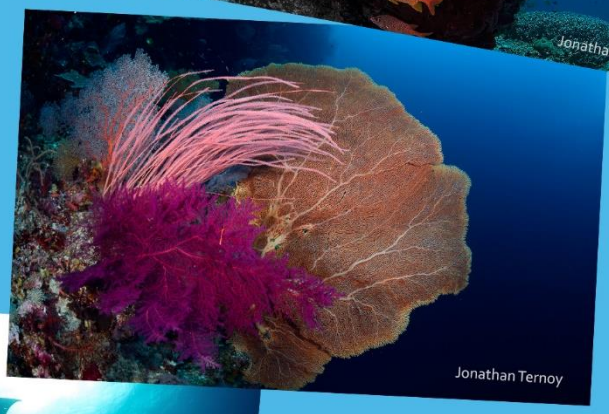
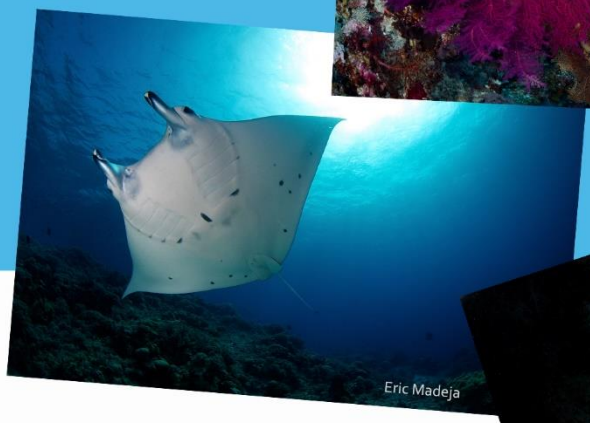
TRNP

Ecosystem Research and Monitoring Report

2015





TUBBATAHA REEFS NATURAL PARK
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TRNP Ecosystem Research and Monitoring Report 2015

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Executive Summary

Five sites are assessed in Tubbataha annually to monitor the condition of the fish populations and benthic community. These are: Site 2 near Seafan Alley; Site 4 near Malayan Wreck; Site 6 near Delsan Wreck; Site 7 near T-wreck; and Jessie Beazley Reef. In each of these sites, there are two replicate stations approximately 200 meters apart. In each of the stations, shallow (5meters) and deep (10meters) areas are assessed, making a total of 20 replicates. In addition to these, the two grounding sites – USS Guardian and Min Ping Yu – are also monitored. The methods used are fish visual census and benthos point intercept following English et al (1997).

Average fish biomass for the whole Tubbataha was estimated 444.8 metric tons/km^2. Healthy reef ecosystems in the Philippines are projected to produce 21 to 40 mt/km^2 of fish (Nañola et al. 2004). All monitoring sites showed improvement in both biomass and density values compared to the previous monitoring year. The number of fish species increased to 339 from 250 in 2014. This may be attributed to the increase in the monitoring area this year.

The iconic napoleon wrasse (*Cheilinus undulatus*), classified as endangered (EN) by the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species™, was present in all monitoring sites. A total of 37 individuals were sighted, ranging in size from 30 to 100 centimeters (1 meter). Other species recorded were the whitetip reef shark (*Triaenodon obesus*), blacktip reef shark (*Carcharhinus melanopterus*) and the grey reef shark (*Carcharhinus amblyrhinchos*). The whitetip reef shark was seen in all monitoring sites. Two individual grey reef sharks were seen in Site 2 and one blacktip reef shark was recorded in Site 7. The IUCN Red List classifies these shark species as Near Threatened (NT). Their presence in the park may suggest that Tubbataha continues to provide a safe and sustaining habitat for these animals whose populations are in the brink of collapse (Camhi et al 1998).

Coral flourish in the shallow waters in front of the ranger station. Photo: Steve de Neef

Significant improvements in fish biomass, density, and species variety were seen in the grounding sites after a year. Fish biomass in the USS Guardian grounding site increased from 119 mt/km^2 in 2014 to 657 mt/km^2 this year. Forty four percent of these are commercially-important species. Fish density in this site also improved. An average of 3,387 individuals/500 m^2 was recorded from only 2,954 in the previous year. Similarly, the fish community in the Min Ping Yu grounding site showed improvement in biomass, density and species richness this year. From only 63.7 mt/km^2 last year, biomass increased to 183.9 mt/km^2. Target species made up 71% of its total biomass. Fish density in this site increased from 1,005 in 2014 to 1,594 individuals/500 m^2. These developments suggest that both grounding sites are in the process of recovery.

The mean live coral cover (hard and soft corals) in the shallow sites is 87.23% and 63.41% in the deep sites. Using the quartile scaling of reef condition established by Gomez et al (1994), this year's live coral cover in the shallow sites fall under the 'excellent' category. Deep sites fall under the 'good' category.

The two islets in Tubbataha, Bird Islet and South Islet, as well as the smaller emerging sand cays are monitored for seabirds year round. The method of assessment follows the protocol established in 2004 (Jensen 2004 unpublished). A total of 27 different bird species were identified during the annual May inventory. Twenty-three of these species were waterbirds of which 13 species may be classified as pelagic or coastal-living seabirds. Of these, six species are breeding in TRNP: Red-footed Booby, Brown Booby, Great Crested Tern, Sooty Tern, Brown Noddy and Black Noddy. Other breeding species include Pacific Reef Heron, Barred Rail, and Eurasian Tree Sparrow.

A minimum of 36,271 adult individuals of the six breeding seabird species were recorded on Bird Islet and South Islet. The result for May 2015 is the highest count ever for TRNP and is substantially greater than the previous record in 2012 of 30,159 adults. The surprising increase is due to the presence of a great number of both Great Crested Tern and of Sooty Tern. The combined total population of all breeding seabirds in 2015 was 187% higher than the first inventory conducted in 1981.

Breeding Great Crested Terns occupy most of the open spaces in the Northeast side of the Bird Islet. Photo: Rommel Cruz

Studies on the following were also conducted in partnership with other institutions: coral disease, elasmobranchs, turtle, and water quality.

For the first time, corals in TRNP were assessed for diseases. The survey was conducted by Dr. Laurie Raymundo and Dr. Alexander Kerr of the University of Guam. They surveyed Sites 2 and 6, as well as the USSG and MPY grounding sites. Six of the described Indo-Pacific coral diseases (white syndrome, black band disease, skeletal eroding band, brown band disease, growth anomalies, and ulcerative white spots) were observed in Tubbataha. White syndrome was, by far, the most common disease and was observed in at least one transect at all sites. Prevalence of diseases were observed to be higher in impacted areas, such as the grounding sites, compared to the monitoring sites.

Overall, disease prevalence in the monitoring sites in TRNP is fairly low compared to other surveyed sites in the Philippines. A fish visual census was done simultaneously with the coral health assessment. Fish species in the two monitoring sites were mostly planktivores such as damselfishes, fairly basslets, surgeonfish and fusiliers. Majority of the fish species in the two grounding sites were herbivorous species. Also, target herbivore species came in high densities in the two grounding sites. These species are the larger species of surgeonfish, tangs, and parrotfish.

Large Marine Vertebrates Research Institute Philippines (LAMAVE) conducted an Elasmobranch Conservation Program in Tubbataha from March to June 2015. A total of 87 Baited Remote Underwater Video (BRUV) surveys were carried out during the said months documenting 285 encounters of 11 species of sharks and rays. The overall catch per unit effort (CPUE) for the total surveys was 1.86 per hour of survey. Grey reef sharks (*Carcharhinus amblyrhynchos*) displayed the highest CPUE with 0.817 sharks encountered per hour of survey. A total of 167 encounters from five species of sharks and rays were recorded during the Underwater Visual Surveys (UVS). The whitetip reef shark (*Triaenodon obesus)* was the most abundant species with 86 encounters over 12 UVS, with a population density of 3.91 individuals per hectare -1, suggesting one of the highest population densities for this species worldwide. Seventy one individual whale sharks (*Rhincodon typus)* were reported and identified and the occurrence of 23 species of

Manta alfredi (Reef manta ray) is a frequent sighting in the park. Photo: David Choy

elasmobranchs inhabiting TRNP was confirmed after integrating data from all the survey methods.

Turtle tagging and laparoscopy were conducted in June. Using rodeo method, a total of 198 turtles were captured, measured and tagged. Turtles underwent laparoscopy to determine sex and age class. Tissue samples were also taken for DNA analysis. During this survey, five recaptures were recorded, four from 2014 and one from 2006. Nine new recruits were also captured, comprising 8% of all juvenile records. Laparoscopy revealed 3:1 ratio of females to males. As in previous years, preliminary results of this year's survey showed a high number of juveniles, nearly 80% of records.

This year water quality was monitored in TRNP. A total of 20 locations established in 2014 were monitored. Out of the 15 parameters, TRNP passed the standards for the highest class for tourism and marine park waters (Class SA) for pH, dissolved oxygen, salinity and biological oxygen demand. The normal levels for the following parameters are still being established for TRNP: temperature, total suspended solids, color, nitrates and phosphates. Oil and grease concentration decreased from last year but most sites inside the lagoon exceeded 1mg/L maximum for Class SA. Some sites failed in the total coliform levels for Class SA. However, all sites passed standards for Class SB (recreational/fisheries waters).

Chapter 1. Introduction

I. Overview

Tubbataha Reefs Natural Park is an off-shore reef located in the middle of Sulu Sea. It comprise 78% of all no-take marine protected areas in the Philippines combined (Weeks 2010). TRNP is located in the apex of the Coral Triangle, the global center of marine biodiversity. It plays a key role in keeping the Sulu Sea as a storehouse of Philippine marine biodiversity (White et al., 2012). Its strict protection is key to supporting fisheries in this region through larval dispersal.

The park is composed of the North and South Atolls and the Jessie Beazley Reef (See Figure 1). The two atolls are separated by a five-nautical mile channel, while Jessie Beazley Reef is located some 12 nm northwest of the North Atoll. There is an uninhabited islet in each of the atolls and a cay made up of marl at the Jessie Beazley Reef.

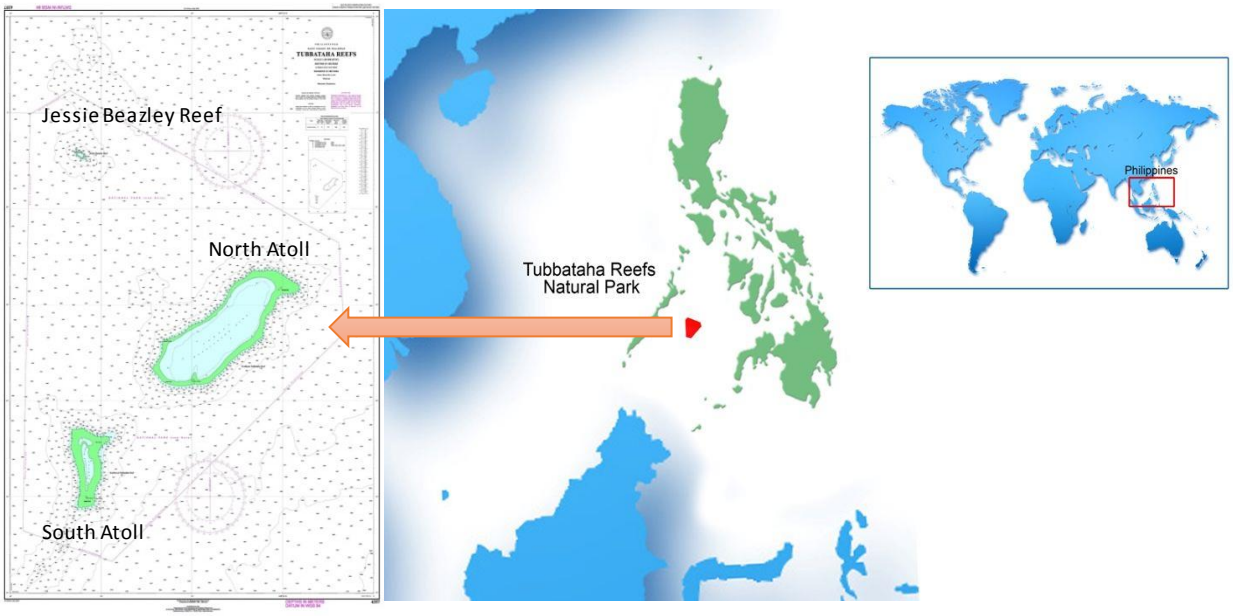

Figure 1. Location map of Tubbataha Reefs Natural Park (NAMRIA).

TRNP was established as a 33,200-hectare no-take national marine park in 1988 through Presidential Proclamation 306 issued by Pres. Corazon Aquino. It was expanded to 97,030 hectares in 2006. In 2010, RA 10067 was issued by the Philippine Government providing the

institutional and organizational framework for the management of the park. It also established a 10-nm buffer zone around TRNP. The total area of Tubbataha, including its buffer zone, is 453,500 hectares.

Tubbataha is internationally recognized, having been inscribed in the UNESCO World Heritage list in 1993 and in the Ramsar List of Wetlands of International Importance in 1999. It is classified as an Important Bird Area for the conservation of congregating seabirds, recognized globally as IBA No. PH057 (Mallari et al 2001 in Jensen 2004, unpublished). Recently, it was included in the roster of ASEAN Heritage Parks.

To date, TRNP is considered as the largest marine protected area in the Philippines (Dygico et al. 2013; Licuanan et al. 2014). Since 1997, yearly monitoring has been conducted to assess reef health and to understand how the reef responds to disturbances. These results were used to inform the formulation of appropriate policies and effective changes in management approaches. This year's survey marks the 19th year of consistent monitoring made possible through collaboration between NGOs, academe, partners and volunteers, e.g., WWF-Philippines, De La Salle University (DLSU) and University of the Philippines - Marine Science Institute (UP-MSI). WWF – Philippines initiated regular monitoring of fish and benthic communities in 1997. It commissioned a number of marine scientists to design the monitoring protocols for TRNP. These protocols have undergone several modifications upon the advice of experts and developments in marine science emerged.

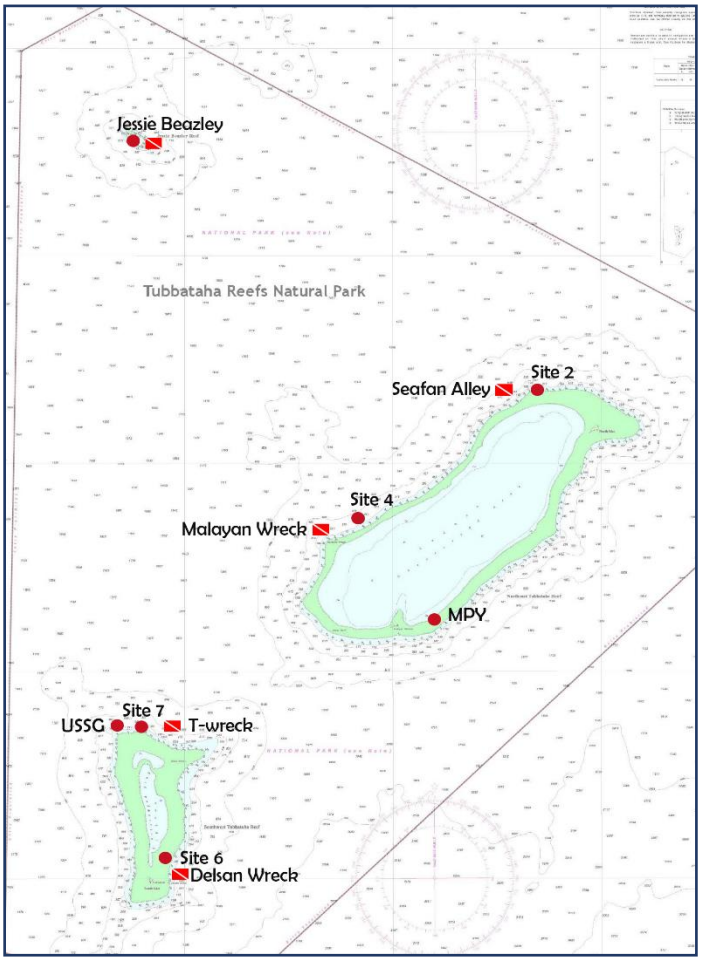

Figure 2. Location of permanent monitoring sites.

Researchers all over the world have signified their interest to conduct specialized researches in the park. In 2014, a team of researchers from the Global Change Institute at the University of Queensland in Australia went to TRNP to conduct underwater census and visualization using the Catlin Seaview Survey method. This year, Dr. Laurie Raymundo, an expert in coral diseases from the University of Guam,

assessed the corals in Tubbataha Reefs for presence and prevalence of diseases. TRNP is also one of the sites being monitored by the De La Salle University for climate-induced changes in coral reefs in the country.

In 2014, TRNP adopted the monitoring protocol introduced by the Department of Environment and Natural Resources (DENR). This was after the research staff and marine park rangers attended the Coral Reef Visualization and Assessment (CORVA) Training which aimed to standardize research methods throughout the country. Following the CORVA design for fish monitoring, TMO added one 50-meter segment and doubled the width of the transect belt this year. In terms of coral monitoring, TMO opted to employ the method of English et al (1994) rather than the Reef Check method recommended by DENR. This is to maintain the level of detail provided by the English et al method, which has been used since 1997.

This report presents the results of the monitoring surveys conducted in 2015 and provides an analysis of the temporal and spatial trends of the benthic community, reef fish and seabird populations.

II. Objectives

Ecosystem research and monitoring (ERM) is one of the four major programs implemented by TMO to ensure the effective conservation of TRNP. The goal of ERM is to determine ecosystem health, measure biophysical indicators of management effectiveness, and to provide the scientific basis for the formulation of proactive strategies and responses to emerging issues. Annual monitoring is conducted to determine any temporal and spatial changes in the coral reef community and other associated ecosystems and species in the area.

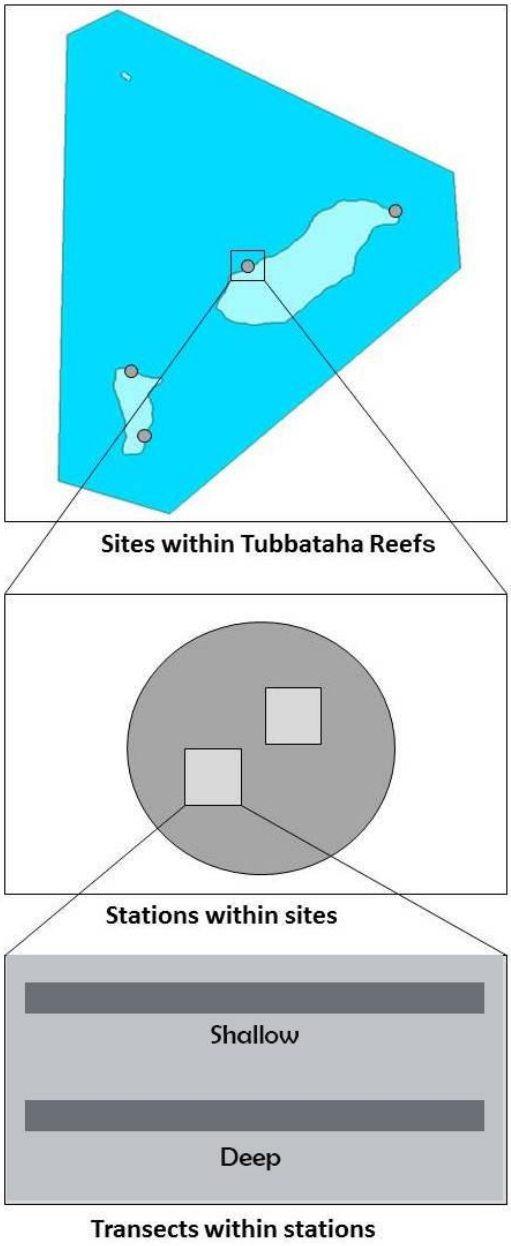

Figure 3. Hierarchical sampling design (Modified from Licuanan et al 2015 unpublished).

III. Monitoring design

Study Sites

From 10 monitoring sites in 1997, only five sites are now monitored in Tubbataha but with more replicates. These sites are: Site 2 near Seafan Alley; Site 4 near Malayan Wreck; Site 6 near

Delsan Wreck; Site 7 near T-wreck; and Jessie Beazley Reef (Figure 2). Monitoring sites retained the original numbers assigned to them in 1997, hence the absence of chronology. In each of these sites, two replicate stations, A and B, approximately 200 meters apart were established. The location of each station is presented in Table 1. In these stations, shallow (5meters) and deep (10meters) areas are assessed to acquire better understanding of the condition of the reefs at varying depths. A diagram showing the hierarchical sampling design is presented in Figure 3.

In addition, the fish and benthic communities in the two grounding sites – USS Guardian and Min Ping Yu – are also assessed. In all of these sites, a team of researchers from the De La Salle University - Br. Alfred Shields Marine Station, also conducts Coral Reef Targeted Research (CRTR) using the photo-transect method in 5meters of water adjacent to the TMO monitoring sites.

Table 1. Location of the TRNP monitoring stations and grounding sites.

Site Name	Stations	Location	Latitude (N)	Longitude (E)
Site 2 (Sea Fan Alley)	Station 2A	North of north atoll	8.93532 °	120.01302 °
	Station 2B	North of north atoll	8.93781 °	120.00851 °
Site 4 (Malayan Wreck)	Station 4A	West of north atoll	8.89236 °	119.90627 °
	Station 4B	West of north atoll	8.89128 °	119.90453 °
Site 6 (Delsan Wreck)	Station 6A	Southeast of south atoll	8.75591 °	119.82881 °
	Station 6B	Southeast of south atoll	8.75186 °	119.82784 °
Site 7 (T-wreck)	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	USSG	North of south atoll	8 49.297°	119 48.187°
	MPY	Southeast of north atoll	8 51.183°	119 56.188°

Seabirds were monitored after the fish and benthos. Monitoring focuses on the two islets – Bird and South Islets – which serve as major breeding grounds for seabirds. Small emerging islets and cays such as the ones in Jessie Beazley, Ranger Station and Amos Rock, and the exposed parts of Delsan Wreck are also surveyed.

Field Surveys and Limitations

The field surveys are conducted between the months of March to June, when weather and sea conditions are generally favorable. See Annex 1 for 2015 research trip schedule.

The major limiting factor for the conduct of regular research and monitoring expeditions in TRNP is weather condition. The unhampered conduct of the surveys depends on the opportunity to sail to the park as scheduled, and when there, on the opportunity to dive safely. Rough sea conditions impede the conduct of underwater monitoring and pose a risk to life and property. Other limitations, specifically for fish and benthos surveys, include the lack of manpower and expertise.

Another consideration throughout the years is the failure to locate the concrete markers installed in the permanent monitoring stations. Some of the marker blocks are overgrown with corals or dislodged by strong wave action. This year, unlike in previous years, the team was successful in locating all the monitoring stations.

For the seabird monitoring, extreme heat or cold, during rains, generally take a toll on the researchers. Boarding and alighting from the vessel is also a dangerous exercise during rough sea conditions. Generally, the distance of the park from the mainland limits the management's ability to sail on short notice and re-provision the vessel, when necessary. The distance also limits the ability to conduct unexpected repairs or secure parts for malfunctioning equipment.

Survey Teams

Fish and Benthos Monitoring Team. Segundo Conales, Jr. (TMO), Roy Magbanua (TMO), Jeric Dejucos (TMO), Prof. Jerome Cabansag (UPV-Tacloban) and Denmark Recamara (UP-MSI) conducted the fish monitoring in all sites this year. The benthic community was assessed by

Rowell Alarcon, Noel Bundal and Maria Retchie Pagliawan of TMO. A team of researchers from the DLSU also joined the trip to conduct CRTR in the vicinity of the established monitoring sites and in the two grounding sites. They are Dr. Wilfredo Licuanan, Eznaira Jeung Narida, Regine Robles and Regina Abesamis.

Seabird Monitoring Team. A total of 19 TMO staff, park rangers and volunteers, headed by an external ornithological consultant, participated in the seabird inventory. The team included seven park rangers and researchers from the TMO and one ranger each from the Philippine Navy, Philippine Coast Guard and the municipal government of Cagayancillo. In addition, volunteers representing the Philippine Biodiversity Conservation Foundation, Inc., the University of the Philippine - Los Baños, Marine Wildlife Watch of the Philippines and Wild Bird Club of the Philippines were part of the team.

For both activities, M/Y Navorca, the WWF-Philippines research vessel, was used as the research platform. Its crew participated in data-gathering, assisted in organizing equipment, and ensured the timely transport of supplies and personnel to the study sites.

Chapter 2. Monitoring fish community

Jeric Dejucos[1], Segundo Conales Jr[1], Roy Magbanua Sr[1], Jeffrey David[1], Denmark Recamara[2], and Jerome Benedict Cabansag[3]

[1]Tubbataha Management Office, [2]University of the Philippines – Marine Science Institute, [3]University of the Philippines – Visayas

I. Overview

Regular monitoring of the fish community in TRNP is undertaken to determine the status of fish populations. Results are compared to previous findings in order to establish trends.

Fish biomass, density, and species richness are some of the parameters used to gauge the condition of the reef ecosystem. Annual monitoring of these parameters were conducted by various agencies since 1997. Fish biomass showed a slightly increasing trend but fluctuations, in some years considerable, were observed from year to year. Similar observations apply to fish density but to a lesser extent.

In 2012, the number of monitoring sites were reduced from 10 to five, which made comparison of results over the years difficult. In-depth comparisons of overall biomass estimates were only possible for 2013 to 2015 because the same number of sites were monitored during these years.

This chapter discusses the status of fish community using the three parameters.

II. Methods

Sampling design

The sampling structure from the previous monitoring year was modified to conform to the new national standard in reef fish monitoring. The sampling design is described in the preceding chapter and illustrated in Figure 3. Each transect is 50 meters long and 10 meters wide, five meters wider than transects of the previous years, thereby doubling the sampling area. The increase in survey size was applied in compliance with national monitoring standards. A total of 40 transects were surveyed in the whole of Tubbataha this year. The deep areas of the USS Guardian and Min Ping Yu grounding sites were also monitored but with lesser number of

replicate transects compared to the annual monitoring sites. A summary of sampling designs implemented in the last three years is shown in Table 2.

Sampling method

Data collection was patterned from Fish Visual Census by English et al. (1997). Divers took note of the scientific name, count, and size estimate to the nearest cm of all fishes encountered within a defined space. In the case of TRNP, each transect was 50 meters long with an imaginary 5-meter coverage on both sides (50 x 10 m or 500 m^2). To make sound observations, recording of data was done in 5-meter stops along the length of the transect. Highly-mobile fish species were recorded first before the slower benthic dwellers. Four divers completed this year's survey; two worked alone in separate transects, while two divers covered the remaining transect. Their work was carried out per site – per station – per depth. Deeper transects were surveyed first with a dive time range of 45 - 60 minutes, followed by the shallow ones, which were completed within 35-50 minutes.

Table 2. Summary of sampling design used in conducting Fish Visual Census in Tubbataha from 2013 - 2015.

	2013	2014	2015
observers	3	2	3
sites	5	5	5
stations	2	2	2
depths	2	2	2
replicates	2	2	2
total no. of transects	40	40	40
transect area	50m x 5m	50m x 5m	**50m x 10m**
total area surveyed (square meters)	10,000	10,000	20,000

Data analysis

Raw data were collated following the format introduced by the DENR through the Coral Reef Visualization and Assessment (CoRVA) system in 2014. Species richness was derived from the actual number of fish species recorded, density and abundance from the actual counts, and biomass from both counts and size estimates. A two-factor analysis of variance (ANOVA) carried out with Microsoft Excel 2013 was used to detect significant differences in overall fish biomass between monitoring sites and between years from 2013 to 2015. A simple Chi square test was used to determine the significance of change in fish biomass and density at the two grounding sites in two years of monitoring. Density was expressed in number of individuals per

500 m² and biomass estimate in metric tons per km². The latter was calculated using the length-weight relationship formula of Kulbicki et al (1993):

$$\mathbf{W} = (\mathbf{a} \times \mathbf{L}^{\mathbf{b}}) \cdot \text{count}$$

Where:

W = weight (biomass) in grams

a, b = fish growth coefficient constants (obtained from CoRVA database and www.FishBase.org)

L = size estimate (total length) in centimeters

One of the datasets obtained from a third transect was not included in the analysis of results because of its inconsistency with the other two transects. The resulting fish biomass of the said transect was disproportionately lower and the fish density yields significantly higher compared to the other two. Fish experts consulted on the matter advised considering the data as an outlier.

III. Results and discussions

Fish biomass

The average fish biomass for the whole Tubbataha has shown significant improvement. From a major decline recorded last year, fish biomass increased to nearly fourfold - from 116.1 to 444.8 metric tons/km². It was the highest record of fish biomass in Tubbataha since 1997. The previous highest record was in 2002 at 354.3 mt/km². Since then, Tubbataha fish biomass never went beyond 330 mt/km² (refer to Figure 4). All monitoring sites showed improvement in both biomass and density values compared to 2014. Site 7 in the South Atoll had the greatest biomass estimate among all sites with 798.30 mt/km². The same site also had the highest biomass estimate last year.

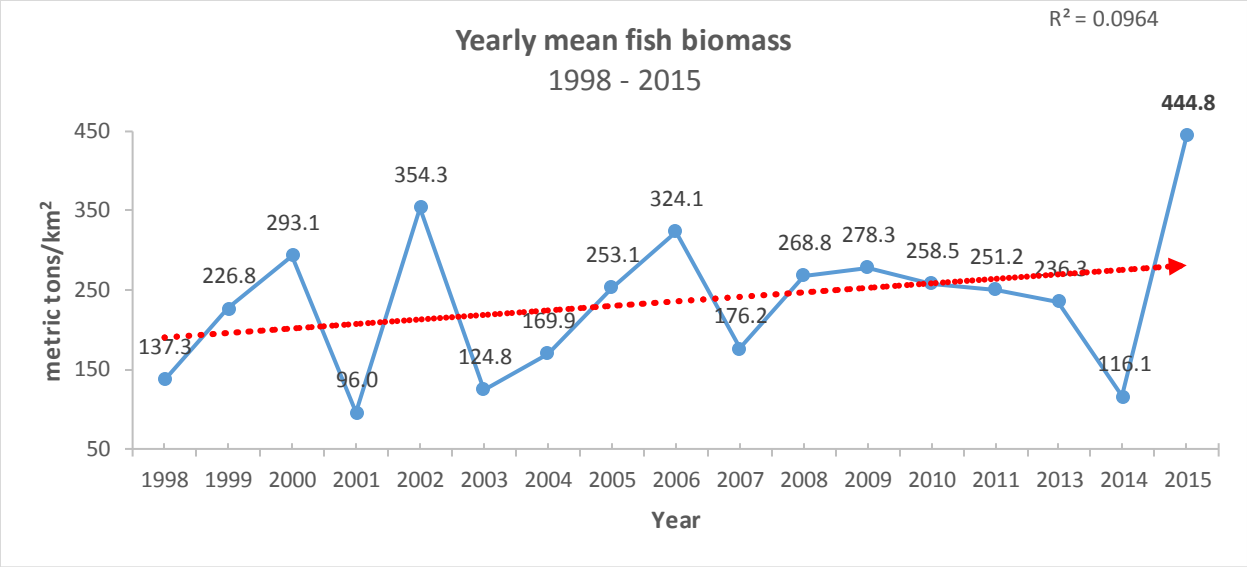

Figure 4. Yearly mean fish biomass of TRNP in metric tons per square kilometer. 2012 data was excluded due to incompleteness.

In order for data of the 2013, 2014 and 2015 to be comparable, values were converted to the least common denominator, e.g., from 250 m² to 500 m². A two-factor Analysis of Variance (ANOVA) was ran to examine the biomass estimates of all sites starting in 2013, to determine variations between values, and to determine the source of variation (see Table 3). The analysis showed that there is indeed a significant difference between yearly biomass estimates ($p = 0.01$). However, the variations between sites (within years) did not significantly affect the resulting average biomass of each year ($p = 0.17$). This suggests that Tubbataha biomass estimates are influenced by temporal variations (between years). Movements of mobile animals such as fishes are influenced by factors such as food source, avoidance to predators, mortality risk, and shifting habitats (Dahlgren and Eggleston 2000). In the local scale, this is associated with feeding, spawning, and ontogenetic shifts in habitat requirements (Sale 2002). Also, the sampling design used and effort exerted in the conduct of Fish Visual Census varied from time to time, depending heavily on existing national protocols and availability of manpower.

Table 3. Result of a two-factor analysis of variance (without replication) on fish biomass values in all sites from 2013 to 2015. Null hypothesis should be rejected if computed F is greater than the F critical value.

Two-factor ANOVA (without replication)						
Source of variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit.***
between years	276558.4	2	138279.1832	**7.64**	**0.01**	4.46
between sites (within year)	122177.5	4	30544.3784	**1.69**	**0.25**	3.84
error	144790.4	8	18098.8034			
total	543526.3	14				

Fish density and species variety

Unlike the fish biomass, only a slight improvement was seen in the average fish density. From 1,555 individuals per 500 m² in 2014, average fish density improved to 1,678 individuals per 500 m² this year. Site 6 had the highest fish density at 2,251 individuals per 500 m². More fish species were recorded in 2015. From 250 different species in 2014, 339 were encountered this year which is more than half of the total number of fish species previously recorded in Tubbataha through years of monitoring (660 species including sharks and rays). This may be attributed to the increase in the area covered this year. The number of fish genera observed also increased from 94 in 2014 to 106 this year. Recorded fish species came from 33 families, also an improvement from last year's 31.

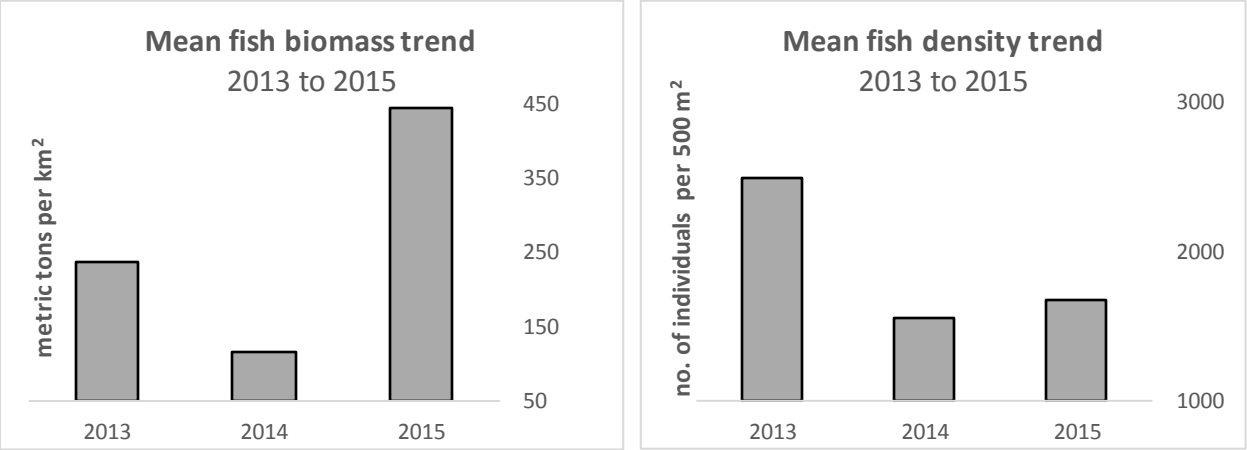

Figure 5. Mean fish biomass and density in each monitoring site from 2013-2015.

Pelagic and demersal species

Being an offshore reef, Tubbataha is regularly visited by pelagic fish species. Pelagic fishes are known to be erratic in nature (Kaunda-Arara and Rose 2004) and tend to form large schools. Families of fish which are considered pelagics are Carangidae (jacks and trevallies), Caesionidae (fusiliers), Carcharhinidae (requiem sharks), Scombridae (tunas and mackerels), Sphyraenidae (barracudas) and subfamily Nasinae (unicornfishes) from the Acanthuridae family (surgeonfishes). In the past, encounters with schools of these species, e.g., jacks and barracudas, heavily influenced biomass figures, causing variability in data and making it difficult to establish biomass trends.

Demersal or reef-associated fishes appear to be better indicators of change because there is strong possibility of encountering the same individual or groups in this species each year. Despite varying actual values of demersal fish biomass in the last three years, its percentage

relative to the total biomass (including the pelagics) did not significantly change. Demersals comprised at least 70% of the total biomass each year and pelagics only about 30% .

Deep and shallow zones

Aside from being pelagic or demersal, the depth where fishes occur also influenced biomass and density (see Figure 7 and Figure 8). Characterized by its wide reef flats leading to abrupt drop-offs, Tubbataha's habitat complexity causes variation to both fish biomass and density. Deep transects (10 meters) often yield higher biomass and density values compared to shallow ones (5 meters).

Larger fish species such as snappers, fusiliers, unicornfishes, sharks and jacks, occasionally in schools, traverse the deeper part of the reef more often, thus greatly influencing the biomass and density yields at this zone. On the other hand, smaller and highly-territorial fish species reside in the shallow zones of the reef. The most common of these are the damselfishes, anthiases, small groupers, small wrasses, small angelfishes, and butterflyfishes.

Fish groups: indicator, target, and major

To further investigate the variations in the three parameters, fishes were clustered into three groups: indicator, target, and major. The indicator group (also called the corallivores) is dominated by, but not exclusive to, the butterflyfishes (Chaetodontidae). These fishes have strong and obvious dependence on corals for food, shelter, and living space (Cole et al. 2008). Because of this, corallivorous fishes are often associated with coral reef health (Hourigan et al. 1988).

Meanwhile, fishes belonging to the target group are commercially important species. Notable members of this group are the surgeonfishes and unicornfishes (Acanthuridae), wrasses (Labridae), emperors (Lethrinidae), snappers (Lutjanidae), parrotfishes (Scaridae), groupers (Serranidae), and the rabbitfishes (Siganidae). These fishes are highly-targeted because of their suitability as food and ornament (Sabater 2002 unpub.), hence their presence or absence is a good measure of fishing intensity within an area.

Lastly, fishes which belong to the major group are the ones which occur in hundreds of thousands, and in some cases, in millions per square kilometer. Key members of this group are the damselfishes (Pomacentridae), fairy basslets and anthiases (Serranidae subfamily Anthiinae) and some angelfishes (Pomacanthidae). These are clustered in a group to distinguish them from other fishes that occur in low numbers.

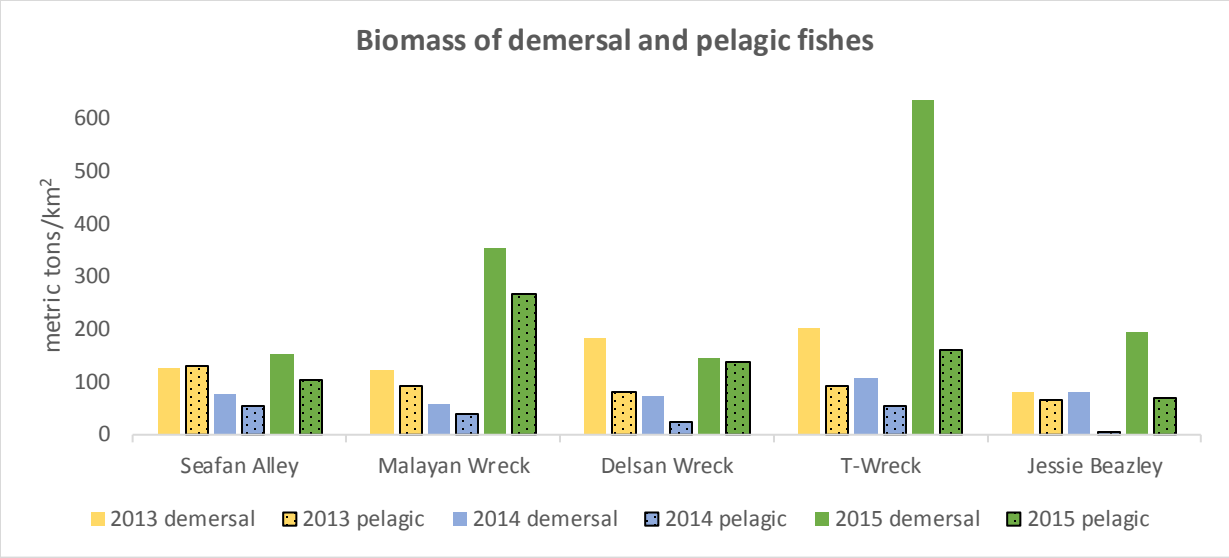

Figure 6. Breakdown of demersal and pelagic fish biomass in Tubbataha.

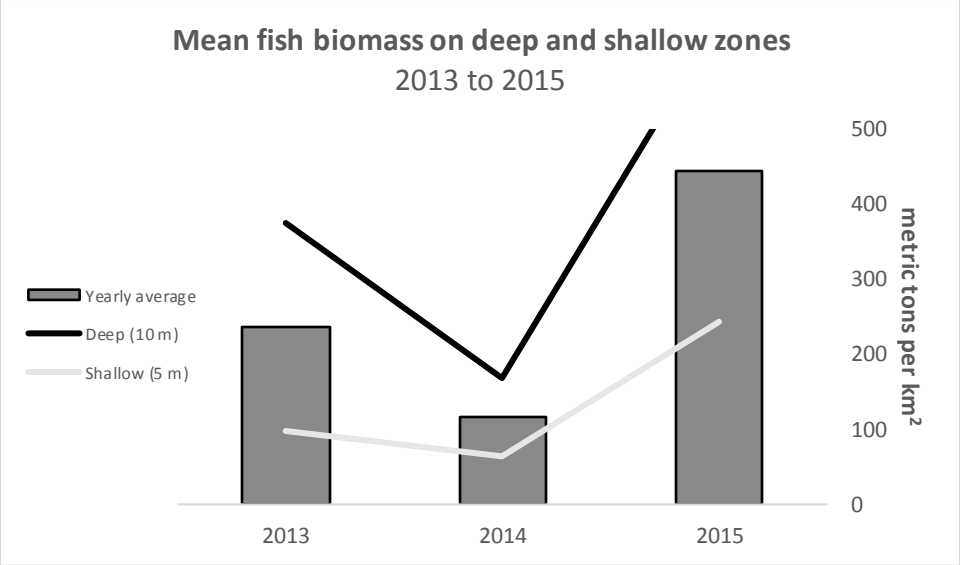

Figure 7. Yearly mean fish biomass per depth in the Tubbataha Reefs.

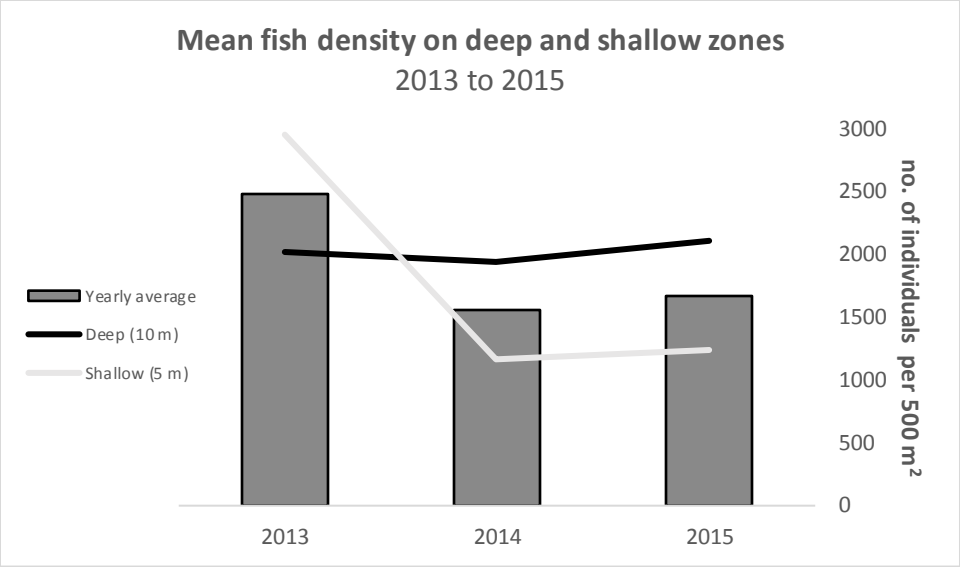

Figure 8. Yearly mean fish density per depth in the Tubbataha Reefs.

Despite improvements from last year, density of all fish groups showed an overall decreasing trend from 2013 to 2015 (See Figure 10). Notwithstanding the said decrease, overall biomass increased during the same period of time (See Figure 9). This could mean that the fish community of Tubbataha is dominated by bigger predatory fishes which contribute to high biomass values but result in low fish densities.

A decreasing trend in biomass was observed in the indicator group, a circumstance that could be a signal of either positive or negative development. Since these fishes are strongly associated with corals, their presence indicates that the coral community is healthy enough to support their dietary and habitat needs. Conversely, chronic predation by corallivores may lead to the demise of their prey coral (Glynn 1996) and further stress corals which are already stressed by the synergistic effects of other disturbances (Bellwood et al. 2006). There is no literature that can directly quantify the effects of corallivores on coral reefs up to now since their activity is greatly influenced by their environment (trigger-response), which is also governed by geographical variability. Indicator species had a mean biomass of 4.3 mt/km² this year, with an average of 23 individuals present in every 500 m². This group consistently comprised 1% of the total biomass and density values in Tubbataha from 2013. The most dominant indicator species this year was the pyramid butterflyfish (*Hemitaurichthys polylepis*) with 529 total individuals recorded estimated to weigh 57.3 kilograms.

On the other hand, the target group, which includes commercially important fishes, was consistently comprising the bulk of total fish biomass in Tubbataha. They amounted to 377.5 mt/km² or 70% of this year's biomass, a little lower than 76% in 2013 and 71% in 2014. The target species with the highest recorded biomass this year was the bumphead parrotfish

(*Bolbometopon muricatum*) which amounted to 2,225.1 kilograms (106 individuals) in all sites combined. The sudden prevalence of this large-bodied species may have influenced the overall biomass estimate this year.

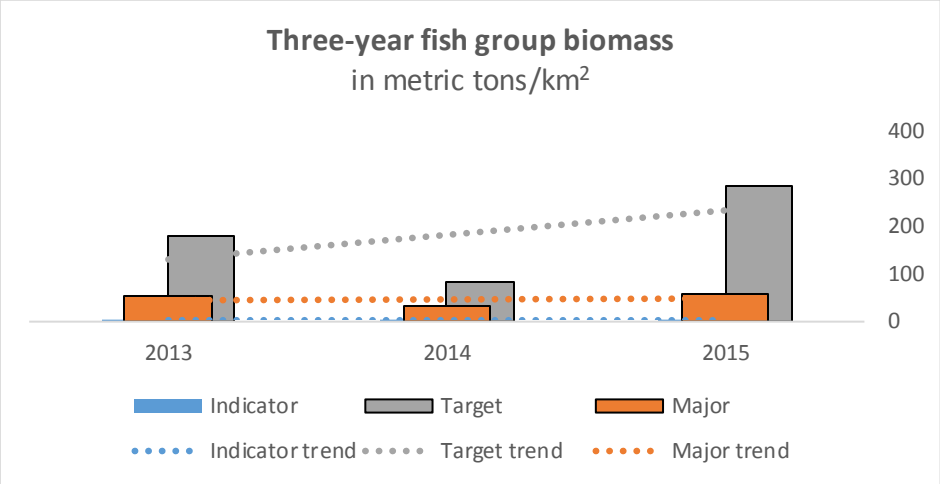

Figure 9. Yearly mean biomass of fish groups in the Tubbataha Reefs.

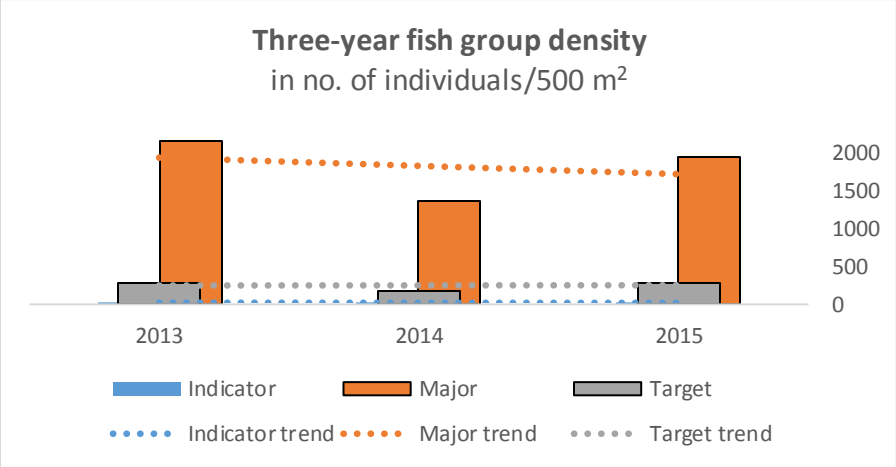

Figure 10. Yearly mean density of fish groups in the Tubbataha Reefs.

Despite their relatively lower biomass compared to the target group, fishes in the major group comprise the bulk of fishes in terms of density. An average of 1,332.6 individuals from the major group were observed in every 500 m² of reef. This is equal to 79% of the total fish density in Tubbataha. The ternate chromis (*Chromis ternatensis*) was the most numerous major species this year. A total of 9,368 individuals were spotted which accumulated 77.4 kilograms.

The most dominant fish species of the three fish groups. The pyramid butterflyfish (a) for the indicator group, bumphead parrotfish (b) for the target group, and ternate chromis (c) for the major group.

Threatened fish species

The iconic napoleon wrasse (*Cheilinus undulatus*), classified as endangered (EN) by the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species™, was present in all monitoring sites this year. A total of 29 individuals were sighted, ranging in size from 30 to 100 centimeters (1 meter). Other species recorded were the whitetip reef shark (*Triaenodon obesus*), blacktip reef shark (*Carcharhinus melanopterus*) and the grey reef shark (*Carcharhinus amblyrhinchos*). The whitetip reef shark was seen in all monitoring sites except in JBR. Two individual grey reef sharks were seen in Site 2 (Seafan Alley) and one blacktip reef shark was recorded in site 7 (T-Wreck). These shark species fall under the Near Threatened (NT) category in the IUCN Red List. Their presence suggests that Tubbataha continues to provide a safe and sustaining habitat for these animals whose populations are in the brink of collapse (Camhi et al. 1998).

Grounding sites: USS Guardian and Min Ping Yu

Tubbataha fell victim to two major ship grounding incidents in 2013. Barely a month through that year, the US minesweeper, USS Guardian, crushed 2,345 m^2 of corals in the South Atoll. Less than three months after that incident, the Chinese fishing vessel, F/V Min Ping Yu, damaged 3,902 m^2 of corals at the North Atoll. The latter vessel carried in its hold thousands of frozen pangolins. In 2014, the Tubbataha Management Office first surveyed the grounding sites simultaneous with the annual fish and benthos monitoring. However, the exact sampling design used in the regular monitoring sites was not applied in these sites. No replicate station was established and only the deep zone (10 m) was surveyed in both areas. The two sites showed the lowest values among all surveyed areas. However, those values were still above the Philippine standards for a healthy reef.

Significant improvements in fish biomass, density, and species variety were observed in the grounding sites after a year (See Figure 11 and Figure 12). Fish biomass in the USS Guardian

grounding site increased dramatically from 119 mt/km² in 2014 to 657 mt/km² this year. Commercially-important fish species contributed 50% to this biomass. Fish density in this site also improved. An increase to 3,387 individuals/500 m² of reef from 2,954 in 2014 was recorded. Despite the big difference in fish density between the two years, the relative percentage of demersal fish species did not change. Demersal fishes constituted 99% of density in 2014 and 2015. This is a distinctive characteristic of this sites compared to the other monitoring sites in Tubbataha and may be caused by the grounding incident. However, there is no available scientific proof to this claim, making it a matter for future studies. A total of 122 fish species were recorded in this site, an improvement from last year's 83 fish species.

Similarly, fish communities in the Min Ping Yu grounding site showed overall improvement. From only 63.7 mt/km² last year, biomass increased to 183.9 mt/km². Target species made up 71% of its total biomass. Fish density in this site was half as much from 1,005 in 2014 to 1,594 individuals per 500 m². Similar to the USS Guardian grounding site, demersal fishes dominated this area. Recorded were 125 different species of fish from only 82 of the last year. These developments suggest that both grounding sites are in the process of recovery since fish biomass, density, and species richness showed improved numbers compared to the previous year.

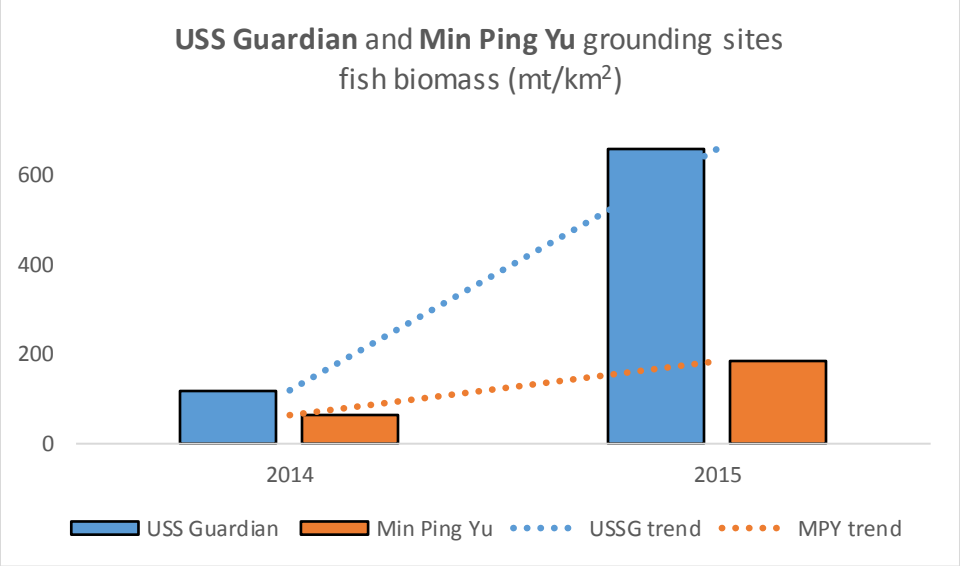

Figure 11. Total fish biomass in the USS Guardian and Min Ping Yu grounding sites in 2014 and 2015. Dotted lines represent trend.

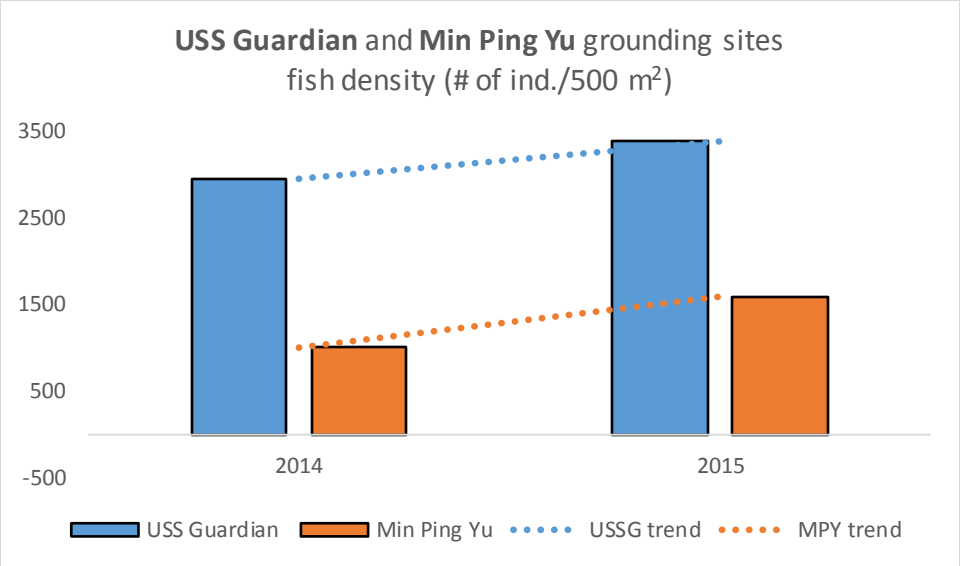

Figure 12. Fish density at the USS Guardian and Min Ping Yu grounding sites in 2014 and 2015. Dotted lines represent trend.

IV. Conclusions

Tubbataha continues to reflect superior values in terms of fish biomass, density, and species variety, nowadays unusual among Philippine reefs. Being an offshore reef, it has naturally higher fisheries potential compared to fringing or barrier reefs (Dantis et al. 1999). But what makes Tubbataha exceptional is its protected status, which is considered the best in the entire country (ADB 2014). Surveys conducted by the World Wildlife Fund (WWF) – Philippines in 2004 (unpub.) showed that other reef areas in the Cagayan Ridge in the Sulu Sea are inferior to Tubbataha in terms of fish biomass and density. The surveyed areas; Basterra, Bancoran and Manuc-Manucan Island, despite sharing common characteristics with Tubbataha, were open to fishing and were not protected. Tubbataha could have suffered the same fate of its neighbors in the Sulu Sea if not for the stringent protection policies that the Tubbataha Protected Area Management Board implemented in the last 15 years.

Tubbataha's fish figures were so outstanding that biomass of fishes in the major group alone exceeded 40 mt/km², reportedly the highest yield of a healthy Philippine reef. It also boasts massive amounts of target species biomass. There was a prevalence of bumphead parrotfishes (*B. muricatum*) at this year's census. These large-bodied fish contributed to the higher overall biomass yield compared to last year.

Oceanographic models show that Tubbataha is a major source and sink of coral and fish larvae that are continuously broadcast throughout neighboring fishing grounds and reefs in the Sulu Sea and beyond. The destruction of Tubbataha could pose serious economic implications considering that about half of the Philippine population depends on food derived from the sea for most of their daily dietary protein intake (Licuanan and Gomez 2000). In the face of climate change, marine pollution, illegal fishing, and habitat degradation, Tubbataha was found to display moderate resilience (Aquino et al. 2011); a characteristic that was built through many years of protection through the collaboration of various agencies and organizations.

Notable improvements in the fish community in the two grounding sites was recorded this year. The recovery of the two grounding sites in terms of fish biomass, density, and species richness could be due to the fact that it is inside the Tubbataha Reefs Natural Park, a coral reef system that is left to its natural state. Their proximity to constant supply of larvae substantiates the spillover effect that scientists identify as the importance of marine reserves. This development may help convince legislators that marine reserves are actually working and are worthy of the country's resources and attention.

V. Recommendations

Fish biomass, density, and number of species not only significantly improved this year, it increased in unprecedented measure compared to 2014. This could be caused by natural temporal variations as suggested by the two-factor ANOVA or it could be due to the variation in the sampling designs between the two successive years. Consistent survey methods need to be implemented to yield sound results for decision-making. It is also likely that changing observers with varied levels of expertise each year had a bearing on the results of the FVC. Employing the same observers every year as much as possible would eliminate bias in survey results.

It is likewise recommended that the two grounding sites be treated equally as TMO's five regular monitoring sites. Literature on reef recovery from groundings in the Philippines is scarce. A closer look at the two grounding sites could yield information beneficial to the marine scientific community and park authorities.

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Chapter 3. Monitoring benthic community

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I. Overview

Monitoring of the benthic community is conducted to determine the current status of the coral reefs using percentage total live coral cover. Results are compared to previous findings in order to establish trends. Annual monitoring of these parameters was initiated by WWF-Philippines in 1997.

Statistical power analysis showed that the benthic cover varied significantly in Sites 1, 3 and 5, resulting in fluctuations in benthic cover through the years (Licuanan et al 2014, Reyes et al 2014). For this reason, the 10 monitoring sites were trimmed down to five in 2012. Sites 2, 4, 6, 7 and Jessie Beazley were retained for monitoring.

The two atolls of TRNP gained more stringent protection earlier than Jessie Beazley Reef, which was annexed to the park only in 2006. Regular monitoring of Jessie Beazley was initiated in 2008. Thus, results from the monitoring site in Jessie Beazley were treated separately from those of the North and South Atolls.

This section presents the changes in the benthic community from 1997 – 2015. A more in-depth comparison was done for three benthic categories which showed the most fluctuations throughout the years. These are: hard corals, dead corals, and algae.

II. Methods

Field survey

The researchers followed the life form categories in English et al (1997) to determine the relative cover of benthic organisms and the non-living components of the reef. The 100-meter transect was divided into 20-meter segments with 5-meter breaks in-between. The life form directly beneath the 0.5-meter marks were then recorded along a 20-meter segment of the transect line. In order to increase accuracy, the number of points for each segment was increased. A modification was introduced to the Reef Check method with the use of a V-bar. The V-bar was placed every 0.5-meter mark with its two proximal ends pointing to the right (McManus 1997). The life form directly beneath the proximal ends of the V-bar were identified and recorded. The V-bar was then flipped to the left, and the life forms at the two ends were again identified and recorded. This yielded a total of 5 data points for every 0.5 meter segment or 200 data points per 20 meters. This procedure was followed in the next three 20-meter segments along the transect line.

Data Processing

Percentage Cover

The percentage cover of each life form was generated by dividing the total number of points in which each life form was observed by the total number of points of all identified life forms (200), and multiplied by 100. The formula is shown below:

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

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.

Data Analysis

Regression

A regression analysis was done to predict whether the life forms are stable, increasing or decreasing. This is represented by the linear trend line plotted together with the data series in the charts. A trend line is most reliable when its R^2 is near or equal to 1. The R^2 is the coefficient of determination and reveals how closely the estimated values for the trend line correspond to the actual data.

Correlation

To determine whether there are differences in the results of benthic cover of hard (HC) and soft corals (SC) over the years, data on the percentage cover of the benthic categories for the deep sites were correlated with the shallow sites. High correlation would suggest how strongly the variables are related.

Paired t-test

The paired t-test was used to calculate the difference between this year's estimates with that of the previous year's at p = 0.05.

III. Results and discussions

A total of five sites comprising ten stations were surveyed in the seven days fieldwork covering a total of 1,000 meters. These studies spanned 19 years from 1997 to the present, one of the longest monitoring studies in the Philippines. Gomez et al (1997) was used to describe current reef health, using total live coral cover – percentage cover of hard and soft corals.

Benthic cover at 10 meters

The mean live coral cover (hard and soft corals) in the deep sites in TRNP this year is at 63.41% (Table 4). This figure is within the average hard coral cover for Tubbataha from 1997-2014. Using the quartile scaling of reef condition established by Gomez et al (1994), this year's live coral cover falls under the 'good' category. The mean hard coral cover for the deep sites this year is 40.9%. This is less than last year's hard coral cover which was recorded at 50.71%. Paired t-test reveals that this decrease in hard corals is insignificant.

Table 4. Overall mean percentage cover at 10 meters in TRNP.

	2014	SD	2015	SD
HARD CORAL	50.71	17.3	40.9	9.91
SOFT CORAL	16.95	11.3	22.51	5.98
MORTALITIES	0.41	0.4	0.56	0.60
ALGAE	12.4	9.03	18.09	8.11
ABIOTIC	14.42	15.52	11.22	15.03
OTHERS	5.14	2.22	6.71	1.17

Table 5. Mean percentage cover per site at 10 meter depth in Tubbataha Reefs Natural Park.

	SITE 2A	SITE 2B	SITE 4A	SITE 4B	SITE 6A	SITE 6B	SITE 7A	SITE 7B	JBA	JBB
HARD CORAL	46.75	59.38	48.63	36.50	30.00	37.13	39.13	54.00	32.13	25.38
SOFT CORAL	12.13	18.75	9.25	18.75	8.25	16.38	26.25	12.25	34.25	68.88
MORTALITIES	0.38	0.63	0.00	0.00	1.63	1.50	0.63	0.63	0.25	0.00
ALGAE	26.75	17.13	27.25	33.75	8.50	14.00	19.25	22.75	9.00	2.50
ABIOTIC	9.25	0.50	10.00	3.88	45.75	25.38	10.13	3.63	2.00	1.75
OTHERS	4.75	3.63	4.88	7.13	5.88	5.63	4.63	6.75	22.38	1.50

The highest hard coral cover this year was recorded in Station 2B (59.38%). This site, located at the northern tip of the north atoll, still has the highest hard coral cover among all the stations and it appears to be the most stable in terms of hard corals. The lowest hard coral cover was recorded in Site JBB, which has a soft corals coverage of 68.88%. There is a high percentage of abiotic components in Site 6A recorded at 33.75%. Algal cover was recorded highest in Site 4B at 33.75%. Mortalities were low across all sites, suggesting that no recent disturbances occurred in the park. A paired t-test was done for all benthic categories to determine if the change from last year was significant. Only algae has significantly changed from 2014 (paired t-test) at p = 0.01.

Benthic cover in the two atolls

The three benthic categories investigated, i.e., hard corals, dead corals, and algae were observed to have major fluctuations in the deep sites of the two atolls through time. As shown in Figure 13, hard coral cover in the sites located in the two atolls is generally increasing. But it is important to note that there was a decrease in the hard coral cover since 2014. A slightly decreasing trend can be seen for both the algal cover and mortalities. However, also notable is the increase in algal cover in the last two years. This is true for almost all the sites, particularly highest at Site 4 for both years.

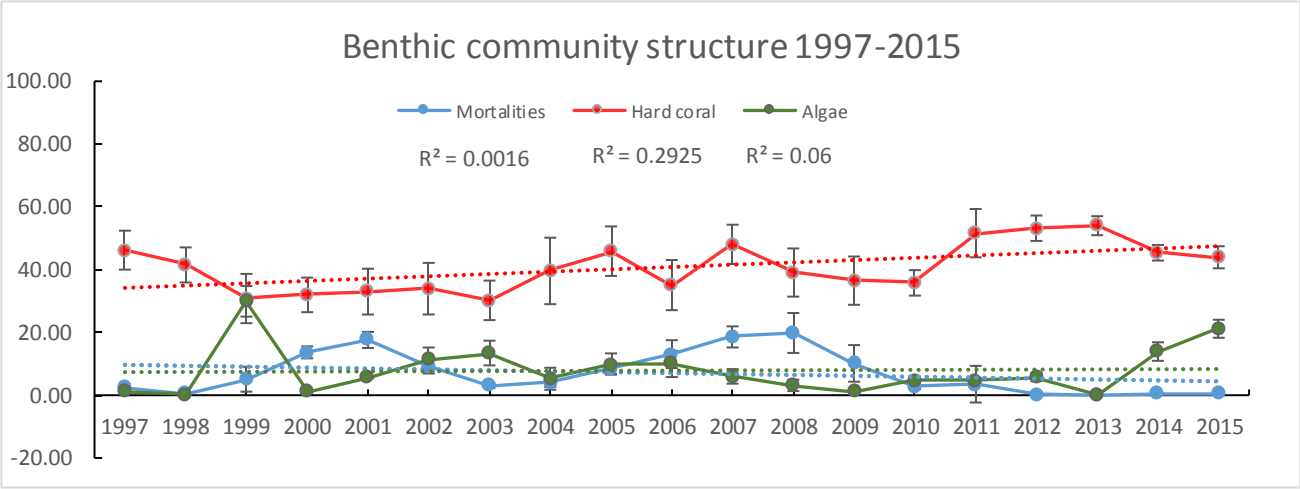

Figure 13. Percentage cover of the three benthic categories in Tubbataha from 1997 to 2015. Error bars represent standard error of the mean.

Spatial variation of hard corals in the two atolls

Figure 14 presents percentage of hard coral cover per site through time. A stable linear trend can be observed in Sites 2 and 7, while a positive trend line was seen in Sites 4 and 6. Generally, the R^2 values were low indicating considerable fluctuations between years. Factors which might have influenced the fluctuations are observer bias and misplacement of transects.

As mentioned by Ledesma et al. (2008 unpublished), the sites' responses to the various disturbances were different. Site 2 was not badly affected by the 1998 El Niño and the storm in 2008. However, a decrease in hard coral cover was recorded in the Site in 2009 and 2010. It can be recalled that 2010 is also an El Niño year that affected a lot of coral reefs in the Philippines. In general, the hard coral cover of the four sites in the two atolls remains stable. A comparison of the hard coral cover of each site for 2014 and 2015 using paired t-test was made. Results reveal that changes for all sites were not statistically significant.

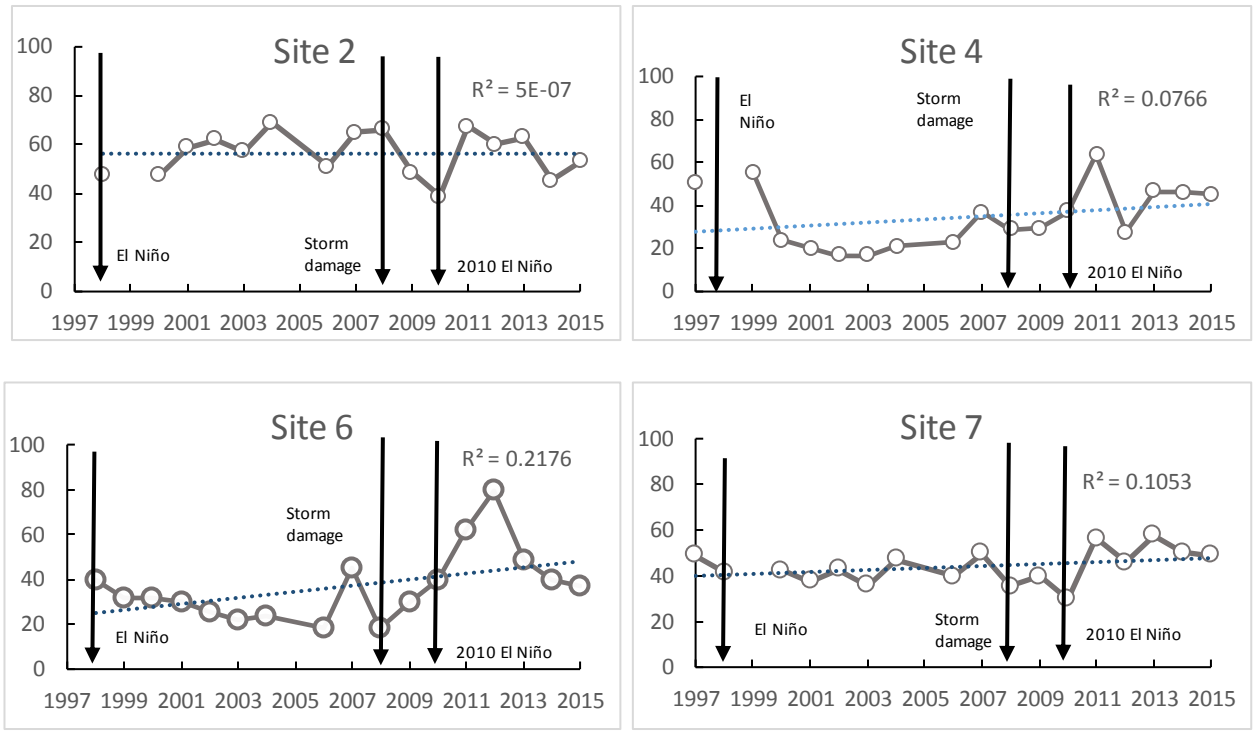

Figure 14. Hard coral cover at Site 2, 4, 6 & 7 at 10 meters from 1997-2015. Major disturbances such as El Niño and storms are highlighted with an arrow. Plotted trendline was added to show general linear pattern through time.

Benthic cover in Jessie Beazley Reef

Table 6. Mean percentage cover of benthic community in Jessie Beazley along with standard deviation.

	2013	SD	2015	SD
HARD CORAL	44	28.28	28.75	4.77
SOFT CORAL	37.5	4.64	51.56	24.48
MORTALITIES	0	0	0.13	0.18
ALGAE	0	0	5.75	4.6
ABIOTIC	17	7.07	1.88	0.18
OTHERS	1	0	11.94	14.76

Coral cover in Jessie Beazley reef this year was compared to 2013 due to the incomparability of the 2014 data. Hard coral cover in Jessie Beazley Reef at 10 meters is estimated at 28.75% (Table 6). This is less than the 2013 record of 44%. The team was unable to locate the previously installed station marker. Although a new marker was established in the same general location, the likely deviation in site location with lower coral cover may have caused a misreading that showed a significant decline.

A paired t-test value of 0.631 suggests that no significant changes occurred between 2013 and 2015. The lower hard coral cover this year may be due to the proliferation of fast growing species such as soft corals in Station A.

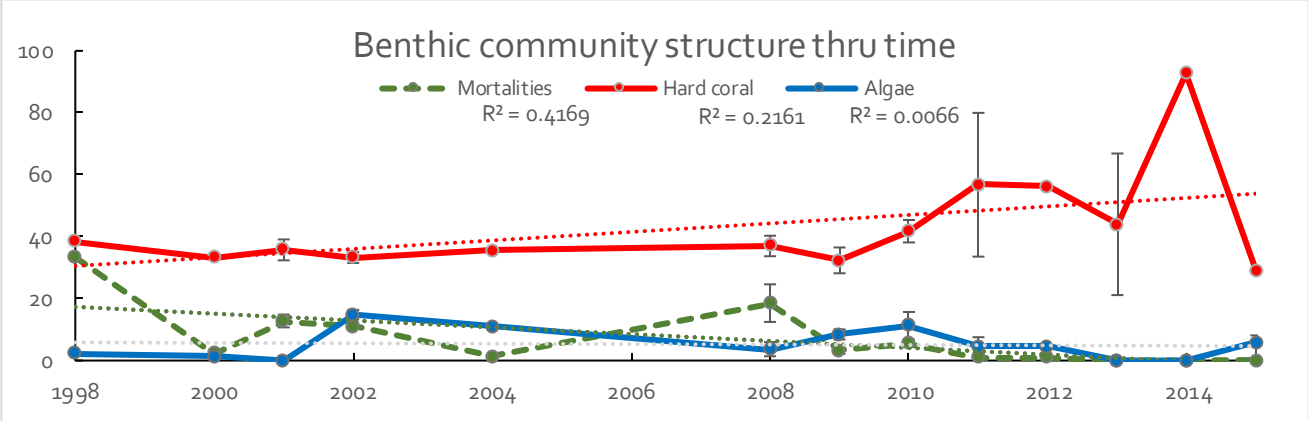

Figure 15. Percentage cover of benthic categories of the two stations at 10 meters in Jessie Beazley Reef from 1998 to 2015. Error bars represent standard error of mean.

Soft coral cover at this depth is more than that of 2013 (37.5%). However, a paired t-test result of 0.30 suggests that the increase is not significant. Mortalities were still recorded at a very low percentage. Algae (mostly coralline) recorded a 5.75% increase, but not significantly, from 2013 (paired t-test = 0.32). One factor could be the difference in the classification of algae used for the two years (2013 and 2015). In 2013, Reef Check classification was used where algae of >1 inch in length is classified as nutrient indicators algae (NIA), while algae <1 inch was classified

under rock (RCK) and fall under abiotic components. On the other hand, 2015 monitoring employed the 31 lifeform classification from English et al (1997) where algae of <1 inch in length, mostly coralline algae at this depth, was classified under algae.

Benthic cover at 5 meters

The mean live coral cover (hard and soft corals) in the shallow sites in TRNP this year is at 87.23% (Table 7). Using the quartile scaling of reef condition established by Gomez et al (1994), this year's live coral cover at the shallow sites fall under the 'excellent' category.

Table 7. Overall mean percentage cover at 5m depth TRNP.

	2014	SD	2015	SD
HARD CORAL	66.63	20.2	75.23	12.76
SOFT CORAL	13.08	23.42	12	8.18
MORTALITIES	0.81	0.97	0.69	1.09
ALGAE	2.23	3.71	0.93	1.12
ABIOTIC	13.44	9.02	6.25	4.92
OTHERS	3.77	2.9	4.91	2.46

Table 8. Mean percentage cover per site at 5m depth in Tubbataha Reefs Natural Park.

SITE	2A	2B	4A	4B	6A	6B	7A	7B	JBA	JBB
HARD CORAL	76.50	64.38	70.75	63.00	92.63	99.38	76.50	79.00	92.13	38.00
SOFT CORAL	4.75	25.00	9.50	12.88	0	0	4.38	6.88	6.75	49.88
MORTALITIES	0.88	0.13	2.75	2.38	0	0.13	0.50	0.13	0	0
ALGAE	3.38	0.63	0.38	0.88	2.00	0	1.38	0.25	0.25	0.13
ABIOTIC	9.63	6.13	9.63	16.00	2.38	0.25	10.00	6.38	0.63	1.50
OTHERS	4.88	3.75	7.00	4.88	3.00	0.25	7.25	7.38	0.25	10.50

In the shallow sites, both stations of Site 6 and Station JBA displayed the highest hard coral cover of 99.38% (Station 6B), 92.62% (Station 6A) and 92.13% (Station JBA). Both shallow stations in Site 6 also showed the highest hard coral cover in 2014. Soft coral cover is highest in JBB, while none was recorded in both stations of Site 6. Mortalities are still low at all sites suggesting that no major disturbances occurred in the park recently. Algae and other fauna are also low for all sites, while abiotic components are low except in Station 4B, where it comprise 16% (Table 8).

Benthic cover in the two atolls

Monitoring shallow sites in the two atolls in TRNP only began in 2001. Figure 16 highlights the three benthic components which have fluctuated through the years. Hard coral cover continues to increase in the shallow monitoring sites, especially in the two stations of Site 6. Consequently, a generally decreasing trend for mortalities and algae is noteworthy.

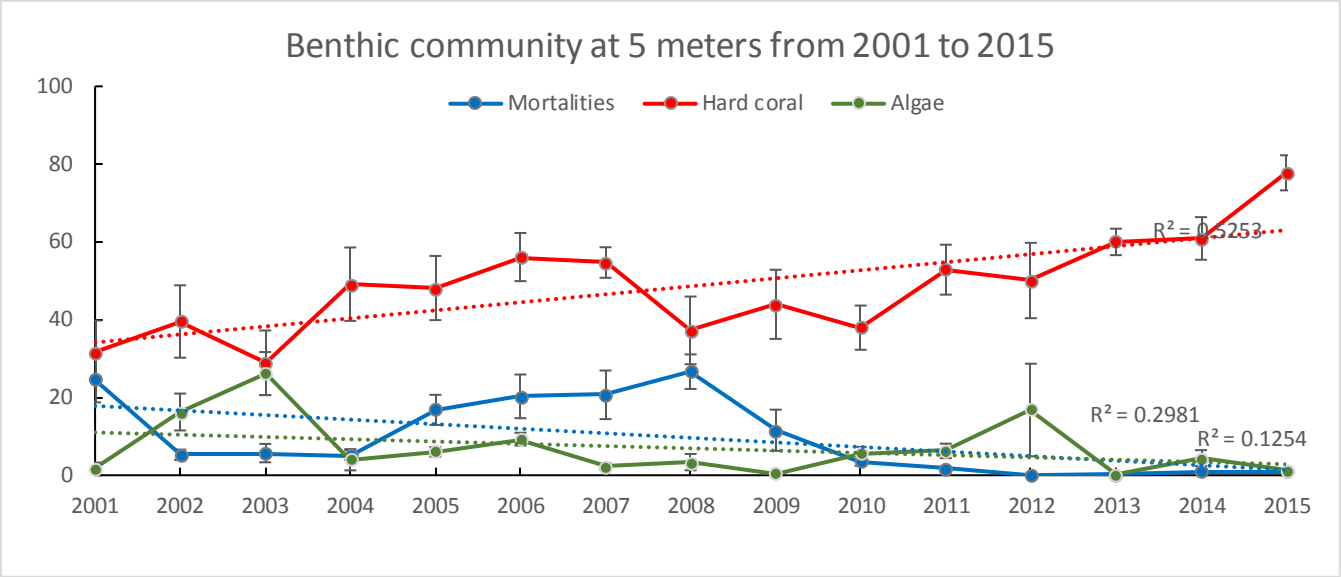

Figure 16. Percentage cover of benthic organisms in the shallow sites in the four stations of the two atolls from 2001 to 2015 with standard error of the mean.

Spatial variation of hard corals in the two atolls

As in the deep sites, Sites 4, 6 and 7 appeared to have been affected by the storm of 2008, while Site 2 remained stable. The opposite happened during the 2010 El Niño event when hard corals in Site 2 dropped while those of Sites 4, 6 and 7 increased. This suggests that different parts of the Tubbataha atolls respond to disturbances in varying ways. A paired t-test was used to compare the hard coral cover of each site for 2014 and 2015. Results revealed that changes for Site 2, 4, 6and 7 were not statistically significant. On the other hand, a notable spike was recorded in Site 6, which may be attributed to the dominance of branching Acropora that could grow faster than other coral species (GBRMPA 2013).

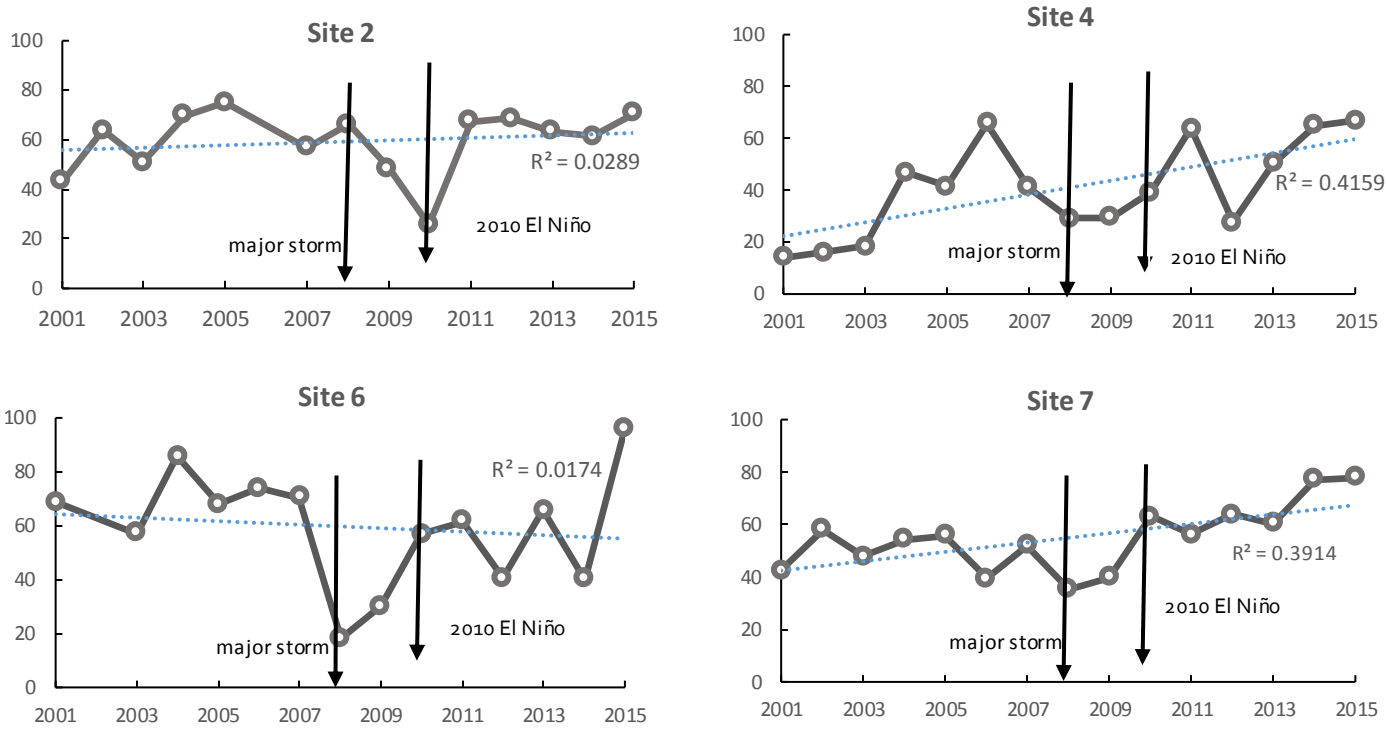

Figure 17. Hard coral cover at Site 2, 4, 6 & 7 at 5 meters from 2001-2015. Major disturbances such as El Niño and storm were highlighted with an arrow. Plotted trendline was added to show the general pattern through time.

Benthic cover in Jessie Beazley Reef

Total live coral cover in the shallow sites of Jessie Beazley was 93.37% (Table 9), which puts it in the 'excellent' category of Gomez et al (1994). Hard coral cover is estimated at 65.06% which is slightly less than that of 2013. A paired t-test result of p = 0.42 suggests that the decrease is not significant.

Table 9. Mean percentage cover of the benthic community in Jessie Beazley Reef at 5 meters.

	2013	SD	2015	SD
HARD CORAL	77	15.55	65.06	38.27
SOFT CORAL	4	1.41	28.31	30.49
MORTALITIES	0	0	0	0
ALGAE	0	0	0.19	0.09
ABIOTIC	4	9.89	1.06	0.62
OTHERS	2	1.41	5.38	7.25

The soft coral cover was 28.31%, which increased from 4% in 2013. Other components maintained minimal coverage this year. Algae and dead corals were recorded at 0.18% and 0%, respectively, suggesting that no major disturbances occurred from 2013 to 2015. Other fauna, mainly consisting of tunicates and zoanthids, were recorded at 5.37%, while abiotic components was estimated at 1.06%. Figure 18 presents the hard coral cover, algae and mortalities in Jessie

Beazley at 5 meters. It is good to note that the hard coral cover in Jessie Beazley has generally increased over time while mortalities and algal cover continue to decrease.

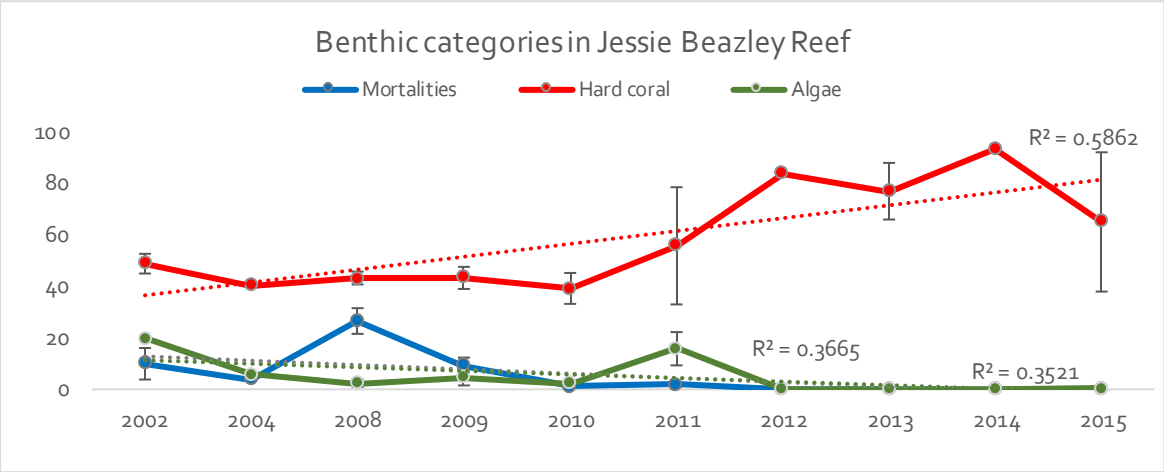

Figure 18. Mean percentage cover of the three lifeforms in Jessie Beazley Reef at 5 meter depth from 2002 to 2015.

Correlation of hard and soft coral cover between depths at the two atolls

A correlation of the hard coral and soft coral cover for both sites was conducted to determine if changes are uniform at different depths. Figure 19 presents the changes in the hard coral cover for the shallow and deep sites. As shown in the graph, hard coral cover for both depths are generally increasing since 1997. Correlation coefficient is moderately positive at r = 0.62 suggesting that the increase in hard corals occur simultaneously at both depths. On the other hand, soft coral correlation coefficient of r = 0.11 suggests a weak positive correlation. This implies that changes in the soft coral cover in deep sites do not coincide with that of the shallow sites. Soft corals seem to be more abundant at deeper transects for almost all sites. This observation is common at steep walls around five to 20 meters deep, characterized by strong current, a habitat preferred by most of the soft coral species (Fabricius and Death 2000).

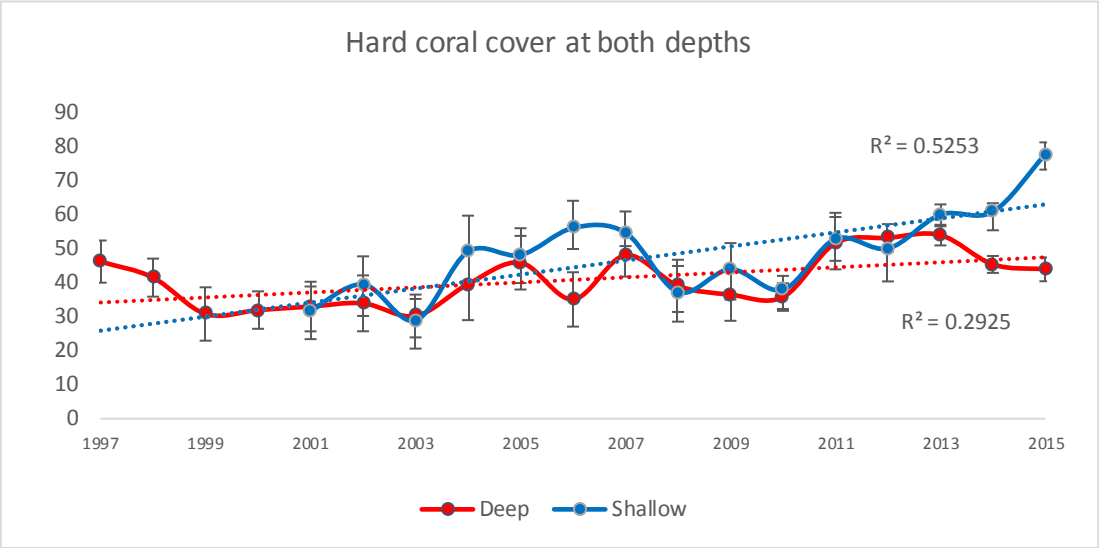

Figure 19. Mean percentage cover of hard corals at both depths. Error bars represent standard error of mean.

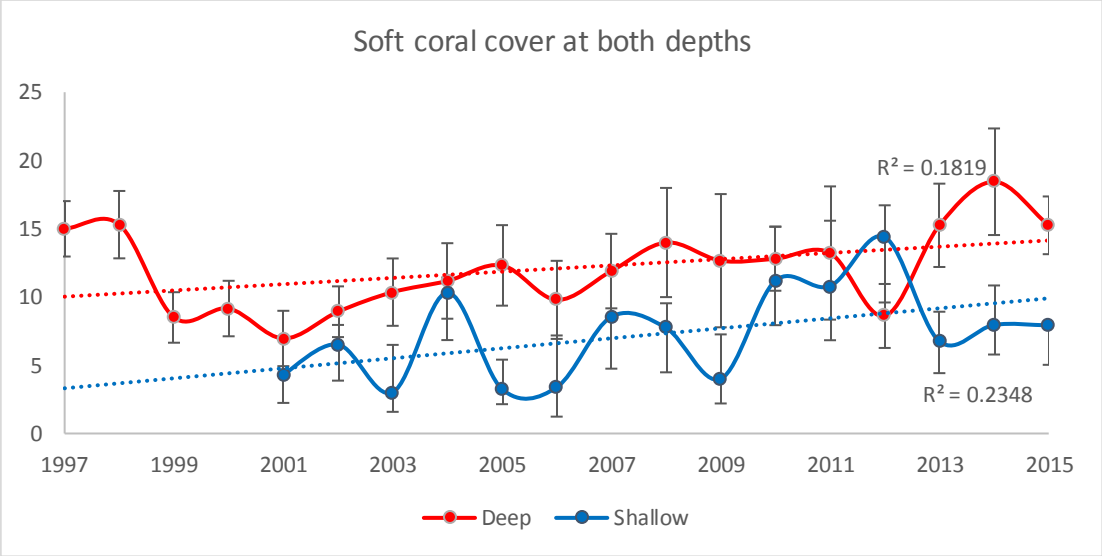

Figure 20. Mean percentage cover of soft corals in at both depths. Error bars represent the standard error of mean.

Correlation of hard and soft coral cover between depths in Jessie Beazley Reef

Monitoring in Jessie Beazley Reef has been subject to various constrains. In some years the survey could not be undertaken due to factors such as weather condition, technical malfunctions, etc. Correlating the hard corals at both depths showed a weak negative relationship at r = -30, implying that changes in hard coral cover at the deep sites in Jessie Beazley reef did not coincide with the changes in the shallow sites. On the contrary, soft coral cover correlation coefficient of r = 0.66 showed a strong positive relationship, suggesting that through time, changes in soft corals in the deep sites coincided with the changes in the shallow sites in Jessie Beazley.

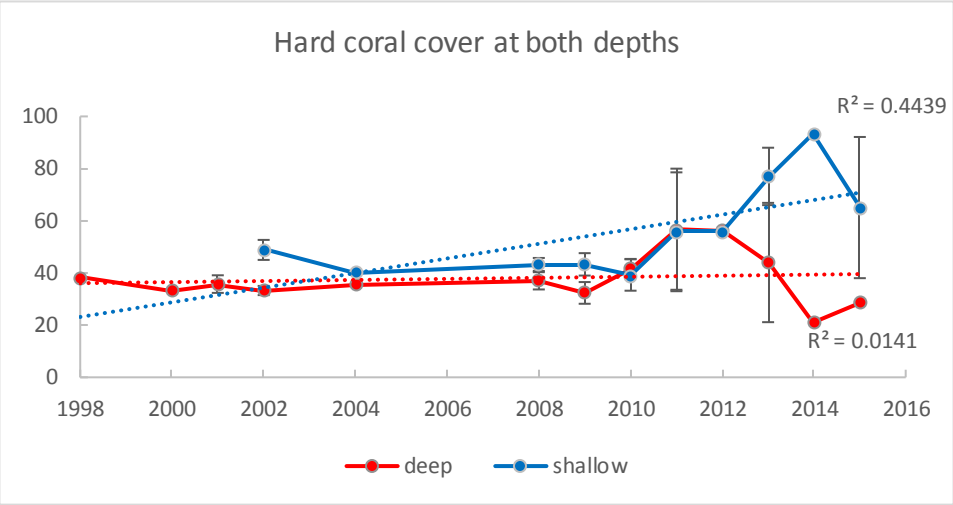

Figure 21. Mean percentage cover of hard corals at both depths. Error bars represent standard error of mean.

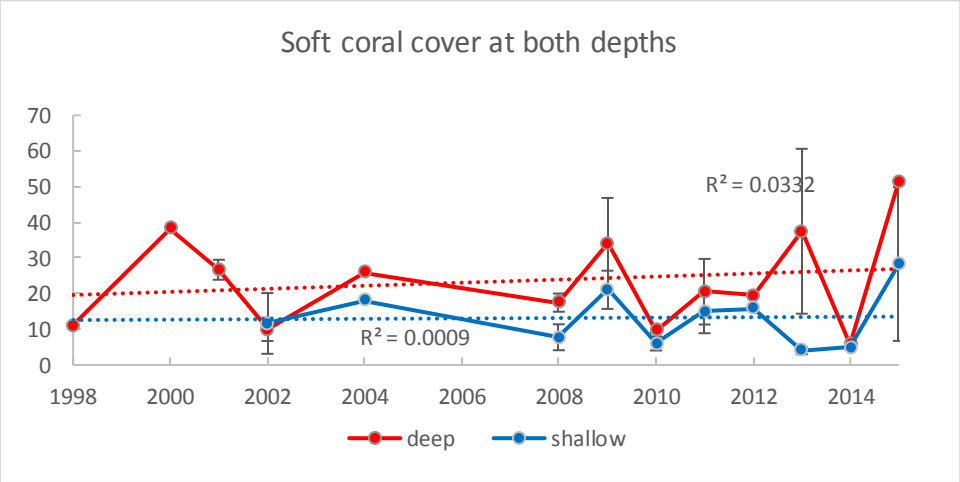

Figure 22. Mean percentage cover of soft corals at both depths. Error bars represent the standard error of mean.

Comparing the results of this monitoring with that conducted in the island of Hawaii reveals that TRNP's live coral cover is higher. The total live coral cover in the reef of Hawaii is from 4-50% at the 25 sites between 2-3 meters and 10 meter depths (Friedlander and Hunter 2015). Furthermore, a study conducted in the offshore reefs in South China Sea recorded a total live coral cover of 11.28% in Zhubi Reefs and 28.31% in Meiji Reefs (Zhao et al. 2013). The conditions of offshore reefs tend to be better than fringing reefs because the former are confronted with lesser pressure, allowing for the proliferation of corals and other marine life.

Licuanan et al (2015 unpublished) proposes a new way of describing the health of coral reefs using the percentage of hard corals only. Using Tubataha as benchmark, this scale was proposed: <22% is poor; <33% is fair; <44% is good; and above 44% is excellent.

In this proposed scaling, the hard coral cover of TRNP's deep sites will be considered 'good'. In general, hard coral cover in TRNP appears to be stable through time (Licuanan et al 2015 unpublished). The mean hard coral cover for the shallow sites is 75.23%. It is higher than the hard coral cover of the deep sites. This value falls under the 'excellent' category in this proposed scale. Hard coral cover in Jessie Beazley falls under 'fair' and 'excellent' classification for the deep and shallow sites, respectively.

IV. Conclusions

To date, TRNP remains healthy, as shown by the results of benthic monitoring. The deep sites are in 'good' condition while the shallow sites have 'excellent' coral cover. This is consistent with the study of Licuanan et al (2014 unpublished) stating that Tubbataha Reefs remain healthy and stable. Because of this, it is proposed that Tubbataha be used as the benchmark in the proposed scaling of reef health in the Philippines (Licuanan et al. 2015 unpublished). Jessie Beazley Reef has improved remarkably over the years. Its present state, in terms of live coral cover, recorded at 93.37% at 5 meters and 80.31% at 10 meters, puts it in "excellent" condition. This supports the effectiveness of the management programs and the no-take policy implemented in the park since 1988.

V. Recommendations

The sampling stations described above should be fixed and permanently marked to ensure the same sections of the reefs are monitored every year. Embedment using stainless steel pin at the start of transect, which will serve as markers specifically at deep sites, should be installed prior to the next monitoring cycle.

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Chapter 4. Monitoring seabird community

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I. Overview

Regular monitoring of seabirds in TRNP is conducted to determine the current status of its population. The population of adults of the six species regularly breeding in the park are monitored and populations and trends are compared with the baseline data.

The total adult breeding population of seabirds in the park is increasing since it was first recorded in 1981. Of the six species regularly breeding in the park, only Brown Booby has not reached its baseline count. Adult counts of the other five species, i.e., Red-footed Booby, Great Crested Tern, Sooty Tern, Brown Noddy and Black Noddy, have increased significantly.

This chapter presents the results of the second quarter inventory as well as a review of the quarterly inventories conducted by marine park rangers. Changes in land area and vegetation in the two islets in Tubbataha is also discussed.

II. Methods

The field work followed methods laid out in 2004 and used since (See Jensen 2011, 2014). The team camped overnight at Bird Islet in order to carry out optimal work. South Islet was only visited in the afternoon of 8 May for a three-hour period. The counts of the breeding bird populations represent a combination of count methods which includes direct day-time inventories of adults, immatures, juveniles, pulli, eggs and nests. In order to determine the total seabird population numbers, an afternoon count of birds flying in to roost was conducted from 4:30PM to 6:30PM on 8 May at South Islet and on 9 May on Bird Islet. Monitoring of the number of dead birds and autopsies were carried out on sample individuals.

Calculations of breeding populations

The methods used to calculate the adult seabird populations are:

- the average distance monitoring results of the birds present at day time;
- day time direct counts of birds, nests and eggs;
- in-flight data (Red-footed Booby *Sula sula*, Brown Booby *Sula leucogaster*, Brown Noddy *Anous stolidus*, Common Noddy *Anous minutus*).

An additional source of data is the result of species-specific control counts of adult Brown Booby at "Plaza" at 5am, of Great Crested Tern *Thalasseus bergii* at high tide along the shorelines, and of Sooty Tern *Sterna fuscata* carried out at the breeding colonies in early evening around 8.30pm. These results are used for comparison with the total result of the standardized day-counts and in-flight counts. The average distance monitoring results are also used as a comparative tool. For details of calculation per breeding species, see Annex 4.

The result of the fieldwork is compared with data sets from the second quarter of the previous years; mainly data sets gathered by TMO staff from 2004 to 2014 and by WWF Philippines from 1998 to 2004. These data sets were analyzed in detail in the 28-year seabird population development report released in 2009 and in the 2004 to 2006 and the 2010 to 2014 seabird field reports (see Jensen 2004, 2005, 2006, 2009, 2010, 2011, 2012, 2013 and 2014). In addition, relevant literature and published data on seabirds were used as references.

Photos were taken from permanent photo documentation sites in Bird Islet and South Islet (Annex 8). These sites were established in 2004 in order to measure changes in land area and in vegetation. In addition, aerial photography was carried out. GPS readings were taken measuring the land area at high tide of both Bird Islet and South Islet. Major equipment used were handheld binoculars (10 x 50), spotting scope (20 x), GPS and cameras.

Vegetative cover was monitored by conducting a census of the condition of trees on the islets. Trees, mostly of *Argusia argentia and Pisonia alba (grandis)*, were classified as either in optimal (good), moderately deteriorating (fair) or severely deteriorating (bad) condition and lastly, as dead. The inventory of 2015 was carried out using the same methodology as all other years, except in 2013, and the trend over time is therefore comparable.

Plastic and other debris such as fish hooks, posing a potential threat to the breeding populations, were removed by the field team.

III. Results and discussions

Monitoring of Changes in Land Areas

Independent sets of measurements were taken using two separate GPS instruments. There were minimal differences in the two measurement results (< 1%). However, at Bird Islet fewer way-points were used compared to 2014 and new GPS equipment were used. A detailed comparison with the previous year's data is therefore not possible, e.g. the calculated increase in the land area and circumference is contradicted by a decrease in the size of 'Plaza' by more than 20%.

Bird Islet: Overall, the land area has decreased by at least 30%; from 18,760 m² in 1981(Kennedy 1982) to less than 13,408m² in 2015 (Table 10). From 2004, the first year when GPS equipment was introduced, the decline in the land area is 21%.

The circumference of the islet is about 561 meters (503 meters in 2013) measured one meter along the vegetation line and the average high tide line. The land area was measured to be 13,408 m² (> 10,220 m² in 2014). However, the area of the 'Plaza' has reduced from 4,124 m² in 2014 to 3,279 m² in 2015. This is the smallest area ever registered for the 'Plaza'. While the GPS data suggests that the land area of Bird Islet is increasing, erosion has continued along sections of the northeastern coastline. This localized erosion started in 2012 (Figure 23). An aerial view of the islet is shown in Figure 24.

Table 10. Approximate changes in the land area of Bird Islet, Tubbataha Reefs Natural Park, from 1911-2015. Source: Worcester 1911, Kennedy 1982, Heegaard and Jensen 1992, Manamtam 1996, WWF Philippines 2004 and Tubbataha Management Office 2004 – 2015.

Year	Land area (length x width)/circumference (m)	Land area (high tide) (m²)	Open area ("Plaza") (m²)	Major sandbars position and condition	Erosion area
1911	400 x 150	60,000	No data	>40,000 m² (?)	No data
1981	268 x 70	18,760	18,000	NW, SE	South coast
1991	>220 x 60	> 13,200	>8,000 (est.)	NW, SE	South coast
1995	265 x 82	21,730	8,000 (est.)	NW, SE	South coast
2004	219 x 73	17,000	>1,100 (est.)	NW: Stable	South coast

				SE : Decrease	
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	13,341	8,000 (est.)	NW, SE: Stable	South coast
2008	No data	12,211	< 8,000	NW: Decreasing SE : Stable	South coast
2009	No data	10,557	< 7,000	NW: Eroded SE : Decreasing	West coast
2010	No data	11,038	4,367	NW: Eroded SE : Stable	South coast
2011	No data	12,968	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	10,955	4,840	NW: Decreasing SE : Stable	North East coast
2014	503	>10,220	4,124	NW: Decreasing SE : Stable	North East coast
2015 1)	<561	<13,408	3,279	NW: Stable SE : Stable	North East coast

Note 1: In 2015 new GPS equipment were used. Detailed comparison with previous year's data is therefore not possible.

Figure 23. Severe erosion of Bird Islet's core of calcite sandstone at the northeastern shoreline on 11 May 2015. Photo shows a water well made of hallow blocks which was originally located inland of the islet. Photo: Arne E. Jensen.

Figure 24. Aerial photography of Bird Islet 5 May 2015. Photo: Teri Aquino, TMO

South Islet: South Islet was originally part of a large sandbar but a circumferential concrete seawall was constructed in the 1970s (Figure 25). The land area remained the same at least until 1981, based on photographic evidence from that year taken by Kennedy (Kennedy1982). In 1991, an ocular inspection revealed that about 1/3 of the seawall had collapsed and was partly submerged (Heegaard and Jensen 1992). The partial collapse of the seawall and continued deterioration of the remaining wall is hastening the erosion of the islet.

The circumference of the islet was not measured in 2015. However, based on one GPS-reading, the land area was 2.913 m² or about the same as in 2014 (2,926 m²). A crack in the northern portion of the seawall, had caused wave movements to transfer several cubic meter of sand along the wall to the outside.

Figure 25. Aerial photograph of South Islet taken 5 May 2015. Photo: Teri Aquino, TMO

Monitoring of Changes in Habitats

Bird Islet: In 2010 the largest trees on North Islet, many of which were observed to be growing well in 1991 (Heegaard and Jensen 1992), had died. Other remaining vegetation has deteriorated as a result of the intensive nesting density of the Red-footed Booby (Jensen 2010) and further accelerated by drought-like conditions, e.g. in 2015. The vegetation in 2015 consisted of about 147 trees of bush-height and seedlings less than 1 foot tall. In 2005, the first year when vegetation was counted, there were about 220 trees and seedlings (Table 11). The vegetation in 2015 included 59 small trees and bushes in optimal or moderately good condition. Sixty percent of the vegetation is severely deteriorating with limited likelihood of survival. The number of seedlings declined by 52% to 13 seedlings compared to 27 recorded in 2014. In the baseline year, 2011, there were 190 seedlings.

Table 11. Condition of vegetation on Bird Islet, May 2005 (baseline year) and 2014 to 2015.

Trees/ Condition	Good (optimal)		Fair (moderately deteriorating)		Bad (severely deteriorating)		Total (live trees)			Dead trees		
	2014	2015	2014	2015	2014	2015	2005	2014	2015	2005	2014	2015
Dead trees										82	1)	62
Mature, live trees (> 3 feet)	0	4	73	12	105	49		178	65			
Small, live trees (2- 3 feet)	17	4	30	28	92	37		139	69			
Seedlings (< 1 feet)	23	7	2	4	2	2	62	27	13			
Total	**40**	**15**	**105**	**44**	**199**	**88**	**220**	**344**	**147**			

Note 1; No data

South Islet: The construction of the seawall in the 1970s facilitated the establishment of a beach forest vegetation of about 125 trees with several trees up to about 30 feet tall. Until 2009, almost all trees were in optimal condition. In 2015 a total of 75 trees - the same number as in 2014 - were recorded (Table 12). Five of these were in a good condition, compared to two in 2014. In 2012 and in 2011, 59% and 73% of the trees, respectively, were in good condition. Four seedlings were found in 2015 compared to one in 2014. Colonization by the Red-footed Booby and extremely dry weather conditions some years may be the main factors that have caused the persistent decline in vegetation. In addition, lower vegetation was also impacted by drought in 2015; eventually caused by an ongoing El Niño climate event.

Table 12. Condition of vegetation on South Islet, May 2011 to 2012 and 2014 to 2015.

Trees/ Condition	Good (optimal)				Fair (moderately deteriorating)				Bad (severely deteriorating)				Dead				Total (live trees)			
	2011	2012	2014	2015	2011	2012	2014	2015	2011	2012	2014	2015	2011	2012	2014	2015	2011	2012	2014	2015
Dead trees													6	9	22	>15				
Mature, live trees (> 3 feet)	70	69	0	1	28	30	38	8	5	6	30	55					103	105	68	64
Small, live trees (2- 3 feet)	2	1	1	0	0	0	0	7	0	0	0	0					2	1	1	7
Seedlings (< 1 feet)	19	9	1	4	0	0	0	0	0	0	0	0					19	9	1	4
Total	**91**	**79**	**2**	**5**	**28**	**30**	**38**	**15**	**5**	**6**	**30**	**55**	**6**	**9**	**22**	**≥15**	**124**	**115**	**70**	**75**

Note: Coco Palms 2011: 13, 2012: 14, 2014: 0, 2015: 3

Avifauna

Review of Park Rangers' Monitoring Data

The TMO Park Rangers regularly conduct inventories and distance counts of the breeding seabird species as part of their monitoring protocol. Since the externally-assisted inventory was conducted in May 2014, the Park Rangers made three inventories using the direct count methods (Annex 6). However, counts of the breeding populations of Pacific Reef Heron *Egretta sacra,* Barrred Rail Gallirallus *torquautus* and Eurasian Tree Sparrow *Passer montanus* were not undertaken.

A total of 11 monthly distance counts of the seabirds of Bird islet and South Islet were also carried out. The inventories included in-flight count on Bird Islet in August 2014 and February 2015. Distance counts of other species, like unidentified frigate birds, and unidentified white egret species were also done.

The reported data are consistent with previous year's results and overall is of good technical quality. However, more accuracy is needed in reporting the breeding data of Brown Booby. For this species, the number of nests reported is unlikely lower than the number of eggs and pulli. This may be due to a failure to be report the total number of nests, including those without eggs and pulli, or failure to record as 'uncounted' nests and eggs that were not counted rather than

reporting the zero value. The results of the Park Rangers' counts of seabirds revealed several important observations (Table 13).

Table 13. Selected results of TMO Park Rangers distance monitoring and inventories from June 2014 to April 2015.

Species	Bird Islet	South Islet
Red-footed Booby	High number of nests in October 2014 (450 nests). High number of adults in June 2014 (1,700) and August 2014 (1,947)	High number of nests in February 2015 (302) compared to the results of the inventory May 2015 (379 nests)
Brown Booby	High number of adults in August 2014 (1,944 individuals). Other months with high numbers were January 2015 (>1800 individuals). Very high numbers of pulli and eggs in August 2014 (507) and again in February 2015 (719) confirming previous years data of peak breeding activities these months	No breeding population
Great Crested Tern	Presence of the species from March to October 2014. Distance estimation of 7,700 adults in June 2014 strongly suggest that the May 2014 inventory count of 4,240 adults based on egg extrapolation, was a substantial under- estimation	No breeding population
Sooty Tern	Very good correlation between distance count data and inventory data August 2014 (4,550 adults and 4,661 adults, respectively). Presence of the species from January 2015 but with peak arrival in February 2015 where 4,910 eggs equivalent to 9,820 adults were counted. No second breeding population present in 2014	No breeding population
Brown Noddy	Species present from April to November 2014 and again from March 2015 with first arrivals in February. Relative high number of eggs (219) found in August 2014	Species present from April to November 214 and again from April 2015
Black Noddy	Species present from March to October 2014. No second breeding population present in 2014	Species present from end April to September 2014 which is one month shorter than usual. Arrival in April 2015 similar to arrival month in 2014. No second breeding population

Avifauna Inventory

A total of 27 different bird species were identified during the May 2015 inventory. For details, see Annex 7. Twenty-three of these species were waterbirds of which 13 species can be classified as pelagic or coastal-living seabirds. Of these, six species are breeding in the TRNP: Red-footed Booby, Brown Booby, Great Crested Tern, Sooty Tern, Brown Noddy and Black Noddy. Other breeding species include Pacific Reef Heron, Barred Rail, and Eurasian Tree Sparrow.

Overall, the seabirds of TRNP breed year round (Heegaard and Jensen 1992, Manamtam 1996, Kennedy *et al* 2000, Jensen 2009, Jensen and Songco 2015). The inventory result therefore represents only the breeding population present during the time of the inventory.

A minimum of 36,271 adult individuals of the six breeding seabird species were recorded on Bird Islet, which hosts about 78% of the population (64% in 2014), and South Islet, which host 22 % (36% in 2014) (Table 14). However, if the result of the Park Rangers' count of Sooty Tern in 14 February 2015 is used, the total would be 38,911 adult individuals. The result for May 2015 is the highest count ever for TRNP and is substantially higher than the previous highest count in 2012 of 30,159 adults. The surprisingly high count result is due to high population presence of both Great Crested Tern and of Sooty Tern. The combined total population of all breeding seabirds in 2015 was 187% higher than the first inventory conducted in 1981 (Kennedy 1982). In comparison, the 2014 and the 2013 inventories showed a minimum of 27,078 individuals and 18,846 individuals of adult breeding seabirds (Table 16). The count results for 2015 showed:

- An increase in the number of adult Red-footed Booby to the highest number recorded in May, although not the highest number of actively breeding individuals over time;
- A continued increase in the population of Brown Booby to the highest number recorded since regular inventories started in 1997. The species continues to have a high reproduction rate although the population is still 36% lower than in the baseline year of 1981;
- Increased breeding population of Great Crested Tern to the highest number ever recorded;
- Second highest breeding numbers of Sooty Tern with very early egg-laying starting in February;
- Continued increase in the Brown Noddy population which is now higher than in the baseline year of 1981;

- Presence of the Black Noddy population similar to the average population for the past five-year period 2010-2014. Low number of nests probably caused by deterioration in breeding habitat.

Table 14. Total count numbers of adult resident seabirds present on Bird Islet and South Islet of Tubbataha Reefs Natural Park, 8 -11 May, 2015.

Species/ Number	North Islet	South Islet	Total
Red-footed Booby *Sula sula*	2,101	1,391	3,492
Brown Booby *Sula leucogaster*	2,353	50	2,403
Great Crested Tern *Thalasseus bergii*	<11,783	604	<12,387
Sooty Tern *Sterna fuscata*	9,820	0	9,820
Brown Noddy *Anous stolidus*	1,409	1,174	2,583
Black Noddy *Anous minutus*	2,544	>5,682	>8,226
Total	**30,010**	**8,901**	**38,911**

Species Account

Data on the number of immature, juvenile and pulli populations and on the number of eggs and nests recorded since 2004 on Bird Islet and South Islet are presented in Table 16. The combined results of the adult populations and their development over time from the two islets are shown in Table 16.

Red-footed Booby: Despite the increasing scarcity of optimal breeding space, the adult population keeps increasing; from 3,074 individuals in 2014 to 3,492 adults in 2015, of which 1,391 individuals, or 40%, were recorded on South Islet (43% in 2014). The population is now 43% higher than in the baseline year of 2004 when about 2,435 adults were recorded.

Compared to 2014 the number of nests was 12% lower: from 431 nests found in 2014 to 379 nests in 2015. The number of pulli and juveniles was also lower by 13% compared to 2014. On South Islet, the number of nests had increased from 60 nests in 2014 to 190 nests in 2015.

On Bird Islet, samples of dead birds were examined. None of them contained plastic debris. The number of dead birds were not counted but assessed to be low and within natural mortality rates.

Table 15. TRNP seabird breeding data April to June 2004-2015 (Bird and South Islet combined). Source: WWF Philippines 2004 and TMO 2004 – 2015.

Species/Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
RED-FOOTED BOOBY												
Immatures	398	1,455	606	597	780	477	677	795	799	426	134	206
Pulli/1st year juvenile	> 35	71	105	116	69	180	88	171	243	312	277	240
Eggs	+	+	+	+	+	+	+	68	>166	>185	>57	>46
Nests	279	217	225	404	361	367	451	369	739	848	431	379
BROWN BOOBY												
Immatures	0	81	26	55	55	61	126	110	140	62	51	28
Pulli/1st year juvenile	43	2	7	12	91	126	125	225	46	28	266	200
Eggs	1	0	18	95	317	48	106	52	69	532	466	55
Nests	117	43	250	89	497	453	513	575	507	618	816	726
GREAT CRESTED TERN												
Immatures	0	1	0	0	0	0	0	0	0	0	0	0
Pulli/1st year juvenile	0	2,100	0	0	0	0	0	0	0	0	0	0
Eggs	0	1,829	0	0	0	515	2,341	498	1,456	3,939	2,120	4,280

SOOTY TERN

Immatures	0	0	0	0	0	0	0	0	0	0	0	0
Pulli/1st year juvenile	0	1,750	0	458	0	846	0	1,764	0	1,258	0	> 3,538
Eggs	9	0	0	63	2	3	5,515	2	1,534	146	37	52

BROWN NODDY

Immatures	0	2	0	0	0	4	1	1	2	3	5	2
Pulli/1st year juvenile	0	0	0	0	0	0	0	0	0	0	0	6
Eggs	0	0	0	3	17	126	438	253	>147	>607	679	571
Nests	115	124	20+	25+	218	384	653	571	709	771	931	960

BLACK NODDY

Immatures	0	0	0	0	0	0	0	0	0	0	0	0
Pulli/1st year juvenile	0	0	0	0	0	0	0	0	0	0	0	30
Eggs	ND	+	0	+	+	430	+	+	>80	>700	>351	>299
Nests	208	3,203	1,131	1,734	1,824	2,680	3,525	3,827	4,282	5,156	3,778	2,397

Brown Booby: The breeding population is found on Bird Islet. On 16 January 2015, Park Rangers counted 2,497 adult birds (extrapolated value). The May inventory resulted in a total of 2,353 adults observed in Bird Islet. This is the highest May count since the count of 3,768 adults in May 1981 (Kennedy 1982) and of 2,060 adults at the end of March 1995 (Manamtam 1996). The May 2015 result is nearly 39% higher than the average for the five-year period from 2010 to 2014 (1,697 individuals). However, the population is still 36% lower than the count of Kennedy in 1981. Given the substantial reduction of the preferred breeding area, 'Plaza', by almost 60% since 1981, there may not be enough space available for the species to increase its population to 1981 levels.

The species continues to be highly reproductive as indicated by 726 nests, the second highest number of nests counted over time (Table 16). However, the number of pulli/juveniles and eggs (200 individuals/55 eggs) were considerably lower than the average for 2010 – 2014 (138 individuals/ 245 eggs) indicating a rather late start in the breeding cycle of the May population.

A total of 101 adult birds, originally banded with color-bands and steel rings in 2007 to 2009 were caught and ring numbers noted down. Of these were 59 banded as adults and 42 as pulli.

Great Crested Tern: The breeding population is confined to the Bird Islet where up to 11,783 adults were counted (4,780 in 2014). This is a staggering 447% higher than the baseline population of 2,264 individuals in 1981 (Table 8) and the highest number ever counted. Similar to the previous years, the population was in the egg-laying stage. The colonies were mainly found at the sandy sections of the southeastern part of the islet.

A smaller number of adult birds, 604 individuals, were observed on South Islet. Some of these showed territorial and breeding behaviors. The species has not been documented to be breeding on the islet since 2003.

Sooty Tern*:* The breeding population is confined to Bird Islet. The last time this species was recorded breeding on South Islet was in 2002. Based on the TMO Park Rangers' count of 4,910 eggs on 14 February 2015, the adult population on Bird Islet was at least 9,820 adults, which in May had produced more than 3,538 juveniles while 52 pairs had eggs. Relatively high numbers of pulli/juveniles were also recorded in 2005, 2011 and 2013 but in 2015 most off-springs were already able to fly and highly mobile. The number of juveniles counted at daytime may not represent the total since the total number of juveniles appears only to have been present from dusk to dawn, when counts were not undertaken.

The population on Bird Islet are migratory and normally absent from November to February. Based on the Park Rangers' data-sets, the species was first observed on 16 January in 2015. The arrival in January and subsequent start of breeding in large numbers from February may eventually be a result of the on-going sea surface temperature anomaly or El Niño phenomenon (Pagliawan 2013 unpublished). However, the species may breed in cycles that are shorter than the calendar

year, and in some years, e.g., 2005, 2006 and 2011, even in sub-annual breeding intervals. This has translated into breeding peaks in different months of the year.

Variations in sea-surface temperature have been shown to negatively influence the species' foraging success at breeding colonies (hence lowering reproductive success) (Erwin and Congdon 2007). However of the nearly 5,000 eggs laid in February 2015, a minimum of 3,538 juveniles were recorded, representing a relative high reproduction rate of at the least 70%.

The population number in 2015 was about 70% higher than the average for the five-year period 2010-2014, 5,762 individuals, and 94% higher than the baseline population of 5,070 individuals in 1981 (Table 16). The species appears to undergo cyclic breeding with fluctuation extremes. These range from years with near absence (1998 and 2003) to peak years, e.g. in 2010, where more than 10,800 individuals were breeding.

On 15 February 2015, the Park Rangers recaptured 111 Sooty Terns which were tagged with number bands from 2007 to 2009. Of the captured terns, 66 where originally caught and banded as adult birds and 45 birds as juveniles. Ten of these were banded in 2007 and are 8 years old, 17 were banded in 2008 and are 7 years while 18 birds were banded in 2009 and are 6 years old. In addition, a juvenile bird banded 3 April 2009 on Bird Islet was found dead at Kabankalan City, Negros Occidental on 7 July 2015 - more than 6 years after it was born. The results indicate that juvenile birds return to the area where they were born at least after six years spent in the open ocean. This observation is similar to those of other colonies in the tropical oceans (del Hoyo *et al* 1996).

Brown Noddy*:* The species is found breeding on both Bird Islet (55%) and South Islet (45%). The total population in 2015 was 2,583 adults (1,865 adults in 2014) which is 49% higher than the average population of 1,732 individuals in the five-year period from 2010 to 2014 and the highest count since the count of 2,136 birds in 1981 (Kennedy 1982). The population is now 21% higher than in 1981.

Similar to 2014 a high number of 960 nests with 571 eggs were recorded and for the first time in May, a total of six newly incubated pulli were found on both Bird Islet and South Islet.

Black Noddy: The species is found breeding on both Bird Islet (31% compared to 24% in 2014) and South Islet (69% and compared to 76% in 2014). A total of 8,226 adults were counted which is similar to the average population for the five-year period from 2010 to 2014, 8,728 individuals. For the first time in May pulli birds were recorded on both islets. The number of nests, however, dropped to 2,397 in 2015 compared to 3,778 nests in 2014. Of these only 641 nests were found on Bird Islet and 1,756 nests on South Islet. The decline in the number of nests from 2013 to 2015 is 38% on Bird Islet and nearly 58% on South Islet. The decline may be attributed to the reduction in suitable breeding vegetation (See Table 12 and Table 13). At least about 3,400 adult birds appeared unable to breed since very suitable breeding spaces were already occupied by other

Black Noddies with nests. This may explain why for the first time ever, 21 pairs of the species were found breeding on the ground on South Islet.

Pacific Reef Heron: In 2015, the breeding population on Bird Islet and South Islet was 14 adults, compared to 11 individuals in 2014. Only one pair was documented on Bird Islet in 2015. Based on datasets since 2004, the population is stable with an average population of 15 individuals. However, the population trend is increasing at South Islet. The average for the five-year period from 2004 to 2009 is 5.0 individuals and from 2010 to 2014 8.6 individuals) compared to an 8% population decrease on Bird Islet.

Barred Rail: In 2015 three to four individuals were seen on Bird Islet. The species has not been recorded on South Islet since 2007. The species was first documented in 2003 on both Bird and South Islets.

Eurasian Tree Sparrow: Three individuals were recorded on South Islet where it is observed annually since 2010. The species has not recorded at North Islet after 2013.

New Species Records

One relatively common migratory shorebird species was recorded for the first time within TRNP: Long-toed Stint *Calidris subminuta*. Its preferred habitat is normally mudflats in freshwater habitats.

Assessment of the impact of the use of drones on seabirds

As part of the documentation of the inventory and a planned educational video production on the TRNP, a drone was used to generate aerial video sequences from about five to 40 meters elevation. The drone produced a relatively low-frequency sound, not unlike the sound of a bee colony. The breeding birds' reaction to the presence and sound of the drone was observed and reactions noted down.

In general no direct reaction was noted among the seabird species except for Sooty Terns. Both adults and juvenile birds of this species reacted instantly and were flushed up into the sky. Consequently, this caused a reaction among Brown Boobies, which left their breeding territories momentarily. Both species returned to their territories once the drone landed. The observations suggest that drone-flying or overflight by any other type of aerial equipment (kites, para-glides, airplanes etc.) need to be strictly regulated near or over Bird and South Islets.

Table 16. Population results and population trend of breeding seabirds in TRNP, April to June 1981 – 2015. Baseline years are underlined. Source: Kennedy 1982, Manamtam 1996, WWF Philippines 1998-2004 and TMO 2004 – 2015.

Species/ Numbers	1981	1995	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Trend (%)
Ground-breeders Sub-total	13,388	3,949	1,744	4,695	7,529	7,635	2,804	5,200	13,825	16,957	7,746	10,534	9,721	18,669	13,592	18,383	15,988	16,448	27,193	+ 103
Masked Booby	150	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	- 100
Brown Booby	3,768	1) 2,060	1,716	1,045	850	577	623	856	1,877	1,108	1,016	1,059	1,018	1,438	1,846	1,879	1,690	1,632	2,403	- 36
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	2) 7,730	<12,387	+ 447
Sooty Tern	5,070	1) 910	28	3,000	6,228	2,123	2	1,200	3,500	7,920	>1,500	3,800	2,700	10,866	3,544	6,359	2,816	3) 5,224	4) 9,820	+ 94
Brown Noddy	2,136	643	0	500	37	775	115	336	590	1,035	530	800	1,570	1,575	2,042	1,492	1,688	1,862	2,583	+ 21
Tree-breeders Sub-total	156	7,128	3,250	3,502	7,042	5,003	1,630	3,240	8,353	8,727	7,902	10,401	9,525	9,975	10,748	11,776	12,858	10,630	11,718	+7,400
Red-Footed Booby	9	0	0	2	44	43	20	2,435	1,947	1,877	2,902	2,513	2,220	2,331	2,395	2,340	2,202	3,074	3,492	+ 43
Black Noddy	147	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	7,556	8,226	+ 14
TOTAL	13,544	11,077	4,994	8,197	14,571	12,638	4,434	8,440	22,178	25,684	15,648	20,937	19,246	28,644	24,338	30,159	28,846	27,078	38,911	+ 187

Notes: 1) End of March data. 2) Based on Park Rangers distance count 1 June 2014. 3) Based on Park Rangers count 9 August 2014. 4) Based on Park Rangers egg count 14 Feb 2015.

IV. Recommendations

Status of management recommendations made in 2014 and recommendations for 2015

The Tubbataha Reefs Natural Park is a UNESCO World Heritage Site and listed as a Ramsar Wetland of International Importance. In 2015 it also became a permanent monitoring site under the East Asian-Australasian Flyway Partnership and an ASEAN Heritage Park. It is the only site in the Philippines of global importance for the conservation of seabirds. The breeding areas on Bird Islet and the South Islet are in need of continued attention including monitoring and protection. The status of recommended management initiatives in 2014 and recommendations for the future include:

Methodology

1. Conduct a mini-workshop among the Park Rangers to level off approaches to and adherence to inventory methodologies in order to identify possible variation in approaches and to increase accuracy.

Status 2015 and continued recommendation:

A methodology discussion was carried out with the TMO rangers and researchers and the Avifauna Consultant on11 May 2015.

Although the quality of the rangers' field work is high, more accuracy is needed. A case in point is the report on the breeding data of Brown Booby for which nests numbers reported were lower than the number of eggs and pulli, an obvious discrepancy in reporting.

The numbers to be reported should be the total number of nests including nest without eggs and pulli.

If eggs or nests are not counted, it should be reported as 'uncounted' instead of being reported with a zero value.

2. To increase capabilities of the Park Rangers, deposit copies of the May Inventory Report at the Ranger Station.

Status 2015 and continued recommendation:

Not carried out 2014/2015. It was agreed that TMO research staff will summarize the results and recommendations of the annual report and share these with the Park Rangers in the field.

Habitat

3. Increase planting of beach forest seedlings on South Islet.

Status 2015 and continued recommendation:

Carried out 2014 and 2015 but drought may have wiped out planted seedlings. Continue the effort during the rainy season.

4. Explore environmentally friendly, soft-engineering solutions to mitigate loss and land area on Bird Islet with a goal to increase it

Status 2015 and continued recommendation:

Techniques to reclaim land in an ecologically responsible way are not known to the TMO. Advice on a technical solution will be requested from Wetlands International.

5. Institutionalize a protocol of regular removal of plastic debris from both North Islet and South Islet.

Status 2015 and continued recommendation:

The activity is carried out on a regular basis as part of the park rangers' terms of reference. It will also be included during the annual May inventories.

Species

6. Continue population and habitat monitoring, which includes monthly distance count estimations and four seasonal inventories in the months of January, May, August and October.

Status 2015 and continued recommendation:

During future inventories, counts of other breeding species (Pacific Reef Egret, Barred Rail and Eurasian Tree Sparrow) and of the migratory Ruddy Turnstone will be included. Inventories using the direct count method will be carried by the Park Rangers at the least two times during the year (October and February). During distance monitoring to be carried out monthly, counts of Ruddy Turnstone and Pacific Reef Egret will be included.

7. Include count of the numbers of dead seabirds during inventories.

Status 2015 and continued recommendation:

Counts were not carried out in May 2015 but will only be carried out during the next May inventories.

8. Investigate if mortalities are caused by plastic objects.

Status 2015 and continued recommendation:

During the May inventory autopsy was carried out on sample birds. This activity will be continued during the next annual May inventories and during the conduct of the quarterly direct counts on the islets.

9. Increase recapture of banded seabirds (Brown Booby, Sooty Tern and Black Noddy) to gain more knowledge on dispersal movements, mortality rates, life expectancies, etc.

Status 2015 and continued recommendation:

Ring reading of banded Brown Boobies and of Sooty Terns was carried out in February and May 2015. The activity will be continued for these species. Recapture of birds on South Islet will not be carried out due to high disturbance risk.

10. Seek funding for sample satellite-transmitter tacking and tracking of the adult and juvenile seabird species.

Status 2015 and continued recommendation:

Not included in the TMO 2014 and 2015 budget. It is recommended to set aside a TMO budget for the activity and use the allocation to seek external co-funding. The activity should focus on all breeding seabird species given the lack of knowledge on the dispersal of both adult and juvenile populations outside of the breeding season.

Public awareness raising

11. Seek funding for production of a video documentary on the seabirds of Tubbataha to be used in public media and educational campaigns.

Status 2015 and continued recommendation:

Several video sequences have been produced since 2008 and new sequences were produced in 2015. It is recommended that a video documentary be produced before May 2016.

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Chapter 5. Other research

This chapter discusses the highlights of the results of research studies conducted in the park this year, e.g. coral disease, elasmobranchs conservation program, turtle tagging and laparoscopy, and water quality monitoring.

Coral disease

Dr. Laurie Raymundo and Dr. Alexander Kerr of UG conducted a study of the coral condition in the Park. They identified six Indo-Pacific coral diseases – white syndrome, black band disease, skeletal eroding band, brown band disease, growth anomalies, and ulcerative white spots – in the survey sites. White syndrome was, by far, the most common disease observed on at least one transect at all sites. Compared to the other sites surveyed in the country, prevalence of diseases in the monitoring sites is fairly low. However, relatively higher prevalence was recorded in the grounding sites. They concluded that the coral communities were healthy with no indication of recent damage. However, they found that disease prevalence was highest in the Min Ping Yu grounding site. They recommended that diving sites also be monitored for coral breakage and diseases. They further suggested that the link between coral trauma due to breakage and the incidence of diseases need to be stressed in diver briefings.

The grounding sites of the USS Guardian and Min Ping Yu showed remarkable recovery in just two years based on the monitoring results. Fractured coral colonies showed new growth and reattachment to the substrate. The presence of healthy corals adjacent to the impacted sites contributed largely to coral recovery. Signs of coral disease were prevalent in the border zones of the grounding sites, emphasizing the impact of stress or trauma in disease development.

Dr. Maypa of Silliman University also conducted a study on the fish populations to determine its relationship to the incidence of coral diseases. Her preliminary analysis showed no significant associations partly because Tubbataha still harbors a generally healthy coral population.

Elasmobranch conservation program

A team of researchers from LAMAVE documented 285 encounters of 11 sharks and rays using the Baited Remote Underwater Video method. Although the grey reef sharks were the most frequently encountered, the white tip shark was noted to be the most abundant. This observation validated previous shark surveys by Walker and Palomar-Abesamis in 2005 and Alava in 2010, that Tubbataha has one of the highest population densities of white tip sharks known in the world.

With the help of tourists, the research team identified a total 23 species of elasmobranchs. Two of these may be new records in the park. Significantly, a total of 53 whale sharks were identified based on survey and the video footage submitted by tourists for this season alone. Together with the whale sharks documented in the previous years, a total of 100 individuals were identified in Tubbataha. This data was uploaded in the Wildbook of Whale Sharks, where 59 individuals were assigned a Philippine identification number. Three whale sharks that were recorded in 2014 were again seen in the park this year. One individual that was first photographed this year was seen in Oslob, Cebu – about 220 nautical miles east of the park – some four months later.

The BRUV surveys documented 18 encounters of tiger shark *Galeocerdo cuvier.* Together with videos and photos from divers, at least seven individuals were identified using dorsal fin notches, scars and markings. Little is known of this animal in Southeast Asia. Thus it was interesting to note that one individual sighted in 2012 was again observed in Tubbataha in 2015. This occurrence suggests that either some tiger sharks use the Park for extended periods of time, or that Tubbataha is a significant part of their migration route.

Turtle tagging and laparoscopy

A total of 194 green sea turtles *Chelonia mydas* were captured via rodeo jumps, and an additional four hawksbill turtles *Eretmochelys imbricata* were captured during the SCUBA dives. Of these, 29 turtles were recaptures from past years (identified via tags applied previously). Of the four hawksbills, one was a recapture from 2014, suggesting hawksbill turtles are not abundant, but are resident on Tubbataha reefs.

Out of 198 turtles, nearly 80% were juveniles. Through laparoscopy, it was established that roughly two-thirds were female. This concurs with findings in other parts of the world with similarly-aged turtle populations. This suggests that Tubbataha is a developmental ground for small turtles. Interestingly, the sex ratio of adult turtles evened out to almost 50:50. The team also noted that 8% of the turtles were new recruits – turtles which have never been to reefs before – signifying a healthy life cycle for turtles going on in the oceans.

Growth and residence period data were determined for 96 turtles recaptured in the park since 2005, 95% of which were juvenile turtles. A verage growth rates were ~3.7 cm / yr, with recapture intervals averaging ~2½ years, ranging from 0.2 to nine years. These growth rates were similar

to other green turtle foraging grounds globally. There was no difference in growth rates amongst male or female turtles. Residence periods were calculated for the recaptured turtles and suggested that female turtles may spend up to an average of 11.2 years at the reefs, while male turtles spend an average of 11.7 years. Lead researcher, Dr. Nicholas Pilcher, concluded that the turtles in the Park are in excellent condition and that the Park is important to the life cycle of sea turtles in the Sulu Sulawesi region.

Turtle DNA Study

Tissue samples were obtained from turtles caught during the tagging and laparoscopy study. These samples were sent to NFRDI for DNA analysis. Results show that turtles caught in Tubbataha are mostly related to the East Africa, Australasia, and Japan populations. It further noted that two genetically distinct groups inhabit Tubbataha waters. This coincided with the observation of Dr. Pilcher who postulated the same based on his observations during the in-water surveys in 2014 and 2015. Meanwhile, two individuals did not relate to any of the populations identified in the genetic bank. This probably means that the two sea turtles came from a population that has not yet been surveyed.

Water quality

TMO researchers and rangers, in collaboration with the PCSDS, conducted baseline water sampling in 2014 and 2015. A total of 20 locations established for monitoring in 2014 were visited this year for assessment. Out of the 15 parameters, TRNP passed in the highest class for marine waters (Class SA) for pH, dissolved oxygen, salinity and biological oxygen demand. The normal levels for the following parameters are still being established for the park: temperature, total suspended solids, color, nitrates and phosphates. Oil and grease concentration decreased from last year but most sites inside the lagoon exceeded 1mg/L maximum for Class SA. Some sites failed in the total coliform levels for Class SA. However, all sites are well within the limit of Class SB (suitable for swimming and skin diving).

Although data is still inadequate to determine a trend, survey results already underline the vulnerability of Tubbataha to marine pollution. The Park passed the national standards for most of the water quality parameters. Results for oil and grease and coliform counts failed to meet the highest standards set by the DENR. The most vulnerable area in the park appeared to be the lagoons where these contaminants tended to gravitate and settle. International maritime traffic may be partially implicated. In the case of dive boats operating within the Park, it was recommended that waste be discharged in areas where currents move away from the reefs. Dr. Raymundo pointed out that the southwestern corner of the south atoll would be the ideal dumping site given the direction of the currents.

In-house research

Three studies were conducted this year by TMO researchers. The first studied the effects of sea surface temperature on coral cover. It was found that, unlike in other sites in the country, increase in sea surface temperature had no significant impact in Tubbataha. A second study ranked reef resilience in the permanent monitoring and grounding sites using herbivorous fish communities. It determined that, while the grounding sites ranked lowest, it still did slightly better than the Jessie Beazley site. It is likely that the low ranking of Jessie Beazley is because it was protected only in 2006, much later than the grounding sites. The third study investigated the effect of sea surface temperature on the breeding behavior of seabirds and found out that it determined the start of egg-laying in great crested terns. All three researches were well-received at the 13th National Symposium in Marine Sciences organized by the Philippine Association of Marine Science (PAMS) in General Santos this year.

Annex 1. 2015 Research Trip Schedule

15 - 19 April	Water Quality Monitoring
23 – 29 April	Coral Disease Study
28 April – 5 May	Fish and Benthos Monitoring
7 – 12 May	Seabird Monitoring
14 – 24 May	Elasmobranchs Conservation Program
2 – 8 June	Marine Turtle Research

Annex 2. In-flight to roost statistics of boobies and noddies on Bird Islet, Tubbataha Reefs Natural Park, April to May 2005 – 2015

Species/Numbers	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average In-flight (%)
	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: 16.30-18.30	May 9: 16.30-18.30	May 9: 16.30-18.30	
Red-footed Booby												
Adult: Daytime	823	655	631	1,241	686	982	1,011	382	830	950	1,499	
In-flight	960	1,171	2,082	1,272	1,534	1,259	1,259	1,680	779	813	602	
Adjusted to 2-hour period	1,012	1,222	2,271	1,272	1,534	1,259	1,259	1,680	779	813	602	
Total	1,835	1,877	2,902	2,513	2,220	2,241	2,270	2,062	1,609	1,763	2,101	
%-in-flight population	55%	65%	78%	51%	69%	56%	55%	81%	48%	46%	29%	**57.6%**
Immature: Daytime	514	>205	275	239	179	194	106	174	125	61	111	

In-flight	588	401	295	541	298	483	483	249	149	5	37	
Adjusted to 2-hour period	941	419	322	541	298	483	483	249	149	5	37	
Total	1,455	>606	597	780	477	677	589	423	274	66	148	
%-in-flight population	65%	69%	54%	69%	63%	71%	82%	59%	54%	8%	25%	**56.3%**
Brown Booby												
Adult: Daytime	629	405	660	691	650	930	1,338	1,060	968	834	1,505	
In-flight	360	225	326	368	368	508	508	819	722	798	848	
Adjusted to 2-hour period	576	235	356	368	368	508	508	819	772	798	848	
Total	1,205	640	1,016	1,059	1,018	1,438	1,846	1,879	1,690	1,632	2,353	
%-in-flight population	48%	37%	35%	35%	36%	35%	28%	44%	43%	**49%**	36%	**38.7%**
Immature: Daytime	22	20	21	20+?	22	30+	96	81	30	13	1	
In-flight	37	6	31	34	39	96	14	59	32	39	25	
Adjusted to 2-hour period	59	6	34	34	39	96	14	59	32	39	25	
Total	81	26	55	54	61	126	110	140	64	51	26	

%-in-flight population	73%	23%	62%	63%	64%	76%	13%	42%	50%	76%	96%	**58.0%**
Brown Noddy												
Adult: Daytime							618	607	1,004	1,045	1,031	
In-flight							1,124	525	142	239	378	
Adjusted to 2-hour period							1,124	525	142	239	378	
Total							1,742	1,132	1,146	1,284	1,409	
%-in-flight population							65%	46%	12%	19%	27%	**33.8%**
Black Noddy												
Adult: Daytime							421	1,098	2,243	1,506	2,412	
In-flight							1,334	1,124	272	318	132	
Adjusted to 2-hour period							1,334	1,124	272	318	132	
Total							1,755	2,222	2,515	1,824	2,544	
%-in-flight population							76%	51%	11%	17%	5%	**32.0%**

Annex 3. In-flight to roost statistics of boobies and noddies on South Islet, Tubbataha Reefs Natural Park 2014 – 2015

Species/Numbers	2014	2015		Species/Numbers	2014	2015		Species/Numbers	2015
Red-footed Booby	May 8: 16.30 – 17.30	May 8: 16.30- 18.30		**Brown Booby**	May 8: 16.30 – 17.30	May 8: 16.30- 18.30		**Noddies, unidentified**	May 8: 16.30- 18.30
Adult: Daytime	401	366		Adult: Daytime	7	22		Adult: Daytime	6,856
In-flight	910	1,020		In-flight	2	28		In-flight	4,678
Adjusted to 2-hour period	1,820	1,020		Adjusted to 2-hour period	4	28		Adjusted to 2-hour period	4,678
Total	2,221	1,386		**Total**	11	50		**Total**	11,534
% in-flight population	82.0	73.6		% in-flight population	18.2	56.0		% in-flight population	40.6
Immature: Daytime	68	58		Immature: Daytime	0	2		Immature: Daytime	NA
In-flight	1	Not counted		In-flight	0	Not counted		In-flight	NA
Adjusted to 2-hour period	2	-		Adjusted to 2-hour period	0	-		Adjusted to 2-hour period	NA
Total	70	> 58		**Total**	0	>2		**Total**	NA
% in-flight population	2.9	-		% in-flight population	0	-		% in-flight population	NA

Annex 4. Breeding species Inventory: Population calculation method per breeding species

Species	Calculation methodology
Red-footed Booby *Sula sula*	The active adult breeding population size is expressed as the number of nests multiplied by two = the minimum number of active adult breeding birds. This result is compared to the day-time number of adult birds counted. Whichever is higher represents the daytime population. The in-flight counts of adult birds are added to the day-time results in order to express the total minimum population. Although more adult birds arrive during the night, there is currently no method used to capture this part of the population given that night counts with flashlight is highly disturbing to the birds.
	Reproduction rate is expressed as the number of nests, eggs and/or pulli, juvenile and immature birds recorded. For the immature population the result of the in-flight count is added.
Brown Booby *Sula leucogaster*	The active adult breeding population size is expressed as the number of nests multiplied by two = the minimum number of active adult breeding birds. This result is compared to the day-time number of adult birds. Whichever count is higher is used to represent the daytime population. The in-flight result of adult birds is added to the day-time result in order to express the minimum adult population present. Since more adult birds arrive during the night, two to three distance counts of adults present at dawn at 'Plaza" is carried out and the average result is compared with the combined results of the day-count and the inflight-count. Whichever of these two counts is the highest is used to express the maximum adult population present.
	Since the species is not breeding at South Islet, the count result from this islet is not included in the calculation of the total population of the species present at TRNP in May.
	Reproduction rate is expressed as the number of nests, eggs and/or pulli, juvenile and immature birds recorded. For the immature population the result of the in-flight count is added.
Pacific Reef Heron	The number of adult birds counted at high tide represents the breeding population. The results from South Islet are added to the result for North Islet in order to express the total population of the species present at TRNP in May.

Egretta sacra	Reproduction rate is expressed as the number of nests, eggs and/or pulli and juveniles found during the inventory of other breeding species.
Barred Rail *Gallirallus torquatus*	The number of adult birds noted during counts of other breeding species represents the breeding population. Nests are difficult to find. If nest is found, one nest represents 2 adult birds
Great Crested Tern *Thalasseus bergii*	Population size is expressed as the number of eggs and/or pulli and juvenile found multiplied by two = the minimum number of active breeding birds. This result is compared to the day-time number of adult birds counted next to the eggs/pulli/juveniles plus the average result of two to three high tide counts along the shoreline. Whichever of these two results is the highest is used to express the maximum breeding population. At South Islet where breeding only occurs irregularly, the number of territorial adult birds are counted and added to the figure for North Islet in order to express the total population of species present at TRNP in May.
	Since the species is not breeding at either Black Rock, Amos Rock or Ranger Station, the count result from these localities are not included in the population calculation.
	Reproduction rate is expressed as the number of eggs and/or pulli and juveniles found.
Sooty Tern *Sterna fuscata*	Population size is expressed as the number of eggs and/or pulli and juveniles recorded multiplied by two = minimum number of active breeding birds. This result is compared to the day-time number of adult birds counted next to the eggs/pulli/juveniles and the average results of two to three evening estimates of the total adult population present at that time. Whichever of these three results is the highest is used to express the breeding population.
	Since the species is not breeding at South Islet, the count result from this islet is not included in the calculation of the total population.
	Reproduction rate is expressed as the number of eggs and/or pulli and juveniles found during the inventory.
Brown Noddy *Anous stolidus*	The population size is expressed as the number of nests found multiplied by two = minimum number of adult birds. This result is compared to the day-time number of adult birds counted next to the nests, the number of birds roosting along the shoreline and the results of the in-flight count. The total of these three count is used to express the maximum adult population present.

	At South Islet in-flight counts are not carried out and only two data sets are used to determine the population at this islet: The number of nests found compared to the number of adult birds counted next to the nests and the birds roosting along the shoreline and on the wreck. The results from South Islet are added to the result for North Islet in order to express the total population of TRNP.
	Reproduction rate is expressed as the number of nests, eggs and/or pulli and juveniles found during the inventory.
Black Noddy *Anous minutus*	The population size is expressed as the average number of nests found during two to three separate counts multiplied by two = the total active breeding population. This result is compared to the average result of two to three daytime counts of birds carried out during nest counts plus the results of the in-flight count. Whichever of the two count results is the highest is used. The results from South Islet are added to the result for North Islet in order to express the total population.
	Reproduction rate is expressed as the number of nests, eggs and/or pulli and juveniles found during the inventory. Because of the nest heights in the vegetation, total counts of eggs and pulli is only possible at North Islet. Identification of immature birds is not possible as they looks similar to adults.
Eurasian Tree Sparrow *Passer montanus*	Population size is expressed as presence of adult birds since nests have not been found.

Annex 5. Seabirds Distance Count: Objectives and method

Objective	Documentation of a) presence or absence of seabird species and b) the relative population trends variation throughout the year.
Method	Distance counts includes all species of boobies, frigatebirds and terns (including noddies).
	Distance counts are carried out as a monthly patrol routine at both Bird Islet and South Islet.
	It is carried out from a patrol boat while sailing with very low speed, interrupted by frequent stops 70-80 meters parallel to the shoreline. If the birds shows signs of being disturbed or start to fly, the distance is too close and needs to be adjusted.
	The count is an estimation of the population numbers carried out by using a binocular with magnification 8 x 50 or 10 x 50. The method does not allow for exact count of population numbers.
	Two Park Rangers conducts the count: One count/estimates the bird population numbers, the other is the count note taker. At least two independent estimation counts are needed.
Analysis	The average estimation figures are then used to determine the population variation trend of the different species throughout the year.
Data storage	The results are reported on a quarterly basis to the TMO in Puerto Princesa. The TMO is responsible for storing and safe-guarding the data.

Annex 6. Results of Park Rangers Counts August 2014 to February 2015 at Bird and South Islet

North Islet							
	2014				2015		
	9-August			13-October	14-February		
	Day Count	Inflight	Total	Total	Day Count	Inflight	Total
RED-FOOTED BOOBY							
Adult	831	1116	1,947	1735	1082	644	1726
Sub-adult	27	56	83	146	9	20	29
Pullus/ juvenile	4		4	45	125		125
Eggs	no count			no count	no count		no count
Nests	184		184	373	450		450
BROWN BOOBY							
Adult	960	984	1,944	1023	282	922	1,204
Sub-adult	36	44	80	27	4	8	12
Pullus/ juvenile	61		61	16	60		60
Eggs	446		446	0	659		659
Nests	365		365	116	551		551
GREAT CRESTED TERN							
Adult	3910		3910	0	0		0
Sub-adult				0	0		0
Pullus/ juvenile	570		570	0	0		0
Eggs	17		17	0	0		0
Nests	0		0	0	0		0
SOOTY TERN							
Adult	4661		4661	450	5200		5200
Sub-adult	15		15	65	0		0

Pullus/juvenile	2353		2353		53		0		0
Eggs	244		244		94		4910		4910
Nests					94		4910		4910
BROWN NODDY									
Adult	845		845		0		43		43
Sub-adult	12		12		0		0		0
Pullus/juvenile	101		101		0		0		0
Eggs	219		219		0		0		0
Nests	378		378		0		0		0
BLACK NODDY									
Adult	697		697		0		0		0
Sub-adult	0		0		0		0		0
Pullus/ juvenile	0		0		0		0		0
Eggs	0		0		0		0		0
Nests	276		276		0		0		0

South Islet

	2014			2015
	7-Aug	5-Oct		24-Feb
RED-FOOTED BOOBY				
Adult	787	306		320
Sub-adult	140	57		41
Pullus/juvenile	21	20		28
Eggs	0			0
Nests	155	116		302
BROWN BOOBY				
Adult	0	0		53
Sub-adult	0	0		9
Pullus/juvenile	0	0		0

Eggs	0	0		0
Nests	0	0		0
GREAT CRESTED TERN				0
Adult	0	0		0
Sub-adult	0	0		0
Pullus/juvenile	0	0		0
Eggs	0	0		0
Nests	0	0		0
SOOTY TERN				
Adult	0	0		0
Sub-adult	0	0		0
Pullus/juvenile	0	0		0
Eggs	0	0		0
Nests	0	0		0
BROWN NODDY				
Adult	444	363		0
Sub-adult	131	5		0
Pullus/juvenile	72	0		0
Eggs	31	0		0
Nests	114	35		0
BLACK NODDY				
Adult	2885	2		0
Sub-adult	63	3		0
Pullus/juvenile	0	0		0
Eggs	0	0		0
Nests	823	132		138

Annex 7. Systematic list of avifaunal records, North and South Islet and Jessie Beazley Reef, TRNP, 8-11 May, 2015.

Breeding species are indicated in bold letters. Taxonomic treatment and sequence follows IOC/Wild Bird Club of the Philippines 2015.

Status/Abundance (within Sulu Sea)	Species name	Number of individuals	Locality	Notes
Migrant Rare	Bulwer's Petrel *Bulweria bulwerii*	1	Pelagic	At 15.50PM between South Atoll and Jessie Beazley Reef
		1	Pelagic	At 18.05PM, north of Jessie Beazley
Resident/Migrant Locally Common	Eastern Cattle Egret *Bubulcus coromandus*	1	South Islet	
Resident Uncommon	**Pacific Reef Heron** *Egretta sacra*	Adults: 1 Nests: 1	Bird Islet	Dark phase
		Adults: 13 Juveniles: 1 Nests: 3	South Islet	Dark phase
Migrant Rare	Chinese Egret *Egretta eulophotes*	1	Bird Islet	

Migrant Locally rare	Christmas Island Frigatebird *Fregata andrewsi*	Immature (2nd year): 1	Bird Islet	
Migrant Locally uncommon	Great Frigatebird *Fregata minor*	Adults: 4-5 Immatures: 2	Bird Islet	3 males (one dead) + 1-2 females
		Adults: 7 Immatures: 7	South Islet	4 males + 3 females
Migrant Locally uncommon	Lesser Frigatebird *Fregata ariel*	Adults: 2 Immatures: 14	Bird Islet	1 male + 1 female Immatures: One 3-4 years old, three 2-3 years old
Resident Locally uncommon	**Red-footed Booby** *Sula sula*	Adults: 2,101 Immatures: 148 Pulli/1st y. juv.: 95 Nests: 189	Bird Islet	
		Adults: 1,391 Immatures: 58 Pulli/1st y. juv.: 145 Nests: 190	South Islet	
Resident	**Brown Booby**	Adults: 2,353	Bird Islet	

Rare	*Sula leucogaster*	Immatures: 26 Pulli/1st y. juv.: 200 Nests: 726		
		Adults: 50 Immatures: 2	South Islet	Not breeding
Resident Common	**Barred Rail** *Gallirallus torquatus*	Adults: 3-4	Bird Islet	
Resident Uncommon	Slaty-breasted Rail *Gallirallus striatus*	Adults: 1	Bird Islet	At the research vessel 11 May. Only
Migrant Common	Long-toed Stint *Calidris subminuta*	1	Bird Islet	New record for TRNP
Migrant Fairly common	Ruddy Turnstone *Arenaria interpres*	2	Bird Islet	
Migrant	Red-necked Phalarope *Phalaropus lobatus*	1	Pelagic	Migrating north of Jessie Beazley Reef
Resident Fairly common	**Great Crested Tern** *Thalasseus bergii*	Adults: < 11,783 Eggs: 4,280	Bird Islet	
		Adults: 604	South Islet	Not breeding
		Adults: 120	Jessie Beazley	Not breeding

Resident Rare	Bridled Tern *Sterna anaethetus*	1	Jessie Beazley	
Resident Rare	**Sooty Tern** *Sterna fuscata*	Adults: >7,180 Pulli/Juveniles: >3,538 Eggs: 52	Bird Islet	Nearly all adults only present at night
		Adults: 4	South Islet	Not breeding
Resident?/Migrant Rare	Roseate Tern *Sterna dougallii*	3	South Islet	Passing by
		2	Bird Islet	Passing by
Resident Uncommon	Black-naped Tern *Sterna sumatrana*	2	Bird Islet	Passing by
		1	South Islet	At reef crest
Migrant Fairly common	White-winged Tern *Chlidonias leucopterus*	2	Bird Islet	Migrating north
Migrant Common	Whiskered Tern *Chlidonias hybrida*	1	South Islet	2nd year bird
Resident Locally rare	**Brown Noddy** Anous stolidus	Adults: 1,409 Pullus: 1 Nests: 596	Bird Islet	First time in May that a pullus is present
		Adults: 1,174	South Islet	First time in May that pulli are present

		Pulli: 5 Immatures: 2 Nests: 364		
Resident Rare	**Black Noddy** *Anous minutus*	Adults: 2,544 Pulli: 7 Nests: 641	Bird Islet	First time in May that pulli are present
		Adults: >5,682 Pulli: 23 Nests: 1,756	South Islet	First time in May that pulli are present. About 3,000 adults at reef crest may be additional birds
Resident Common	Collared Kingfisher *Todiramphus chloris*	1	South Islet	
Resident Common	**Eurasian Tree Sparrow** *Passer montanus*	0	Bird Islet	
		3	South Islet	
Migrant Common	Eastern Yellow Wagtail *Motacilla tschutschensis*	2	Bird Islet	
		1-2	South Islet	
Migrant Rare	White Wagtail *Motacilla alba*	1	Bird Islet	

Annex 8. Comparison of the landscape and habitats seen from the permanent photo documentation sites on North Islet and South Islet, May 2015 and May 2004.

Bird Islet:

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

Photo name code: B1 01 Comments: 5 shots (Stitched by Microsoft ICE) Date: May 10, 2015

Photo nos.: DSC_32303447-DSC_32343451

Viewing angle for photo: facing NE 038º

Film no: 27, 28

Photo no (camera):

Photo name code: BI 02

Photo no (negative):

Comments: 2 shots good angle

Date: May 7, 2004

Photo name code: BI 02

Comments: 1 shot

Photo nos.: DSC_32123428

Date: May 10, 2015

Viewing angle for photo: facing E 067°

Film no: 14 Photo no (negative):

Photo name code: BI 04 Photo no (camera):

Comments: 1 shot plaza Date: May 7, 2004

Photo Doc Site NI No. 04 - 2004

Photo name code: BI 04

Comments: 1 shot plaza

Date: May 10, 2015

Photo nos.: DSC_32053421

Viewing angle for photo: facing S 165° Comments: 3 shots panoramic view Photo name code: BI 03

Film no: 22, 23, 24 Date: May 7, 2004 Photo no (camera):

Photo name code: BI 03 Comments: 5 shots stitched (Microsoft ICE)

Date: May 10, 2015 Photo no (camera): DSC_32053422-DSC_32053426

South Islet:

Viewing angle for photo: facing S 060°

Film no: 35

Photo name code: SI 01

Photo no (camera): 01

Photo name code: SI 01

Date: May 9, 2015

Comments: single shot including parola at the background