dr. Laurie Raymundo (University of Guam; coral disease and coral community structure), with Aileen Maypa (Ph.D. cand., University of Hawaii; fish taxonomy and fisheries biology) and colleagues from Silliman University, Kathryn Rosell and Pablina Cadiz, assisting. The team returned in 2007 accompanied by graduate students Pablo Rojas and Roxanna Myers of the University of Guam.

This second year of work included five MPAs previously surveyed: Balicasag Is., Bohol; Gilutungan Is., Mactan, Cebu; Basdiot and Saavedra, Moalboal, western Cebu; Zaragosa, Badjian, western Cebu; and Apo Is., Dauin, Negros Oriental. In addition, four new sites were added: Tawala and Bil-isan, Panglao Is., Bohol; Talima, Olango Is., eastern Cebu; and Maayong Tubig, Dauin, Negros Oriental (see Fig. 1).

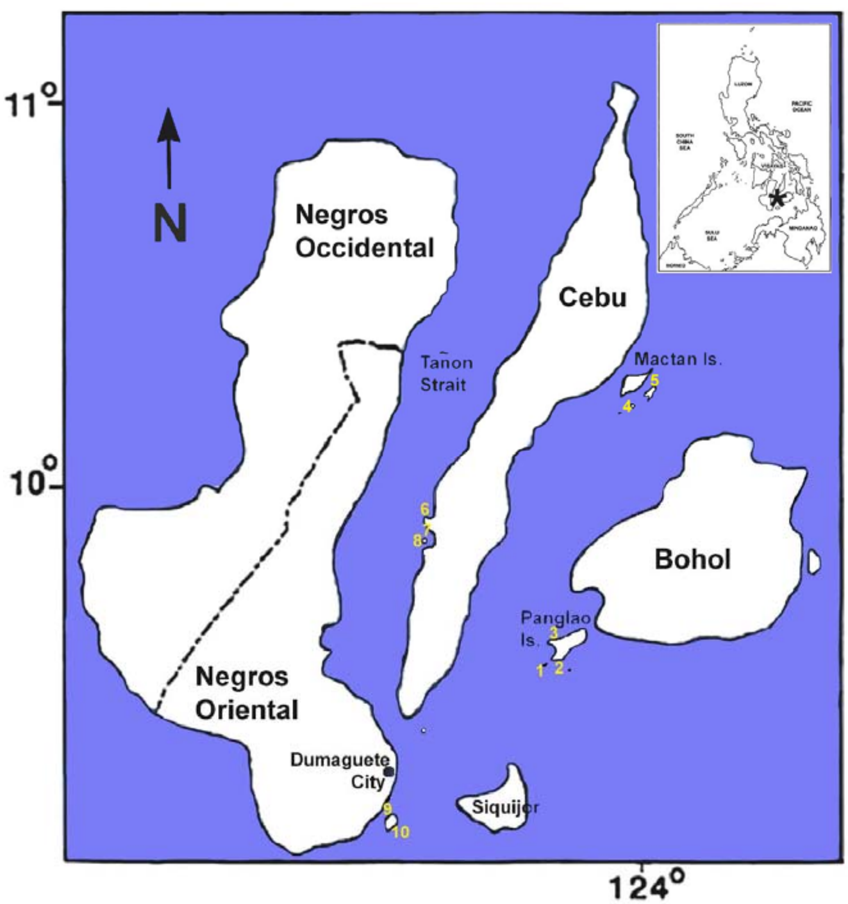


Figure 1. Ten Marine Protected Areas and adjacent fishing grounds surveyed in the Central Visayas, June-July 2007: 1) Balicasag Island; 2) Tawala, Panglao Is.; 3) Bil-isan, Panglao Is., 4) Gilutungan Is.; 5) Talima, Olango Is.; 6) Saavedra; 7) Basdiot; 8) Zaragosa Is.; 9) Maayong Tubig; 10) Apo Is.

The primary objective of this project is to test for a link between diversity in fish assemblages and health and disease in associated coral communities. Our working hypothesis is that when a fish community is protected from overharvesting, it will create healthier conditions in the reef community via the diverse ways that fish interact with other species. We are examining reef health by measuring the amount of disease in the coral community. At the same time, we present data that examine how effective each MPA is, by assessing the diversity and biomass in each fish community and comparing these factors with the adjacent fishing ground, as well as with nearby MPAs.

II. Methods

We used a paired design, wherein MPAs are selected that are well-managed for at least five years, are located on a contiguous reef system that contains both the MPA and an adjacent fishing ground, and is not visibly impacted by poor water quality (siltation, pollution, nutrient enrichment, etc.). At each location, once the MPA boundary was located, we established replicate belt transects (n=3-6) along the reef crest (when present) in the reef zone of highest coral, between 3m and 7m depth. Along each transect, data were collected on the following: 1) percent composition by: live hard coral, soft coral, coral rubble, dead standing coral, coral rock/ pavement, fleshy macroalgae, sand, and silt; 2) coral colony counts per genus; 3) diseased colony counts by coral genus and disease type; 4) population characteristics and severity of disease of diseased colonies; and 5) reef complexity (Fig. 2). This procedure was undertaken in both the MPA and in the adjacent fishing grounds.

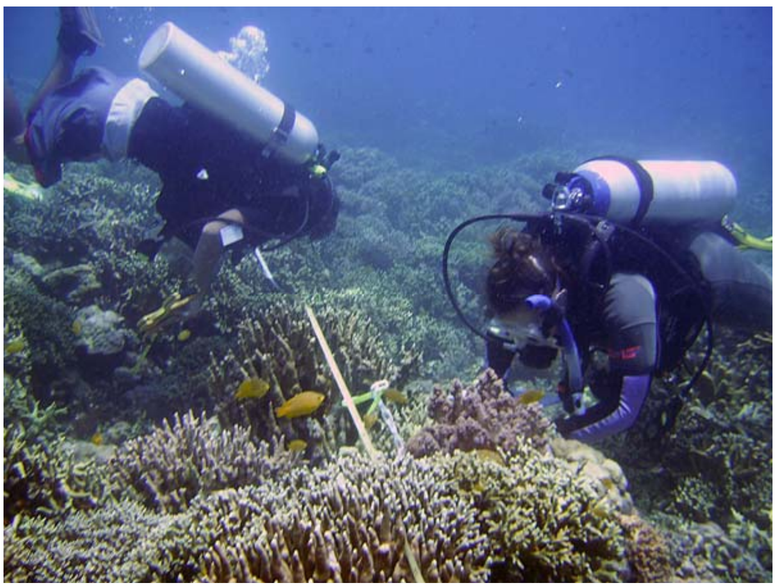


Figure 2. Pablo Rojas and Roxanna Myers make detailed descriptions of diseased corals within the Zaragosa Marine Protected Area.

In the same area within which benthic transects were laid, replicate transects were also accomplished for the fish community, using underwater fish visual census. All fish were identified to species, counted, and their length estimated. Biomass per species was calculated using the ReefBase database for length-weight relationships per species (Fig. 3).

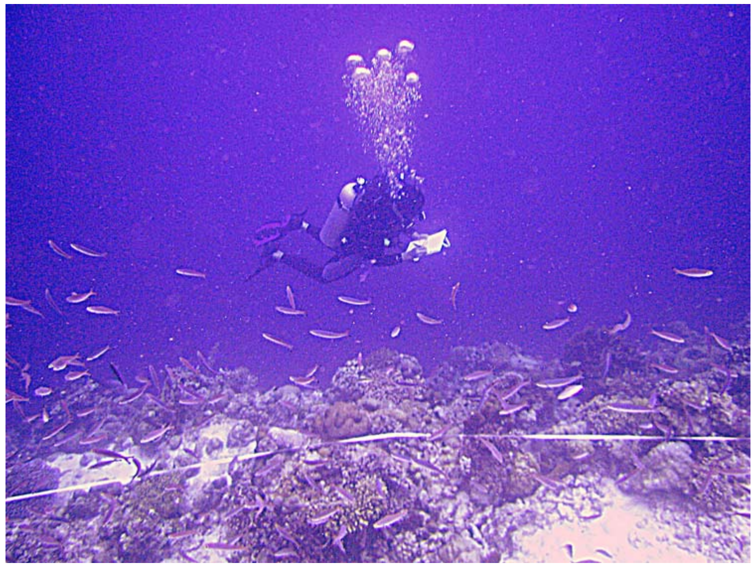


Figure 3. Aileen Maypa completing a fish visual census in Gilutungan, Cebu.

This report compiles summary data for all 10 reefs surveyed in 2007. For each reef surveyed, we present here a description of the reef as a whole, the benthic composition, the disease states we observed, their prevalence on each reef, the host species of coral displaying the disease signs, and summary fish abundance data per site. We also list potential management issues that we observed or encountered during our surveys, so that the respective managing bodies in each municipality can act upon these issues and improve management.

III. Summary Results

A comparative look at the relative amounts of live hard coral, coral rubble and dead standing coral can provide a picture of the overall status of the condition of a reef. Coral cover alone is not a good indicator of reef condition, as a low percent cover value does not necessarily represent a damaged reef in poor condition. A large amount of coral rubble, relative to live coral, can indicate past physical damage, such as that from storm weather and destructive fishing. A large amount of dead standing coral can suggest recent coral mortality from bleaching, disease, or an outbreak of coral predators, such as those mentioned above. Therefore, we present a summary of these three parameters in Figure 4. Specific notes are presented in the individual summaries, below.

Reef complexity is a measure of habitat availability for fish and invertebrates, and varied between reefs (Fig. 5). In most sites, complexity did not vary significantly between the MPA and the fishing grounds, suggesting that in most cases, the fishing grounds showed no major physical damage from fishing. Individual observations unique to each site are discussed separately, below.

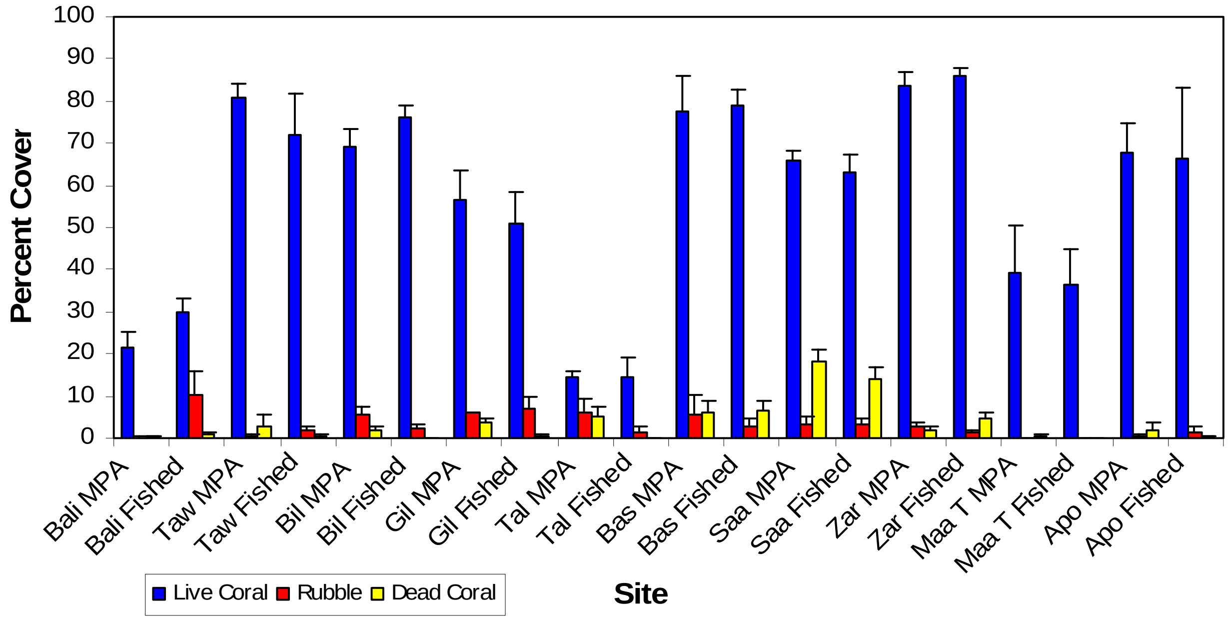


Figure 4. Summary of selected benthic attributes for all 20 sites surveyed (i.e., inside MPA and in adjacent fishing ground for 10 reefs). Mean +/- SE.

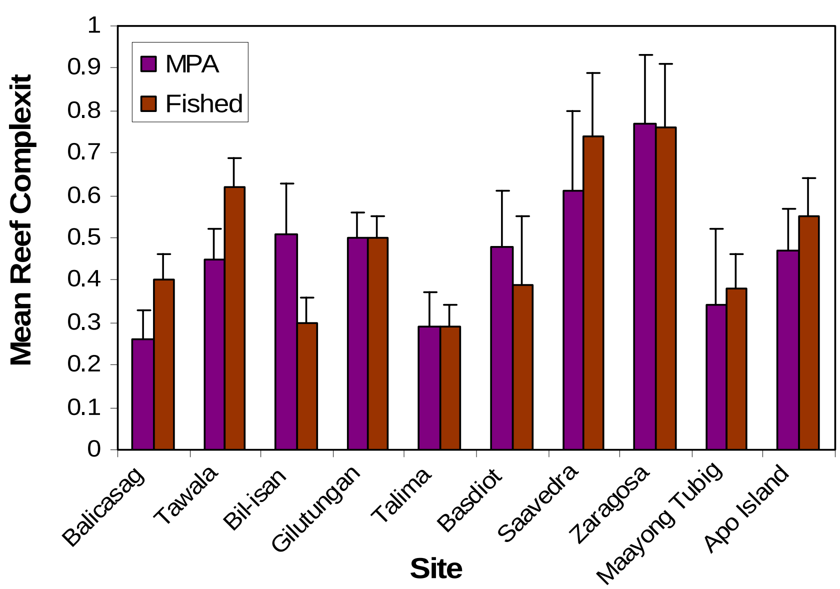


Figure 5. Mean reef complexity per site, comparing MPAs and fishing grounds in 10 surveyed reefs. Mean +|/- SE; n=3-6 transects per site.

Data on fish abundance and biomass are still being processed. Figure 6 summarizes fish diversity in the surveyed sites. Many of the sites showed relatively high diversity, with little difference between the MPA and the fishing grounds. However, several of the fishing ground values are lower than that of the MPA, reflecting the effects of fishing. Individual sites are discussed below.

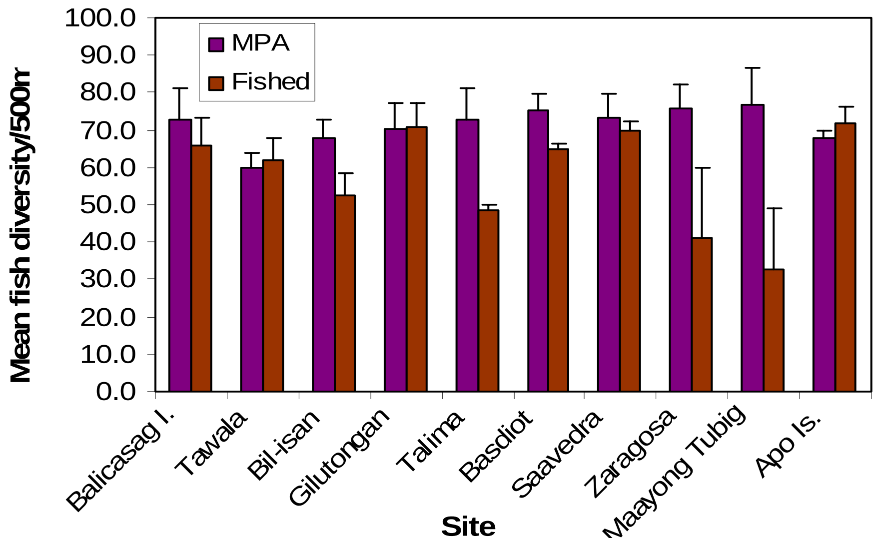


Figure 6. Fish assemblage species diversity at 10 reefs, comparing Marine Protected Areas and adjacent fishing grounds. N=3 transects per site; Mean +/- SE.

In Figure 7a, we present representative photographs of the six diseases and syndromes that we observed affecting our surveyed reefs. These diseases have all previously been described and identified from the Philippines (Raymundo et al. 2003; Kaczmarsky 2005; Raymundo et al. 2005). During this survey, we did not encounter any disease state not previously described, though prevalence of individual diseases changed slightly between 2006 and 2007. White Syndrome was the most common disease observed, followed by Ulcerative White Spot Disease and Skeletal Eroding Band. We observed no evidence of any disease outbreaks on any of our surveyed reefs, though several sites showed relatively high overall mean disease prevalence. Total disease prevalence (i.e., the percent of surveyed colonies affected by disease) ranged from a low of 1.7% (Maayong Tubig MPA) to a high of 8.4% (Basdiot fishing ground). In general, disease prevalence was lower within the MPAs and higher within the fishing grounds in paired sites. We discerned this pattern in the 2006 surveys, as well.

Figure 7b presents some of the more common non-disease sources of stress or damage that corals experience in our reefs. It is important to note these as well, as they can represent a weakened coral; one that may be more susceptible to disease. Such observations can also provide information regarding other potential stressors on a reef. In addition, some of these organisms, such as the Crown-of-Thorns starfish *(Acanthaster planci;* COTS) and the corallivorous gastropod *Drupella* spp., can experience population outbreaks which cause tremendous coral mortality, and their population numbers should be tracked over time. *Drupella* was locally abundant in certain reefs, as were COTS, but we observed no evidence of outbreaks of either of these organisms in any of our surveyed reefs. Macroalgal abrasion by *Sargassum* was occasionally observed, particularly with massive *Porites* (Figure 7b-A), and patchy bleaching of unknown cause was common in certain sites.

Southeastern Bohol

Balicasag Island

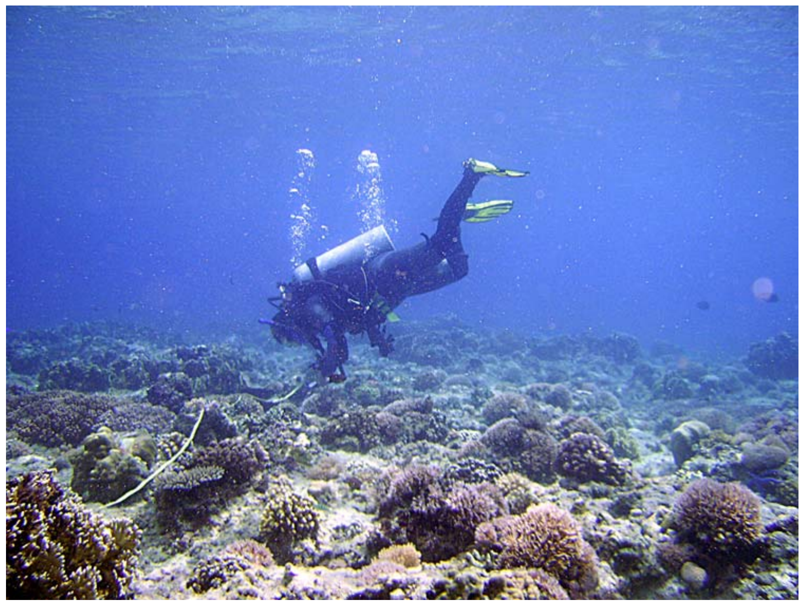


Figure 8. The reef flat and crest community within the Balicasag Marine Protected Area, showing a reef of low complexity, dominated by small coral colonies.

The Balicasag reef is characterized by low relief (Fig. 8); complexity and live hard coral cover were the lowest of all sites (Figs. 4 and 5), both inside the MPA and in the fishing ground. Substrate was dominated by pavement, and coral colonies were small. *Pocillopora* spp. and *Seriatopora* spp. dominated the coral community; both are known to be rapid colonizers. As was stated in last year's report, the aggressive coral-killing sponge *Terpios* sp. was speculated to be the primary cause of past coral mortality, and was still present at a depth slightly below the reef crest. However, in spite of past coral mortality, recruitment within the MPA appears to be quite high, and this has allowed coral cover to increase. Comparing 2006 and 2007 surveys, live hard coral cover increased from 11% to 21% within the MPA and from 25% to 29% in the fishing ground. The reef outside the MPA appeared to be less affected by this sponge, and this is visible in the higher coral cover, larger colonies, and greater abundance of *Porites* spp. Fish diversity values were among the highest of all sites, both within the MPA and in the fishing grounds.

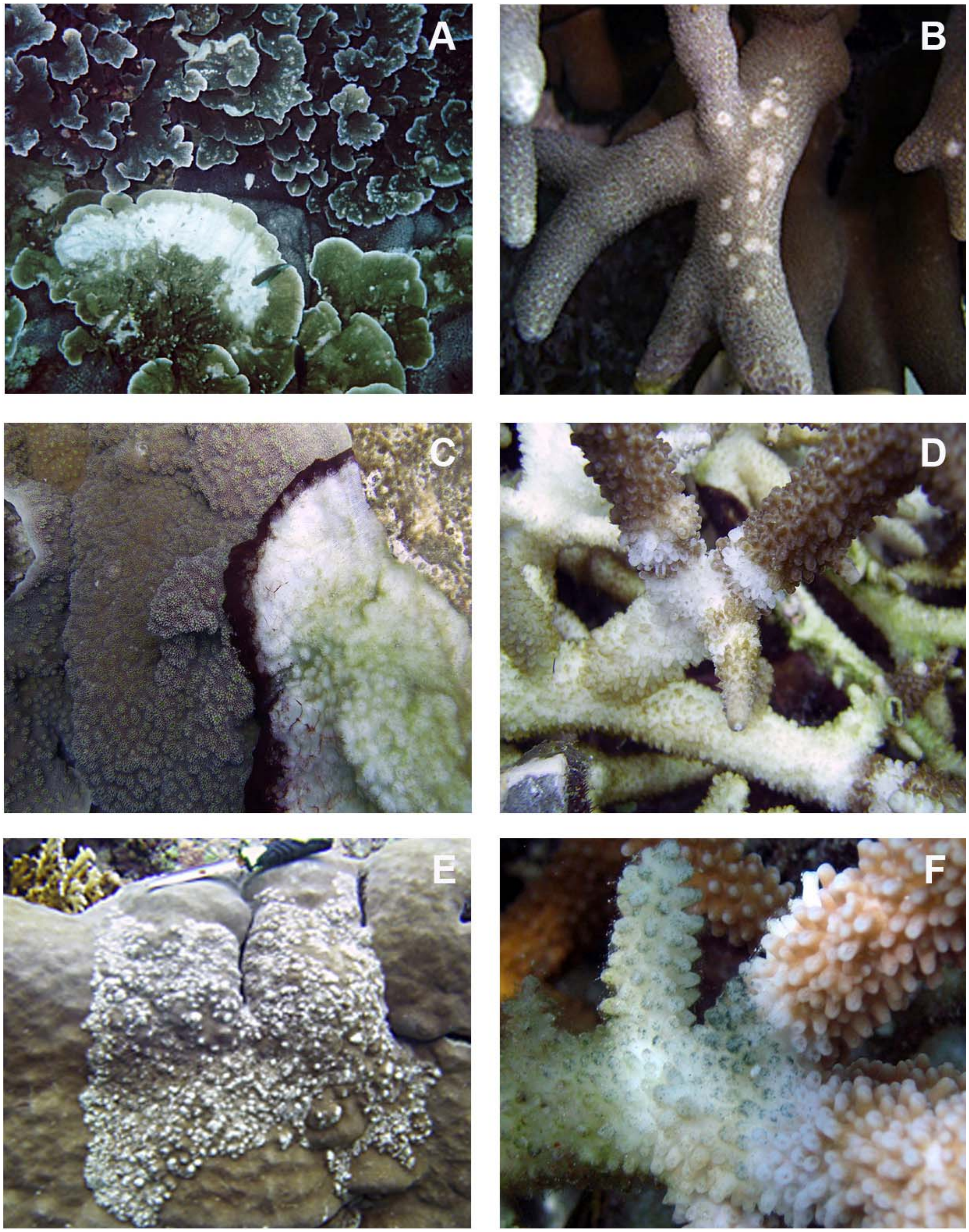


Figure 7a. Commonly-encountered diseases affecting Philippine coral reefs. A) White Syndrome (WS); B) Ulcerative White Spot Disease (UWS); C) Black Band Disease (BBD); D) Brown Band Disease (BrB); E) Growth Anomaly (GA); F) Skeletal Eroding Band (SEB).

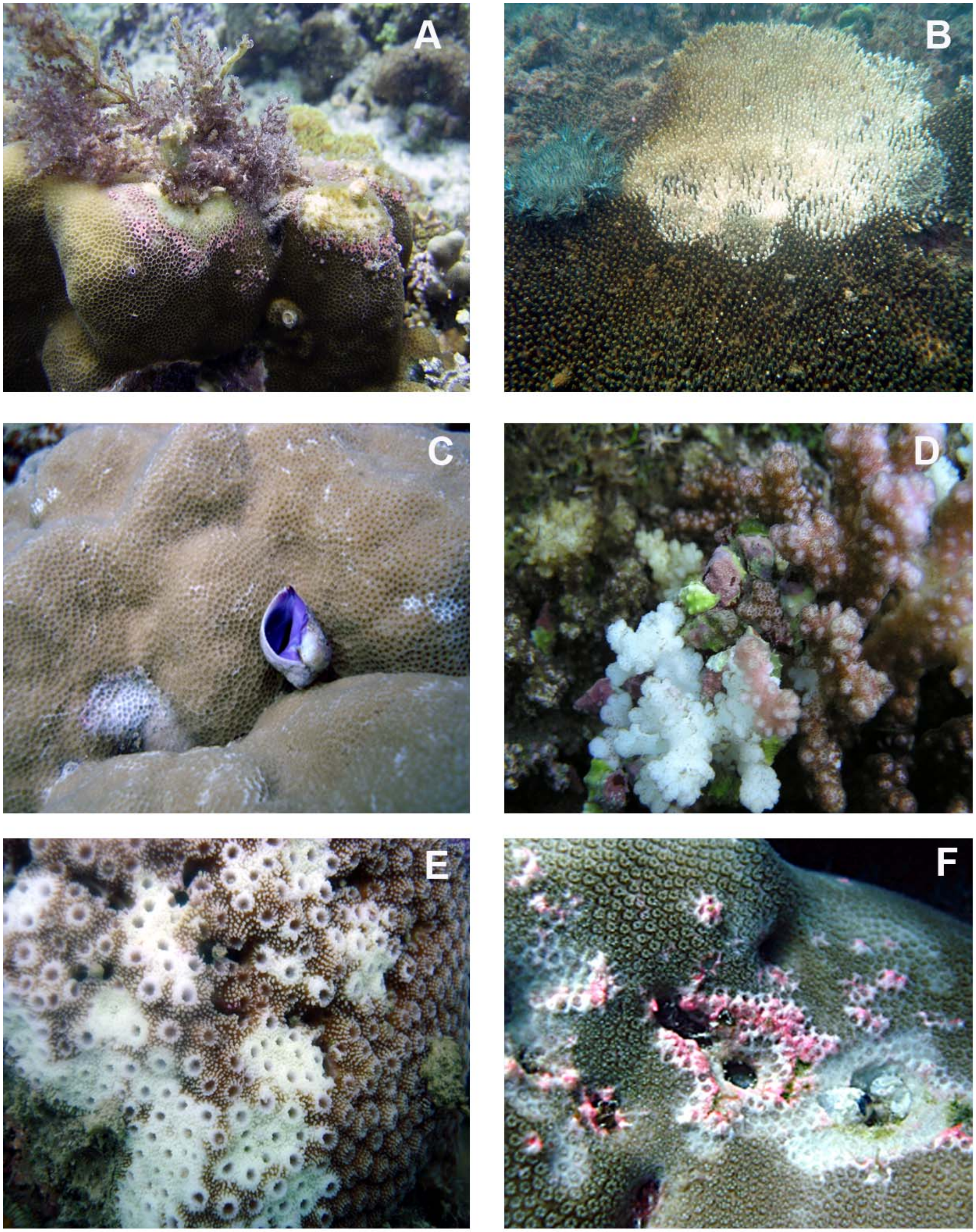


Figure 7b. Commonly-encountered states of compromised health in Philippine corals. A) macroalgal overgrowth and abrasion; B) Crown-of-Thorns starfish predation; C) predation by the corallivorous snail, *Coralliophila violacea;* D) predation by the corallivorous snail *Drupella rugosa;* E) patchy bleaching of unknown cause; F) pigmentation response due to unknown predation.

Disease prevalence was low inside the Balicasag MPA (2.2%), but much higher in the fishing ground (7.1%). These values increased from 2006; total prevalence was 0.25% within the MPA and 0.29% in the fishing ground in previous surveys. White Syndrome was the dominant disease, patchy bleaching was also common, and predation by *Drupella* and Crown-of-Thorns starfish were also observed.

Tawala, Panglao

This reef was not previously surveyed in 2006, so the data here represent a baseline. The Tawala reef was marked by high relief and complexity and very high coral cover (Fig. 4 and 5), dominated by the genus *Porites* (Fig. 9). The reef crest was in very good condition, and there was little dead standing coral and coral rubble, both within the MPA and in the fishing ground. The reef flat was dominated by the macroalga *Sargassum* and soft corals. As with Balicasag, there was little difference in fish diversity within the MPA and the fishing ground; both were relatively high.

Figure 9. The Tawala MPA reef crest, showing dominance by *Porites cylindrica* with high relief and high cover.

As the reef crest was dominated by *Porites*, it was not surprising that disease prevalence was relatively high (6.4% in the MPA; 3.9% in the fishing grounds). Five out of six disease states were observed: growth anomalies, skeletal eroding band, ulcerative white spots, white syndrome and black band disease were all observed affecting *Porites cylindrica*. *Coralliophila violacea,* which show a preference for *Porites*, were also common, and several colonies showed *Drupella* feeding scars.

Bil-isan, Panglao

This reef was also surveyed for the first time in 2007. The nearshore area was dominated by a seagrass bed, and no well-formed reef crest was present. *Sargassum* cover was higher in the fishing ground than within the MPA. Transects were laid along the slope, parallel to shore, at a depth of 6m. Below this depth, the substrate was sand and rubble, dominated by the macroalga *Padina* sp. Fishers reported that the slope had been blasted in the 1970s; rubble was still very apparent. *Padina* was also common in shallower depths, and overgrew corals. Coral cover was, therefore, patchy, but still high in places, averaging 69% in the MPA and 76% in the fishing ground (Fig. 10). Rubble patches were also apparent, though not as common as on the deeper slope. Fish diversity was visibly higher within the MPA than in the fishing grounds, which may be a reflection both of the recovery of the fish assemblage due to protection and fishing pressure in the fishing grounds.

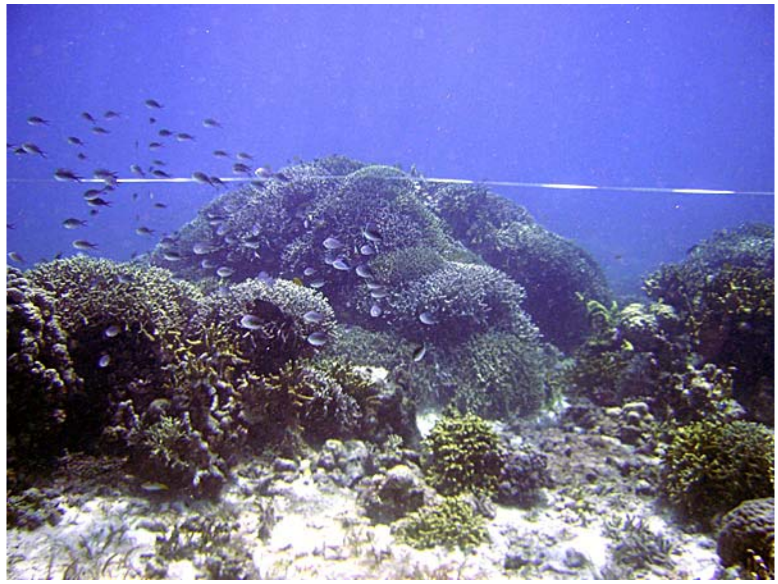


Figure 10. High relief and high coral cover patch within the Bil-isan MPA.

Disease prevalence averaged 6.6% within the MPA and 5.6% within the fishing grounds. Diseases observed were white syndrome, skeletal eroding band, ulcerative white spots and growth anomalies.

Eastern Cebu

Gilutungan Island

The Gilutungan reef flat is characterized by a mixed seagrass bed with patchy coral. Surveys were conducted along the reef crest, within the MPA and on either side of it, within the fishing grounds. The condition of the reef was markedly different within the MPA and outside. Mean live coral cover was slightly higher in the MPA (56.7%) than in the fishing

Figure 11. A school of snappers, *Lutjanus boutton,* along the reef crest within the Gilutungan MPA.

grounds (51.1%), though complexity was similar in both areas. Coral cover was lower inside the MPA than the previous year (2006: 60%), though cover was much higher outside than the year before (2006: 11%). However, it is doubtful that the substantially higher coral cover value obtained in 2007 in the fishing ground is due to coral growth and recruitment. We speculate that this large difference may have been due to the placement and number of replicate transects. The 2007 transects may be more representative of the reef as a whole, as a greater number of transects were read during this second survey. Massive corals of the family Faviidae were very common on this reef crest, with more fragile branching morphologies occurring slightly deeper. These figures did not change significantly from the 2006 surveys. The fishing ground showed much more damaged and dead coral, macroalgae, and corallivores *(Drupella).* Fish diversity, however, was very high both in and out of the MPA; the calculated values were almost the same (Fig. 6; Fig. 11). Such high diversity even within the fishing ground may reflect a recovery of the fish assemblage due to a decrease in fishing pressure, as more fishers have become involved in the tourism trade. The visibly greater damage to the reef outside of the MPA boundaries, however, suggests that much of the damage may have been from past fishing activities, or tourism-related activities.

As with Balicasag, Gilutungan exhibited very low mean total disease prevalence in 2006 surveys (0.54% in the MPA; 0.83% in the fishing grounds). One year later, prevalence had markedly increased (2.7% in the MPA; 4.5% in the fishing grounds). The pattern of lower prevalence within the MPA still held, however. White syndrome was the most common disease; skeletal eroding band and patchy bleaching were less common, but consistently found along our transects. *Coralliophila* and *Drupella* predation were observed in both areas, though the gastropods were more common in the fishing grounds.

The potential for tourism-related damage was quite high, given the volume of tourists that visit the site on a daily basis. From our observations, most tourists do not possess good water skills, and breakage of corals from physical contact with boats and swimmers may be a significant source of coral damage. In addition, we heard an average of 10 dynamite blasts per hour from nearby islands during our morning dives. It is clear that the fisher’s management organization needs continued vigilance and support from local government to continue to protect this reef.

Talima, Olango Island

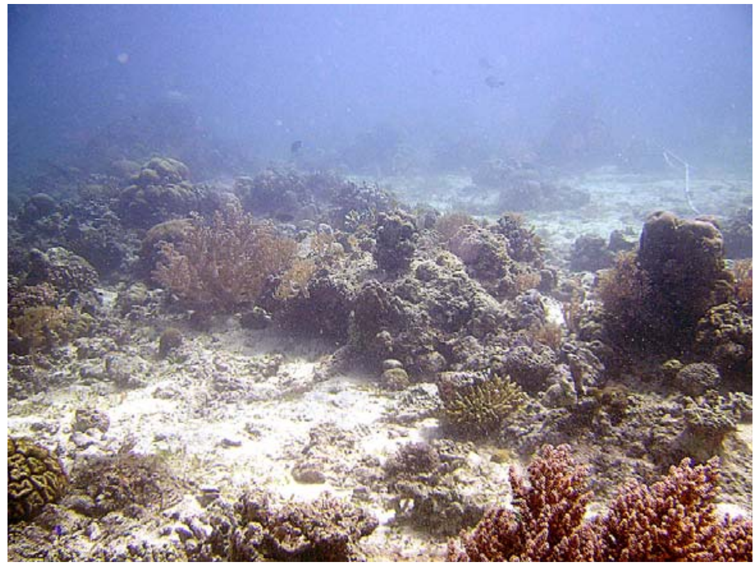


Figure 12. Low relief, poor visibility and high amounts of dead standing coral characterized the Talima MPA and fishing ground reef.

Talima is a new site, not surveyed in 2006. There was no well-defined reef crest, so surveys were conducted on the reef flat at 6-7m depth. Coral cover was patchy and interspersed with sand and seagrass (Fig. 12). Percent coral cover was the lowest of all sites, both inside the MPA (14.3%) and in the fishing grounds (14.6%). Visibility was poorer than at most other sites and siltation appeared to be high. Dead standing coral colonies were common, but mortality was not recent and may have reflected damage or stress to the reef prior to protection. Community composition was similar inside the MPA and in the fishing ground, though there was more dead coral and *Sargassum* outside. Corals of the family Faviidae were common, and there was evidence of recruitment in many small colonies. If these are able to survive the silty conditions, then coral cover should increase in the future as long as management measures remain constant. Fish assemblage diversity was significantly higher within the MPA than in the fishing grounds. This may reflect the effect of good management in spite of low coral cover, with high fishing pressure outside the MPA.

Total mean disease prevalence was 2.7% inside the MPA and 4.7% outside. White syndrome and skeletal eroding band were common. A major source of stress and possible coral mortality in this reef is siltation. This should be monitored. Recruitment, though visible and high, may not result in significant changes in coral cover in the future if siltation remains a problem, as this is a major source of recruit mortality.

Southwestern Cebu/Taňon Strait

Basdiot

The Basdiot reef is characterized by high complexity and live coral cover, both within the MPA and outside (Fig. 13). Coral condition is quite good, and fragile and branching morphologies in the genera *Montipora* and *Porites* dominate. Live hard coral cover averaged 77.8% and 78.8% in the MPA and fishing ground, respectively. Both values have increased from 2006 (70.3% in the MPA; 66.2% in the fishing ground). There was some rubble and dead coral in both areas of the reef, most of it occurring in extensive branching *Montipora* beds. A total of seven sea turtles were observed during fish visual census, and one of the patches of coral breakage was speculated to be a turtle bed. Another potential source of rubble and dead coral was a COTS outbreak which occurred 3-5 years ago, according to anecdotal reports. However, the increase in live hard coral cover suggests that recovery from these sources of mortality is rapid and high. Fish assemblage diversity was significantly higher within the MPA than in the fishing ground (Fig. 6), which probably reflects the effects of management and recovery.

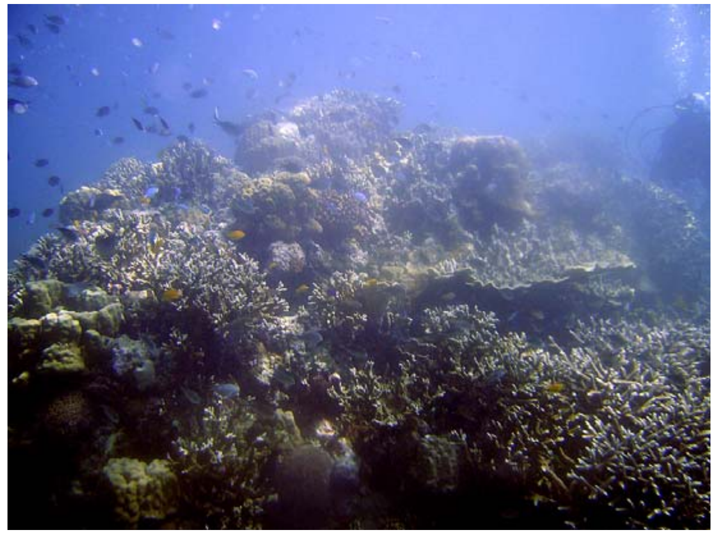


Figure 13. High relief and coral cover along the reef crest in the Basdiot MPA. Note the abundance of fragile branching growth forms.

Mean total disease prevalence averaged 4.1% within the MPA and 8.4% in the fishing ground; both values are higher than those calculated for 2006 (2.5% in the MPA; 6% in the fishing ground). White syndrome and skeletal eroding band were the most common diseases, and ulcerative white spots, black band disease, growth anomalies were also present. *Drupella* were common, particularly since *Montipora* is a preferred food source, though they were much more dense within the fishing ground than within the MPA.

Saavedra

This reef has been recently affected by a COTS outbreak; an anecdotal report from the Coastal Conservation Education Foundation stated that there had been a removal activity 3 weeks prior to our surveys. The reef crest showed high complexity, and table growth forms of the genus *Acropora* and massive *Porites* were common (Fig. 14). The reef flat was dominated by pavement and patch reefs. Live hard coral cover within the MPA had decreased from 2006 (75.9%) to 65.7%, which may possibly reflect high coral mortality from COTS and *Drupella*. Live coral cover in the fishing ground was similar to that in the previous year (2006: 62.9%; 2007: 60.2%). We observed several large colonies of table *Acropora* and thickets of staghorn

Acropora that were <75% dead. Fish were visibly abundant inside of the MPA, and diversity was very similar in both sections of the reef.

Figure 14. Saavedra MPA, showing extensive table colonies of the hard coral *Acropora*, which dominate in this reef community.

In spite of the high diversity of the fish assemblage within the fishing grounds, there was ample evidence of fishing activity. Dead standing coral was highest in this reef than any other (Fig. 4), and damage to hard coral from anchors and fish traps was extensive in some areas. In particular, ropes that were used to lower large traps over the reef crest were highly destructive. They were attached to, and laid across, live coral colonies, and pulled up when the traps were retrieved. This type of activity results in significant damage to corals via breakage and abrasion.

Black band disease was common in the fished reef; other diseases observed included skeletal eroding band, white syndrome, growth anomalies, and ulcerative white spot. However, only white syndrome and skeletal eroding band were observed within the MPA. Mean total disease prevalence was 4.9% in the MPA and 7.8% in the fishing grounds. These figures varied only slightly from 2006 (MPA: 3.7%; fishing ground: 7.5%).

Zaragosa Island

This reef is characterized by a narrow reef flat with high cover of both hard and soft corals, and a high-diversity reef crest that slopes sharply along a wall (Fig. 15). Coral cover is very high along the reef crest in this reef, both inside the MPA (83.5%) and in the fishing grounds (86.2%). These figures have increased

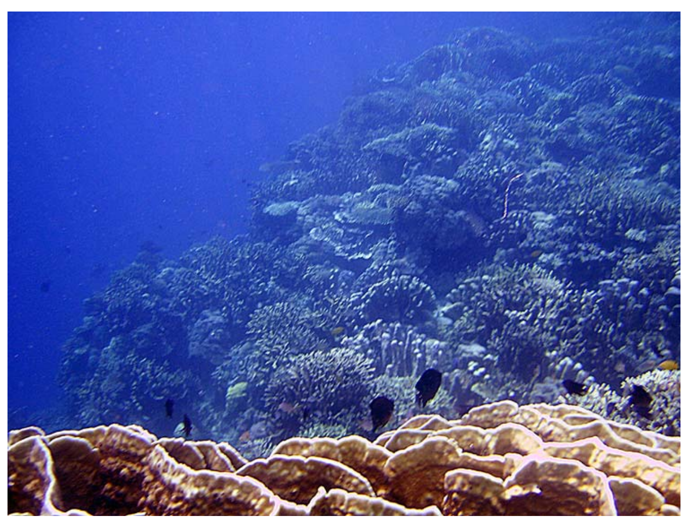
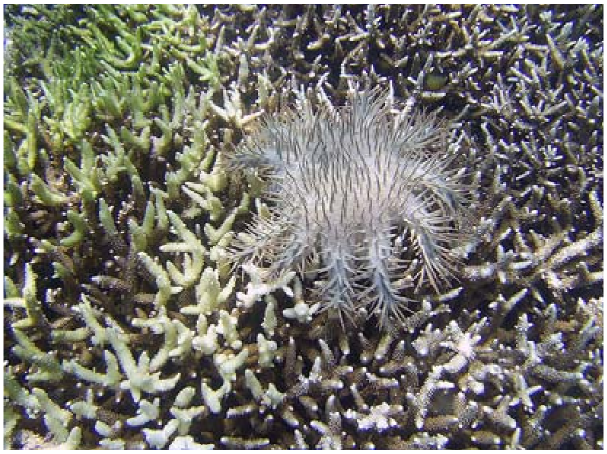


Figure 15. The Zaragosa reef crest, showing high coral diversity, cover and relief.

since the 2006 surveys (MPA: 73.9%; fishing grounds: 64.9%). Reef complexity values are the highest among all reefs surveyed, and do not differ significantly inside and out of the MPA (Fig. 5). However, in spite of the rich and diverse fish habitat, fish abundance was visibly very low both within the MPA and in the fishing grounds. Fish diversity was significantly higher within the MPA than in the fishing grounds (Fig. 6).



Crown-of-Thorns starfish were abundant within the fishing ground; we counted 12 individuals within a 15-min. swim (Fig. 16). However, although COTS were more abundant at this site than any other we surveyed, this number does not reflect an outbreak population density. Nonetheless, COTS was responsible for significant coral mortality, and such observations warrant monitoring. Given that both nearby Basdiot and Saavedra reefs had experienced increases in COTS numbers resulting in removal activities, monitoring of COTS population numbers should be undertaken on a regular basis. Mean total disease prevalence was relatively low, both inside the MPA (3.4%) and outside (3.8%). These values are slightly higher than was observed in the 2006 surveys (MPA: 1.9%; fishing grounds: 3.0%). Black band disease and growth anomalies on *Porites* were the common diseases seen.

Negros Oriental

Maayong Tubig

This reef was added in 2007 and not previously surveyed in 2006. It is characterized by patchy coral cover interspersed with sand and sparse seagrass, with no development of a reef crest (Fig. 20). The reef community was dominated by corals from the families Pocilloporidae and

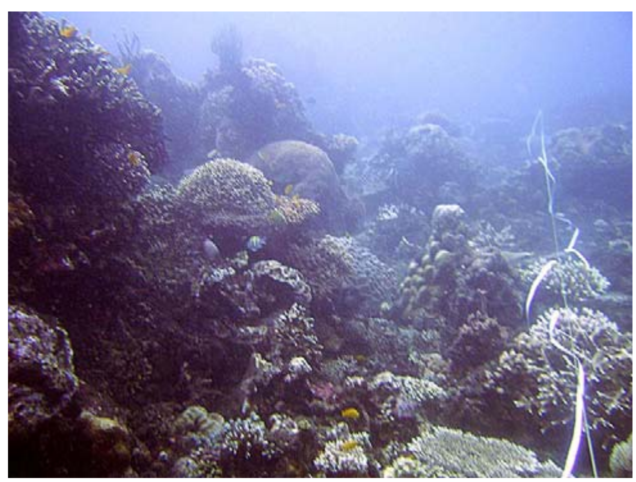


Figure 20. A high-relief coral community within the Maayong Tubig MPA.

Figure 21. A colony of *Acropora*, showing tissue death from siltation, algal overgrowth and skeletal eroding band (arrow).

Acroporidae. Being located near a river, it is affected by heavy silt deposition. Siltation, along with abundant macroalgae, appear to be the biggest threats to the health of this reef (Fig. 21). Due to the patchiness of coral, overall live hard coral cover was relatively low (Fig. 4; MPA: 39%; fishing ground: 36%), as was reef complexity (Fig. 5). Fish assemblage diversity was significantly higher within the MPA than in the fishing grounds, and diversity within the MPA was amongst the highest of all sites surveyed (Fig. 6).

As stated earlier, the main sources of mortality are siltation and algal overgrowth. Abundant macroalgae suggested a nutrient source, coupled with low herbivory. The river undoubtedly acted as a point source for land-based nutrients such as untreated sewage and agricultural run-off. Disease prevalence was relatively low (MPA: 1.7%; fishing grounds: 3.5%), which may have reflected the effects of patchy and lower coral cover, as well as abundant silt.

Apo Island

The Apo Island Marine Reserve is a narrow reef flat of high relief (Fig. 22), with a reef crest dominated by large colonies of *Galaxea fascicularis.* Nearshore to the crest, diversity is much higher, and characterized by a mixed hard and soft coral community. The fishing ground in Can-uran was also surveyed, and is contiguous with the reserve reef community. Coral cover inside (67.8%) and out (66%; Fig. 4) of the marine reserve did not differ significantly, though values did differ somewhat from the 2006 surveys: (MPA: 40.8%; fishing ground: 72.9%). However, these values reflected the location of the transects, rather than a large increase in coral cover. The 2006 transects within the MPA were within an area of high soft coral cover on the reef flat, while the 2007 transects encompassed both reef flat and crest. Fish diversity values were comparable inside and out of the MPA, reflecting the effects of continued management and sustainable fishing practices.

Figure 22. High complexity and diversity of coral cover, both hard and soft, within the Apo Is. Marine Reserve.

In 2006, we noticed several large colonies of the plate-forming coral *Echinopora lamellosa* infected with black band disease (Raymundo *et al.* 2006). The rapid rate of tissue loss suggested the possibility that this disease may be on the verge of an outbreak, so we set up a monitoring plan, to follow the progress of this disease. After one year of monitoring, four of the monitored colonies had lost 90% of their tissue, but the disease had failed to spread to other nearby colonies, except for a single colony of *Coeloseris mayeri* (Rosell and Raymundo, in prep; Fig. 23). We continue to monitor this situation. In the 2007 surveys, we noticed a high prevalence of brown band disease among the thicket-forming *Acropora* stands in Can-uran. We will also continue to monitor this. Mean total disease prevalence within the MPA was 4.9%, and in the fishing grounds, 5.4%. These values differ slightly from the 2006 values (MPA: 3.9%; fishing grounds: 6.2%).

Figure 23. A colony of *Coeloseris mayeri* infected with Black Band Disease within the Apo Island MPA. The colony has lost 75% of its tissue.

IV. Conclusions and Recommendations

Crown-of-Thorns starfish can reach outbreak population numbers that can be devastating to a coral reef in a relatively short period. It is important, therefore, to establish baseline (i.e., the average or "normal") population numbers, so that if the population starts to increase, with a concurrent rise in coral mortality, then removal activities can be undertaken. Likewise, *Drupella* can also cause localized mortality, particularly since they target certain species (*Acropora* and *Montipora*, but others as well), and reach outbreak population levels. Shells can be removed in heavy infestations, as part of a management effort.

We saw visible effects of fishing effort in several reefs: particularly in Bil-isan, Gilutungan and Saavedra. Anchors, ropes, traps and other equipment should be deployed in such a way that avoids live coral colonies. This was particularly true of Saavedra, where large traps were deployed at deeper depths along the reef wall/slope, and fixed in place with large ropes tied to coral heads in the shallows. The paths across which these ropes were dragged were very clear in the form of broken and abraded coral colonies and rubble.

In Gilutungan, heavy tourism activity showed a potential for long-term, chronic damage. We recommend that tourism be regulated; i.e., a maximum number of visitors per day should be decided upon by the management body, and tourist guides should be trained to prohibit direct contact with the reef. Visitors should be briefed regarding destructive diving and snorkeling practices, so that this reef can remain relatively intact long-term. This cannot be stressed too much; the long-term viability of tourism operations is heavily reliant on a good reef condition, which can only be maintained with environment-friendly interactions between tourists and the reefs they visit.

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