TUBBATAHA REEFS NATURAL PARK

Research and Monitoring

Annual Report

2013

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EXECUTIVE SUMMARY

The Tubbataha Reefs Natural Park (TRNP) is a marine protected area composed of two coral atolls, North and South Atolls including the Jessie Beazley Reef, remotely located in the Sulu Sea. It is 92 nm southeast of Puerto Princesa City, Palawan. It is rich in marine biodiversity and has been declared a World Heritage Site by UNESCO. Based on previous surveys and research studies, the TRNP harbors 7 species of seagrass, over 360 species of corals, 690 species of reef fish, 13 species of cetaceans, 6 resident breeding species of seabirds, 19 species of sharks and rays, 2 species of marine turtles, and 75 invertebrate species. It has one of the highest reef fish abundance and biomass in the country. Because of these attributes, it has invited a lot of attention from divers and poachers, as well as scientists and researchers, not only from within the country but also overseas. Since it is strictly a no-take zone with only recreational diving and research activities allowed, it is zealously watched over by the marine park rangers who guard the park 24/7. Marine park rangers also help conduct research monitoring activities annually together with various visiting scientists. This year, the park rangers witnessed two incidents of ship groundings; one by the US Navy minesweeper, USS Guardian, and the other a Chinese fishing vessel, Min Ping Yu. Coral reef damage covered an estimated area of 2,345 square meters and 3,902 square meters, respectively. The numerous threats being continuously faced by this global and national marine treasure highlight the importance of continuous management activities and a long-term monitoring program.

Since 1997, the Tubbataha Management Office (TMO), with assistance from WWF-Philippines and various academic institutions and non-government organizations (NGOs), has been implementing a standardized research and monitoring program. The research and monitoring program of the TRNP aims to determine any spatial and temporal changes in the coral reef community and other associated ecosystems and species in the area over time. This year, the monitoring surveys were facilitated by the WWF-Philippines, in collaboration with the University of the Philippines Marine Science Institute (UP-MSI) and De La Salle University (DLSU). This report presents the current status of coral, reef fish and seabird communities in the TRNP, building on the data collected by the TMO monitoring team, various scientists, and institutions that have helped Tubbataha over the years.

For the benthic community structure, the point-intercept method modified from Reef Check was used this year to obtain percentage cover of hard coral and other benthic attributes. Underwater fish visual census following the methods of English et al. (1997) was used to determine species richness, abundance and biomass of the reef fish communities in the TRNP. As part of the transition towards utilizing Reef Check survey methods for future monitoring, the Reef Check fish survey was also done on the same transects

where FVC was conducted. Only four of the original monitoring sites were surveyed this year. These were the sites that yielded consistently high coral cover over the years, namely Sites 2, 4, 6 and 7. For the seabird inventory, species counts included monthly distance counts, direct day-time inventories (counts of adults, juveniles or pullus, eggs and nests) and afternoon count of birds flying in to roost (in-flight counts). Habitat changes were compared with previous records that included photo-documentation of the islets, areal extent of the islets through GPS readings and inventory of the vegetation cover. The year-long monitoring data (regular inventories and distance counts) obtained by the park rangers was also reviewed.

Overall, mean hard coral cover in the TRNP (both Tubbataha and Jessie Beazley Reefs) was 49.0% for the deep stations (10 m) and 68.5% for the shallow stations (5 m), respectively. Hard coral cover for both depths in Tubbataha Reefs was in good condition (i.e. 50-75% coral cover, Gomez et al. 1994). In Jessie Beazley, hard coral cover in the deep stations was fair at 44% (i.e. 25-49%, Gomez et al. 1994) while the shallow stations have excellent coral cover at 77% (i.e. 75-100%, Gomez et al. 1994). In general, the shallow stations generally had higher hard coral cover than the deep stations. The coral condition index in both the Tubbataha and Jessie Beazley Reefs were positive, except in one deep station in Jessie Beazley where a negative value was obtained. Positive coral condition index would indicate that live coral cover was higher than algae and other fauna. Over the years, hard and soft coral cover displayed fluctuations that were caused by natural disasters, such as El Niño in 1998, storm damages in 2008 and an outbreak of the crown of thorns starfish from 2007 to 2010. Despite these disturbances, the coral communities still managed to recover and showed an increasing trend since 2001.

A total of 265 reef and reef-associated species from 35 families were observed during the 2013 monitoring surveys. Mean fish species richness ranged from 42 to 83 species per station. The most abundant species was the Bicolor Chromis (*Chromis margaritifer),* which was observed in all sites, but found in large numbers in Jessie Beazley. Among the target species, the Bluestreak Fusilier (*Pterocaesio tile)* was the most abundant, and was also numerous in Jessie Beazley. The Pyramid butterflyfish (*Hemitaurichthys polylepis*) was the most abundant coral indicator species. Several endangered and/or rare species, which are uncommon elsewhere in the country, were also readily encountered in the TRNP, such as the humphead wrasse (*Cheilinus undulatus*), whitetip reef sharks (*Triaenodon obesus*) and various species of rays and turtles. Mean fish abundance for TRNP was 2,431.0 individuals/250m^2. Mean fish abundance ranged from 709 - 2,746 individuals/250m^2. The maximum abundance was always observed in Jessie Beazley. Overall, the deep transects yielded higher abundance of target species, such as groupers, jacks and fusiliers. Meanwhile, mean fish biomass in TRNP was estimated at 227.9 metric tons/km^2. This ranged from 146.4 - 285.8 metric tons/km^2. The target species comprised the bulk of the fish biomass in

the TRNP, contributing around 60-90% to the total mean fish biomass even if it only contributed roughly <15% to the total mean fish abundance. These results show that the TRNP still hosts reef fish abundance and biomass values that are unsurpassed by any other site in the country. It remains to be the ideal state which other marine protected areas could aspire to be.

A total of six (6) resident seabird species were observed breeding in the North and South Islet during this period: *Sula sula* (Red-footed Booby), *S. leucogaster* (Brown Booby), *Sterna bergii* (Great Crested Tern), *S. fuscata* (Sooty Tern), *Anous stolidus* (Brown Noddy) and *A. minutus* (Brown Noddy). Of these six resident seabird species, a total of 28,901 adults were counted, with 18,922 in the North Islet (including those found in the Ranger Station and Amos Rock) and 9,979 in the South Islet. This was the second highest count conducted over the years (2012 had the highest count) and was due to high population densities of the Great Crested Tern and the Black Noddy representing over 70% of the total count. Other breeding species observed during the study period were the *Egretta sacra* (Eastern Reef Egret), *Gallirallus torquatus* (Barred Rail) and *Passer montanus* (Eurasian Tree Sparrow). Four new species were also recorded (2 resident and 2 migratory), *Gallicrex cinerea* (Watercock), *Collocalia fuciphaga* (Germains's Swiftlet), *Actitis hypoleucos* (Common Sandpiper) and *Oceanodroma monorhis* (Swinhoe's Storm Petrel). It was the first record of the Swinhoe's Storm Petrel in the Philippines, a species that breeds in Russia, China, North and South Korea and Japan and is classified as Near Threatened (IUCN 2013). There were 31 different bird species identified during this inventory although overall the total number of species, whether migratory or resident, that has been recorded in the TRNP from 1911 to 2013 is 108. Meanwhile, there has been a steady decrease over the years in the total land area of the North Islet with continued erosion over the northeastern shoreline. However, in the South Islet, where a seawall and lighthouse exists, total land area has remained relatively stable and has even slightly increased in size. Both islets, however, have shown a decrease and deterioration of vegetation. The present condition of the vegetation in both islets was attributed to the intensive nesting density of the Red-footed Booby.

In summary, the 2013 monitoring surveys still reveal the richness of the marine ecosystems and species in the TRNP despite various threats and pressures encountered over time. The transition of coral reef monitoring methods to Reef Check may need to be assessed further. Reef Check methods are more focused on assessing human impact on reefs and are less detailed (e.g. 10 benthic categories as compared to the 31 lifeforms currently being monitored in Tubbataha), as opposed to other methods that are designed to be more ecological in focus. Since the main interest of the TMO in monitoring the coral reefs in TRNP is to follow changes in live coral cover, transitioning to the modified Reef Check method for benthic communities should be sufficient to achieve this and will make the monitoring program more management-oriented (as opposed to being ecologically-oriented)

although this is entirely dependent on the needs and objectives of the TMO. However, the same may not hold for monitoring reef fish communities. The Reef Check methods for fish surveys are limited to recording the presence/absence and abundance of several indicator species while many other commercially important target species are not assessed and fish biomass cannot be obtained from the data collected. As the TMO considers these parameters important for management purposes, the previous fish visual census methods is actually still being followed, especially since comparisons with data from previous years are also being done. Finally, because of the importance of the TRNP as the only site in the Philippines of global importance for seabird conservation, key recommendations for seabird management should include the following: habitat rehabilitation (regenerating beach forest species only) and removal of nests of Red-footed Booby from the South Islet to protect the last breeding habitat of the Black Noddy in the Philippines; continued monitoring (annual and seasonal) and recapture of banded seabirds should be increased to gather more information on the seabirds of TRNP; lobbying with the DENR-PAWB for the inclusion of seabirds into the list of threatened species under the Wildlife Act; and increasing public awareness, such as production of video documentaries of the seabirds of Tubbataha, to highlight the uniqueness of the TRNP.

Chapter 1. GENERAL INTRODUCTION

I. Overview

The Tubbataha Reefs Natural Park (TRNP) is one of the Philippine's marine treasures because of its biodiversity, beauty and uniqueness. It is found in the middle of the Sulu Sea (N 8°50'677" E 119°55'734") and is composed of two uninhabited atolls, North and South Islet, and the Jessie Beazley reef. It was established as a 33,200-hectare no-take national marine park in 1988 by Pres. Corazon Aquino and was later expanded to 97,030 in 2010 under RA 10067 by Pres. Gloria Macapagal-Arroyo. It has also been declared a UNESCO World Heritage Site in 1993, inscribed in 1999 in the Ramsar List of Wetlands of International Importance and is the only site in the Philippines considered of global importance for seabird conservation being the last remaining intact rookery in the country. Because of these attributes it has attracted attention from divers and poachers. For example, the invertebrate commonly called Topshell (*Trochus niloticus*), which is abundant in the TRNP, was the target of some fishers who have been caught poaching inside the park from 2006 to 2009. Scientists and divers from within and outside the country also frequent the TRNP. In fact, tourism revenues in 2013 reached 4.15M. Revenues gained from tourism through collection of park fees from dive boats and divers help fund the TRNP's management, research and enforcement activities, among others. A portion of the annual tourism revenue goes to the Municipality of Cagayancillo.

Years of protection and management by the Tubbataha Management Office (TMO) have helped maintain the richness of TRNP's ecosystem. Biophysical monitoring activities have been made possible through the years with the participation and assistance of many government agencies (DENR, PCSDS, Philippine Navy, Philippine Coastguard, Provincial Government of Palawan, LGU of Cagayancillo), non-government organizations (CI, GIZ, WWF-Philippines) and academe (DLSU, UP-MSI, Silliman University). Through the concerted efforts of all these organizations, TRNP has become the example of what a marine protected area could be, with the highest reef fish abundance and biomass among all sites studied in the Philippines. However, findings from regular monitoring have shown that this present state could just be easily damaged by natural causes, like bleaching (1998), storm damage (2008), and crown-of-thorns infestation (2008-2010), and/or from human activities, like ship grounding events (Greenpeace vessel, US Navy minesweeper, Chinese fishing vessel) and poaching (Topshell from 2006 to 2009). These events and survey results have helped the Tubbataha Protected Area Management Body (TPAMB) make decisions to improve the management of the TRNP, such as the continued training of the TMO park rangers and research team in monitoring, expansion of the protected area to include the Jessie Beazley Reef in 2006, and conducting on-going consultations to declare the TRNP as a Particularly Sensitive Sea Area (PSSA).

This report presents the results of the monitoring surveys that were conducted in 2013 and provides information on the temporal trends of the benthic, reef fish and seabird populations, as well as the modifications in the monitoring protocol being followed in the TRNP.

II. General Objective

The research and monitoring program of the TRNP aims to determine any spatial and temporal change in the coral reef community and other associated ecosystems and species in the area. Results from the program are being used to formulate new or make adjustments in existing management policies and strategies.

III. Research and Monitoring Design

Study Sites

The Tubbataha Reefs Natural Park is situated in the middle of the Sulu Sea (N 8°50'677" E 119°55'734") and covers a total area of 97,030 hectares plus a 10-nautical mile buffer zone. The park is composed of two coral reef atolls separated by a 5-nm channel and Jessie Beazley Reef, located about 14 nm north of South Atoll and about 10 nm northwest of the North Atoll.

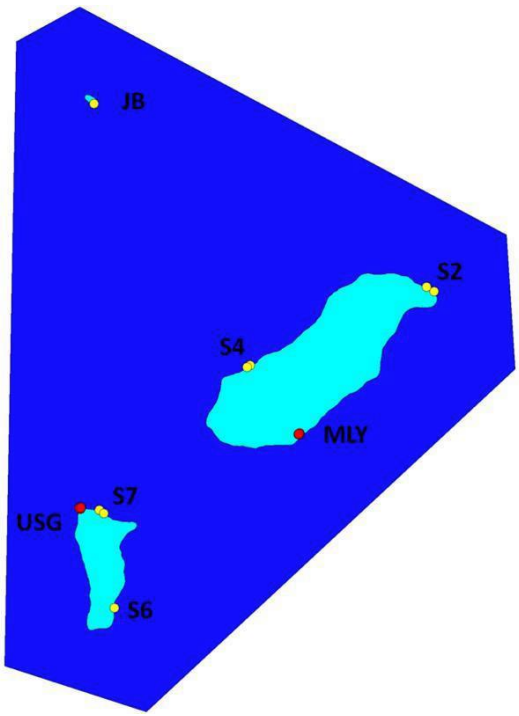

Figure 2. TRNP map and study site.

In previous years, a total of 10 permanent transect sites were set around TRNP, four sites in the North Atoll and three sites in the South Atoll that were consistently monitored until 2011, and three sites in the Jessie Beazley which were difficult to monitor throughout the years due to logistical constraints. These transect sites were marked with the use of a Global Positioning System (GPS) and cement blocks that were fastened into the rock substratum to permanently mark the sites. During the 2012 monitoring, five sites were assessed: site 2 and 4 in the North Atoll, and site 6 and 7 in the South Atoll, and only one site in Jessie Beazley. These were done as part of the proposed transition of utilizing Reef Check survey methods for future monitoring.

In 2013, only four of the original monitoring sites were surveyed. These were the sites that yielded consistently high coral cover over the years, namely Sites 2, 4, 6 and 7 (Figure 1). Additional stations were added in each of the site; hence, a total of eight stations were surveyed in Tubbataha Reefs (Table 1). In addition to this, two new sites were established in Jessie Beazley.

Meanwhile, the grounding sites were located in points indicated as USG and MLY Figure (1). These sites were assessed separately using the CRTR method employed by DLSU and UP-MSI.

Table 2. Location of the TRNP monitoring stations and grounding sites.

Site Name	Stations	Location	Latitude (N)	Longitude (E)
Sea Fan Alley (Site 2)	Station 2A	North of north atoll	8.93532 °	120.01302 °
	Station 2B	North of north atoll	8.93781 °	120.00851 °
Malayan Wreck (Site 4)	Station 4A	West of north atoll	8.89236 °	119.90627 °
	Station 4B	West of north atoll	8.89128 °	119.90453 °
Delsan (Site 6)	Station 6A	Southeast of south atoll	8.75591 °	119.82881 °
	Station 6B	Southeast of south atoll	8.75186 °	119.82784 °
T-wreck (Site 7)	Station 7A	North of south atoll	8.80850 °	119.81907 °
	Station 7B	North of south atoll	8.80656 °	119.82169 °
Jessie Beazley	Station JBA		9.04393 °	119.81599 °
	Station JBB		9.04557 °	119.81348 °
Grounding sites	USG	North of south atoll	8 51 183°	119 56.188°
	MLY	Southeast of north atoll	8 49.297°	119 48.187°

Field Surveys

The annual surveys are part of the long-term monitoring program for TRNP. These surveys are done only during the summer months of March to June when sea conditions are generally calm and safe for travel. The month of October presents another small window of opportunity to travel to Tubbataha. It is a transition period between the southwest and northeast monsoons. However, the weather at this time is still unpredictable.

The biggest limiting factors in the conduct of regular research and monitoring expeditions in TRNP are the weather and distance. Everything depends on calm weather for the conduct of surveys and research activities. Other related limitations are: (1) manpower; (2) food and water storage; and (3) equipment failure. The area is remote and there is no freshwater source nearby or other options in case of equipment failure.

Survey Teams

Fish and Coral Survey Team: A total of 15 individuals participated in the fish and coral monitoring activity. The team was composed of 6 members from the academe (DLSU and UP-MSI), 3 from WWF-Philippines and 6 from the TMO (park rangers, research monitoring members and the Park Manager). This year's survey was also made possible with the assistance of WWF- Philippines staff and M/Y Navorca boat crew.

Seabird Inventory Team: A total of 16 park rangers, TMO staff and volunteers participated in the seabird inventory (see Annex 1 for list). The park staff included three rangers and two research assistants from the TMO, one ranger from the Philippine Coast Guard, one ranger from the Philippine Nay and one ranger representing the municipal government of Cagayancillo. In addition six volunteers representing the TMO, the Philippines Biodiversity Conservation Foundation, Inc., and Birdtour Asia assisted the team. WWF Philippines and its crew on M/Y Navorca likewise assisted the team and made the fieldwork possible.

Chapter 2. MONITORING BENTHIC COMMUNITY STRUCTURE

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I. Introduction

The Tubbataha Reefs Natural Park (TRNP) is one of the last remaining coral reef areas of its kind in the Philippines. It is internationally renowned for its ecological importance and aesthetic value. It provides important ecosystem services, which underpin Filipinos with its resultant economic benefits and incalculable social and historical values. Unfortunately, it is not totally safe from issues that threaten its stability, such as climate change and illegal fishing, to name a few. Thus conservation efforts have to be prioritized and hastened to counter its degradation and maintain ecological balance to ensure food security and that future generations will experience all the wonders of a rich habitat such as Tubbataha Reef (Ledesma et. al., 2009).

WWF-Philippines has committed to help protect the Tubbataha Reefs Natural Park since 1997 and provides the Tubbataha Protected Area Management Board (TPAMB) with the technical and scientific information needed as basis for management decisions and strategy formulation. This year's survey was made possible with the collaboration of different institutions, such as the University of the Philippines Marine Science Institute (UP-MSI) and De La Salle University (DLSU). This paper presents the results of the coral reef monitoring surveys from 2001 – 2013. The research and monitoring program is designed to give annual updates on reef health while detecting spatial and temporal changes. The scientific data collected provide the basis for the formulation of management strategies.

II. Methods

Field Methodology

For the 2013 monitoring surveys, a modified Reef Check (Reef Check®) point-intercept method was used in line with the transitioning of data collection in the TRNP. As in previous methods used, this method still provides the relative abundance of benthic organisms and non-living components of the reef, *albeit* with fewer lifeform categories to identify (Table 2). In this method, a 100-meter transect line was laid along the bottom. The lifeform directly beneath the 0.5-meter sampling mark was then recorded along a 20-meter

segment of the transect line. To increase the number of points for each segment, the method was modified by using a stainless steel V-bar which was placed at every 0.5-meter mark with its 2 proximal ends pointing to the right (McManus 1997). The lifeform directly beneath the proximal ends of the V bar were then identified and recorded. The V-bar was then flipped to the left, and the lifeforms at the two ends were again identified and recorded. This renders a total of 5 data points at every 0.5 meter instead of just 1 data point in the original method. Hence, for each 20-m segment, a total of 200 points is generated. The same procedure was done in the next three 20-m segments along the transect line, each separated by 5 meters. Hence, there were four replicate segments per transect (station).

The modified Reef Check surveys were conducted along two depth contours (5m and 10m depths). In each transect, a standard monitoring sequence was followed to ensure the most limited disturbance to natural fish behavior (i.e., 1 - fish surveys; 2 - benthic surveys; and 3 - invertebrate surveys). For the invertebrate surveys, the survey teams counted the indicator invertebrates along the four 20-m x 5-m belt segments (Reef Check®).

Table 2. The basic Reef Check substrate categories.

Code	Category
HC	**Hard Coral** (includes blue coral, fire coral and organ pipe coral)
SC	**Soft Coral** (includes zoanthids)
NIA	**Nutrient Indicator Algae** (Includes seaweed that proliferates with high nutrient input)
OT	**Other** (includes other living or non-living substrata, such as, hydroids, anemones, gorgonians and ascidians)
SP	**Sponge**
RC	**Rock** (includes any surface that coral could settle onto. Including rock covered with turf algae and dead coral)
RKC	**Recently Killed Coral** (includes coral that has died in the last year. Such coral will still have a white or partially white skeleton and may be slightly overgrown with algae)
RB	**Rubble** (included dead coral of 0.5 cm diameter)
SI	**Silt**
SD	**Sand** (includes pieces less than 0.5 cm in diameter)

Data Analysis

Percentage Cover

The percentage cover of each life form was generated by dividing the total points of a each life form by the total points of all identified life forms (200) multiplied by 100 such as shown below.

$$\text{Percentage cover of life form A} = \frac{\text{Number of points of life form}}{\text{Total number of points in the transect (200)}} \times 100$$

For the graphs presented in this report, mean values for all eight segments (both shallow and deep transects) were computed, along with standard deviation and standard error.

Regression

A regression analysis was done to predict whether the populations are stable, increasing or decreasing. This is represented by the linear trendline plotted together with the data series in the charts. A trendline is most reliable when its R-squared value is near or equal to 1. The R-squared value is the coefficient of determination and basically reveals how closely the estimated values for the trendline correspond to the actual data.

Correlation

To determine whether there were any differences in the results of benthic cover (HC and SC) over the years, data on the percentage cover of the benthic categories for the deep site were correlated with the shallow sites. The data used came from the set of sites (Site 2B, 4B, 6B, 7B, JbA and JbB) that are referred to as "old sites." High correlation would suggest how strongly the variables are related.

Benthic Indices

Based on the results of the benthic categories, condition and mortality indices were computed to provide additional information on the condition of the reef.

Equation:

a. Condition Index = LOG Live coral / Dead coral + algae+ Other fauna

b. Mortality Index = Dead coral / Live coral + Dead coral

c. Development Index = LOG Live coral +Dead coral+ Algae +Other fauna / Abiotic

d. Succession Index 1 = LOG Algae / Dead coral + Other fauna

e. Succession Index 2 = LOG Other fauna / Dead coral + Algae

III. Results and Discussion

A. Tubbataha Reef

For 2013, mean hard coral cover in the deep sites (10-m depth) was estimated at 54% while mean soft coral cover was at 15.25% (Table 3). Mean live coral cover (HC + SC) puts the reefs into the "good" category based on quartile scaling of reef condition (Gomez et al. 1994). Site 2A yielded the highest coral cover at 91% (Figure 2). Mean percentage cover of abiotic components, such as rocks and rubbles, was high mainly due to the natural make up of the reef. Rock was highest in the deep stations of Sites 4A, 4B, 6A and 7A while rubbles were predominantly high in Sites 6A, 7B and 6B (Figure 2). No mortalities were encountered in all the sites this year, which could be attributed to the newly established sites and dropping of old sites.

In the shallow sites (5-m depth), mean hard coral cover was estimated at 60%, and was slightly higher compared to the deep sites (Table 3). Hard coral cover was generally high, ranging from 58-64%, except in Site 4A where it was only 37% (Figure 3). Soft coral cover at this depth was observed to be low, with a mean cover of only 6.75% (Table 3). In general, soft coral cover was higher at the deep sites as it relies more in the areas with strong currents. Mean live coral cover summed up to 66.75%, putting the reefs at this depth into the "good" category. For abiotic components, such as rocks and rubbles, mean cover was 21.75% and 7.6%, respectively (Table 3). These were observed to be higher in the shallow sites compared to the deep sites while sand and silt displayed minimal cover at both depths. Percentage cover of other fauna was very low to almost none at both depths (Table 3).

A comparison between the old and new sites was done to determine whether there were differences in percentage cover of coral and other components. Prior to the proposed transition of data collection as well as the dropping of other sites with low coral cover, it also serves as baseline information for the newly established sites in Tubbataha. Results showed that mean hard coral cover in the deep stations of the new and old sites did not differ significantly at 52% and 56%, respectively (Figure 2). Soft coral cover was higher in the new sites as opposed to the old sites. Higher cover of abiotic components was also observed in the new sites at this depth, mostly consisting of rocks and rubbles. Other fauna, such as nutrient indicator algae, was less observed at this depth compare to shallow area (Figure 2).

Table 3. Mean percentage cover of the different benthic attributes at 10m and 5m depths in the Tubbataha Reefs monitoring sites.

Benthic Lifeform	Deep (10 m)	Shallow (5m)
Hard Coral	54 %	60 %
Soft Coral	15.25 %	6.75 %
Recently Killed Coral	0	0.25 %
Nutrient Indicator Algae	0.125 %	0.25 %
Sponge	1.25 %	1.625 %
Rock	19.625 %	21.75 %
Rubble	9.25 %	7.625 %
Sand	0	0.875 %
Silt	0	0
Others	1%	0.75 %

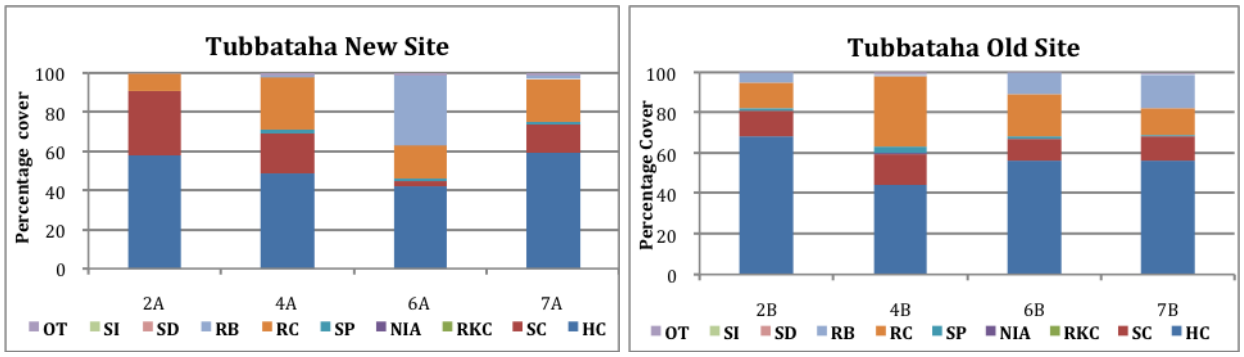

Figure 2. Mean percentage cover of the different benthic lifeforms in the new (left) and old (right) sites of Tubbataha Reefs at 10 m depth.

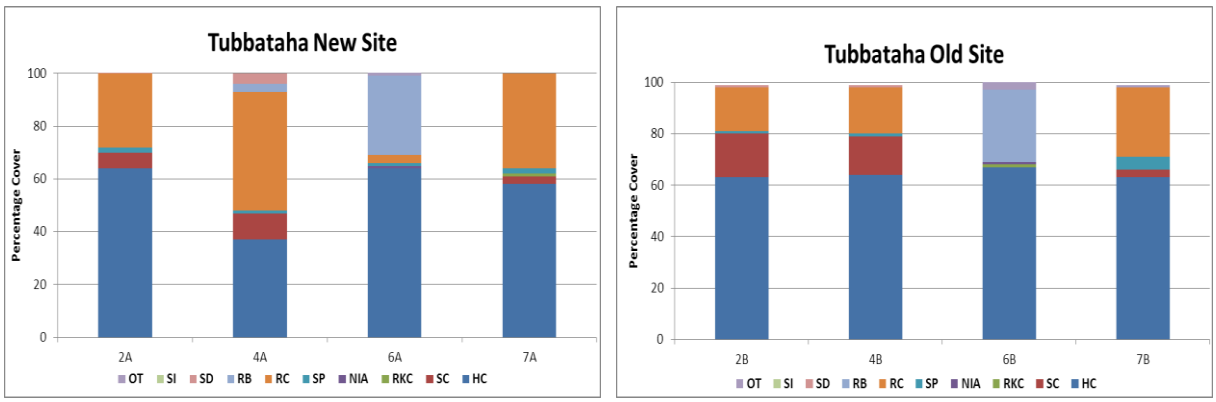

Figure 3. Mean percentage cover of the different benthic lifeforms in the new (left) and old (right) sites of Tubbataha Reefs at 5 m depth.

The mean substrate cover in the shallow stations of the new sites was estimated at 56%, lower than what was recorded in the old sites (Figure 3). High percentage cover was observed in Site 6B at 67%, which consisted of monospecific *Isopora bruegemanni,* and followed by Sites 6A, 2B and 2A. Soft coral cover was lower in the new sites than in the old sites at 5% and 9%, respectively (Figure 3). Rock was estimated at 28% and 15% in the new and old sites, respectively. Abiotic components were slightly higher in the new sites as opposed to the old sites, covering 28% and 15%, respectively. Moreover, other fauna appeared to be low in both old and new sites.

Over the years, hard corals displayed fluctuations that were caused by natural disasters, such as El Nino in 1997-98, storm damages in 2008 and proliferation of crown of thorns in 2008 until 2010. Despite these disturbances coral reefs still managed to recover and showed an increasing trend since 2001 (Figure 4). Mean hard coral cover decreased in 2008 due to storm damage. The shallow sites were more susceptible to storm damage than deep sites. It decreased again in 2010 due to crown of thorns infestation but seemed to have recovered since then (Figure 4). Overall, trend over the years remained increasing differing only in 2004 and 2006, the year that high estimation was observed. An increase was recorded in 2004, six years after the El Niño event. This may be an indication of the duration it takes for a reef to heal after a disturbance like bleaching (Ledesma et al., 2008) The hard coral cover relationship between depths displayed a correlation coefficient of 0.523.

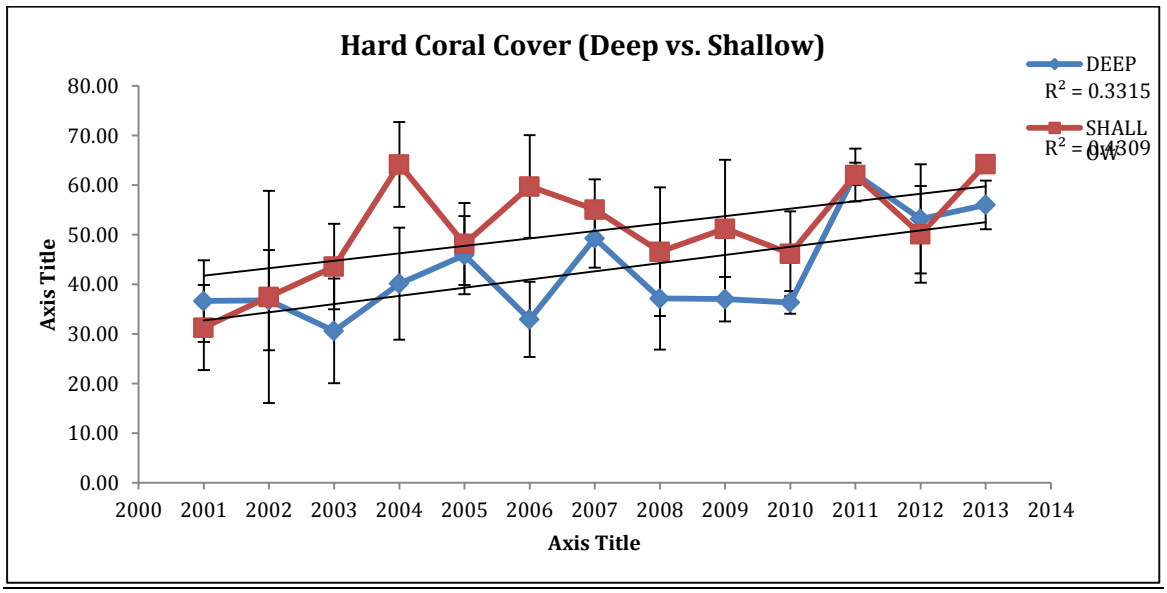

Figure 4. Mean percentage hard coral cover in the deep (blue line) and shallow (red line) stations of Tubbataha Reefs from 2001 to 2013. Error bars represent the standard error of the mean.

Meanwhile, soft corals displayed a stable trend in the deep sites but an increasing trend in the shallow sites (Figure 5). The correlation coefficient for soft coral cover between deep and shallow sites was low at 0.073. Soft corals seemed to thrive more in the deeper sites compared to the shallows.

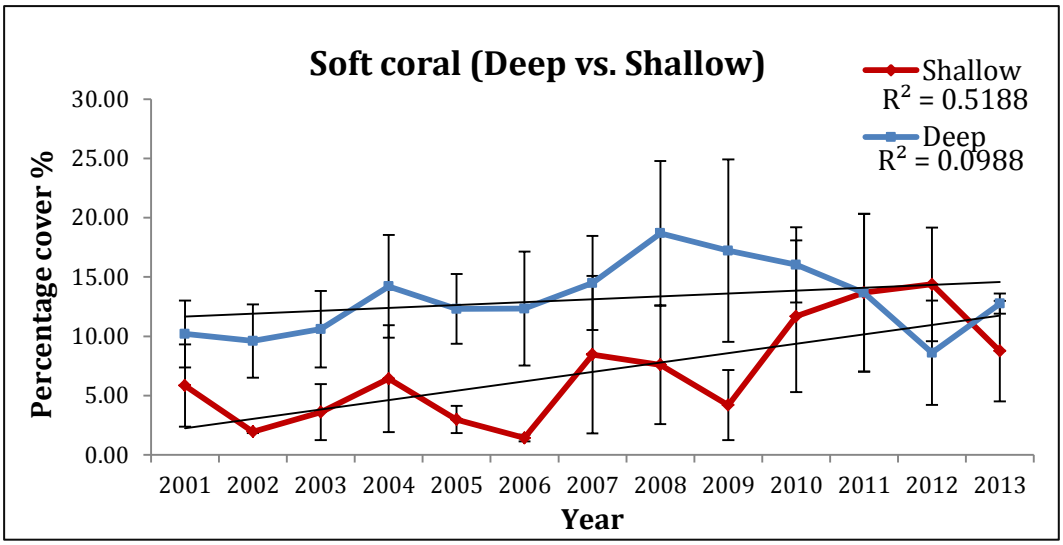

Figure 5. Mean percentage soft coral cover in the deep (blue line) and shallow (red line) stations of Tubbataha Reefs from 2001 to 2013. Error bars represent the standard error of the mean.

Benthic Indices

Condition index

This index shows the proportion of live coral cover relative to the cover of dead corals, algae and other fauna. If live coral cover is high while the cumulative cover of algae, other fauna and dead corals is low, this yields a high condition index and *vice-versa*. An equal proportion of the said categories would yield an index that is approaching zero. All sites in shallow and deep displayed a positive condition index (Figure 6). In general, the shallow stations had higher condition indices than the deep stations in almost all sites.

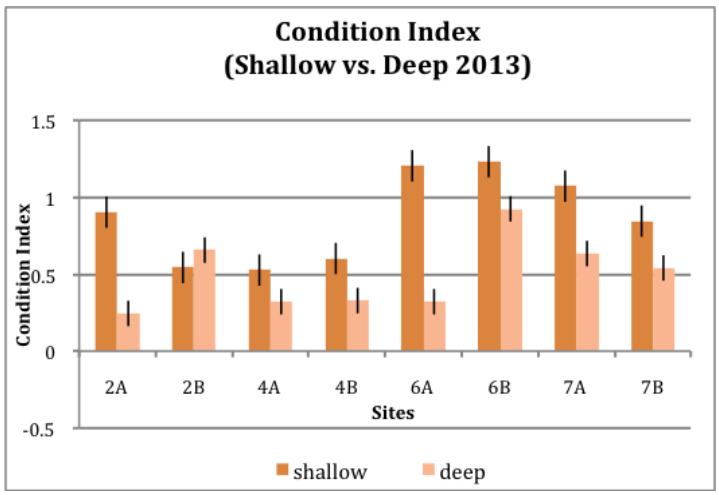

Figure 6. Condition Index at deep and shallow sites of Tubbataha Reef.

Mortality index

Mortality index is the proportion of dead corals relative to the sum of live and dead corals. Only three out the eight sites displayed positive mortality indices, all of which were in the shallow areas (Figure 7). Site 6 is characterized by flourishing monospecific stands of branching corals, which are fragile and thus often most vulnerable to wave damage (Licuanan et. al., 2000). This could be the reason why mortality index was positive in this site while other sites had zero mortality.

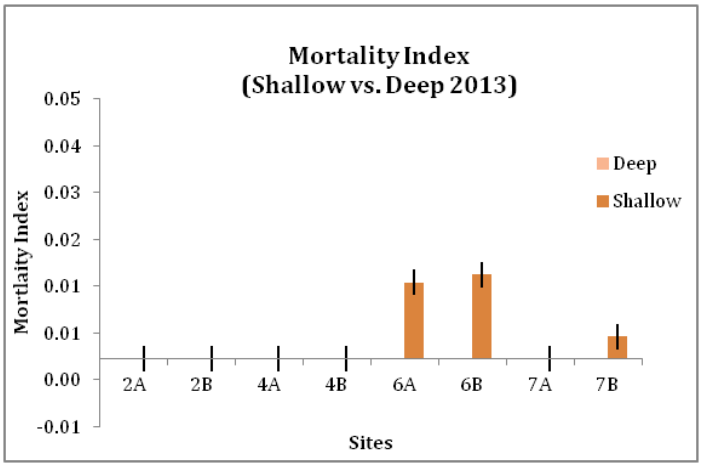

Figure 7. Mortality index at deep and shallow sites of Tubbataha Reefs.

Development Index

Development index is the proportion of living benthic components relative to the non-living component. Development potential of an area is said to be high if it has high live component cover as there are lots of organisms to contribute to the improvement of the reef. On the contrary, development potential is low if non-living components are more dominant for they do not contribute directly to reef recovery. Noticeably, almost all sites garnered positive development indices at both depths except in the shallow area of Site 6A (Figure 8). Sites 4B, 6A and 7B had high indices, thus suggesting that these sites are more likely to regain to their present condition after a disturbance since many organisms will contribute to its growth.

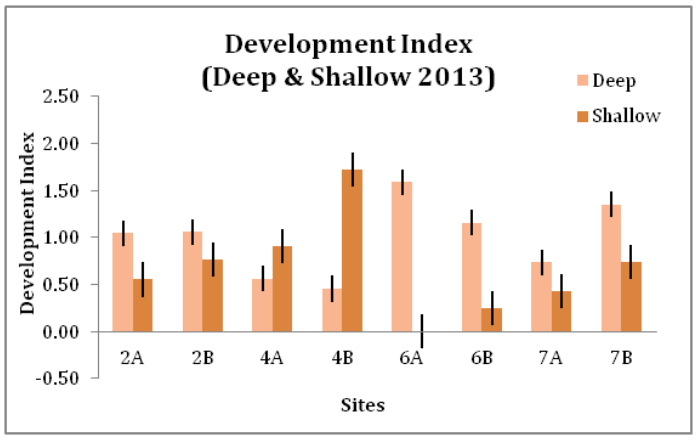

Figure 8. Development Index at deep and shallow sites of Tubbataha Reefs.

Succession Index for algae

The succession index for algae is the relative proportion of algae cover over, dead coral and other fauna. This index points out the likelihood that algae will colonize the open spaces of the reef. Three out of eight sites, mostly in the found shallow stations, had negative indices while other sites had zero indices (Figure 9). This indicates that the algae will not probably colonize in the open spaces (Figure 9). These sites are mainly composed of high abiotic component, such as rocks and rubbles thus it is unlikely for algae to proliferate in the area.

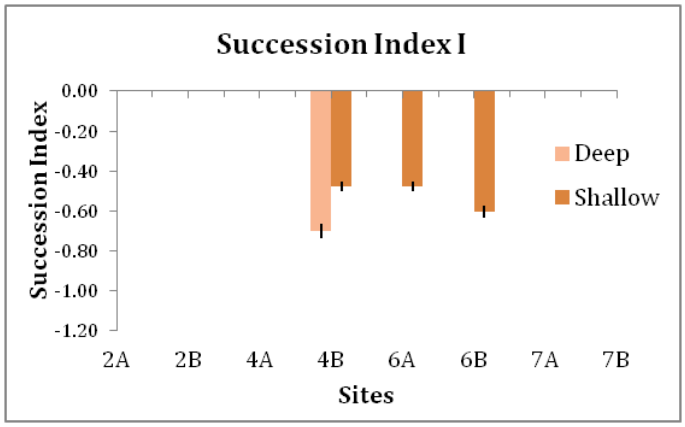

Figure 9. Succession index for algae at deep and shallow sites of Tubbataha Reefs.

Succession index for other fauna

This index shows the relative proportion of other fauna over dead coral and algae. The succession index for other fauna indicates the probability of the latter to take over open spaces. Results revealed that there is a probability for other fauna to colonize open spaces of Site 4B, as well as in the shallow areas of Sites 6B and 7A as shown by their positive index (Figure 10). Meanwhile, other sites had zero values due to the absence of other contributing factors in the areas.

Figure 10. Succession index for other fauna at deep and shallow sites of Tubbataha Reefs.

Invertebrate Survey

The most common target invertebrate species recorded at the 10m-depth sites were giant clams and sea cucumber while lobsters and banded coral shrimps were observed in some sites only (Figure 11). Giant clams were present in four out of eight sites with a mean occurrence of 1-2 individuals per

100m^2 transect. Giant clams with sizes ranging from 10-20 cm were commonly abundant at this depth (Figure 12, left).

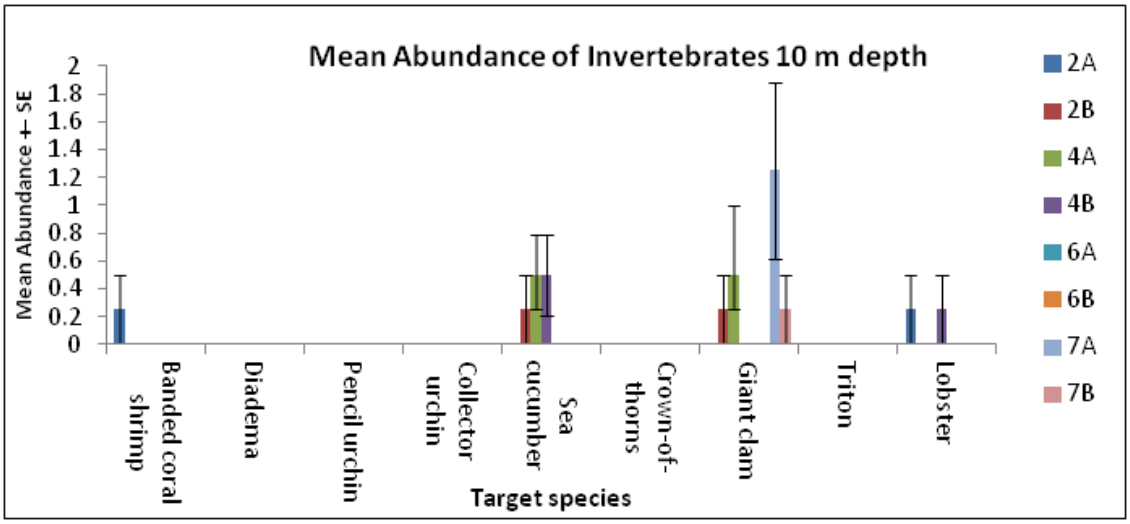

Figure 11. Mean abundance of target invertebrate species per 100m transect observed in the deep sites of Tubbataha Reefs. Error bars denote standard error of the mean.

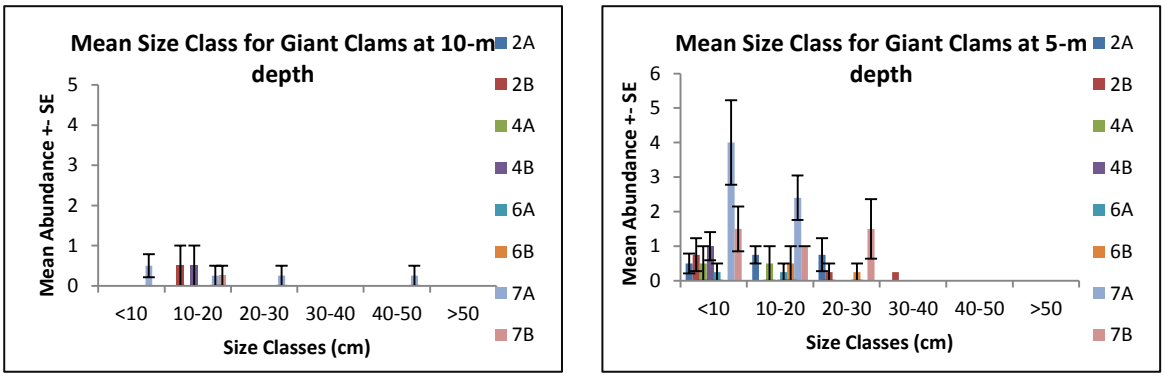

Figure 12 Mean abundance per 100-m transect of giant clams according to size class observed in the deep (left) and shallow (right) sites in Tubbataha Reefs. Error bar represent standard error of the mean.

The presence of sea cucumber was also observed in site 2B, 4A and 4B though only few. Though the rare species of triton was not observed during this survey, its presence in Tubbataha could not be completely ruled-out. The pristine and highly turbid water condition at this depth could explain the absence of *Diadema* sea urchins, often considered to be a likely indicator of nutrient pollution. The Crown-of-Thorns starfish (COTS) was also totally absent at both depths, which could be a result of the vigilant monitoring conducted

by the rangers due to the possibilities of flare-up after the last infestation in 2010.

Similar to the deep site, the eight shallow sites (5-meter depth) showed partial differences in terms of composition and frequency of target invertebrate species. Only giant clams, sea cucumber and *Diadema* were observed in all transects (Figure 13). Giant clams were the most abundant invertebrates and were commonly encountered in most of the sites as opposed to the deep sites, with a mean density of 2-3 individuals per 100m^2 transect. Giant clams of size classes ranging from less than 10 cm and from 10-20 cm were recorded the most (Figure 12, right). Sea cucumbers were few and were only seen in 3 out of 8 transects (Figure 13).

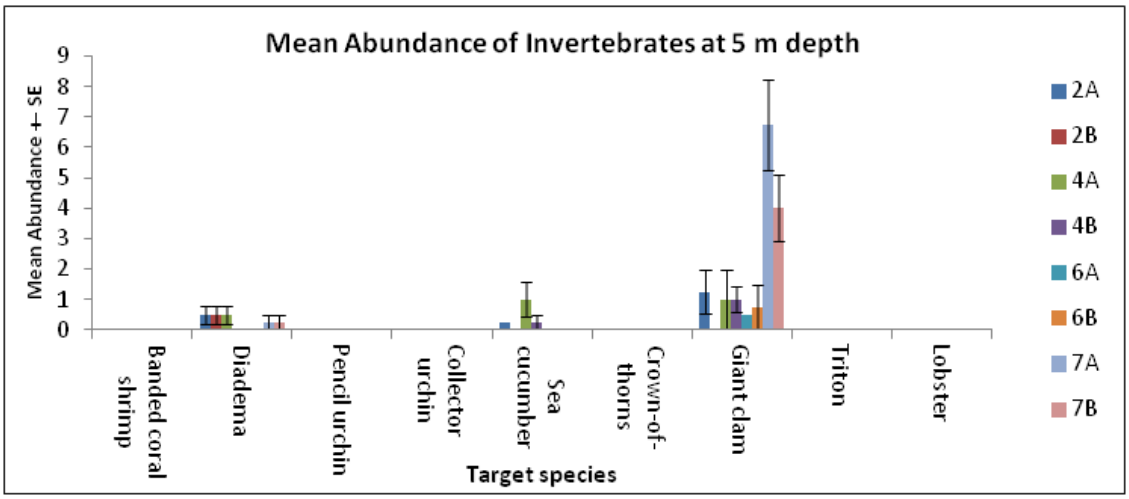

Figure 13. Mean abundance of target invertebrate species per 100m transect observed in the shallow sites of Tubbataha Reefs. Error bars denote standard error of the mean.

B. Jessie Beazley Reef

Yearly monitoring at Jessie Beazley was not possible due to some logistical constraints. Mean hard coral cover in Jessie Beazley at the deep sites (10m depth) was estimated at 44%, which was less than that in the shallow sites (Table 4.). This puts the reefs "fair" condition based on the quartile scaling of the reef. Soft coral cover was also high at 37.5% while the other benthic components were low for this survey (Table 4). Rocks and rubble were low at 4.05% and 6.55%, respectively.

For the shallow sites (5m depth), mean hard coral cover was 77% while soft coral cover was only 4% (Table 4). Hard coral cover was higher as opposed

to deep sites, while soft coral attained higher at depth of 10-meter compared to the shallow areas. Based on the quartile scaling of reef conditions by Gomez et al. (1994), total live coral cover at this depth is classified under excellent condition (>75% cover). This high coral cover can mainly be attributed to the physical composition of the reef wherein corals seem to be more intact as compared to other sites in Tubbataha. Abiotic components, such as rubble, rocks and sand, were low at 7%, 5.5% and 4%, respectively (Table 4).

Table 4. Mean percentage cover of the different benthic attributes at 10m and 5m depths in the Jessie Beazley Reefs monitoring sites.

Benthic Lifeform	Deep (10 m)	Shallow (5m)
Hard Coral	44 %	77 %
Soft Coral	33.5 %	4 %
Recently Killed Coral	0 %	0 %
Nutrient Indicator Algae	0 %	0 %
Sponge	1.5 %	2 %
Rock	4.05 %	5.5 %
Rubble	6.55 %	7 %
Sand	2.5 %	4 %
Silt	0 %	0 %
Others	0 %	0%

The monitoring of the reef at two different depths was done in order to compare responses to disturbances and recovery over time. Hard corals displayed minimal differences in its values in some years, thus it generated a more stable trend particularly in deep sites (Figure 14). Meanwhile shallow sites displayed an increasing trend. Hard coral cover for both depths did not vary greatly though some years do not have error bars due to lack of replications. The mere fact that Jessie Beazley was not completely destroyed, given that it was open to fishing up until 2006 is a good sign of its resilience. Since most of the year the reef is inaccessible, it gives time for it to recover from anthropogenic impacts brought about by fishing from the past.

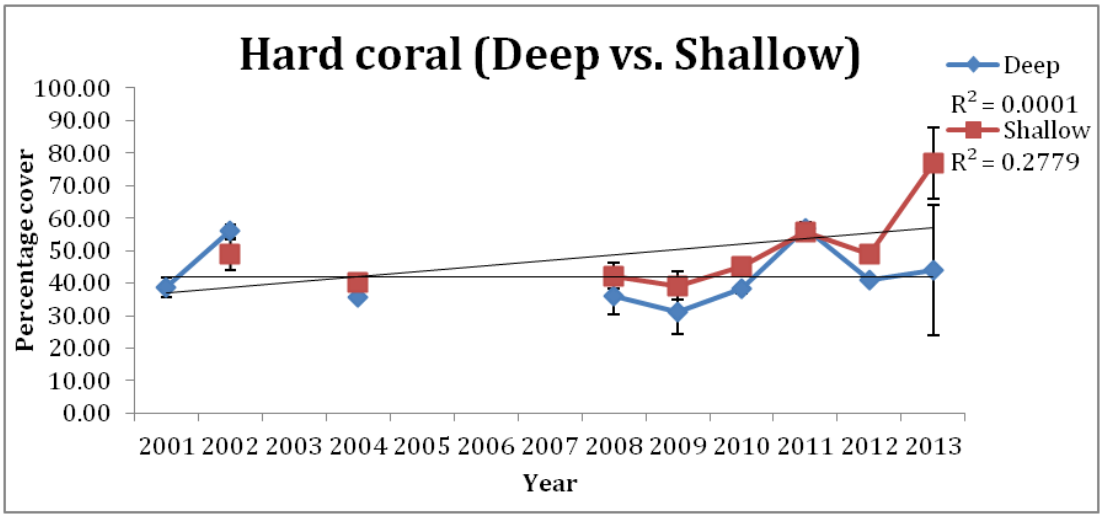

Figure 14. Mean percentage hard coral cover in the deep (blue line) and shallow (red line) stations of Jessie Beazley Reefs from 2001 to 2013. Error bars represent the standard error of the mean.

Meanwhile, soft coral cover showed somewhat an erratic trend, though its cover decreased from last year specifically at deep sites (Figure 15). In the shallow sites, soft coral cover displayed a slightly decreasing trend (Figure 15). Some years do not have error bars because of the lack of replication, which was usually due to some logistical constraints.

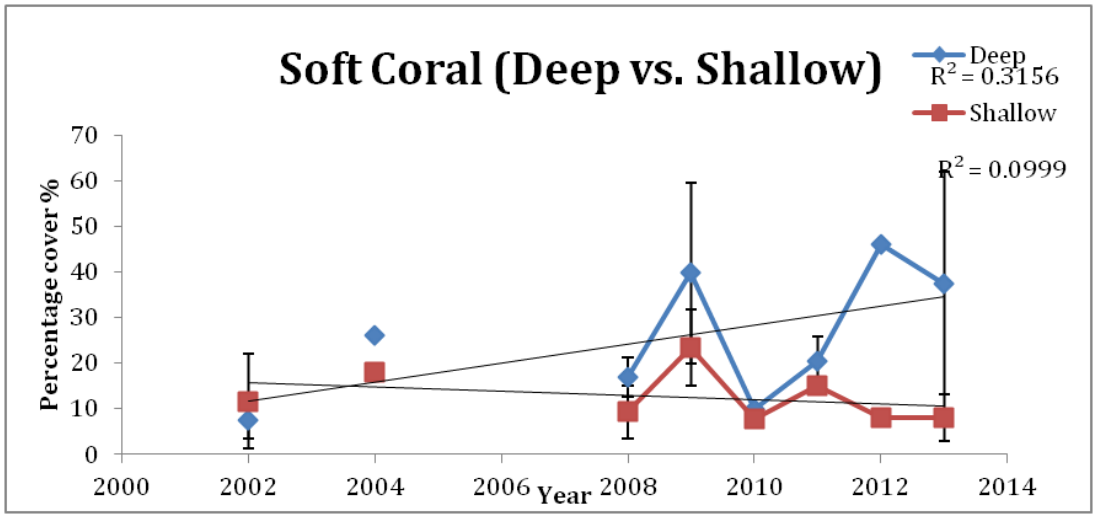

Figure 15. Mean percentage soft coral cover in the deep (blue line) and shallow (red line) stations of Jessie Beazley Reefs from 2001 to 2013. Error bars represent the standard error of the mean.

Benthic Indices

Some of the indices could not be computed because of the values obtained for some of the lifeforms needed for the equation were close to or equal zero. Meanwhile, there were no mortalities (i.e. recently dead) observed this year.

Condition index

In Jessie Beazley, three out of four sites displayed positive condition indices except for the deep site of Site JB2 (Figure 16). A negative condition index was observed for the deep. This was attributed to higher soft coral compared with hard coral cover, which were 62% and 24%, respectively. The shallow site appears to have a higher condition index as opposed to the deep sites.

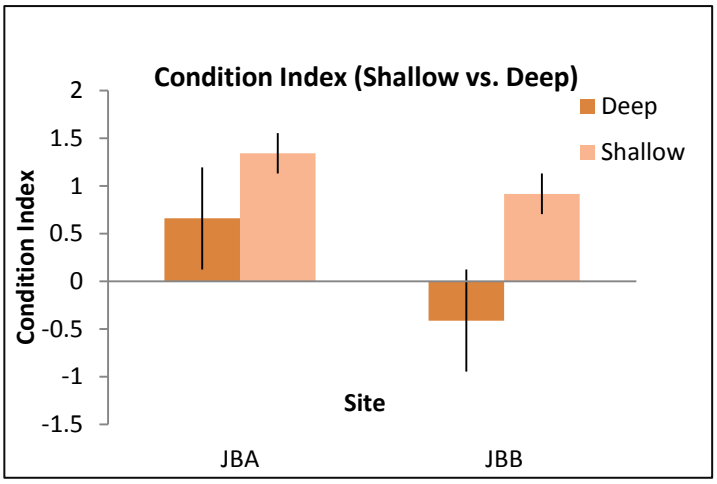

Figure 16. Condition Index at the deep and shallow sites of Jessie Beazley Reef.

Development Index

All sites displayed positive development indices but this was more pronounced in the shallow areas (Figure 17), suggesting that the shallow reef has higher chances of recovery from disturbances.

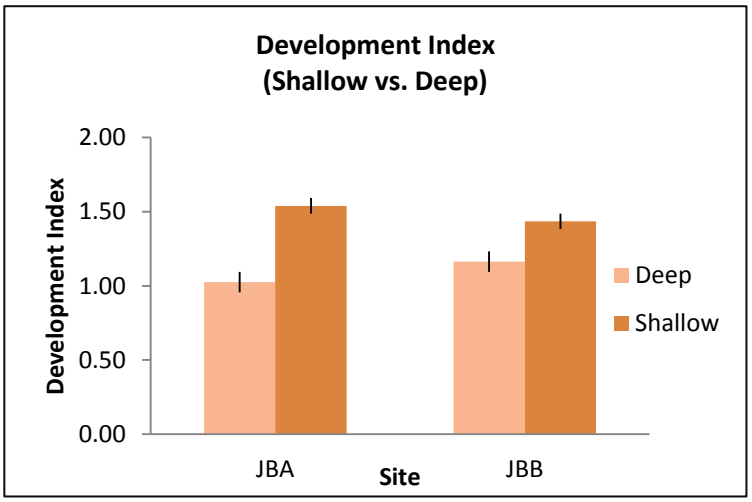

Figure 17. Development index at the deep and shallow sites of Jessie Beazley Reef.

Invertebrate Survey

Only two target invertebrate species were observed in the deep sites (10-m depth) of Jessie Beazley Reefs. These were giant clams and banded coral shrimp, and were only recorded at site JBB (Figure 18, left). Only two individuals of giant clams were recorded, with sizes ranging from 10-20 cm (Figure 19, left). Meanwhile, the shallow site at Jessie Beazley displayed higher abundance of giant clams as compared to the deep site (Figure 18, left). The size class ranging from 10-20 cm was more dominant at the shallow site (Figure 19, left). Other target invertebrate species were not observed at this depth except for the lobster. The Crown-of-Thorns starfish was also absent at

both depths. Dominant species of sharks and some turtles were also noted as rare animal sightings but were not included in the graphs.

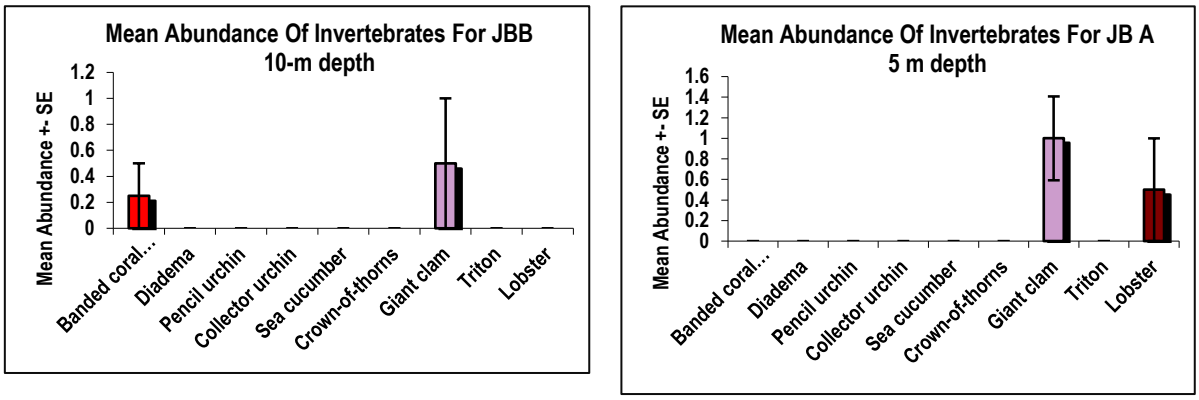

Figure 18. Mean abundance per 100-meter transect of target invertebrate species in the deep (left) and shallow (right) sites of Jessie Beazley Reefs. Error bar represent standard error of the mean.

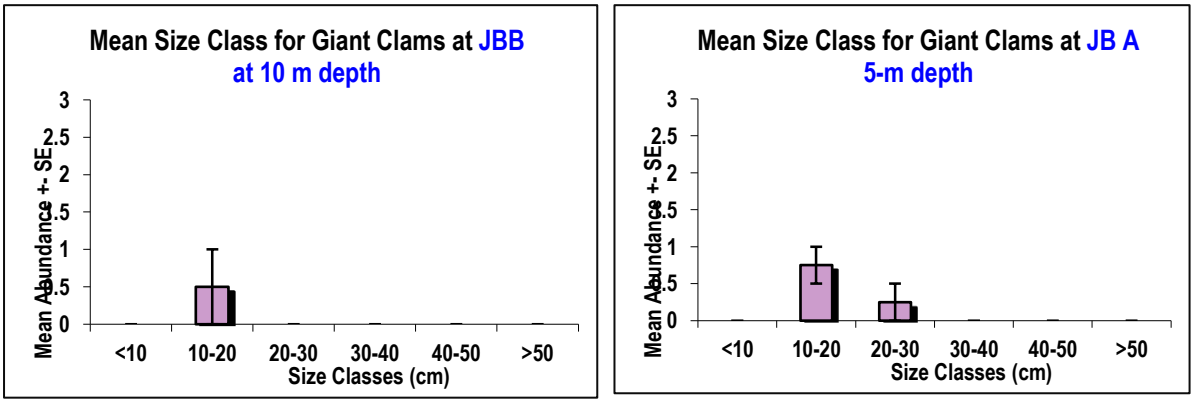

Figure 19. Mean abundance per 100-m transect of giant clams according to size classes observed in the deep (left) and shallow (right) sites of Jessie Beazley Reef. Error bar represent standard error of the mean.

IV. References

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Chapter 3. MONITORING REEF FISH COMMUNITY STRUCTURE

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I. Introduction

The Philippines as an archipelagic country is largely dependent on fisheries for food. Since the 1980's, the country's fisheries stock has been on the decline. With the increasing population, this led to problems in food security which promoted destructive and illegal fishing methods. Marine protected areas (MPAs) have been implemented to avert this downward spiral of marine resource degradation.

Currently, Tubbataha Reefs Natural Park (TRNP) is considered as the country's most pristine coral reef ecosystem. Comprised of two large atolls and nearby Jessie Beazley Reef, the park covers an area of over 90,000 hectares and is the largest MPA in the country. The area harbors a great diversity of marine life, including associated reptile and avian fauna. TRNP is popular in the recreational dive industry for its diverse and colorful corals and drop-offs, and remarkable fish life. It is one of the few places in the country where one can observe reef fishes reaching their terminal adult stage.

To ensure the effectiveness of protection, the Tubbataha Management Office (TMO), in partnership with the World Wildlife Fund, conducts annual monitoring surveys in TRNP. This year's monitoring was conducted on May 2013 with technical support from the De La Salle University and the Marine Science Institute of the University of the Philippines - Diliman. Past surveys have indicated that TRNP is still in very good condition, showing usually high numbers of reef fish in both abundance and biomass.

II. Methods

Field Methodology

Tubbataha Reef National Park is located in the middle of the Sulu Sea (N 8°50'677" E 119°55'734"). The survey assessed 9 monitoring stations located in 5 sites. In each site 4 transects were laid, 2 transects in the shallow pat of the reef (reef crest, 3-6 m depth) and another 2 in the deep part (upper reef slope (8-12 m depth). The coordinates of the stations are shown in Table 2.

Fish Visual Census (FVC) technique (English, et al., 1997) was used to determine the species diversity, abundance and biomass in the study sites. In each site, two fish monitoring teams were deployed. One team conducted FVC in the shallow part of the reef while the other team surveyed in the deep portion. FVC was done on the same transects laid for the coral survey. After the line had been laid, observers waited for about 5-10 minutes before the actual census to allow for the disturbed fish community to return to their normal behavior. Starting at one end of the line, all fishes within a 5m x 5m imaginary quadrat were identified up to species level (if possible) and their numbers and estimated sizes recorded. The observer swam to and briefly stop at every 5-m mark along the line until the transect line was completed. The faster moving fishes were counted first before the slower ones. Each transect covers an area of 250 m^2 (50m long x 5m width). All fish sizes of target, indicator, and other species were estimated to the nearest centimeter using the total length (TL). Target species are the commercially-important fishes, coral indicator species are coral-associated, and other species are those that belong to neither group. Fish biomass was based on the relationship, $W=aL^b$, where W is the weight in grams; a and b are the growth coefficient values taken from published length-weight data; and L is the length of the fish in centimeters (English, et al., 1997).

As part of the proposed transition of utilizing Reef Check survey methods for future monitoring, Reef Check fish survey was also done on the same transect where FVC was conducted. In this method, each diver swam slowly along the transect counting the indicator fish. The diver stopped at every 5 m, and then waited one to three minutes for any indicator fish to come out of hiding, before proceeding to the next stop point (fish are counted along the entire length of each 20 m transect). This was a combined timed and area restricted survey: four segments x 20 m long x 5 m wide = 400 m^2. There are four 5 m gaps where no data were collected. There are a total of sixteen "stop and go" points, and the goal is the finish the belt transect in under an hour. Table 5 shows the indicator species that are recorded for the Indo-Pacific.

Table 5. Indicator fish species for Reef Check surveys in the Indo-Pacific.

Common Name	Scientific Name
Grouper / coral trout (>30 cm)	Serranidae
Barramundi cod	*Cromileptis altivelis*
Butterflyfsh (any species)	Chaetodontidae
Humphead (Napoleoon) wrasse	*Cheilinus undulatus*
Bumphead parrotfish	*Bolbometopon muricatum*
Sweetlips	Haemulidae (e.g. *Plectorhinchus* spp.)
Parrotfish (>20 cm)	Scaridae
Snapper	Lutjanidae
Moray eel (any species)	Muraenidae
Anemone fish / clown fish	Pomacentridae (e.g. *Amphiprion* spp.)

A note was made on any sighting of rare animals such as manta rays, sharks, and turtles. If these are off-transect records, they are written as comments. Off-transect records of Humphead Wrasse and Bumphead Parrotfish were also noted.

Data Analysis

A total of 40 transects were surveyed. Information on species richness, abundance, and biomass were compared across depths and monitoring stations. This was then evaluated to national standards (Nañola et al 2006). This information was also compared with previous monitoring data to observe changes across years.

III. Results and Discussion

Reef Fish Community Structure

Species richness, abundance and biomass are shown in Table 6. A total of 265 reef and reef-associated species from 35 families were observed in this survey. Average fish species richness varied from 42 species at Delsan Shallow to 83 species at T-wreck Deep. The most abundant species was the Bicolor Chromis (*Chromis margaritifer),* which was present in all sites and found in large numbers in Jessie Beazley. Among the target species, the most abundant was the Bluestreak Fusilier (*Pterocaesio tile),* which was also numerous in Jessie Beazley. The Pyramid butterflyfish (*Hemitaurichthys polylepis*) was the most abundant coral indicator species commonly found in Malayan Wreck. Table 7 shows the top 10 species and families based on the number of individuals sighted in all 40 transects. Except for the anthiases (*Pseudanthias* spp.), the rest of the fishes in the top species list are damselfishes. Both of these groups form huge schools over tabular and branching corals, particularly in the shallows. Similar to other reefs in the country, the families Pomacentridae and Labridae are on the top families list. However, the presence of various target fish families in the top list is uncommon. It is noteworthy to observe the subfamily Epinephelinae, which comprises the groupers in the list.

Table 6. Reef fish abundance and biomass values of the monitoring sites in the TRNP.

	Sea Fan Alley A		Sea Fan Alley B		Sea Fan Alley	Malayan Wreck A		Malayan Wreck B		Malayan Wreck	Delsan A		Delsan B		Delsan
	Deep	Shallow	Deep	Shallow	Mean	Deep	Shallow	Deep	Shallow	Mean	Deep	Shallow	Deep	Shallow	Mean
Species Richness	66	59	62	50	272	75	55	71	54	228	74	51	61	42	295
Family Richness	21	18	21	14	291	21	17	22	19	243	23	17	21	16	317
Abundance	1656	818	873	1055	1100	1103	870	904	934	953	1045	1172	761	1692	1167
Standard Error ±	636	204	315	120	318	330	476	301	131	309	259	554	153	1120	521
Target species	339	113	119	88	164	239	74	107	41	115	147	60	163	30	100
Coral indicator species	28	16	32	14	22	27	10	83	9	32	22	9	40	4	18
Other species	1289	689	723	953	913	837	787	715	885	806	877	1104	559	1659	1049
Biomass	653.2	112.7	146	113.3	256.3	302.1	77.2	404.3	47	207.6	428.1	116.1	390	39.4	243.4
Standard Error ±	507.7	32.7	40.1	17.3	149.5	46.5	10.2	63	0.4	30	289.1	19	169	12.7	122.5
Target species	566.7	93	111.4	85.4	214.1	230.8	34	229	22.5	129.1	258	91.1	187.6	17.9	138.7
Coral indicator species	14.6	3.1	12.3	2.8	8.2	6.3	2.5	38.5	1.9	12.3	8.6	1.7	30.3	1.2	10.5
Other species	71.8	16.6	22.3	25.1	34	57.3	40.7	136.7	22.6	64.4	161.4	23.2	172.1	20.3	94.3

Table 6. Abundance and biomass values of the monitoring sites in TRNP (*continued*).

	T-wreck A		T-wreck B		T-wreck	Jessie Beazley A		Jessie Beazley B		Jessie Beazley
	Deep	Shallow	Deep	Shallow	Mean	Deep	Shallow	Deep	Shallow	Mean
Species Richness	83	52	72	52	181	63	35	60	52	452
Family Richness	20	19	23	16	192	19	14	20	17	489
Abundance	680	589	787	780	709	1491	1914	1162	4965	2383
Standard Error ±	0	84	178	2	66	146	627	175	43	247
Target species	241	159	137	117	164	178	33	200	72	121
Coral indicator species	57	13	38	14	30	13	4	19	13	12
Other species	382	417	613	650	515	1300	1878	944	4880	2250
Biomass	512	158.2	368.5	104.7	285.8	208.8	54.9	198.3	123.7	146.4
Standard Error ±	0	43	79.6	7	32.4	84.1	18	69.2	38.3	52.4
Target species	448.8	129.1	236.9	80.9	223.9	150.5	15.7	162.5	48.1	94.2
Coral indicator species	20.3	2.7	18.4	2.6	11	3.2	0.8	4	2.5	2.6
Other species	42.9	26.4	113.3	21.2	50.9	55.1	38.4	31.8	73.2	49.6

Table 7 . Top ten reef fish species and families.

Species	Total	Family	Total
Chromis margaritifer	7,571	Pomacentridae	25,669
Chromis amboinensis	7,124	Serranidae: Anthiinae	13,755
Pseudanthias dispar	5,558	Caesionidae	2,206
Chromis ternatensis	4,764	Labridae: Corinae	1,791
Pseudanthias tuka	4,485	Acanthuridae	1,695
Pseudanthias huchtii	2,568	Chaetodontidae	762
Pomacentrus coelestis	1,530	Balistidae	634
Dascyllus reticulatus	1,080	Labridae: Cheilininae	585
Chromis xanthura	1,052	Serranidae: Epinephelinae	440
Chromis weberi	991	Scaridae	419

Endangered species, which are uncommon elsewhere, were frequently encountered in TRNP. The Humphead wrasse (*Cheilinus undulatus*) was observed in Delsan, Seafan Alley, and T-wreck. A Whitetip reef shark (*Triaenodon obesus*) was recorded in Delsan. A couple of Grey reef sharks and a Whitetip reef shark (*Triaenodon obesus*) were recorded in Delsan. There were other sightings of rare species, including rays and turtles, but these were off-transect observations.

The mean reef fish abundance for TRNP was 2,431 individuals/250 m^2. Among the monitoring sites, Jessie Beazley has the highest abundance with a mean of 2,746 individuals/250 m^2 (Figure 20). In contrast, T-wreck has the lowest abundance with a mean of 709 individuals/250 m^2. In general, abundance values did not vary significantly between deep and shallow parts of the reef within the same site, with the notable exception of Sea Fan Alley A, Delsan B, T-wreck B, and Jessie Beazley B. For Sea Fan Alley A and T-wreck B, the deep transects have higher abundance values. In contrast, Delsan B and Jessie Beazley B have higher reef fish abundance value in the shallow transects. The interestingly high abundance value in Jessie Beazley B shallow warrants further review as this may be a case of observation bias.

The higher reef fish abundance observed in Jessie Beazley is a function of the strong current conditions in the area which provides a stable supply of food and nutrients for both the coral and reef fish communities. Zooplanktivores, i.e. Chromis (*Chromis* spp.) and Fairy basslets / Anthiases (*Pseudanthias* spp.), are particularly numerous, forming large schools over coral heads.

Overall, the deep transects yielded higher target species abundance as the top predators, i.e. groupers, and reef-associated species, i.e. jacks and fusiliers, are often encountered in deeper waters particularly if the site have very steep slopes or walls. There is also a higher abundance of coral indicator species in deeper transects, especially in Malayan Wreck Deep and T-wreck Deep with 83 and 57 individuals / 250 m^2, respectively.

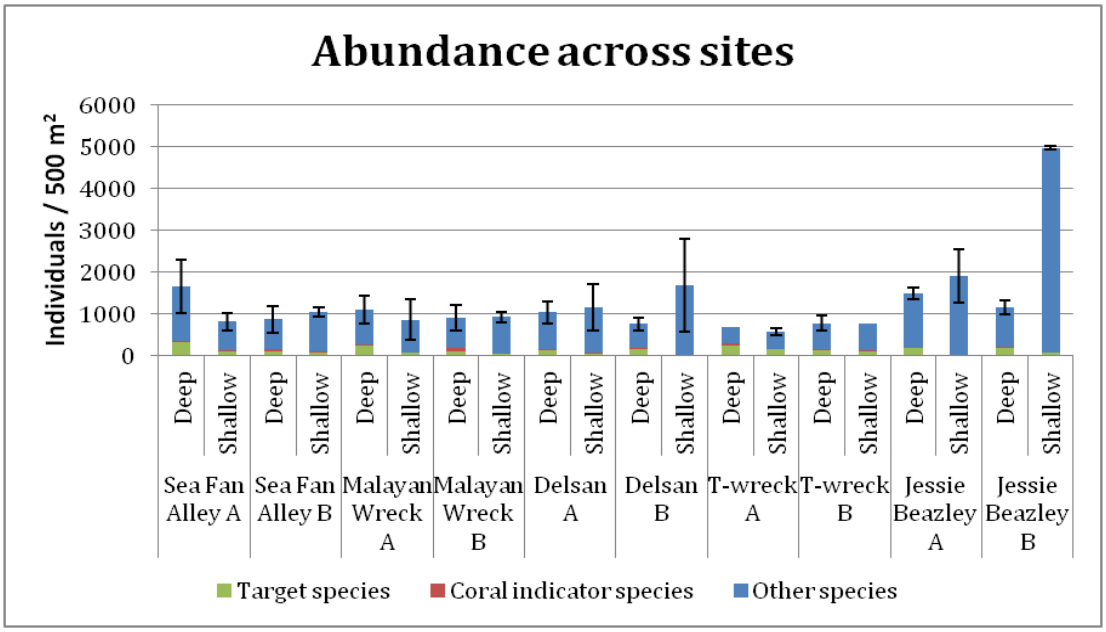

Figure 20. Mean reef fish abundance (in individuals/500m²) in the monitoring sites of TRNP.

The average biomass of TRNP for this monitoring period is 227.9 MT/km². Target species comprise the bulk of reef fish biomass, roughly 60-90% of the biomass in each station (Figure 21). Since most target species are found in deeper water, the deep transects have significantly higher biomass values compared to shallow ones. T-wreck has the highest mean biomass among the sites with 285.8 MT/km². This is followed by Sea Fan Alley and Delsan with a mean transect biomass of 256.3 MT/km² and 243.4 MT/km², respectively,

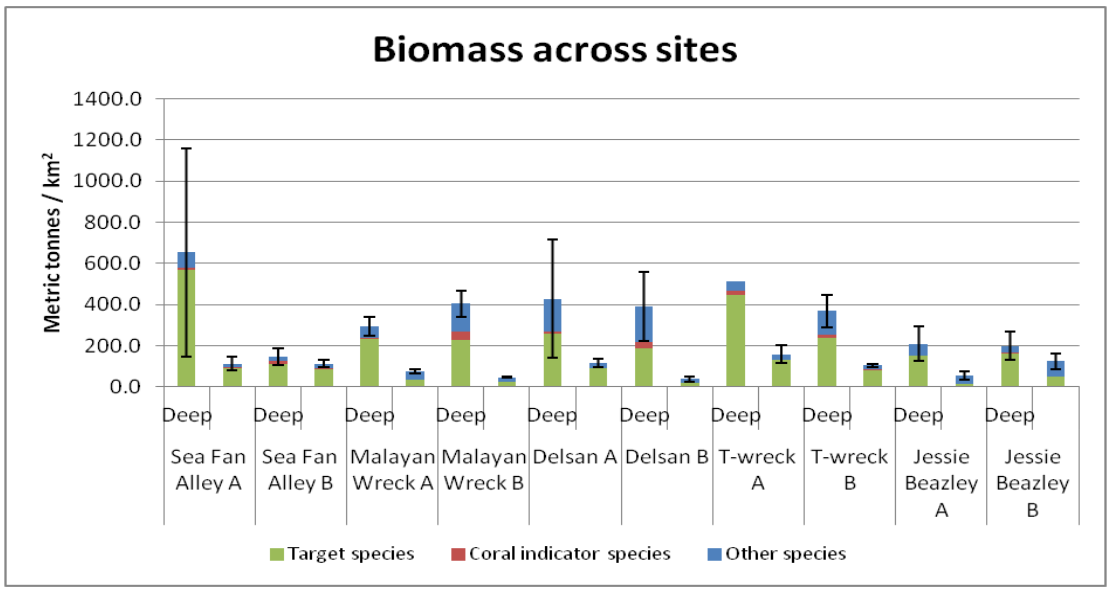

Figure 21. Mean reef fish biomass (in metric tons/km²) in the monitoring sites of TRNP.

Jessie Beazley has the lowest mean biomass at 146.4 MT/km^2. This is due to the low relief and reef complexity in the area which provides fewer habitats for fish. All the biomass values, however, are very high relative to national standards.

T-wreck has the highest target species biomass with an average of 223 MT/km^2. The target species biomass alone is higher than the overall reef fish biomass of other marine protected areas in the country. In T-wreck, schools of fusiliers, jacks, and surgeonfishes are often encountered. Malayan wreck has the highest coral indicator biomass with a mean of 12.3 MT/km^2.

Looking at depth gradients, reef fish abundance is higher in the shallow portion of the reef (Figure 22, left). This is where a lot of branching and tabular corals are located. Both coral life forms harbor large schools of damselfishes and anthiases. An opposite trend is revealed by the biomass data, with the deep transects having higher values (Figure 22, right). Again, most of the large target species are often found in the reef slope including sharks and schools of fusiliers and jacks, all of which contributes enormously to the overall biomass.

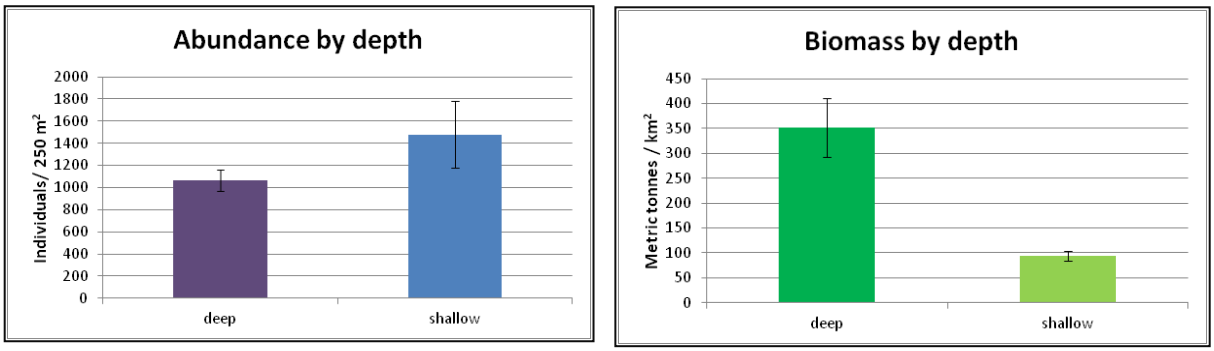

Figure 22. Mean reef fish abundance (left) and biomass (right) in the deep and shallow sites of TRNP.

Comparing the present biomass values with the previous surveys, mean fish biomass increased from 2012 but is similar to the 2010 values (Figure 23). The present biomass value is also comparable to the 1999, 2005, 2008, and 2009 value, which was around 220-250 MT/km^2 (Figure 24). The figures suggest that, over the years, very high biomasses are typical in TRNP.

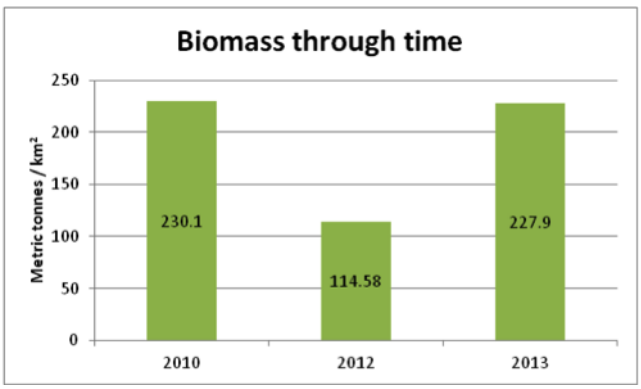

Figure 23. Mean reef fish biomass from 2010-2013.

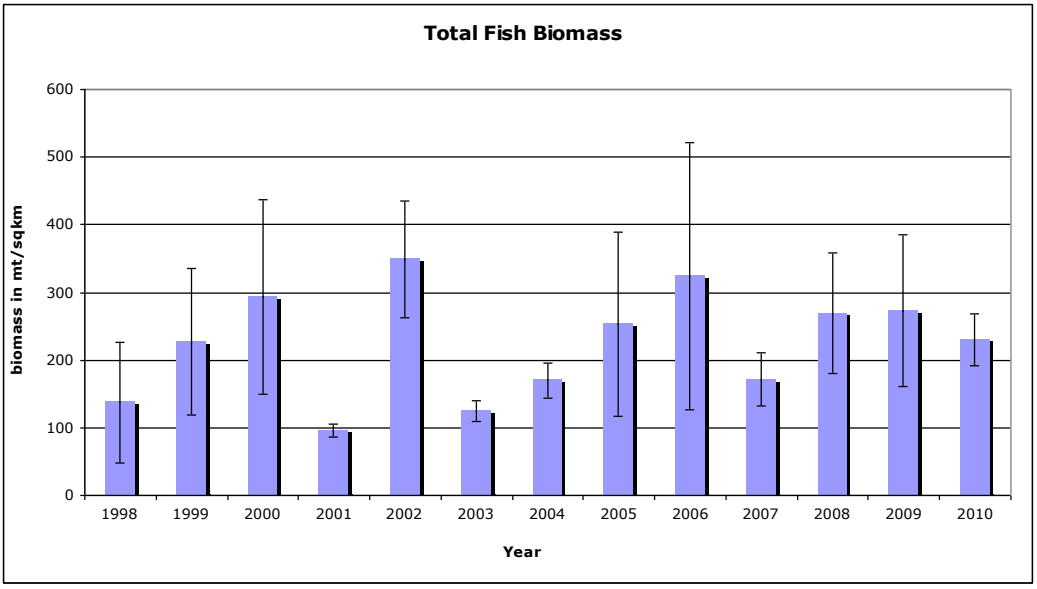

Figure 24. Mean reef fish biomass from 1998-2010 in the TRNP.

TRNP has reef fish community abundance and biomass values that are currently unsurpassed by any other site in the country. It remains to be the ideal state which other marine protected areas aspire to be. Through the decades, the remote location of TRNP, coupled with sound and efficient management, has allowed it to be a prime model of a pristine reef environment.

Reef Check Results

The following series of figures are outputs of the Reef Check surveys done on the same transect as the fish visual census surveys (Figures 25-38). Generally, the TRNP stations are in very good condition. All the stations have recorded butterflyfishes and groupers, and parrotfishes were observed in most of the sites. Although not shown in the graphs, sharks and turtles were also observed off transect as mentioned earlier in the discussion.

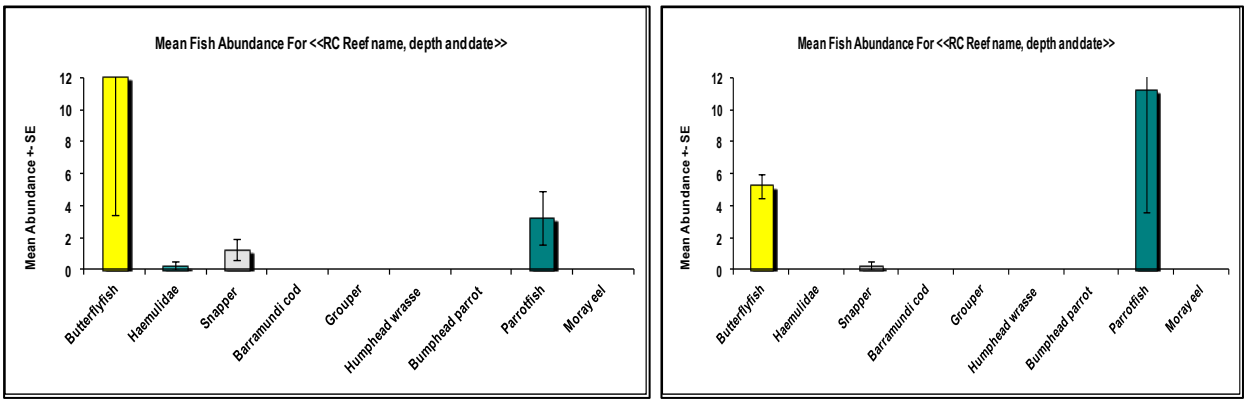

Figure 25. Mean reef fish abundance in Sea Fan Alley A Deep (left) and Shallow (right) obtained from Reef Check surveys.

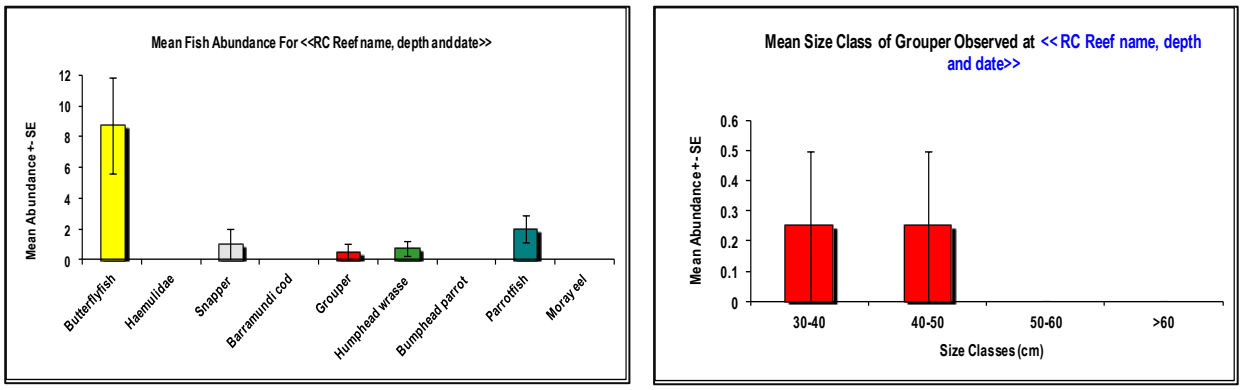

Figure 26. Mean reef fish abundance per family (left) and size class of groupers (right) in Sea Fan Alley B Deep obtained from Reef Check surveys.

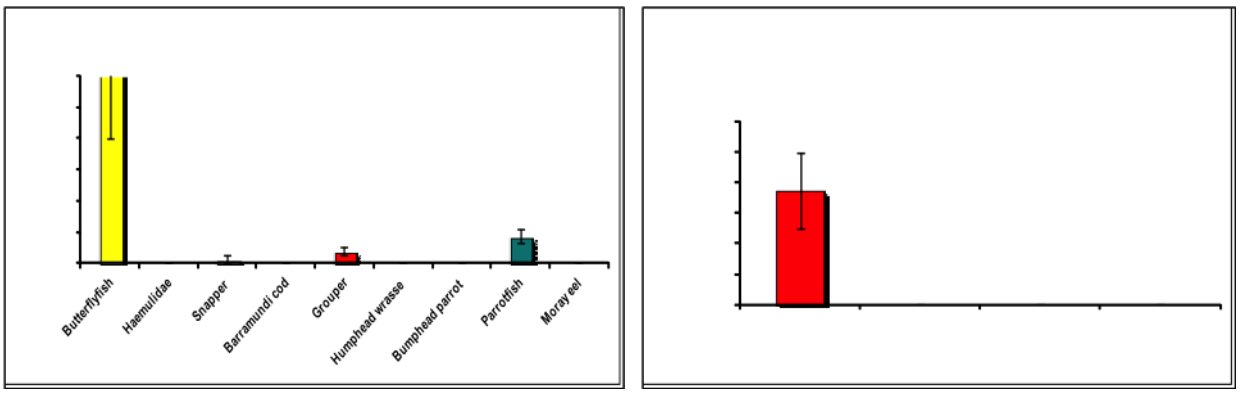

Figure 27. Mean reef fish abundance per family (left) and size class of grouper (right) in Malayan Wreck A Deep obtained from Reef Check surveys.

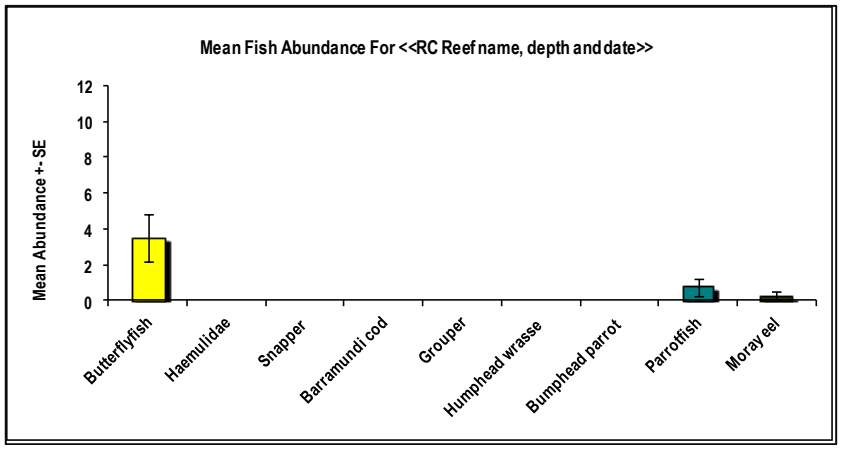

Figure 28. Mean reef fish abundance in Malayan Wreck A Shallow obtained from Reef Check surveys.

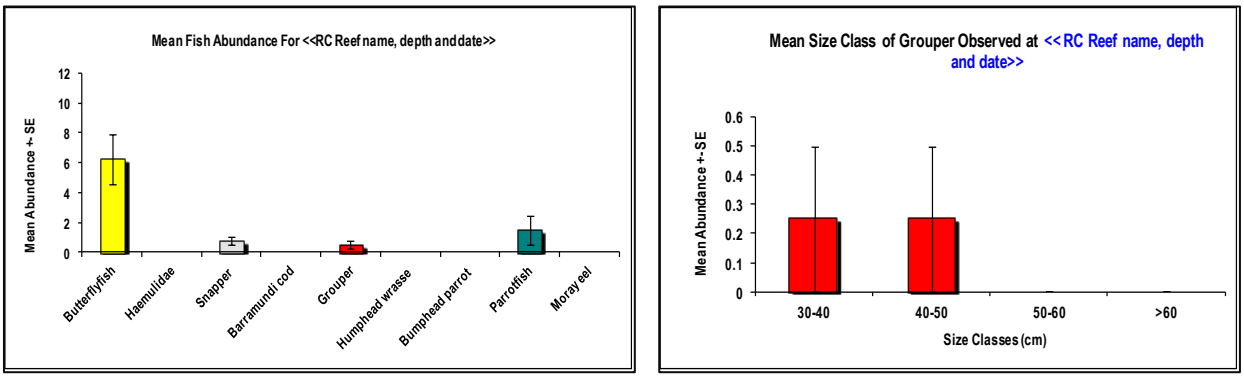

Figure 29. Mean reef fish abundance per family (left) and size class of groupers (right) in Malayan Wreck B Deep obtained from Reef Check surveys.

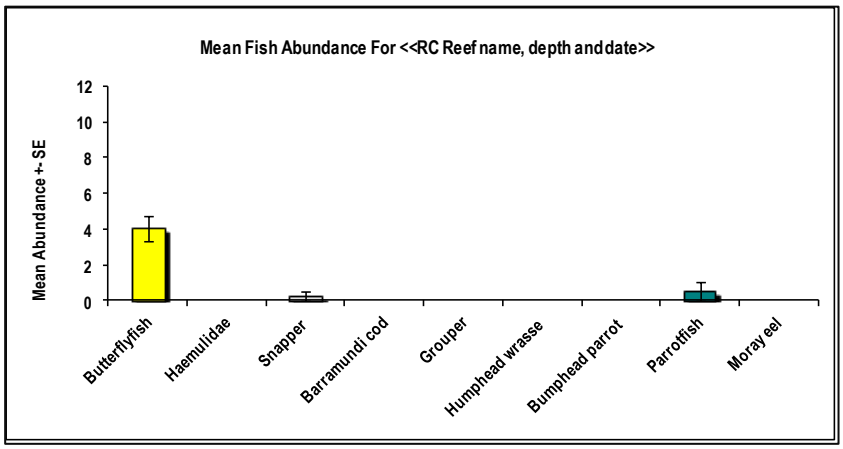

Figure 30. Mean reef fish abundance in Malayan Wreck B Shallow obtained from Reef Check surveys.

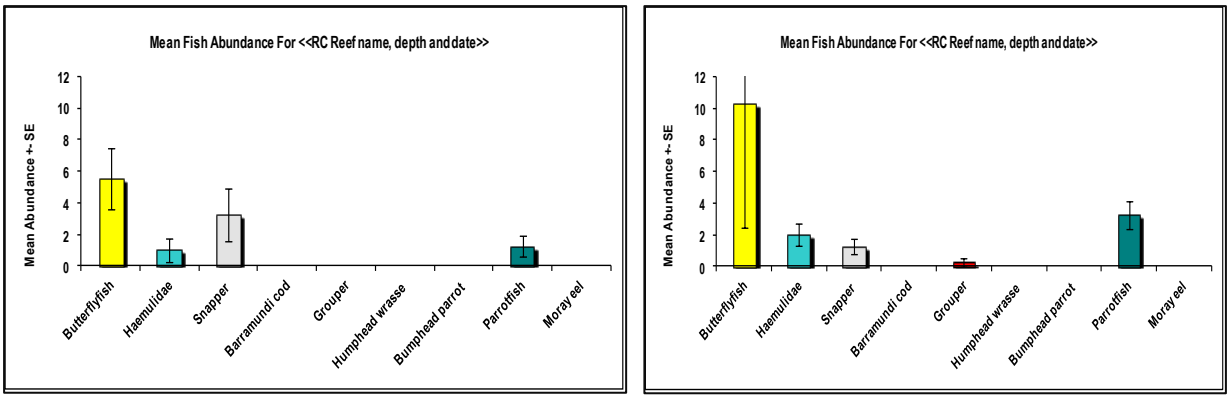

Figure 31. Mean reef fish abundance in Delsan A Shallow (left) and Deep (right) obtained from Reef Check surveys.

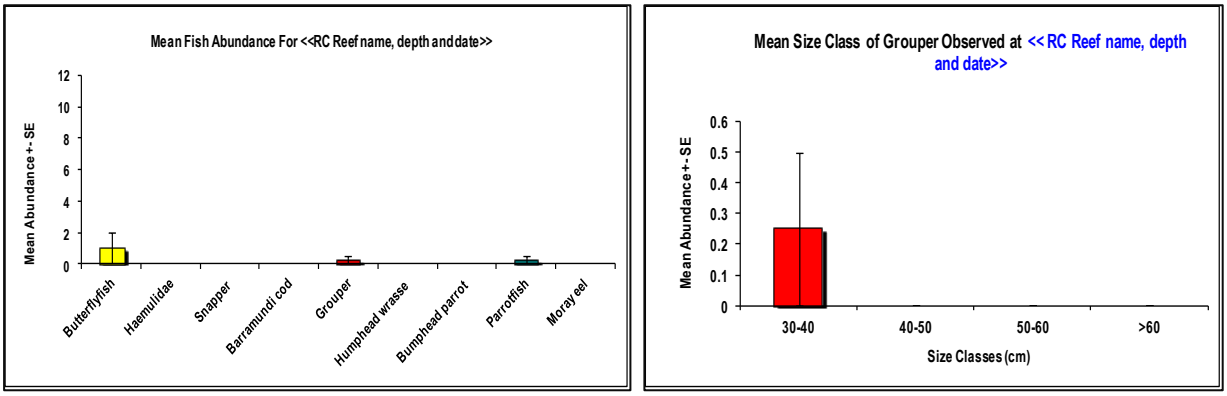

Figure 32. Mean reef fish abundance per family (left) and size class of groupers (right) in Delsan B Shallow obtained from Reef Check surveys.

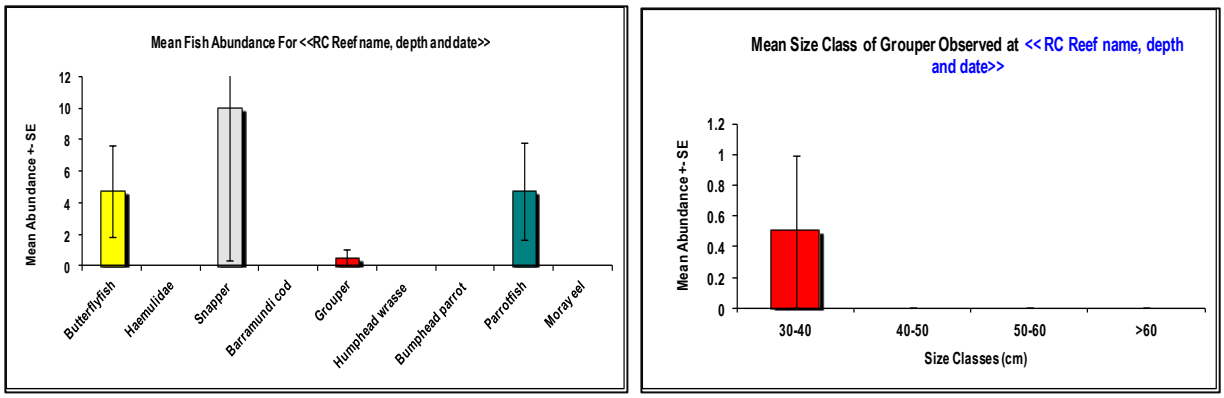

Figure 33. Mean reef fish abundance per family (left) and size class of groupers (right) in T-wreck A Deep obtained from Reef Check surveys.

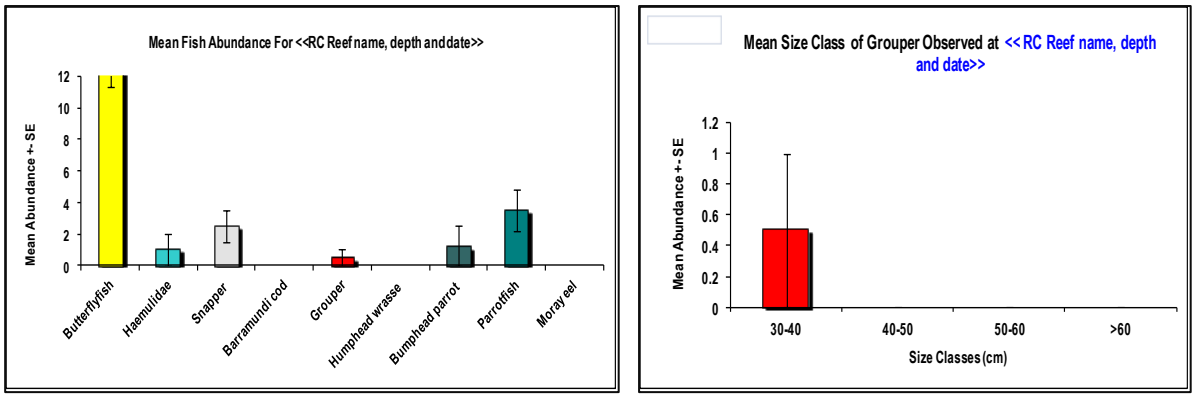

Figure 34. Mean reef fish abundance per family (left) and size class of groupers (right) in T-wreck B Deep obtained from Reef Check surveys.

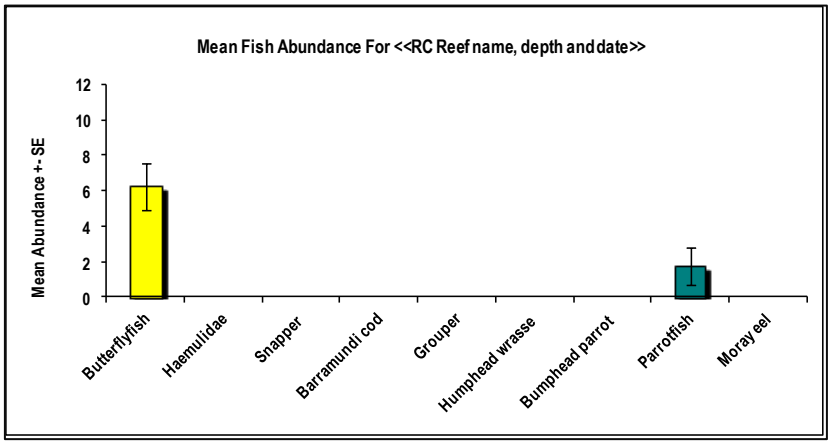

Figure 35. Mean reef fish abundance in T-wreck B Shallow obtained from Reef Check surveys.

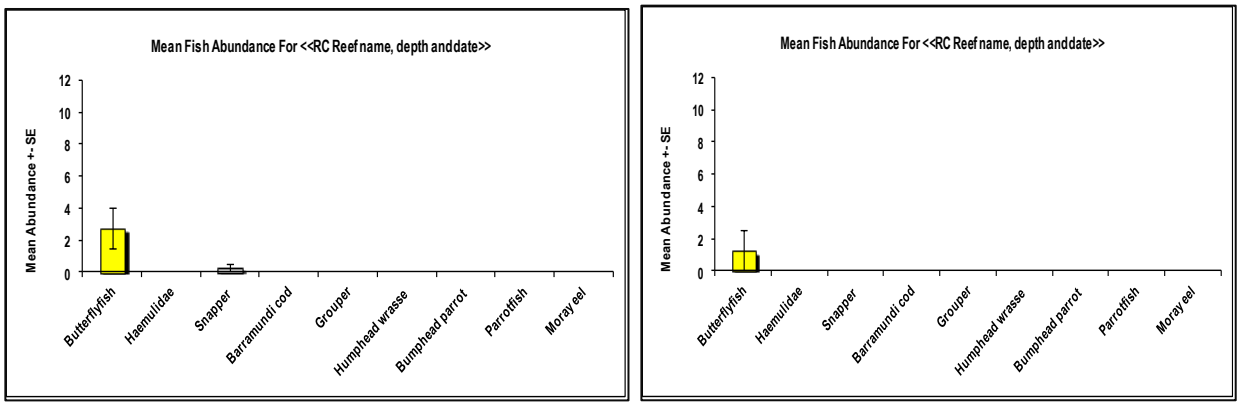

Figure 36. Mean reef fish abundance in Jessie Beazley A Deep (left) and Shallow (right) obtained from Reef Check surveys.

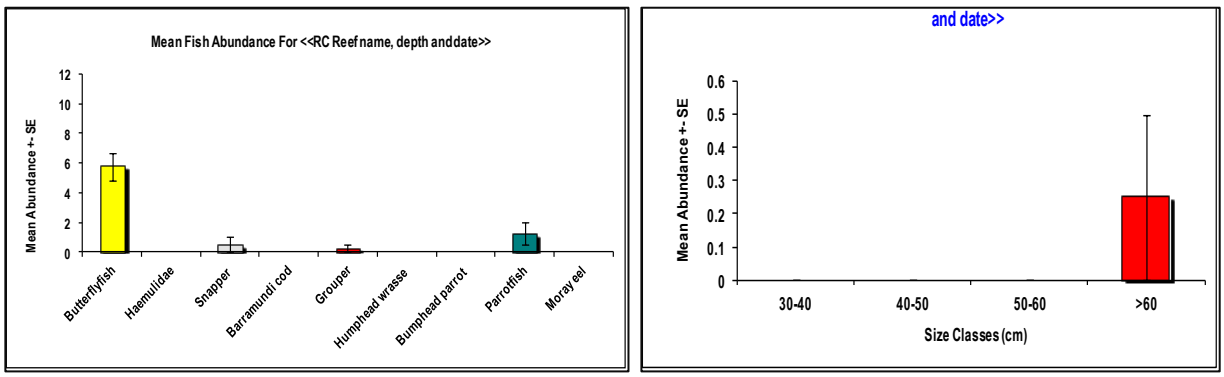

Figure 37. Mean reef fish abundance per family (right) and size class of groupers (left) in Jessie Beazley B Deep obtained from Reef Check surveys.

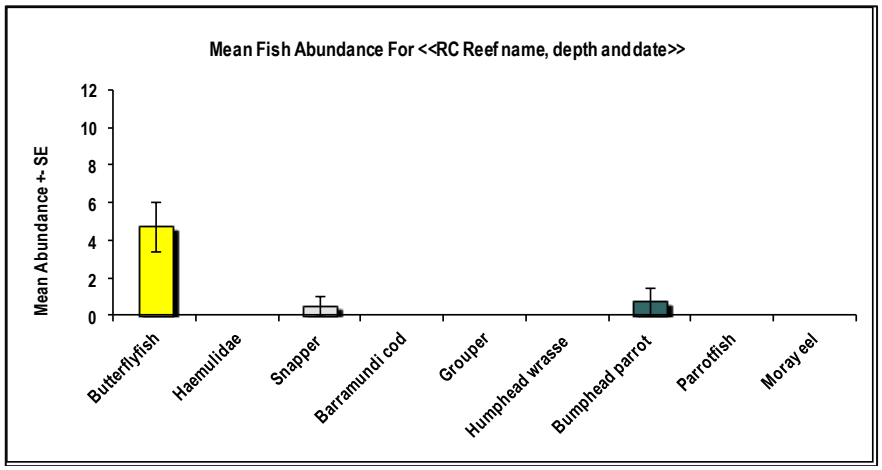

Figure 38. Mean reef fish abundance in Jessie Beazley B Shallow obtained from Reef Check surveys.

IV. References

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Nañola Jr, C., P. Alino, H. Arceo, W. Licuanan, A. Uychiaoco, M. Quibilan, W. Campos, A. Alcala, A. White, and E. Gomez. 2006. Status report on coral reefs of the Philippines - 2004. Proceedings of the 10th International Coral Reef Symposium, (pp. 1055-1061). Okinawa, Japan.

Chapter 4. MONITORING AND INVENTORY OF SEABIRDS AND THEIR BREEDING AREAS IN THE TUBBATAHA REEFS NATURAL PARK & WORLD HERITAGE SITE

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I. Introduction

Tubbataha Reefs Natural Park (TRNP), located a distance from the nearest human habitation, has become a refuge and flyway for seabirds and is the only site in the Philippines considered to be of global importance for seabird conservation. Aside from being a UNESCO World Heritage Site, a Wetland of International Importance under Ramsar, TRNP represents the only known breeding area for the endemic subspecies of Black Noddy (*Anous minutus worcestri)*, one of the remaining breeding areas for Sooty Tern (*Sterna fuscata*) and Brown Noddy (*Anous stolidus*), and was the last known breeding area for the Masked Booby (*Sula dactylata*) in the Philippines.

The earliest record of seabird populations in Tubbataha was from Worcester (1911). It was a long time before subsequent surveys were done in 1981, 1991 and 1995 (Kennedy, 1982; Heegaard & Jensen, 1992; Manamtam, 1996). This was followed by annual inventory of seabird populations by WWF-Philippines starting 1997. The seabird monitoring protocol in the TRNP was initially laid out in 2004. A comprehensive training in seabird identification, monitoring and survey techniques was undertaken with park staff and rangers from the Tubbataha Management Office (TMO), including Philippine Navy and Coast Guard personnel. Thereafter seabird monitoring was conducted annually by the trained park rangers and the research team of the TMO. Regular seabird inventory and monitoring is done to be able to provide information on the status of seabird populations in the area and the condition of their habitat to the Tubbataha Protected Area Management Board (TPAMB) in order for them to come up with sound management decisions for seabird conservation.

II. Methods

Field work at Tubbataha Reefs Natural Park (TRNP) was conducted from May 8 to May 11, 2012, with visits to the South Islet and the Ranger Station on May 8, North Islet on May 9-11, and Jessie Beazley Reef on May 11. On May 7, introductions to the inventory methodology were conducted at the Tubbataha Management Office (TMO) with the park staff and volunteers. Major equipment used was handheld binoculars (10 x 50), spotting scope (20-60 x), GPS and cameras. Discussions pertaining to previous monitoring reports of the TMO Park Rangers since the 2012 inventory were conducted during the

field work. During fieldwork weather was dominated by thunderstorms with almost daily heavy rain showers, sometimes with extensive cloud cover and occasionally strong western winds. During daytime temperatures ranged from about 28° to 30° Celsius. Throughout the fieldwork deliberations on methodology and other protocols continued on a daily basis.

Field activities followed the seabird monitoring and inventory methodology established in 2004 and used since. The team camped overnight at North Islet in order to carry out optimal work. South Islet was only visited in the morning of May 8 for a three-hour period. All species counts represent a combination of count methods which includes direct daytime inventories of adults, juveniles, pullus, eggs and nests of the breeding seabird species. In order to validate the total seabird population present, an afternoon count of birds flying in to roost (Red-footed Booby *Sula sula,* Brown Booby *Sula leucogaster*, Brown Noddy *Anous stolidus*, Common Noddy *Anous minutus*) was conducted from 4:30PM to 6:30PM on May 9 on North Islet (Annex 2). For logistical reasons, in-flight counts could not be carried out on South Islet, hence, the actual number of Red-footed Booby and Black Noddy flying in to roost is unknown.

Photos were taken of the permanent photo documentation sites of North and South Islets. These sites were established in 2004 to document habitat changes – changes in land area and vegetation. GPS readings were taken measuring the land areas at high tide of both North Islet and South Islet.

The results of the fieldwork is compared with data sets from the second quarter of previous years; mainly data sets gathered by TMO staff from November 2004 to March 2013 but also by WWF-Philippines from October 1997 to April 2004. These data sets are analyzed in detail in the 28-year seabird population development report released in 2009 and in the 2004 to 2006 and the 2011 and 2012 seabird field reports (see Jensen 2004, 2005, 2006, 2009, 2010, 2011 and 2012). In addition, relevant literature and published data on seabirds were used as reference.

III. Results and Discussion

Monitoring of Changes in Land Area

Two independent sets of measurements were taken using two different GPS instruments. As in the previous years there are differences in the area measurements taken: The difference for North Islet is 764 m^2 (7% variation) and for South Islet 113 m^2 (4% variation). Measurements of the circumference of the two islets showed insignificant variation of less than 1%. The data variation is most likely due to differences in the equipment's' technical accuracy. For reasons of comparison the data results closest to the 2012 dataset are used.

North Islet: The circumference of the islet is about 548 meters measured mainly one meter along the vegetation line and the average high tide line. The land area was measured to be 10,936 m^2 or about 1,560 m^2 or 12.5% lesser than in 2011. Overall, the land area has decreased from 17,000 m^2 in 2004, or by 35.7%. Compared with the 1981 baseline measurement the decrease in land area is about 42% (Table 8).

Erosion of the island's core of cemented calcite sandstone along a portion of the northeastern shoreline had continued since 2012. Changes in other portions of the coastline were not visible (Figure 39).

Figure 39. Aerial photograph of North Islet taken in 25 January 2013. (Photo: Teri Aquino)

Measured against the 1981 baseline land area (Kennedy 1982), the decline in the land area has occurred unevenly with the largest percentage decrease occurring in the most recent years. From 1981 to the first GPS measurement in 2004 the islet had shrunk only 9%. From 2004 to 2008 the land area decreased annual with an average of 9% per year. In 2009 the land area was stable compared to the previous year, 2008. From 2009 to 2011 North Islet grew larger, most notably from 2010 to 2011. The islet is now of the same size as it was in 2008.

South Islet: The circumference of the islet in 2013 was about 230 meters and the average land area measurement was 2,860 m^2; slightly higher than the measurement of 2,716m^2 in 2010 (Figure 37).

Table 8. Changes in the land area of North Islet, Tubbataha Reefs Natural Park, from 1911- 2013. (Source: Worcester 1911, Kennedy 1982, Heegaard and Jensen 1992, Manamtam 1996, WWF Philippines 2004 and Tubbataha Management Office 2004 – 2013)

Year	Land area (length x width)/circumference (m)	Land area (high tide) (m^2)	Open area ("Plaza") (m^2)	Major sandbars position and condition	Erosion area
1911	400 x 150	60,000	No data	>40,000 m^2 (?)	No data
1981	268 x 70	18,760	18,000	NW, SE	South coast
1991	>220 x 60	>13,200	>8,000	NW, SE	South coast
1995	265 x 82	21,730	8,000	NW, SE	South coast
2004	219 x 73	17,000	1,100	NW: Stable SE : Decrease	South coast
2005	No data	15,987	4,000(est.)	NW, SE: Stable	South coast
2006	No data	14,694	7,900 (est.)	NW, SE: Stable	South coast
2007	No data	11,794	8,000(est.)	NW, SE: Stable	South coast
2008	No data	10,921	< 8,000	NW: Decreasing SE : Stable	South coast
2009	No data	10,726	< 7,000	NW: Eroded SE : Decreasing	West coast
2010	No data	11,038	4,367	NW: Eroded SE : Stable	South coast
2011	No data	12,965	4,000 (est.)	NW: Stable SE : Stable	North East coast
2012	590	12,494	3,892	NW: Stable SE : Stable	North East coast
2013	548	10,936	4,840	NW: Decreasing SE : Stable	North East coast

South Islet was originally a sandbar but in the late 1970s a circumferential concrete seawall was constructed converting the sandbar into an artificial islet. The land area remained the same until 1981, based on photographic evidence from 1981(Kennedy 1982). In 1991, an ocular inspection revealed

that about 2/3 of the land area was still protected by the seawall as about 1/3 of the seawall had collapsed and was partly submerged (Heegaard and Jensen 1992). The collapsed seawall section functions as a wave breaker that largely prevents erosion. However, the top sections of the intact sections of the seawall wall are progressively deteriorating.

Figure 40. Aerial photograph of South Islet taken January 2013. (Photo: Teri Aquino)

Monitoring of Changes in Vegetation

Vegetative cover is monitored by conducting a census of the condition of trees in the islets. Trees, mostly *Argusia argentia and Pisonia alba (grandis),* are classified either as dead or in a good (optimal), fair (moderately deteriorating) or bad (severely deteriorating) condition.

North Islet: In 2010 all larger trees on North Islet, many of which were observed growing well in 1991 (Heegaard and Jensen 1992), had collapsed and most of the other remaining vegetation were in bad condition as a result of the intensive nesting density of the Red-footed Booby.

Due to difficulties in defining individual mature live trees, of which many are intertwined bush-size trees, this year's count on North Islet cannot be directly compared with the results from previous years. However, the vegetation in 2013 had trees in bush-height and included about 250 seedlings and very small trees (Annex 3). The majority of the vegetation is in deteriorating condition, of which nearly 20% were either dying or dead. The number of seedlings had declined by 58% to 117 seedlings compared to 275 seedlings recorded in 2012 (Table 9).

Table 9. Condition of higher vegetation on North Islet, May 2011, 2012 and 2013.

North Islet															
Trees/ Condition	Good (optimal)			Fair (moderately deteriorating)			Bad (severely deteriorating)			Dead			Total		
	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013
Dead trees										45	45	94	25	45	94
Mature, live trees (> 3 feet)	16	0	165	19	22	37	8	3	20				43	25	222
Small, live trees (2- 3 feet)	33	154	134	38	0	270	20	0	58				111	154	462
Seedlings (< 1 feet)	190	275	117	0	0	43	0	0	5				190	275	165
Total	239	429	416	57	22	350	28	3	83	45	45	94	369	499	943
Note: Coco Palms 2011: 3, 2012: 2, 2013: 3															

South Islet: On South Islet a total of 191 trees, including several trees up to about 30 feet tall, were recorded. Of these, only 6% compared to 59% in 2012 were in a good condition and no seedlings were found (Table 10). In 2009, almost all trees on South Islet were in good condition. This is the result of the establishment and increase in the nesting population of the Red-footed Booby.

Avifauna

Review of Park Ranger's Monitoring Data

The TMO park rangers conduct regular inventories and distance counts of the breeding species as part of their seabird management protocol. One inventory was conducted on both islets in November 2012 and in March 2013. The November 2012 inventory showed remarkable high numbers of adult Red-footed Booby and Brown Booby. See species accounts below.

Distance counts, where rangers count the birds from the patrol vessels 50 meters from the shoreline, were conducted 17 times from June 2012 until March 2013; 9 times at North Islet and 8 times at South Islet. The results were all within normal values for the period. The distance counts help the park management in determining absence and preference of the species and in monitoring the seasonal population trends.

Table 10. Condition of higher vegetation on South Islet, May 2011, 2012 and 2013.

South Islet															
Trees/ Condition	Good (optimal)			Fair (moderately deterioriating)			Bad (severely deterioriating)			Dead			Total		
	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013
Dead trees										6	9	0	6	9	0
Mature, live trees (> 3 feet)	70	69	9	28	30	82	5	6	68				103	105	159
Small, live trees (2-3 feet)	2	1	3	0	0	2	0	0	11				8	1	16
Seedlings (<1 feet)	19	9	0	0	0	4	0	0	12				19	9	16
Total	91	79	12	28	30	88	5	6	91	6	9	0	136	134	191
Note: Coco Palms 2011: 13, 2012: 14, 2013: 10. Papaya 2012: 1, 2013: 0															

Avifauna Inventory May 2013

A total of 31 different bird species were identified (Annex 4). Fourteen of the species were pelagic or coastal living seabirds of which six species are breeding in the TRNP: Red-footed Booby, Brown Booby, Great Crested Tern *Sterna bergii*, Sooty Tern *Sterna fuscata*, Brown Noddy and Black Noddy. Other breeding species include Eastern Reef-Egret *Egretta sacra*, Barred Rail *Gallirallus torquatus*, and Eurasian Tree Sparrow *Passer montanus*.

Overall, the seabirds of TRNP breed year round (Heegaard and Jensen 1992, Manamtam 1996, Kennedy et al 2000, Jensen 2009). The inventory results therefore represent only the breeding population present during the time of inventory.

A total of 28,901 adult individuals of six breeding seabird species were documented on North Islet and South Islet (Table 11). The result is the second highest count ever and close to the result for 2012. The population level is now 118% higher than the first detailed inventory conducted in 1981 (Kennedy 1982). In comparison, the 2012 and the 2011 inventories showed a minimum of 30,168 individual and 24,338 individuals of adult breeding seabirds (Table 12). The high count result of 2013 is mainly a result of the highest breeding population densities ever recorded of Great Crested Tern and of Black Noddy representing more than 70 % of the total count.

Table 11. Total count numbers of adult resident seabirds present on North Islet and South Islet of Tubbataha Reefs Natural Park, May 8-11, 2013.

Species/ Number	North Islet (including Ranger Station and Amos Rock)	South Islet	Total
Red-footed Booby *Sula sula*	1,609	593	2,202
Brown Booby *Sula leucogaster*	1,690	55	1,745
Great Crested Tern *Sterna bergii*	9,154	640	9,794
Sooty Tern *Sterna fuscata*	2,808	8	2,816
Brown Noddy *Anous stolidus*	1,146	542	1,688
Black Noddy *Anous minutus*	2,515	8,141	10,656
Total	18,922	9,979	28,901

Species Account

Data on the number of the sub-adult, juveniles and pullus populations and data on the number of eggs and nests recorded since 2004 on North Islet and South Islet are presented in Table 12 and shown in Figures 41 to 46. The results of the adult populations and their development over time from the two islets are shown in the same figures, and in Table 12. There are no breeding species found anywhere else in TRNP.

Red-footed Booby: The increasing scarcity of optimal breeding spaces has forced the species to occupy even the lowest bush vegetation near, and sometimes, at ground-level, but the total breeding population of around 2,200 adults remains stable. In 2013 the population was 10% lower than in the baseline year of 2004 when the species established its breeding presence in TRNP. However, if in-flight population data from South Islet is added, this year's total would be 2,487 adults or around the same as in 2004 (Annex 2).

Table 12. Seabird breeding data 2nd quarter (April-June) 2004 – 2013. Tubbataha Reefs Natural Park (North and South Islets). (Source: WWF-Philippines 2004 and Tubbataha Management Office 2004 – 2013)

Species/Yr	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
RED-FOOTED BOOBY										
Sub-adults	398	1,455	606	597	780	477	677	795	799	426
Pullus/ 1st year juvenile	35+	71	105	116	69	180	88	171	243	312
Eggs	+	+	+	+	+	+	+	68	166+	185+
Nests	279	217	225	404	361	367	451	369	739	848
BROWN BOOBY										
Sub-adults	0	81	26	55	55	61	126	110	140	62
Pullus/ juvenile	43	2	7	12	91	126	125	225	46	28
Eggs	1	0	18	95	317	48	106	52	69	532
Nests	117	43	250	89	497	453	513	575	507	618
GREAT CRESTED TERN										
Sub-adults	0	1	0	0	0	0	0	0	0	0
Pullus/ juvenile	0	2,100	0	0	0	0	0	0	0	0
Eggs	0	1,829	0	0	0	515	2,341	498	1,456	3,939
SOOTY TERN										
Sub-adults	0	0	0	0	0	0	0	0	0	0
Pullus /juvenile	0	1,750	0	458	0	846	0	1,764	0	1,258
Eggs	9	0	0	63	2	3	5,515	2	1,534	146
BROWN NODDY										
Sub-adults	0	2	0	0	0	4	1	1	2	3
Pullus/ juvenile	0	0	0	0	0	0	0	0	0	0
Eggs	0	0	0	3	17	126	438	253	147+	607+
Nests	115	124	20+	25+	218	384	653	571	709	771
BLACK NODDY										
Sub-adults	0	0	0	0	0	0	0	0	0	0
Pullus/ juvenile	0	0	0	0	0	0	0	0	0	0
Eggs	ND	+	0	+	+	430	+	+	80+	700+
Nests	208	3,203	1,131	1,018	1,824	2,680	3,525	3,827	4,282	5,156

Table 13. Population development and percentage development trend of breeding seabirds on North and South Islet, Tubbataha Reefs Natural Park, April to June 1981 – 2013. Baseline years are indicated with underline. (* End of March data) (Source: Kennedy 1982, Manamtam 1996, WWF Philippines 1998-2004 and Tubbataha Management Office 2004 – 2013)

Species/ Numbers	1981	1995	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Trend (%)
Ground-breeders Sub-total	**13,388**	**3,959**	**1,753**	**4,695**	**7,538**	**7,641**	**2,808**	**5,195**	**13,825**	**10,867**	**7,716**	**10,534**	**9,721**	**18,711**	**13,600**	**18,332**	**16,043**	**+ 20**
Masked Booby	150	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Extinct
Brown Booby	3,768	2,070*	1,725	1,045	855	582	627	851	1,877	1,108	1,016	1,059	1,018	1,442	1,850	1,888	1,745	- 54
Great Crested Tern	2,264	335	0	150	414	4,160	2,064	2,808	7,858	6,894	4,700	4,875	4,433	4,790	6,160	8,653	9,794	+ 333
Sooty Tern	5,070	910*	28	3,000	6,228	2,123	2	1,200	3,500	1,950	1,500	3,800	2,700	10,866	3,548	6,359	2,816	- 45
Brown Noddy	2,136	643	0	500	37	775	115	336	590	1,035	500	800	1,570	1,575	2,042	1,492	1,688	- 21
Tree-breeders Sub-total	**307**	**7,128**	**3,250**	**3,502**	**7,042**	**5,003**	**1,520**	**3,240**	**8,241**	**8,827**	**7,902**	**10,403**	**9,525**	**9,338**	**10,746**	**11,776**	**12,858**	**+4,090**
Red-Footed Booby	9	0	0	2	44	43	20	2,435	1,835	1,877	2,902	2,513	2,220	2,331	2,395	2,340	2,202	- 10
Black Noddy	294	7,128	3,250	3,500	6,998	4,860	1,610	805	6,406	6,850	> 5,000	7,890	> 7,305	7,644	8,351	9,436	10,656	+ 49
TOTAL	**13,695**	**11,087**	**5,003**	**8,147**	**14,580**	**12,644**	**4,438**	**8,435**	**22,066**	**19,694**	**15,618**	**20,937**	**19,246**	**28,049**	**24,346**	**30,168**	**28,901**	**+118**

The Park rangers' inventory results from 3 November 2012 showed an all-time high in the number of species with 2,479 adult individuals counted on North Islet alone. If the result is adjusted with the number of birds flying in to roost before dusk, the total would be 3,949 adults (Annex 2). With an estimated 300 adults present on South Islet, the population would, for the first time in the history of TRNP, have passed 4,000 individuals.

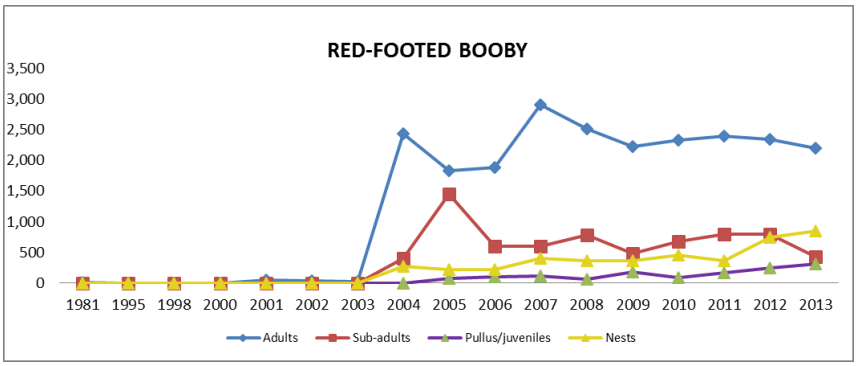

Figure 41. Population development of Red-footed Booby from 1981 to 2013.

Compared to 2012, the number of nests increased by nearly 15%: from 739 nests to 848 this year, the highest number ever recorded. The number of pullus and juveniles (312) is also a record high. On South Islet the species has increased its breeding population by 100% compared to the status in May 2012, with 279 nests counted.

Brown Booby: The breeding population is on North Islet and the number of 1,745 adult birds is about 7.5% lower than in 2012 but the highest in 15 years. However, the population is still about 50% lower than the count during the baseline year of 1981 (Kennedy 1982). It appears to be in excellent reproductive condition, and the species breeds all over the islet but still with the highest density at the *Plaza*. A high number of 618 nests were found and is comparable to 1995 results. The number of 532 eggs recorded was the highest ever documented. Similar to 2012, the number of pullus and juveniles was very low, suggesting active breeding in the second quarter of 2013 again started late. The number of sub-adult birds was similar to the average for 2005-2013, 69 individuals. The number of sub-adults before 2005 is unknown.

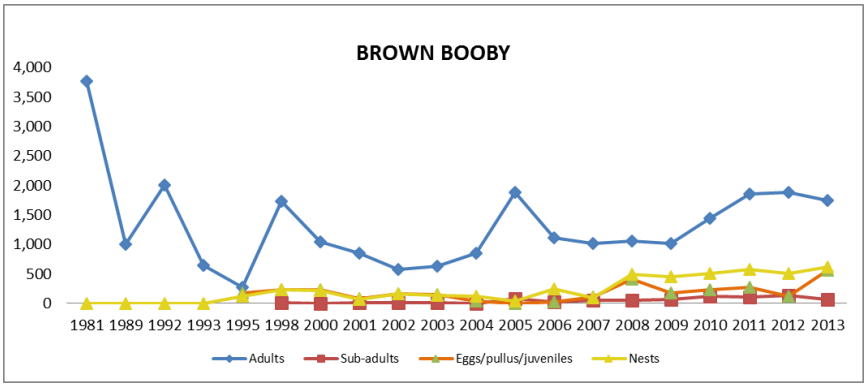

Figure 42. Population development of Brown Booby from 1981 to 2013.

On 3 November 2012 the park rangers counted 1,698 adult birds. If in-flight data were gathered, the total would have been more than 2,330 individuals

(Annex 2). This would be the second highest count since the one conducted during the baseline year of 1981(Kennedy 1982).

Great Crested Tern: The breeding population is confined to the North Islet and in 2013 mainly found at the eastern sections of *Plaza*. The number of breeding birds was the highest ever counted, 9,794 individuals and the population is 333% higher than the baseline count in 1981. Second highest count is from 2012 where 8,653 individuals were breeding (Table 13). The terns were in early stages of the breeding cycle with 3,939 eggs laid in very dense colonies.

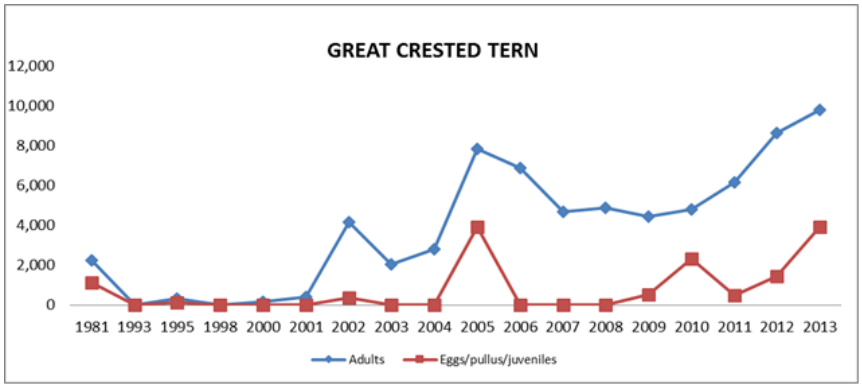

Figure 43. Population development of Great Crested Tern from 1981 to 2013.

A relatively high number of adult birds were observed on South Islet, 640 individuals. Several of these showed territorial and breeding behaviors. The species has not been documented breeding on the islet since 2003.

Sooty Tern: The breeding population is confined to the North Islet and in 2013 mainly found in a narrow vegetated area next to the southeastern section of the *Plaza*. The minimum population of 2,816 individuals is low compared to the peak years of 2010 and 2012. It also appears to be 45% lower than in the 1981 count (Table 13). However, the species seems to undergo cyclic breeding with fluctuation extremes ranging from years with less than 100 individuals to peak years with more than 6,000 breeding individuals. If the baseline count 1981 is compared with the average breeding population the past five years of 5,240 individuals, the current population size is about the same is in 1981.

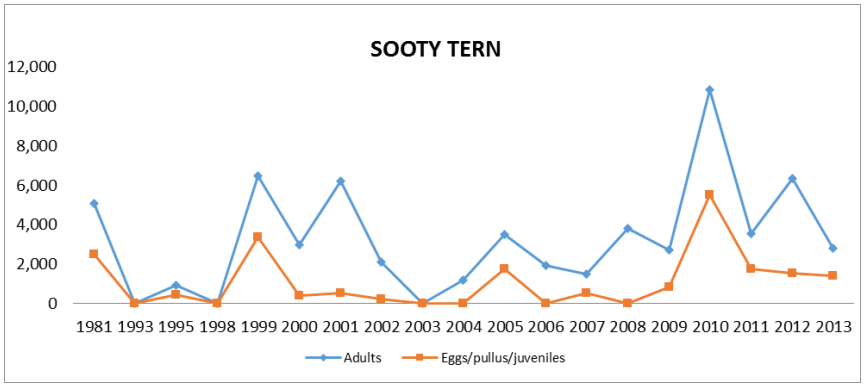

Figure 44. Population development of Sooty Tern from 1981 to 2013.

The Sooty Tern was in the middle of its breeding season and feeding 1,258 pullus and juveniles, with only 158 eggs waiting to be hatched. The species is still absent from South Islet where it was last observed breeding in 2002.

Brown Noddy: The total population was 1,688 adult birds, which is the second highest count result since regular inventories started in 1997. The result for 2013 is 20% lower compared to the baseline count of 1981 but the population on both islets appears to grow slowly. A significant record of 573 nests with 405 eggs was made on North Islet this year.

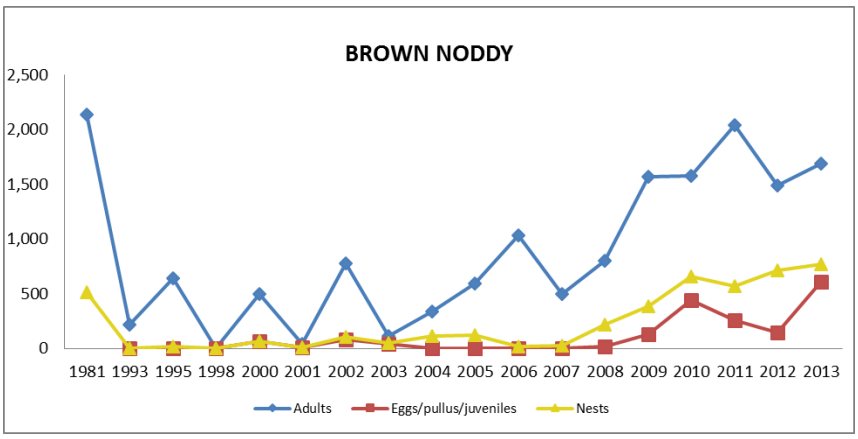

Figure 45. Population development of Brown Noddy from 1981 to 2013.

Black Noddy: Again in 2013 the breeding population had grown to 10,656 individuals, the highest record ever. The increase from 2012 is 13% but the results from North Islet and South Islet shows big differences: on North Islet the population has declined from around 6,000 individuals in 2005 and 2006 to about 2,400 individuals in 2012/2013. On the South Islet the species established its main breeding population in 2006 with about 3,300 individuals and it has since grown steadily by 145% to 8,141 individuals in 2013. In 2012 77% of the populations were breeding on South Islet, and in 2013 76%. The continued breeding on South Islet since October 2005 is a response to the decline in breeding habitats on North Islet as a result of the influx of the Red-footed Booby.

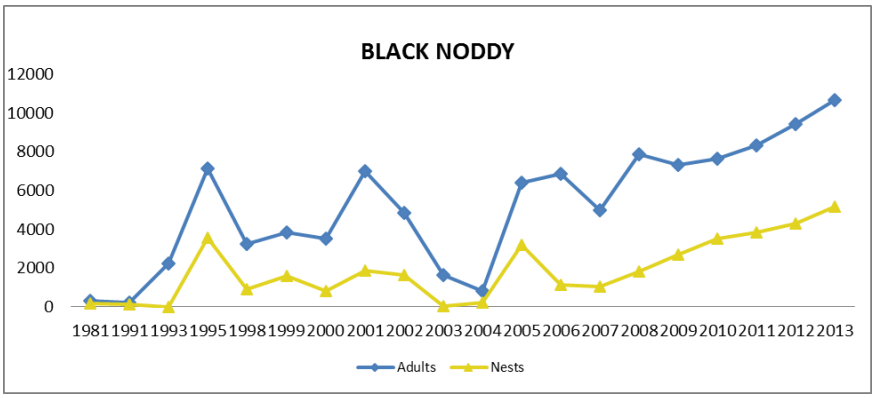

Figure 46. Population development of Black Noddy from 1981 to 2013.

Other breeding species

Eastern Reef-Egret: The breeding populations of Eastern Reef-Egret on North Islet and South Islet in 2013 were 17 adults with two nests. Two juveniles were

also counted. The population variation from 2004 to 2013 was from 8 to 17 adult individuals with nearly all individuals being of the dark phase.

Barred Rail: The species was first documented in 2003 in both North and South Islets, and in 2005 a nest was found on North Islet. In 2013 one or two birds were seen in North Islet but none in South Islet. The rail species has not been recorded in the South Islet since 2007.

Eurasian Tree Sparrow: Up to eight individuals breed in North Islet. Since 2010 from three to eight individuals have been recorded in the South Islet. It is possible that the species breeds in this islet as well.

New Avifauna Records

Four species, two resident and two migratory, were recorded for the first time within TRNP. The number of documented species in the TRNP recorded since 1911 (Worcester 1912) or over a period of about 100 years is now 108 species.

A Watercock *Gallicrex cinerea,* a common resident wetland species, was observed at South Islet. On North Islet, a swiftlet flew by. It was most likely Germain's Swiflet *Collocalia fuciphaga,* with a distributional range from the provinces of Palawan and Tawi-Tawi to the islands of Panay and Ticao.

The migratory shorebird Common Sandpiper *Actitis hypoleucos* a globally widespread species were present at South Islet and the Near Threatened (IUCN 2013) pelagic seabird species Swinhoe's Storm Petrel *Oceanodroma monorhis* was observed from M/S *Navorca* north of Jessie Beazley Reef (Figure 44). It was the first time this species was photographed in the Philippines. It breeds in Russia, China, North and South Korea and Japan and overwinters in the northern Indian Ocean. It probably transmigrates annually through Philippine waters.

Figure 47. Swinhoe's Storm Petrel Oceanodroma monorhis recorded on 11 May, 2013 north of Jessie Beazley Reef. (Photo: Robert Hutchinson)

IV. Recommendations

The Tubbataha Reefs Natural Park is a World Heritage Site and it is the only

site in the Philippines of global importance for seabird conservation. The North Islet and the South Islet and their seabird populations are in need of continued monitoring and active management and protection.

Similar to the 2012 management recommendations, key seabird management actions should include:

Habitat

- Regeneration of beach forest on South Islet where trees have died.
- Prevent planting Coconut Palms on South Islet.

Species

- Although perhaps no longer feasible, removal of nests of Red-footed Booby from South Islet in order to protect the last breeding habitat of the Black Noddy in the Philippines should be considered a priority.
- Continue population and habitat monitoring, which includes monthly distance count estimations and seasonal inventories in the months of January, May, August and October.
- Lobby with DENR-PAWB for the inclusion of seabirds as nationally threatened species.
- Increase recapture of banded seabirds (Brown Booby, Sooty Tern and Black Noddy) to gain more population knowledge in dispersal movements, mortality rates, life expectancies, etc.

Increase public awareness and knowledge

- Produce a video documentary on the seabirds of Tubbataha to be used in public media campaigns and highlight the uniqueness of the Tubbataha seabirds in all other public and educational initiatives.

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ANNEXES

Annex 1. 2013 Seabird Research Team.

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Lisa-Marie Paguntalan, Director (PBCFI)

Annex 2. In-flight to roost statistics of boobies and noddies on North Islet, Tubbataha Reefs Natural Park from 2005 to 2013.

Species/ Numbers	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average (Apr-May) counts
	May 10: 17.00-18.15	Apr 28: 16.30- 18.25	May 8: 16.30- 18.20	May 7: 16.00-18.00	May 7: 16.30- 18.30	May 13: 16.30- 18.30	May 9: 16.30- 18.30	May 10: 16.30- 18.30	May 10: 16.30-18.00	
Red-footed Booby										
Adult: Daytime	823	655	631	1,241	686	982	1011	382	830	
In-flight	960	1,171	2,082	1,272	1,534	1,259	1259	1,680	779	
Adjusted to 2-hour period	1,012	1,222	2,271	1,272	1,534	1,259	1259	1,680	779	
Total	**1,835**	**1,877**	**2,902**	**2,513**	**2,220**	**2,241**	**2,270**	**2,062**	**1,609**	
%-in-flight population	55%	65%	78%	51%	69%	56%	55%	81%	48%	59.3
Sub-adult: Daytime	514	205+	275	239	179	194	106	174	125	
In-flight	588	401	295	541	298	483	483	249	149	
Adjusted to 2-hour period	941	419	322	541	298	483	483	249	149	
Total	**1,455**	**606+**	**597**	**780**	**477**	**677**	**589**	**423**	**274**	
%-in-flight population	55%	67%	54%	69%	63%	71%	83%	59%	54%	62.0

Species/ Numbers	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average (Apr-May) counts
Brown Booby										
Adult: Daytime	629	405	660	691	650	930	1,338	1,060	968	
In-flight	360	225	326	368	368	508	508	819	722	
Adjusted to 2-hour period	576	235	356	368	368	508	508	819	772	
Total	**1,205**	**640**	**1,016**	**1,059**	**1,018**	**1,438**	**1,846**	**1,879**	**1,690**	
%-in-flight population	48%	37%	35%	35%	36%	35%	28%	44%	43%	37.3
Sub-adult: Daytime	22	20	21	20+?	22	30+	96	81	30	
In-flight	37	6	31	34	39	96	14	59	32	
Adjusted to 2-hour period	59	6	34	34	39	96	14	59	32	
Total	**81**	**26**	**55**	**54**	**61**	**126**	**110**	**140**	**64**	
%-in-flight population	73%	23%	62%	63%	64%	76%	13%	42%	50%	56.6

Species/ Numbers	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average (Apr-May) counts
Brown Noddy										
Adult: Daytime							618	607	1,004	
In-flight							1,124	525	142	
Adjusted to 2-hour period							1,124	525	142	
Total							**1,742**	**1,132**	**1,146**	
%-in-flight population							65%	46%	12%	41.0
Black Noddy										
Adult: Daytime							421 ?	1,098	2,243	
In-flight							1,334	1,124	272	
Adjusted to 2-hour period							1,334	1,124	272	
Total							**1,755**	**2,222**	**2,515**	
%-in-flight population							76%	51%	11%	46.0

Annex 3. Comparison of the landscape and habitat development seen from the permanent photo documentation sites on North Islet and South Islet, May 2013 and May 2004.

North Islet, May 2004:

Viewing angle for photo: facing NW 180° Comments: panoramic view Photo name code: BI 01

North Islet, May 2013:

Annex **4.** Systematic list of avifaunal records, North and South Islet and Jessie Beazley Reef, Tubbataha Reefs Natural Park, 8-11 May 2013. Breeding species are indicated with bold names. Sequence follows Kennedy et al. 2000.

Status/Abundance (within Sulu Sea)	Species name	Number of individuals	Locality	Notes
Migrant Rare	Bulwer's Petrel *Bulweria bulwerii*	1	North of Jessie Beazley Reef	N 09 04.62, E119 45.062
Migrant Accidental	Swinhoe's Storm Petrel *Oceanodroma monorhis*	1	North of Jessie Beazley Reef	First documented record for the Philippines
Resident Locally uncommon	Red-footed Booby *Sula sula*	Adults: 1,609 Sub-adults: 274 Pullus/1st y. juv.: 154	North Islet	
		Adults: 593 Sub-adults: 124 Pullus/1st y. juv.: 36	South Islet	Nest increase by 100% compared to 2012
Resident Rare	Brown Booby *Sula leucogaster*	Adults: 1,690 Sub-adults: 62 Pullus/1st y. juv.: 28	North Islet	
		Adults: 55 Sub-adults: 6	South Islet	Not breeding
Migrant/Resident? Locally uncommon	Great Frigatebird *Fregata minor*	Adults: 5 Sub-adults: 2	North Islet	Male 2 + female 3
		Adults: 13 Sub-adults: 3	South Islet	Male 4 + female 9
Migrant Locally uncommon	Lesser Frigatebird *Fregata ariel*	Sub-adults: 3	North Islet	Male 2 + female 1
		14	South Islet	Migrating north

Status/Abundance (within Sulu Sea)	Species name	Number of individuals	Locality	Notes
Resident Uncommon	**Eastern Reef-Egret** *Egretta sacra*	Adults: 7 Juvenile: 2	North Islet	Dark phase
		Adults: 11 Nests: 2	South Islet	Dark phase
Resident/ Migrant Common	Little Egret *Egretta garzetta*	1	South Islet	
	Little Heron *Butorides striata*	1	South Islet	
Resident/ Migrant Locally Common	Cattle Egret *Bubulcus ibis*	1	North Islet	
Migrant Uncommon	Peregrine Falcon *Falco peregrinus*	1	South Islet	Juvenile male of subspecies *calidus*
Resident Locally uncommon	**Barred Rail** *Gallirallus torquatus*	1-2	North Islet	
Resident Uncommon	Slaty-breasted Rail *Gallirallus striatus*	1	South Islet	
Resident Fairly Common	Watercock *Gallicrex cinerea*	1	South Islet	New record for Tubbataha Reefs
Migrant Common	Common Sandpiper *Actitis hypoleucos*	2	South Islet	New record for Tubbataha Reefs
Migrant Common	Grey-tailed Tattler *Heteroscelus brevipes*	1	North Islet	

Status/Abundance (within Sulu Sea)	Species name	Number of individuals	Locality	Notes
Migrant Fairly common	Ruddy Turnstone *Arenaria interpres*	1	North Islet	
		14	South Islet	Migrating north
Resident Uncommon	Black-naped Tern *Sterna sumatrana*	2	Jessie Beazley	
Resident Fairly common	**Great Crested Tern** *Sterna bergii*	Adults: 9,154	North Islet	
		Adults: 640	South Islet	Not breeding
		Adults: 92	Jessie Beazley	Not breeding
Migrant Uncommon	Common Tern *Sterna hirundo*	1	Jessie Beazley	
Resident Rare	**Sooty Tern** *Sterna fuscata*	Adults: 2,808 Pullus and juveniles: 1,258	North Islet	Based on number of juveniles and eggs
		Adults: 8	South Islet	Not breeding
		Adults: 60	Jessie Beazley	Not breeding
Migrant Fairly common	White-winged Tern *Chlidonias leucopterus*	10	North Islet	Migrating north
		31	South Islet	Migrating north
		21	Jessie Beazley	Migrating north
Migrant Common	Whiskered Tern *Chlidonias hybrida*	2	Jessie Beazley	
Resident Locally rare	**Brown Noddy** Anous stolidus	Adults: 1,146	North Islet	Based on number of nests
		Adults: 542	South Islet	Based on number of birds

Status/Abundance (within Sulu Sea)	Species name	Number of individuals	Locality	Notes
Resident Rare	**Black Noddy** *Anous minutus*	Adults: 2,515	North Islet	Based on number of birds. Actual count of nests was 1,027
		Adults: 8,141	South Islet	Based on number of birds. Actual count of adult birds was 4,129. Increase by 13% compared to 2012
Resident/ Migratory Uncommon	Brown Hawk-Owl	1	South Islet	
Resident Uncommon	Swiftlet sp *Collocalia sp.*	1	North Islet	New record for Tubbataha Reefs. Probably Edible-nest Swiftlet *Collocalia fuciphaga*
Migrant Common	Oriental Reed-Warbler *Acrocephalus orientalis*	1	South Islet	
Migrant Uncommon	Lanceolated Warbler *Locustella lanceolata*	1	South Islet	
Migrant Common	Grey Wagtail *Motacilla cinerea*	2	South Islet	
Migrant Common	Yellow Wagtail *Motacilla flava*	2	North Islet	Subspecies *simillina* and *tschutschensis*
		4	South Islet	Subspecies *simillina*
Resident Common	**Eurasian Tree Sparrow** *Passer montanus*	8	North Islet	
		8	South Islet	