Coral Cay Conservation

Crown of Thorns Sea Star (Acanthaster planci)

Assessment Report

Napantao, San Francisco, Southern Leyte, Philippines

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Abstract

Crown-of-Thorn Seastars (*Acanthaster planci*), also known as CoTs, are a major threat to coral reef systems across the Indo-Pacific. At outbreak levels they have the capacity to destroy reef communities and alter the ecological diversity of an ecosystem. There have been several outbreaks of *A. planci* in Sogod bay, Southern Leyte, the Philippines, in recent years meaning on-going monitoring of their populations is advised. As part of our remit and close ties to the Barangay of Napantao, San Francisco, Coral Cay Conservation carried out a CoTs assessment on the Napantao MPA. The results of the assessment are positive with low numbers of *A. planci* being recorded both inside the MPA and adjacent to it.

Acknowledgements

Coral Cay Conservation would like to express our gratitude to the Provincial Government of Southern Leyte (PGSL). Our work would not be possible without the support of the Provincial Environmental and Natural Resource Management Office (PENRMO) and other members of the PGSL. We would also like to thank the Municipality of San Francisco for supporting this assessment. Finally, we would like to thank our trained volunteers and staff who collected the data during this MPA assessment.

Coral Cay Conservation

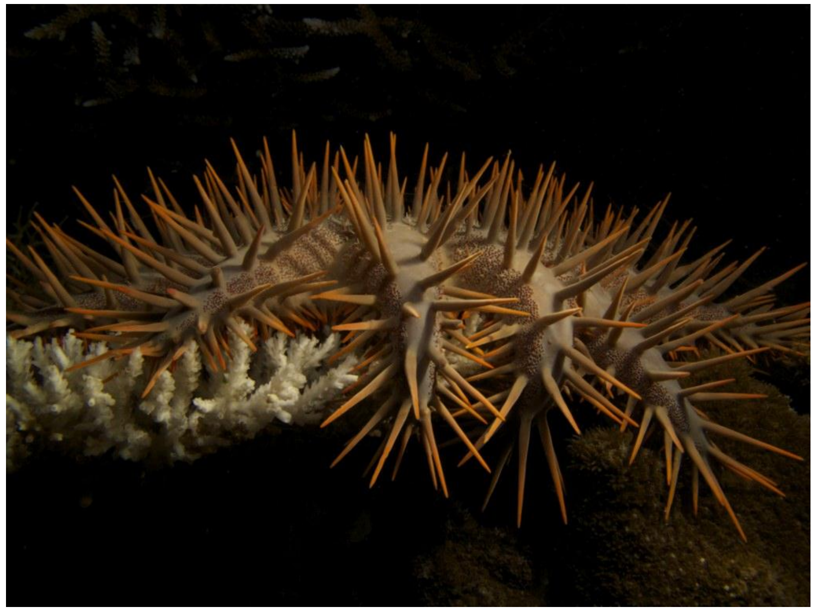
Coral Cay Conservation (CCC) is a not for profit organisation, founded in 1986 by a British scientist. CCC's mission is:

> "Providing resources to help sustain livelihoods & alleviate poverty through the protection, restoration & management of coral reefs & tropical forests."

In order to achieve this mission, CCC has carried out conservation projects all over the world, including in the Philippines, Belize, Honduras, Malaysia, Cambodia and Fiji. CCC successfully set up Marine Protected Areas and provided scientific data that has been used to manage local marine resources. The project in Danjugan Island in the Philippines between the years 1996-1999 was particularly successful and the reefs around the island received the accolade of Best Managed Reef in the Philippines in 2002. Since 1995, CCC has worked with the Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI) and local communities to survey and safeguard reef and rainforest areas in the Philippines. To date these have included coastal regions of the Southern Negros Occidental, Anilao, Palawan, Danjugan Island and the forests of North Negros.

At the invitation of the Provincial Government of Southern Leyte, CCC began its survey work in Sogod Bay in September 2002. CCC is conducting a collaborative program to survey the region's coral reefs and provide training and conservation education opportunities for project counterparts. The aim is to develop local capacity and ensure the long-term protection and sustainable use of marine resources throughout Southern Leyte.

1. Introduction



The Crown-of-Thorns Seastar (*Acanthaster planci*, Figure 1) is a voracious predator of Scleractinian corals and poses one of the most significant threats to coral reef ecosystems (Pratchett, 2005). Growing to a size in excess of 50cm an adult *A. planci* is capable of consuming vast quantities of coral per year. At outbreak levels this has caused significant and lasting damage to reef communities throughout the tropics. In particular it has been recorded that coral communities already stressed by changes in global climate, salinity and outbreaks of disease, struggle to recover from increased levels of predation from *A. planci* (Birkland, 1990). *A. planci* has a range that covers the tropical waters of the Indo-Pacific and Red Sea, but is not known in the Caribbean.

A. planci reproduce through sexual reproduction, with males and females releasing eggs and sperm into the water column during mass spawning events in high summer. These events are synchronised by changes in light intensity and temperature. The quantity of eggs released is dependent on the size of the female, with large individuals releasing in the region of 60 million eggs per breeding season (Mundy et al., 1994). During outbreak events when the proximity of males and females is high, fertilisation rates can be as great as 95% (Lucas, 1973). For this reason populations of *A. planci* can increase by several orders of magnitude in a relatively short period of time.

Within the first 24 hours fertilised eggs go through a series of changes and grow into free swimming larvae which disperse in the water column and are transported by prevailing currents. After one month larvae settle onto the benthos and begin the final metamorphosis into their adult phase. During the early benthic phase, juvenile sea stars face a high rate of mortality by predation. Due to the large potential for food input per unit biomass, *A. planci* are however able to grow rapidly and will attain a size of 25cm within 2 years (Brodie et al., 2005). Thus, the ability of *A. planci* to reach adult size in a short time period mitigates the risk of predation and increases juvenile survivorship.

A. planci tend to feed at night and are frequently observed moving across coral colonies. They feed in the same manner as all sea stars, by extruding their stomachs onto the flesh of the corals. Enzymes contained within the stomach then break down the coral tissue the nutrients are absorbed. The damage created by this process leaves tell-tale scars of exposed corallite cups devoid of any living tissue.

1.1 Outbreaks

During an outbreak of *A. planci* numbers rise to an unsustainable level, and can cause potentially devastating levels of damage to reef corals and the communities that depend of them. Historically major outbreaks occurred on average every 50 years (Fabricius et al., 2010). This lag between severe events provided the fast growing species of coral, preferentially predated by *A. planci*, sufficient time to re-grow to pre-outbreak levels and offered resilience to lasting ecological damage. In recent decades the rate of major outbreaks has increased reducing recovery time and increasing the pressure on reef communities (Brodie et al., 2005). Typically, outbreaks last 4-5 years although severe events have lasted three times this long. The sudden explosive booms in *A. planci* population are followed by equally rapid declines. This is more often as a result of mass disease outbreak than a factor of food scarcity. Sea stars have relatively primitive immune systems compared to vertebrates and so are subject to massive viral infection. This classic boom-bust population dynamic is due in large part to the inherent properties of their life history, such as high fecundity and rapid growth rates (Pratchett, 2005).

A. planci are capable of causing 1^{st}, 2^{nd} and 3^{rd} order effects on reef communities. In increasing level of severity, these order effects result in the reduction of surface cover of hard corals, species diversity and colony size distribution. This can lead to a phase shift, away from coral dominated ecosystems to reefs characterised by other encrusting animals such as soft corals. This loss of hard coral will inevitably reduce the topographic complexity of the reef and limit the diversity of species it can support. Ultimately there can be a shift from a diverse ecosystem to algal dominated reef, characterised by reduced species diversity, dominated by algal grazers such as urchins (Diadema) and herbivorous fish.

In the early 1980s an outbreak of *A. planci* around an island in southern Japan killed virtually all of the coral on a large area of reef. The loss of such a large proportion of the living coral led to a devastating decline in species. By 1986 what remained of the erect coral skeleton, left after the outbreak had all but collapsed due to wave action and bio-erosion, resulting in a flat plain of coral rubble. This dramatic decline in topographic complexity ultimately decreased the carrying capacity of the area resulting in a dead reef landscape, devoid of fish (Yokochi and Ogura, 1988).

During periods between outbreaks, *A. planci* exist on reefs at low background levels. At these densities they are a natural component of reef communities. Indeed fossil records indicate that they have been an active part of reef ecosystems for thousands of years (Walbarn et al., 1989). As a natural part of a reef ecosystem, and at the right density, *A. planci* fill an ecological niche and provide a service that benefits the community as a whole. Reports suggest that *A. planci* in low densities help maintain coral diversity by preferentially predating fast growing coral species, including Acroporids. This has a positive effect for slower growing corals such as *Porites* sp., and enhances competition and species diversity on the reef. The carrying capacity of any reef system will determine the optimal number for a healthy population.

1.2 Causes of outbreaks

The direct cause of outbreaks is widely debated. In reality the cause of any outbreak is likely very complex and will be influenced by a range of factors that determine its severity. Furthermore the importance of any one causal factor will likely differ for different reef sites. It has been shown that in the last century the frequency and intensity of outbreaks has increased (Fabricus et al., 2010). In the last 100 years direct and indirect anthropogenic impacts on reefs have increased dramatically and are likely contributory factors to the rise in frequency of outbreaks. Two main hypotheses have been proposed for outbreak frequency increase. Firstly the larval survival hypothesis suggests that the larval stage is critical in the life-cycle of *A. planci* and will determine potential changes in adult population. Increasing survivorship through this stage will greatly increase the numbers of *A. planci* attaining adult size and sexual maturity. There are a number of possible causes associated with increased larval survivorship including, the increased widespread presence of pesticide residues in marine environment as a factor in limiting predation on *A. planci* by reducing the abundance of predatory invertebrates. Likely more important however, is the increased nutrient supply from terrestrial runoff. New farming methods and destructive deforestation practices on land have led to an increase in nutrient load from freshwater sources into the oceans. Elevated nutrient levels often cause eutrophication episodes and phytoplankton blooms. If an episode occurs concurrently with *A. planci* spawning the result is unusually high survival of larvae. The phytoplankton blooms reduce the morality rate of larvae due to starvation and in addition provide ample food resource for larvae predators thus both enhancing rates of growth and survivorship (Lucas, 1982). Birkeland (1982) noted that large outbreaks tend to only occur on reefs around high continental land masses and not low coral atolls. Furthermore, outbreaks occur 2-3 years after periods of very high rainfall on land. This spatial pattern is explained by the fact that far greater quantities of nutrients run off high landmasses with deep soils than low-lying coral atolls. The lag time after rainfall events to an outbreak is explained by the development time of juvenile *A. planci* into visible adults.

The second hypothesis suggests that predator removal as a result of increased commercial fishing practices, increases populations of *A. planci*. This hypothesis assumes that the population is controlled by predation and that the removal of predatory fish would allow an ecological release of *A. planci* from predation pressure. However, evidence that predatory fish significantly impact numbers through predation is weak and largely anecdotal. Indeed a study into the diet of humphead wrasse (Cheilinus undulatus), often cited as a predator of *A. planci*, found no evidence that they had been predated despite being at outbreak levels on certain sections of the reef (Sweatman, 1995).

Alternatively it has been suggested that overfishing of predatory fish could lead to trophic cascades. With fewer large piscivorous fish there is an ecological release of predation on smaller benthic feeding fish species such as wrasse. With greater numbers of benthic feeders, abundances of benthic inverts decrease. Benthic invertebrates are important natural predators of settlement stage *A. planci*. Therefore a fall in their number would precipitate an expansion in *A. planci* numbers (Sweatman, 2008).

Pratchett (2005) proposed that outbreak events could occur as a result of two conditions; (1) a sudden and large single mass recruitment event or (2) a progressive accumulation of *A. planci* over a number of generations. Many studies focus on outbreaks that have seemingly been triggered by single events that led to the mass recruitment of one cohort of *A. planci*. In the study however Pratchett (2005) showed that the population structure of an outbreak of *A. planci* around Lizard Island on the Great Barrier Reef, Australia, comprised individuals from at least 4 separate cohorts. It is suggested that the outbreak resulted from a pro-longed build-up in *A. planci* numbers over multiple recruitment events. This finding shows that in certain cases outbreaks can occur independently of sudden recruitment events and indicates that factors responsible for the onset of outbreaks are likely subtle and difficult to measure.

1.3 Marine Protected Areas

Marine Protected Areas (MPAs) have become an increasingly valuable tool for resource managers to protect and conserve endangered marine ecosystems. They have a range of benefits that not only conserve marine resources for their own intrinsic value but also for the benefit of human populations that rely on them (World Bank, 2005). Well designed and enforced MPAs have the potential to withstand a wider range of threats than unprotected reefs. Coral reefs within MPAs seem to be better able to withstand *A. planci* outbreaks. Sweatman (2008) reports that reefs on the Great Barrier Reef (GBR), Australia, open to fishing pressure were 3.75 times more likely to have an outbreak than reefs within a no-take MPA. Due to trophic cascades caused by removal of large predatory fish, reefs outside MPAs may lack invertebrates that prey on juvenile CoTs. Furthermore MPAs are often located to protect areas that contain a high diversity of habitats and species. Studies suggest that interactions between coral populations can moderate the impact of *A. planci* outbreaks. A high diversity and density of hard coral is characterised by high rugosity that provides refuges for coral away from *A. planci*. As a consequence reefs are better able to recover from predation and are more resilient to outbreaks (Kayal et al., 2011).

1.4 Report Aim

This study was conducted over the months of May and June 2013, in the coastal waters of Napantao, San Francisco, Southern Leyte, Philippines. The area surveyed is a long term MPA managed by the Barangay of Napantao (Figure 2). Using a rapid assessment methodology this study aimed to assess the numbers of *A. planci* inside and outside the MPA.

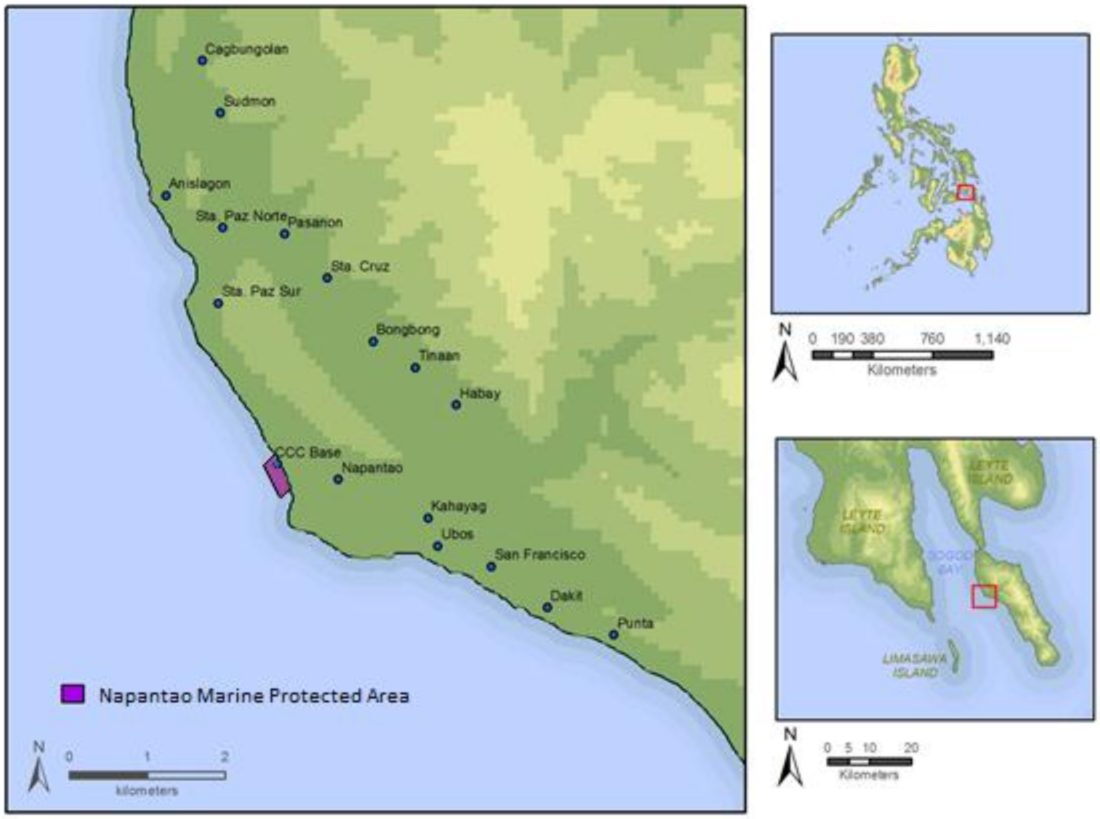


Figure 2- Map of San Francisco Municipality indicating the boundaries of the Napantao MPA surveyed in this assessment.

2. Methodology

The assessment of the MPA was conducted using a methodology adapted from the Reef Check method for recording reef invertebrates. The Reef Check methodology is widely recognised and is used to survey coral reefs around the world. It was developed in the 1990s with the aim of gathering as much data as possible about the global status of coral reefs (Hodgson et al. 1999). The data from around the world is analysed on a yearly basis and updates about the status of coral reefs are published. Reef Check provides a general picture of the ecological status of a reef and the human impacts affecting it.

Survey transects were conducted at depths of 6 metres and 12 metres, both inside and outside the MPA (Figure 3). Each transect was 100 metres long and divided into 4 replicates of 20 metres each. Between each replicate there was a 5 metre gap where no data was recorded. This survey set up allows for robust statistical analysis of the collected data.

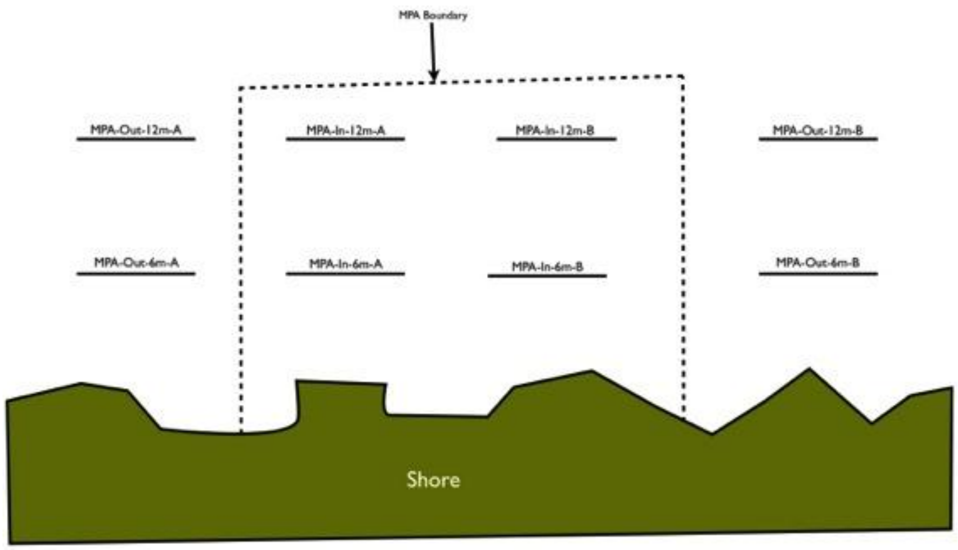


Figure 3 – Survey plan of the CoTs assessment. Each transect was 100 meters long and is divided into 4 replicates.

2.1 Belt Transects

Data was recorded along a 'belt' transect where *A. planci* were counted 2.5m either side of the transect line along the four 20m replicates (Figure 4). Each transect was surveyed by two divers. The first laid out the survey line with the buddy following behind looking for CoTs on one side of transect line. On the return leg, one diver counted *A. planci* on the other side of the transect line whilst the buddy reeled in the line. *A. planci* are generally nocturnal and so hide from direct sunlight during the day. Divers looked in holes and under overhangs to inspect for *A. planci* that may be hiding.

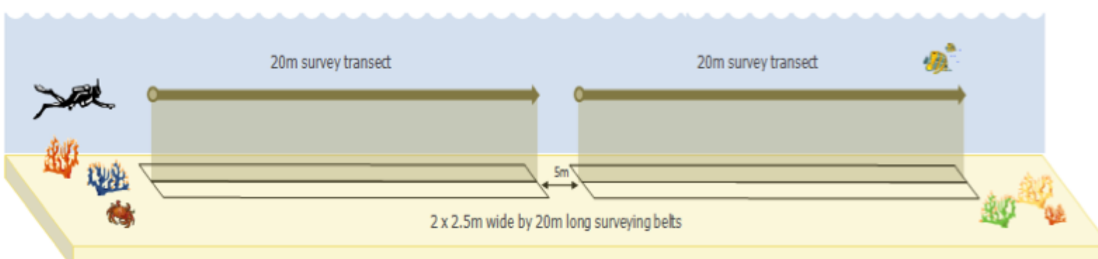


Figure 4 – Survey method for recording CoTs. The diagram shows 2 of the 4 replicates in a 100m transect.

2.2 Data Analysis

Each 20m belt transect was treated as an independent replicate. This produced n=16 inside the MPA and n=16 outside the MPA, when not considering depth. At each of the survey depths, 6m and 12m, there were n=8 replicates inside and outside the MPA.

To test for statistically significant differences between inside and outside the MPA, Mann-Whitney U tests were used. Preliminary inspection of the data revealed that the variances were not homogeneous and it had a non-normal distribution. Transformations of the data did not sufficiently alter this to warrant using a parametric test.

3. Results

The assessment at the MPA site in Napantao was conducted over the months of May and June 2013. It was conducted over 8 dives by trained volunteers from Coral Cay Conservation.

Overall abundance of *A. planci* in the area surveyed was low. Inside the MPA mean abundance was 1.19 ± 0.46 per $100m^2$ (mean ± SE). Outside the MPA the mean abundance of *A. planci* was 0.86 ± 0.27 per $100m^2$ (Figure 5). The difference in abundance between outside and inside the MPA was not significant ($p = >0.05$).

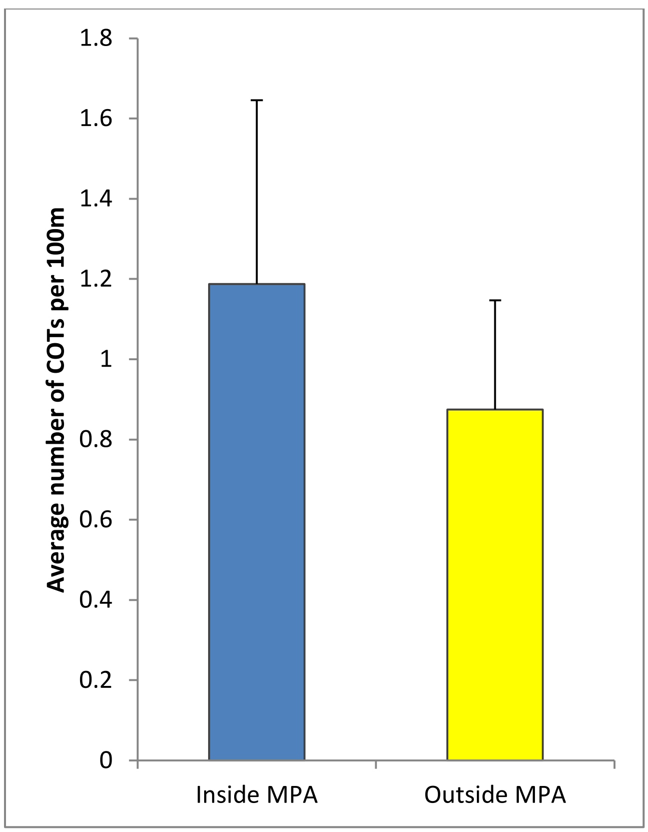


Figure 5 – Average abundance of *Acanthaster planci* per $100m^2$ inside and outside the proposed MPA. Data are mean average per replicate; error bars indicate standard error of the mean.

Inside and Outside the MPA, distribution of *A. planci* appeared not to be even over depth, with the average abundance at 12m being 0.44 ± 0.16 per 100m² and at 6m being 1.63 ± 0.46 per 100m². When statistical analysis was undertaken however there was no statistical difference found (p = >0.05) (Figure 6).

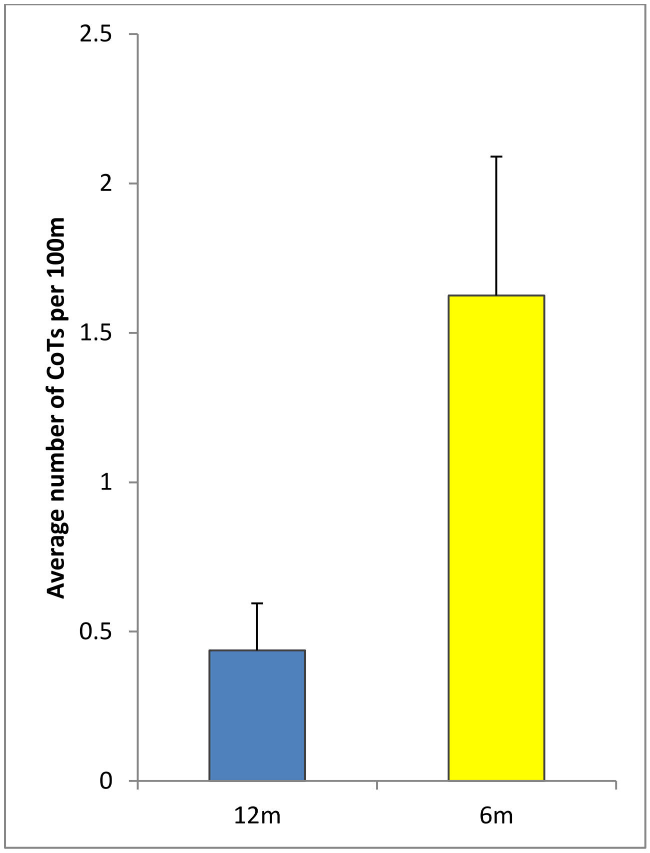


Figure 6 – Average abundance of *Acanthaster planci* per 100m² at 6m and 12m. Data are mean average per replicate; error bars indicate standard error of the mean.

4. Discussion

Due to natural variations between populations, it has been difficult to define what abundance levels of *A. planci* may constitute an outbreak. Definitions for a non-outbreaking reef have ranged from 6 individuals per km^2 to 14,000 individuals per km^2 (Moran and De'ath, 1992). This wide degree of variability has led to some difficulty in determining when a reef is threatened by a CoTs outbreak and when numbers are within acceptable levels. It is usually necessary to take into account factors such as the relative abundance of live and recently killed coral, in addition to overall number of individual *A. planci*. Generally reefs can be classified into three groups depending on their CoTs status: 1. Active Outbreak, 2. No Recent Outbreak and 3. Recovering (Moran and De'ath, 1992).

The assessment of the MPA in Napantao reported a relatively low abundance of *A. planci* unlikely to be within outbreak levels. Hard coral cover recorded during the MPA assessment of Napantao showed a very healthy cover of hard coral which improves the reefs ability to cope with larger numbers of CoTs (Kayal et al., 2011). There were few examples of recently killed coral colonies, suggesting the coral has had little recent predation. Throughout Napantao reef there can be seen a high diversity of coral species including slow growing Porites sp. and faster growing Acropora sp. *A. planci* preferentially predate on fast-growing coral species such as Acropora (Pratchett, 2007) and therefore a reef containing healthy colonies of these species is a good anecdotal indicator that the CoT population is in healthy balance to the reef.

The relatively low numbers of *A. planci* recorded in the survey is a positive sign for the reefs around Napantao and San Francisco as a whole. Using conservative estimates of healthy population levels for CoTs, the numbers found fall within acceptable boundaries.

5. Recommendations

The findings of this assessment should be used as an on-going positive indicator that CoT numbers are within acceptable level. Due to its relatively small scope however this report should not be taken as a holistic assessment. Instead, the results should stimulate the continued monitoring of the region for evidence of outbreaks. It should be noted that within recent years there have been several CoTs outbreaks within the Sogod Bay area (Padre Burgos, Limasawa, and Tabugon) and therefore continual monitoring is strongly advised.

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