Ecosystem Research and Monitoring Report 2017

Tubbataha Reefs Natural Park

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TRNP Ecosystem Research and Monitoring Report 2017

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Executive Summary

This report presents the results of the annual fish, benthos and seabird monitoring in the Tubbataha Reefs Natural Park. Standard fish visual census and benthos point intercept methods were used to assess fish community and reef benthos, respectively. Seabird population was assessed using the method established by Jensen in 2004, an adaptation of DAO 13, s 2000. Special assessments on seagrass, *Tectus niloticus* and *Hippopus hippopus* were also undertaken.

Reef benthos and fish population were assessed at five and 10 meters, to be able to characterize the community at varying depths. The average live coral cover in the deep and shallow transects are 60.94% and 79.2%, respectively. This put the deep sites in good condition, while the shallow sites in excellent condition, according to the quartile scaling of Gomez et al. (1981). There was an observed increase in abiotic components in the deep transects of Site 3, because of the increase in rubbles. The possible reason for this are the number of storms which traversed Sulu Sea in 2016. Although the storms did not directly pass through Tubbataha, they generated strong waves that exacerbated the northeast monsoon. The strong waves may have caused for the branching *Isopora bruggemanni* (dominant coral species in Site 3) to break and be dislodged to the deeper parts of the reef, creating the damage and thereby causing the abiotic components to increase.

Photo-transect method was also employed this year to assess reef benthos. Assessment of photographs using CPCe resulted in hard coral cover of 29% in deep transects and 44.8% in shallow transects. These values are relatively low compared to the results from the benthos point intercept method. Interestingly, the results of the photo-transect method in the shallow transects are comparable to the hard coral cover (37%) reported by DLSU using the same method. Thus, the use of photo-transect method is recommended for the assessment of the benthic community in TRNP. We also recommend the collection of data such as coral recruitment and rugosity to better characterize the coral reef community in TRNP.

A total of 314 fish species belonging to 43 Families and Subfamilies were identified in TRNP this year. Species richness was estimated at 63 species per 500m² which falls under very high level based on categories established by Hilomen *et al.* (2000) for coral reef fishes . Reef fish density in deep and shallow stations of TRNP is mainly represented by Family Pomacentridae (Damselfishes) and Subfamily Anthiinae (Anthias) of Family Serranidae. Mean reef fish density in deep (1436 ind/500m²) is relatively higher in comparison with shallow (1221 ind/500m²) station, however, the difference is not significant. Based on the categories for reef fish density established by Nañola et al. (2014), both shallow and deep stations of TRNP fall under high level.

Reef fish biomass in deep stations of Tubbataha Reefs Natural Park (TRNP) is mainly represented by Family Acanthuridae (Surgeonfishes) and Carangidae (Trevallies), while shallow stations are represented by Family Balistidae (Triggerfishes) and Carangidae. Mean biomass of fish community in deep stations (179 mt/km²) is relatively higher than in shallow stations (124 mt/km²). In addition, the estimated fish biomass in both deep and shallow stations fall under very high level based on categories suggested by Nañola et al. (2004).

Pelagic fish biomass was estimated at 35% of the total and is largely represented by families Acanthuridae subfamily Nasinae and Carangidae. This present estimate of pelagic fish biomass is relatively lower than in 2015 assessment (46%). Alternatively, demersal fish biomass constitutes 65% of the total and is mainly represented by family Balistidae (triggerfishes) in the present assessment. Target fish biomass of the present assessment constitutes 69.4% of total fish biomass and is largely represented by family Acanthuridae (Surgeonfishes) and Carangidae (Jacks and Trevallies). Major species constitutes 30% of the total fish biomass in TRNP and is largely represented by families Balistidae (Triggerfishes), Pomacentridae (Damselfishes), and Serranidae subfamily Anthiinae (Basslets/Anthias). Moreover, indicator species (1%) is mainly represented by Family Chaetodontidae.

Reef fish density in deep stations of the grounding sites of Ming Ping Yu and USS Guardian is represented largely by Family Pomacentridae and Subfamily Anthiinae. The shallow station is represented largely by

Families Acanthuridae and Labridae (Wrasses). Based on categories used by Nañola et al. (2014) for reef fish density, both deep and shallow stations of the grounding sites fall on moderate level. On the other hand, reef fish biomass in both deep and shallow stations of the grounding sites (Ming Ping Yu and USS Guardian) of TRNP is largely represented by Family Balistidae and Acanthuridae. In general, fish density (ind/500m^2) and biomass (mt/km^2) in USS Guardian grounding site is relatively higher than estimates in Ming Ping Yu.

The observed high proportion of target fish species biomass and the presence of endangered and near threatened fish species serve as indication of the positive impacts of a strictly enforced protected reef. It is recommended to maintain standardized assessment of the conduct of fish visual census among observers to prevent observer biases.

The land area of the Bird Islet has decreased by 18.4%; from 18,760 m^2 in 1981 (Kennedy 1982) to about 15,307m^2 in 2017. From 2004, the first year when GPS was used to measure the islets, the decline in the land area has been 10% each year. Erosion along sections of the northeastern coastline, first noted in 2012, has continued although in a much smaller scale since 2016. The land area of South Islet (2,980 m^2) had remained the same since May in 2016, however, continued deterioration of the remaining seawall was noted. Vegetation in both islets continue to deteriorate, leaving the tree-nesting species with very limited nesting place.

A total of 34 species of birds were identified during the inventory. Of these, the Oriental Plover *Charadrius veredus*, rare in the Philippines, Common Redshank *Tringa totanus,* Terek Sandpiper *Xenus cinereus,* and Gull-billed Tern *Gelochelidon nilotica* were new records for TRNP. The total number of avifauna species recorded in TRNP is now 115 species. A total 37,218 adult individuals of six breeding and one attempting to breed species were recorded; 30,414 individuals on Bird Islet and 6,804 individuals on South Islet. Bird Islet hosted about 82%, and South Islet hosted 18% of the breeding seabirds this year.

The total result of the May count in 2017 is about 4% lower than in 2016 and in 2015. The combined population of all breeding seabirds in 2017 was 175% higher than the first inventory conducted in 1981. There was an observed increase in the population of Great Crested Tern, Brown Booby,and Brown Noddy. A decrease, however, was recorded for the two tree-nesting species - Black Noddy and Red-footed Booby. As in 2015, the breeding season

of Sooty Tern started in February. On 11 May an adult male Masked Booby was again found in the main colony of Brown Booby at the 'Plaza". It is assumed to be the same bird that was recorded on the very same date in 2016. Since 2016 the species has occupied at least one patch within the territory of the Brown Booby, where it first incubated a Brown Booby egg alternately with a female Brown Booby. Later it was observed feeding the off-spring.

Only 12 dead specimens were found in Bird Islet compared to 28 in 2016. Considering that the Brown Booby is known to rear only one out of two pulli born, and with records showing several Brown Booby with two eggs, the absence of dead pulli specimens is noteworthy. The highlight of the necropsy findings was a high prevalence of external parasites collected from the 12 specimens. These include soft tick, louse flies, skin beetles and chiggers.

The seagrass assessment this year covered a total sampling area of 750m^2. A total of five seagrass species were recorded in the assessed sites - *Cymodocea rotundata*, *Halodule pinifolia*, *Halophila minor*, *Halophila ovalis* and *Thalassia hemprichii.* Of the five species recorded, *Halophila ovalis* and *Halodule pinifolia* were found to be the dominant species in terms of shoot density. The highest seagrass density was recorded in Ranger Station 2 while the lowest was in South Islet. The dominant seagrass species (*Halophila ovalis* and *Halodule pinifolia)* as well as the absence of slow-growing species such *Thalassia hemprichii* in both Bird and South Islets might be due to the strong wave action around the islets.

Nine sites were selected for the assessment of *Tectus niloticus*, covering a total area of 6,800 m^2. Seven of these nine sites coincide with those surveyed in 2006 and 2008. The average density of *T. niloticus* in this survey is 31 individuals/200 m^2, which is lower compared to 2008 ((40 ind/200 m^2). The decrease in density may have been influenced by the very low density in Site 4 (Jessie Beazley Reef) with only 1 ind/200m^2. The average basal diameter of *T. niloticus* in this study is 79mm ± 19.4mm, higher than the result of the baseline assessment in 2006 (Dolorosa et al. 2010) which is 67mm ± 14.6mm. However, it is slightly lower than the last survey conducted in 2008 which is 82mm ± 16mm (Dolorosa and Jontila 2012). Majority of the *T. niloticus* measure 51mm to 110mm in basal diameter. These are classified as mature individuals, and were observed across all sites. *Hippopus hippopus* was surveyed around the Ranger Station and covered a total area of 7,000 m^2. A total of 157 individuals of *Hippopus hippopus* were recorded at the seven transects, resulting to an average density of 22 individuals/1000m^2.

The baseline assessment on Napoleon wrasse recorded a total of 633 individuals or around 7 individuals/ha. Density comparison using Mann-Whitney U test showed no significant difference between the North (6.1 individuals/ha) and South (9.8 individuals/ha) Atolls. However, a significant difference was observed between the eastern (4.7 individuals/ha) and western (9.5 individuals/ha) sides of the reefs. This suggests that Napoleon wrasse favors a relatively sheltered environment. Size frequency distribution yielded a high density of mature individuals measuring 40 to 80 cm total length (TL), numbering more than 400 individuals. The largest individual observed was between 130 to 150 cm TL. Juveniles were observed inside the lagoon of the North Atoll. These findings clearly illustrate the importance of TRNP as a source of Napoleon wrasse in the Sulu and adjacent seas.

Reef benthos monitoring of DLSU reveals that hard coral cover (HCC) and generic diversity of Tubbataha reefs continued to show resistance to prevailing environment challenges. The average HCC from 2012-2017 is 34%, with no statistically significant change over the same period. An overall 4% decline in HCC (41% on 2016 to 37% on 2017) was observed between the 2016 and 2017 monitoring data. Changes in HCC were also observed at the site level. There were declines in Site 1 (12% decline from 2016) and Site 3 (10% decline from 2016), and a 4% increase in Site 2. The changes were larger at the station level for Site 1 and Site 3. The decline that was reported during 2016 in Site 3 was attributed to damage from logs and *payao* floats. Log damage was again observed during 2017 monitoring. On the other hand, HCC in Site 2 has been increasing slightly over time. The increasing trend coral cover in here might be caused by new coral recruits or the yearly growth of dominant corals. The latter might be a reasonable explanation for the increase since the dominant corals in the site are mostly fast-growing branching corals.

The results of the monitoring of fixed 4x4m plots showed an increasing hard coral cover (HCC) at the USS Guardian plots. Coral recruits, mainly *Pocillopora*, were observed in the plots as early as the first monitoring, 16 months from the grounding and 14 months since the vessel was removed from the reef. However, these early recruits did not persist into the subsequent monitoring periods and rapid turnover was apparent up to the present. The 2017 plots, nonetheless, had other coral taxa (mainly faviids) growing to appreciable size. This indicates slower-growing, longer-lived corals are beginning to have a larger role in the recovery of coral cover. It is projected that HCC in the Ground zero plots will not be different from the adjacent control plot in five years.

In contrast, no trend in HCC can be seen at the two Min Ping Yu (MPY) impact plots. HCC in the MPY adjacent control plot increased in the first three years of the monitoring, indicating recovery is possible in the area, despite the predominantly sandy substrate. The coral recruits, mostly colonies of *Pocillopora*, seen in these plots were too few to lead to measurable recovery in coral cover.

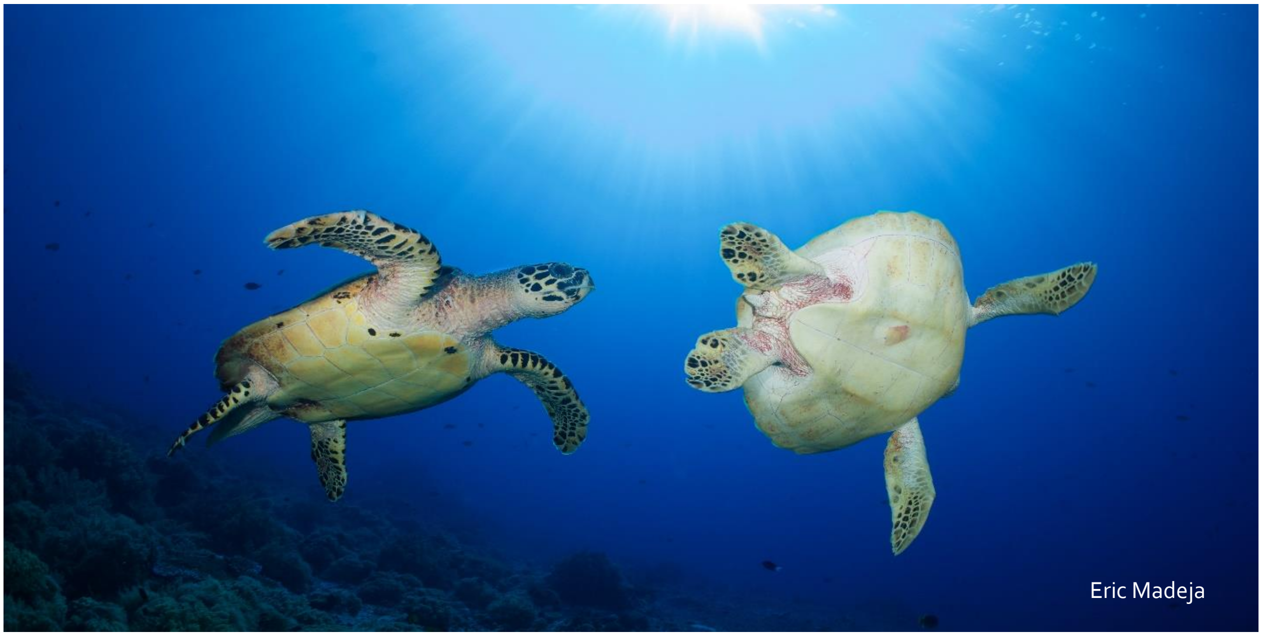
1 INTRODUCTION

1.1 Overview

The Intergovernmental Panel on Climate Change stated in its 2014 report that 'Coral reefs are one of the most vulnerable marine ecosystems and more than half of the world's reefs are under medium or high risk of degradation'. World's coral reefs has already experienced three major bleaching events – in 1998, 2010 and 2014 – 2017. The latter being the longest bleaching event ever recorded, which brought huge impacts in a lot of coral reefs, e.g., the Great Barrier Reefs, losing at least 29% of its shallow-water corals (GBRMPA 2017). Natural phenomenon, e.g., sea temperature rise and typhoons, coupled with human-induced disturbances cause coral reefs to deteriorate.

As a response, managers and scientists have designed tools to monitor changes in the health of corals and reef-associated species, and be able to design management strategies to better conserve these resources. The Tubbataha Reefs Natural Park is one of the largest marine protected areas in the country and is one of very few managed under a 'no-take policy'. Research and monitoring, being one of its conservation strategies, is designed to:

- determine ecosystem health;
- measure biophysical indicators of management effectiveness, and;
- provide the scientific basis for formulation of proactive strategies and responses to emerging issues.


Eric Madeja

The results of monitoring activities conducted in the park reflect the effectiveness of management programs. They also serve as guide for the Tubbataha Protected Area Management Board (TPAMB) to arrive at science-based management decisions and policies. Regular monitoring of the health of the reefs started in 1997, which was spearheaded by World Wildlife Fund (WWF) – Philippines. Other organizations, such as Conservation International (CI) – Philippines, and different academic institutions likewise contributed to monitoring activities, either in the form of funds or expertise. Beginning in 2013, ERM is led by the Tubbataha Management Office (TMO) with critical advice and guidance from partners.

This report presents the results of the monitoring surveys conducted in 2017 and provides an analysis of temporal and spatial trends of the benthic community, fish and seabird populations. Special assessment on seagrass, *Tectus niloticus* and *Hippopus hippopus* were also undertaken.

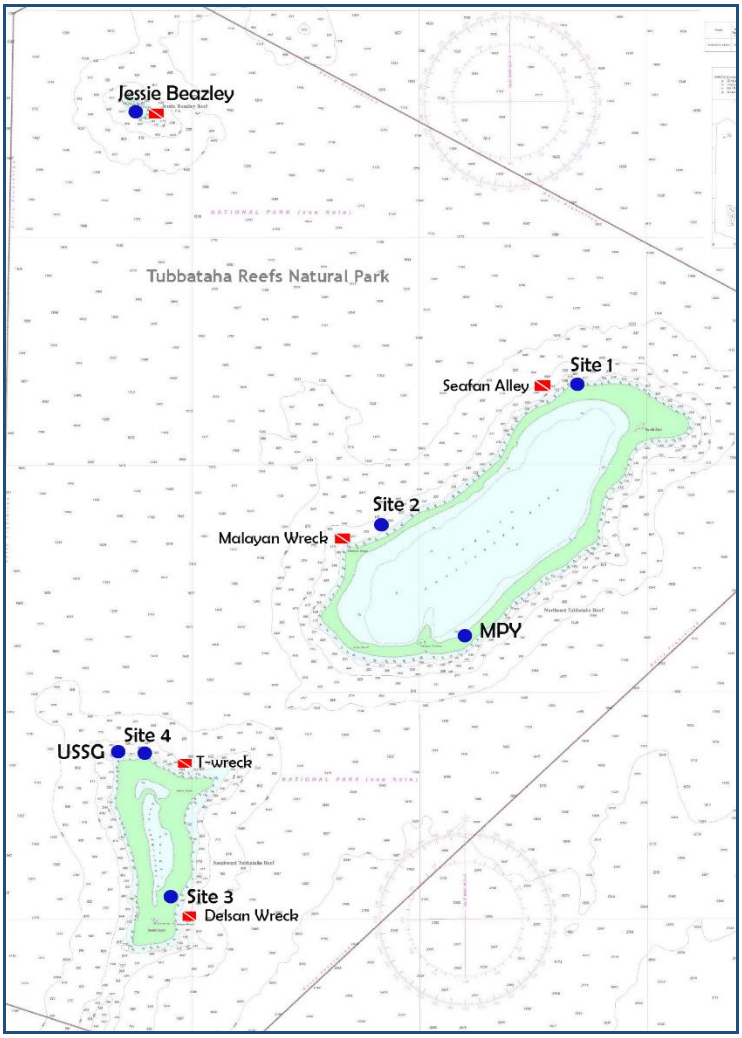


Figure 1. Location map of the monitoring sites.

1.2 Monitoring design

Study Sites

TMO currently monitors five sites located in the North Atoll, South Atoll and the Jessie Beazley Reef (Figure 1) to describe the status of the fish and benthic communities. In each site, two replicate stations, approximately 200 meters apart, were established. The geographic location of each monitoring stations is provided in Annex 2. The two ship grounding sites, USS Guardian (USSG) and Min Ping Yu (MPY), have been monitored since 2013 as they are ideal for assessing changes through time. In each of the stations, shallow (5meters) and deep (10meters) areas are assessed to acquire better understanding of the condition of the reefs at varying depths. This hierarchical sampling design is presented in Figure 2. In the same stations, researchers from the De La Salle University – Br. Alfred Shields Marine Station monitor the spatial and temporal changes in the shallow portions of the reef using the photo-transect method.

Seabirds were monitored in Bird Islet, South Islet and Jessie Beazley Reef. Emerging sand cays were also visited to take into account resting seabirds. The inventory of seabirds followed the protocols designed by Jensen (2004).

Field Surveys

The fish and benthos surveys were conducted on 28 April to 5 May while the seabirds survey was conducted on 7 to 13 May. In-house researchers and marine park rangers were assisted by volunteer researchers from the UP-Mindanao, Jose Rizal Memorial State University, De La Salle University, Philippine Biodiversity Conservation Foundation, Inc., and UP-Los Baňos. The members of the monitoring team are listed in Annex 1.

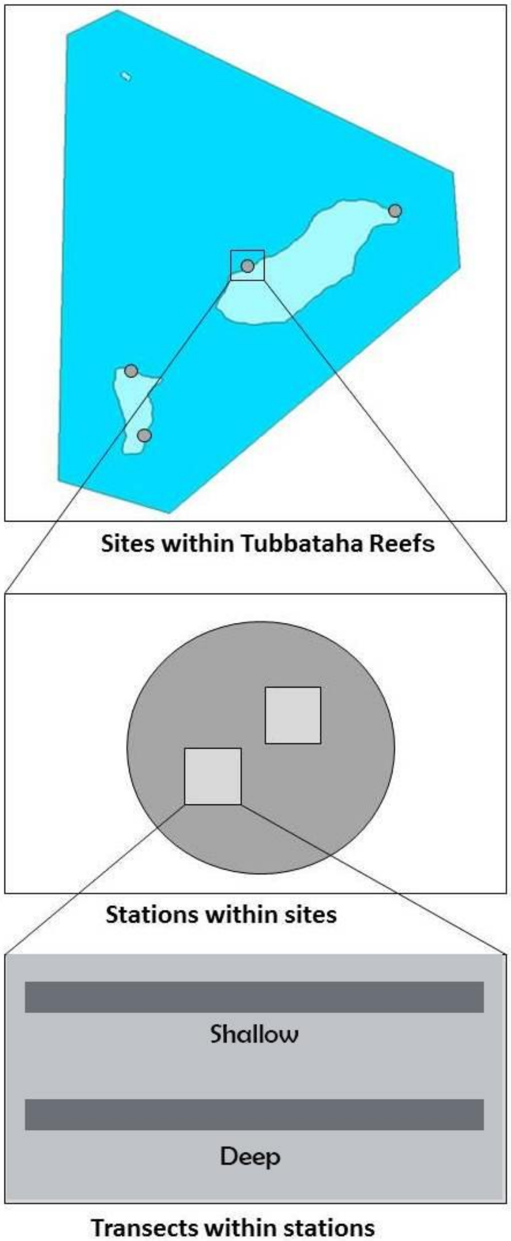


Figure 2. Hierarchical sampling design (Modified from Licuanan et al 2016).

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2 BENTHIC COMMUNITY

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2.1 Overview

The state of coral reefs throughout the world is changing rapidly, the causes of which are believed to be largely anthropogenic. Monitoring the health of coral reefs and triggers of change is necessary to address the causes and management interventions to mitigate their effects. Managers and scientists have an important role in communicating these changes and what they mean to the public. The Tubbataha Reefs, being one of the most effectively managed MPAs in the region, could provide insights on how reefs in their natural state respond to certain issues and threats. In this section we discuss two decades' worth of benthic monitoring data of TRNP specifically designed to inform management decisions.

2.2 Methods

Sampling Design

Benthos point intercept was used to categorize the reef benthos in TRNP. The researchers followed the life form categories described by English et al. (1997). This method is used to determine the relative cover of benthic organisms and the non-living components of the reef. Four 20-meter transects were laid in the substrate at each depth. Each transect was placed approximately five (5) meters away from each other to avoid pseudo-replication and thus provide four independent transects. A 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 transects.

In the same transect lines, photo-transect method was employed, taking photos of the reef benthos every meter. The photos were processed using the Coral Point Count with Excel extensions (CPCe), scoring 10 random points in every frame.

Statistical treatment

Percentage Cover

The percentage cover of each life form was computed for every station. This was generated by dividing the total number of points per life form by the total number of points of all identified life forms (200), and multiplied by 100. The formula is shown below:

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

The graphs shown in this report are the mean values of the four transects at each depth and are presented 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 trendline plotted together with the data series in the charts. A trendline is most reliable when its R^2 value is near or equal to 1. The R^2 is the coefficient of determination and basically reveals how closely the estimated values for the trendline correspond to the actual data.

Correlation

To determine whether there 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 at p = 0.05.

Photo-transect method

Photo-transect method was also employed in the same transects. Photographs were taken every meter of the transect using a digital camera mounted on an aluminum monopod. This produced 20 frames of photos per transect, and was repeated in the other three 20-meter transects. Photos were then processed using Coral Point Count with Excel extensions (CPCe) (Kohler and Gill, 2006). Benthic categories of the ten random points were recorded for every 1x1 meter frame (Reyes et al. 2014 unpub.), producing a total of 200 data points per 20 meters.

2.3 Results and Discussion

Benthic cover at 10 meters

This year, the average hard coral cover for all sites is 37.33% at 10 meters. Hard coral cover at this depth is a little less compared to 2016. However, when compared to the 2013 data, a significant difference (t = 0.004) is observed.

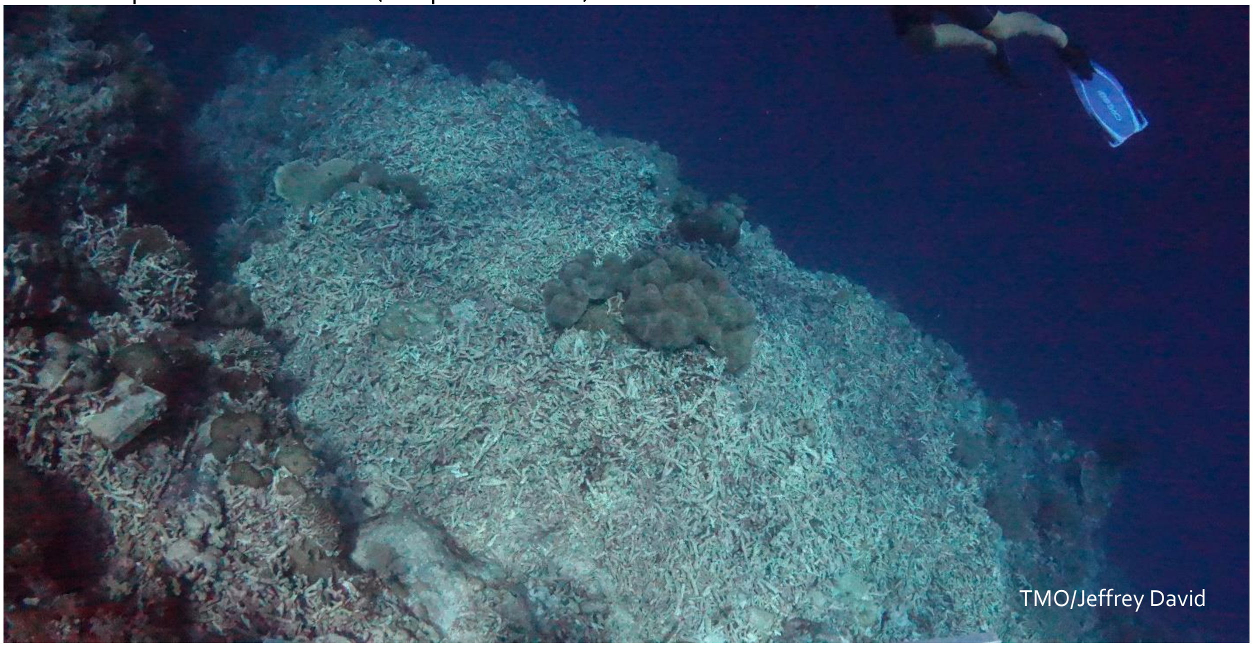
The triggers for its decline could not directly be addressed in this monitoring design. Some ecological factors which might have influenced the decline are elevated sea surface temperature (Bruno and Selig 2007), diseases (IUCN 2016) and bioerosion due to strong wave action (Grimsditch and Salm 2006). Soft corals on the other hand, decreased from 26.16% in 2016 to 23.61% this year. The difference is not significant. A significant difference can be observed from 2013, when soft coral cover was 19.70%, to 2017 with 23.61%.

Table 1. Five-year mean percentage cover of benthic categories at 10-meter depth in Tubbataha Reefs Natural Park

	2013	2014	2015	2016	2017
Hard coral	52.00	50.78	43.93	38.76	37.33
Soft coral	19.70	16.72	15.25	26.16	23.61
Mortalities	0.00	0.42	0.70	0.91	0.99
Algae	0.10	12.36	21.17	17.26	8.98
Others	1.90	5.18	5.40	7.96	7.85
Abiotic	26.50	14.53	13.56	8.93	21.73
Total	100	100	100	100	100

The total live coral cover at 10 meters remained "Good", with 60.94% live coral cover, based on Gomez et al. (1997). Mortalities have remained very low since 2013. Meanwhile the algae, primarily composed of coralline algae, decreased this year at 8.98%. In contrast, abiotic components recorded an increase of 94% from last year (change is significant at t= 0.009, p=0.02). In 2016 high amount of rubbles was observed in Stations 3A (19.25%) and 3B (26.87%). This year, abiotic components almost doubled at Stations 3A (37.25%) and 3B (58.87%).

Tropical typhoons are the most common cause of large-scale natural disturbances in coral reef ecosystems (Fabricius et al. 2008, Wilkinson and Souter 2008, Lugo-Fernandez and Gravious 2010). The marked increase in abiotic components this year may be attributed to typhoons that crossed the Sulu Sea in 2016. Tropical storm Marce passed the northern part of the Sulu Sea in November 2016 with a 62-88 km/hr wind speed. The more severe tropical storm Nina slowly traversed the Sulu Sea in December 2016. Although these natural disturbances did not directly hit Tubbataha, they generated strong waves that exacerbated the northeast monsoon. Stations 3A and 3B are primarily composed of the branching *Isopora bruggemanni*, which is susceptible to breakage and bleaching (Marshall and Baird 2000; Floros et al 2004; Heron et al. 2008). The strong waves may have caused the branching *Isopora bruggemanni* to break and be dislodged to the deeper parts of the reef, creating the damage and thereby causing the abiotic components to increase (see photo below).



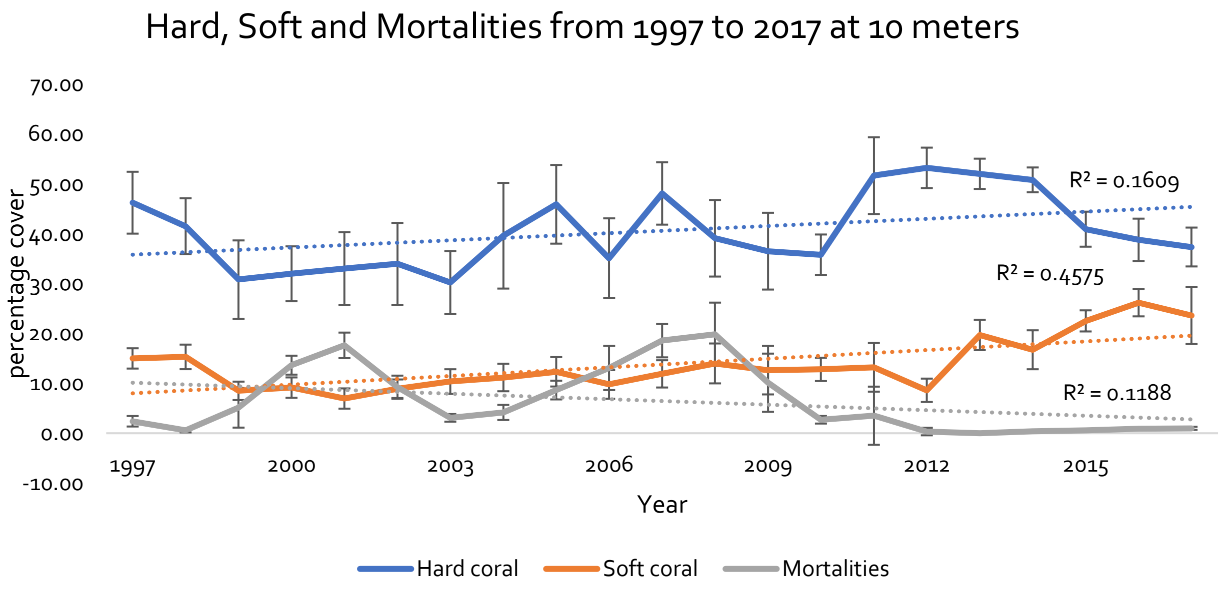


Figure 3. Overall mean percentage cover of hard corals (blue), soft corals (orange) and mortalities (grey) at 10-meters depth. Error bar represent standard error of the mean, while trendline was plotted to determine trajectory of benthic cover through time.

Over the years, hard coral cover at 10 meters showed a slightly increasing trend. The 2017 value falls within the range of the 20-year mean value (1997- 2017) (Figure 3). Soft corals, on the other hand, continue to show increasing trend, especially from 2013 to 2017 (Figure 3). Over the years, mortalities seem to remain low.

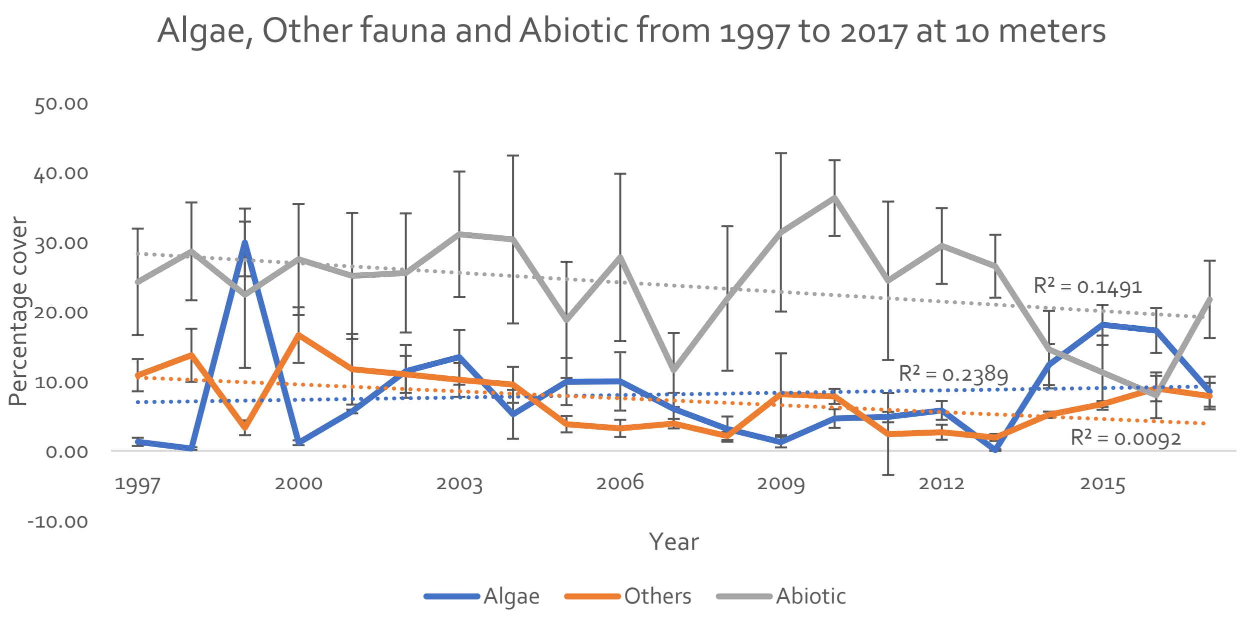


Figure 4. Overall mean percentage cover of algae (blue), other fauna (orange) and abiotic (green) at 10-meter depth. Error bar represent standard error of the mean, while the trendline shows the trajectory of benthic cover through time.

In Figure 4, an increase in algae can be observed from 2014 to 2016. Algae in Tubbataha is mostly coralline algae which are an important part of the reef ecosystem because they help build the reef by depositing calcium carbonate, resisting wave, and by cementing sediments (Dethier 1994; Castro and Huber 2012), thus allowing other benthic organisms to thrive (Gherardi and Bosence 1999; Vermeij et al 2011). Abiotic components, i.e., rocks, rubbles and sand, have decreased from 2013 to 2016. The increase in abiotic components this year was apparent in Stations 3A and 3B, possibly due to storms that passed by Sulu Sea.

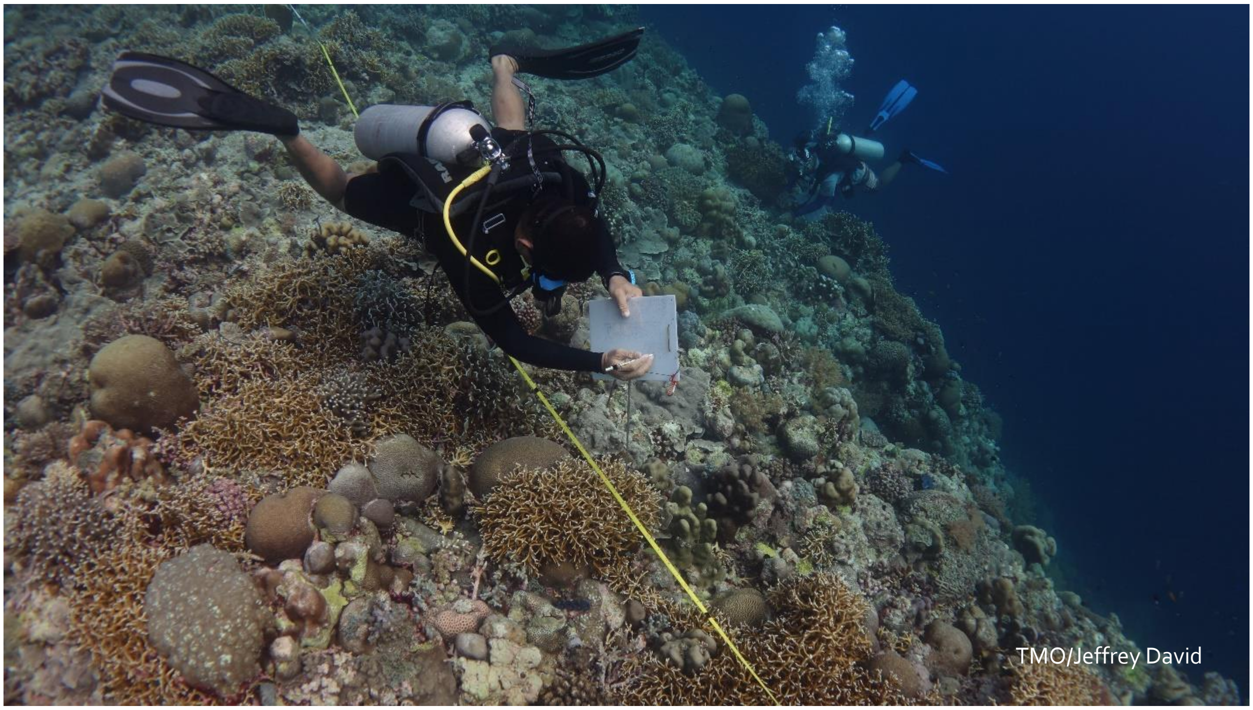
Benthic cover at 5 meters

This year, hard coral cover at five meters is 65.3%, or 7% lower than in 2016. However, the change is insignificant (t= 0.14). Since 2013, the trend in hard coral cover is increasing (Table 2). Hard corals in this depth are a mix of Acropora (Sites 2 and 3) and non-Acropora species (Sites 1, 4 and JB).

Table 2. Mean percentage cover of benthic categories in all the sites at five-meter depth.

	2013	2014	2015	2016	2017
Hard coral	57.46	63.57	67.96	70.80	65.30
Soft coral	13.86	6.75	16.65	13.91	13.88
Mortalities	0.76	0.22	0.71	0.14	0.95
Algae	3.53	0.25	2.04	0.64	1.35
Others	3.98	2.14	6.23	3.93	3.93
Abiotic	20.36	26.96	6.41	10.09	14.60
Total	100	100	100	100	100

Soft corals remained the same and has increased since 2013. The availability of open spaces seems to be beneficial to the faster growth of soft corals compared to other benthic organisms. Overall, the live coral cover at this depth (79.20%) is "excellent" based on Gomez et al. (1981). Mortalities affected only 1.0% and remained very low since 2014. Coraline algae, as the main lifeform observed under the category of algae, showed a slight increase compared to 2016. Other fauna accounted for 3.9% at this depth and is slightly lower compared to 2016. Abiotic components slightly increased but the change was insignificant.



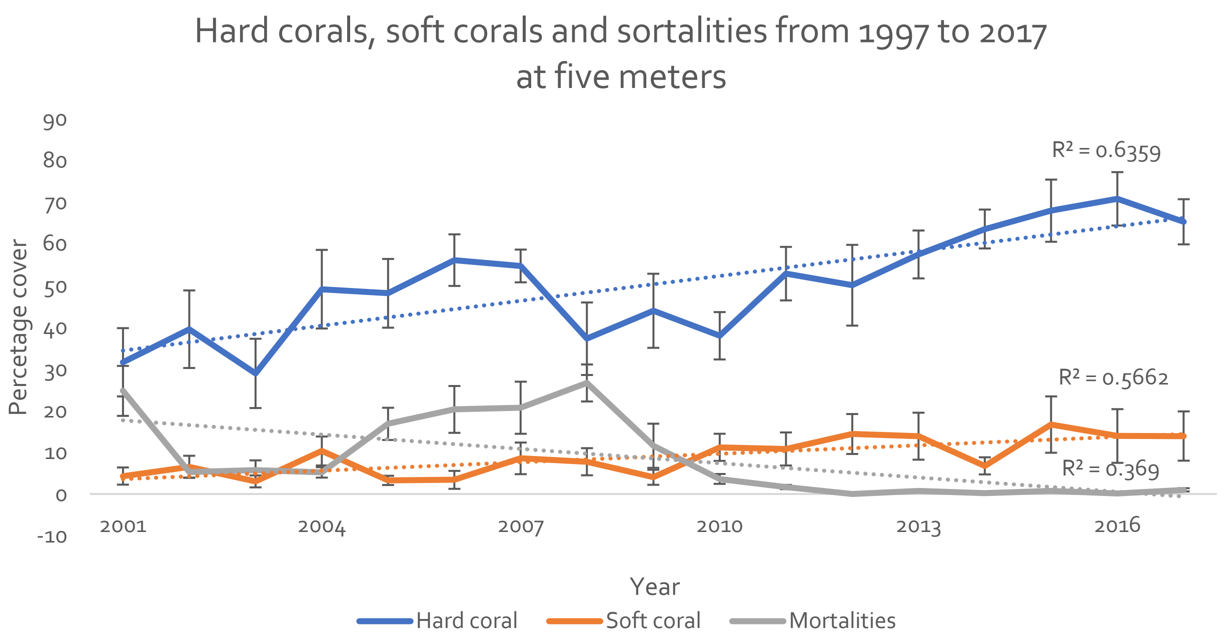


Figure 5. Overall mean percentage cover of hard corals (blue), soft corals (orange) and algae (grey) at 5-meters. Error bars represent standard error of the mean, while trendline was plotted to determine trajectory of benthic cover through time.

Over the years, hard coral cover at 5 meters showed an increasing trend. It doubled from the baseline value of 32% in 1997 to 65.3% in 2017 (Figure 5). Meanwhile, soft corals displayed a slightly increasing trend over the years, while mortalities continued to display a decreasing trend throughout time. TRNP experienced several disturbances in the past but it has still managed to recover. The strict protection and enforcement of the no-take policy may be considered as one of the major factors in its natural recovery from stress.

Figure 6 demonstrates that algae, other fauna, and abiotic components continue to show a declining trend in shallow sites.

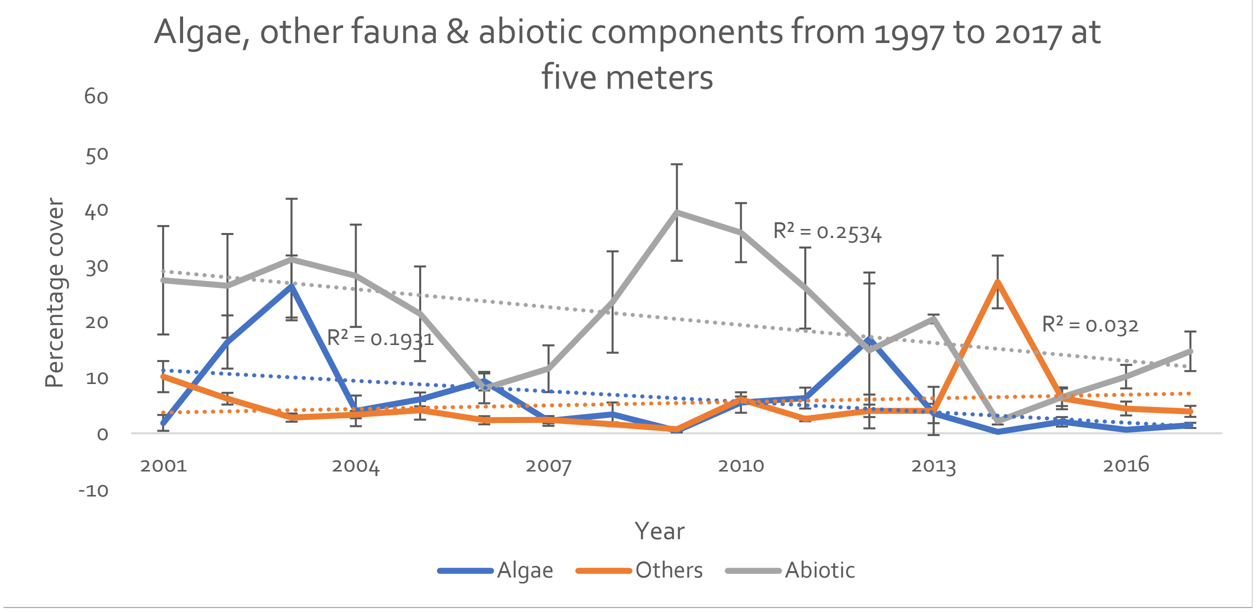


Figure 6. Overall mean percentage cover of algae (blue), other fauna (orange) and abiotic components (green) at 5-meters. Error bar represent standard error of the mean, while trendline was plotted to determine trajectory of benthic cover through time

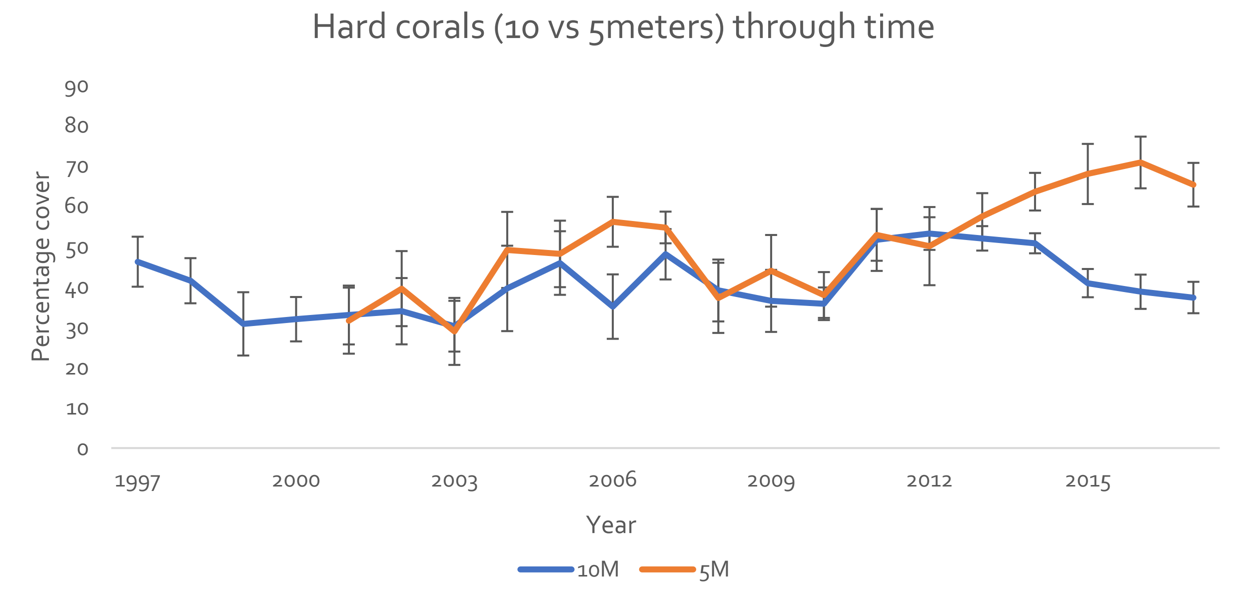


Figure 7. Correlation of hard coral from 10m vs. 5m through time. Error bars represent standard error mean across the sites.

The percentage cover of hard corals in the two depths are summarized in Figure 7. This was done to see the trend of hard corals and how they changed at different depths. Hard coral cover correlation coefficient remains positively weak at r = 0.403 suggesting that through time, hard corals increase simultaneously at both depths until 2014 when hard coral cover at 10 meters started to decrease.

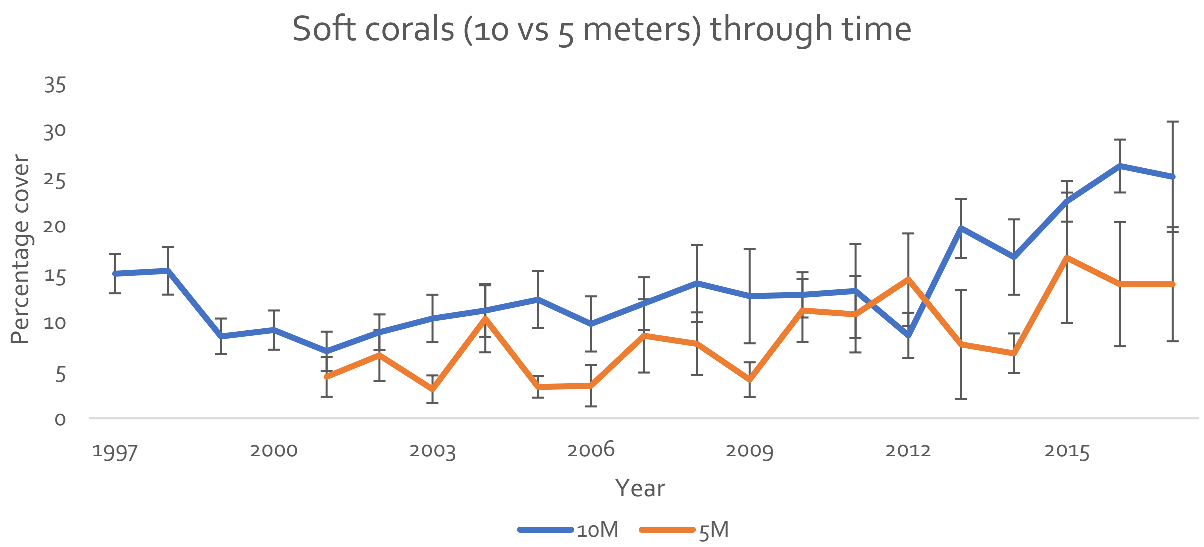


Figure 8. Correlation of soft corals from 10m vs. 5m through time. Error bars represent standard error of the mean across sites.

In the case of soft corals, the correlation coefficient (r = -.60) suggests a moderate negative relationship (Figure 8). This suggests that the increase and decrease in soft corals at both depths does not coincide in most years.

Photo-transect method

Photo-transect method employed in the deep and shallow transects in TRNP resulted in hard coral cover of 29% in deep and 44.8% in shallow transects (See Table 3). The latter is comparable to the 37% hard coral cover from DLSU's assessment in the shallow parts of the monitoring sites. The results of the photo-transect method (of both TMO and DLSU) produced lower percentage of hard coral cover compared to the benthos point intercept method. One factor might be the highly randomized points provided by the CPCe software, which are distributed in the 1x1 meter frame, compared to the stratified random points scored in the benthos point intercept, which are relatively near the transect line.

Table 3. 2017 benthic cover using photo-transect method.

Benthic category	Shallow (%)	Deep (%)
Hard corals	44.8	29.1
Soft corals	5.9	14.2
Other biota	5.5	9.2
Mortalities	0.7	0.8
Algal assemblage	17.6	31.8
Abiotic components	25.5	14.9

2.4 Conclusion

The results of the two decades of continuous monitoring have been valuable in the formulation of sound decisions for TRNP in the past. Changes in benthic community structure was monitored over time at both deep and shallow sites, showing that the pattern of changes at these depths differed. Overall, the live coral cover at 10 meters remains in "good" condition through time, displayed by the slightly increasing trend of both hard and soft coral cover. The reef at five meters is in "excellent" condition, as temperature increase from 2013 onwards, the hard corals in TRNP appear to be resilient, compared to other sites in the country and in the region where massive coral bleaching were reported. Furthermore, soft corals remained in stable condition, while a very low percentage of mortalities were recorded over the years.

Benthos point intercept produced higher hard coral percentage compared to the photo-transect method employed in the same transect lines. On the other hand, photo-transect method employed in TMO's transects produced hard coral cover values which are relatively close to DLSU's hard coral cover value.


Bo Mancao

2.5 Recommendations

To further study the status of the reefs and its resilience to climate change and other phenomenon, we recommend the use of photo-transect method. The photo-transect method will be able to generate more robust data, i.e., coral genera, species count, etc., which can be comparable to other sites in the Philippines. This method was prescribed by the DENR for coral assessments in the country (Technical Bulletin No. 05: Guidelines on the Coastal and Marine Ecosystem). This method will decrease the bottom time of the researchers conducting the assessment, while creating a catalogue of photos which may be used for comparison to the succeeding years. This method also allows the data to be reviewed and verified by other researchers, which minimizes researcher bias in identification.

We also recommend the collection of additional data such as coral recruitment and rugosity, to be able to quantify the rate of coral growth and its resilience to changes in the environment. Coral recruitment survey may be employed along the transect using a 0.2 x 0.2 meter quadrat placed in random order, counting only >40mm coral spats. This will give the managers a better understanding of coral ecology, reef resilience capacity and the potential of TRNP for natural recovery after disturbances.

This should also be supported by the collection of environmental parameters using local temperature loggers (at least one each for North atoll, South atoll and Jessie Beazley Reef) to provide water temperature data collected *in situ* throughout the year. This could give information on local temperature changes within TRNP which could be correlated with the increase or decrease of coral cover.

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3 REEF FISH COMMUNITY

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3.1 Overview

Tubbataha Reefs Natural Park (TRNP) is recognized as a unique example of an atoll reef with very high density of marine species. TRNP is also believed to play a key role in the process of reproduction, dispersal and colonization of the entire Sulu Sea system by a wide variety of marine species, and supports fisheries in surrounding fishing grounds (whc.unseco.org). It is host to internationally threatened and endangered marine species. This report provides information on the present status of fish communities in TRNP.

3.2 Methods

Reef Fish Assessment

Using the geographic coordinates of sampling locations from previous assessment reports, the same reef sites were located (Figure 1) in TRNP using a Garmin 60CSx GPS equipment. Attributes of the fish community – species diversity, density, and biomass were assessed using SCUBA following the daytime fish visual census (FVC) described by English et al. (1997).

A total of five (5) sites were identified to monitor the health of the reefs, each with two (2) stations. Only one station was established for each of the grounding sites (Ming Ping Yu and USS Guardian) because the length of the damaged area will only require one station to monitor changes in fish populations (Appendix 1). The two stations in each site have an approximate distance of around 300 – 500m apart. In each station, there were three (3) 50-m long replicate transects (except in Ming Ping Yu and USS Guardian where only two (2) were established due to lack of manpower) established in shallow (5 meters) and deep (10 meters) areas of the reef. Assessment of adult fish species were carried out along a 50 x 10m arbitrary corridor (an approximate area of $500m^2$). All fish species along each corridor were identified, counted, and their total length (in cm) estimated for use in estimating fish biomass.

Data Analysis

Fish biomass was estimated using the length-weight model established for fish (Pauly, 1984) through the equation:

$$W=aL^b$$

Where **W** is the weight of fish in grams, **L** is the estimated total length of fish in centimeter (cm), and **a** and **b** are regression parameter values obtained from the Fishbase database (www.fishbase.org).

Temporal and spatial variations in fish density and biomass will be tested for significant differences using t-test, single-factor analysis of variance (ANOVA), and two-factor analysis of variance (ANOVA) by using the freeware Paleontological Statistics (PAST) software package (ver. 2.09).

3.3 Results and Discussion

Reef Fish Community Structure

A total of 314 fish species belonging to 43 Families and Subfamilies were identified in the Tubbataha Reefs Natural Park. Species richness was estimated at 63 species per $500m^2$ which falls under very high level (>50 species/$500m^2$) based on categories established by Hilomen et al. (2000) for coral reef fishes (Annex 3).

Density of Reef Fishes

Reef fish density in deep and shallow stations of TRNP is mainly represented by Family Pomacentridae (Damselfishes) and Subfamily Anthiinae (Anthias) of Family Serranidae (Figure 9). Mean reef fish density in deep (1436 ind/$500m^2$) is relatively higher in comparison with shallow (1221 ind/$500m^2$) station (Annex 4). The observed difference, however, is statistically not significant (t-test; $p>0.12$). Moreover, based on the categories for reef fish density established by Nañola et al. (2014), both shallow and deep stations of TRNP fall under high level (1134-3796 individuals/$500m^2$) (Annex 3).

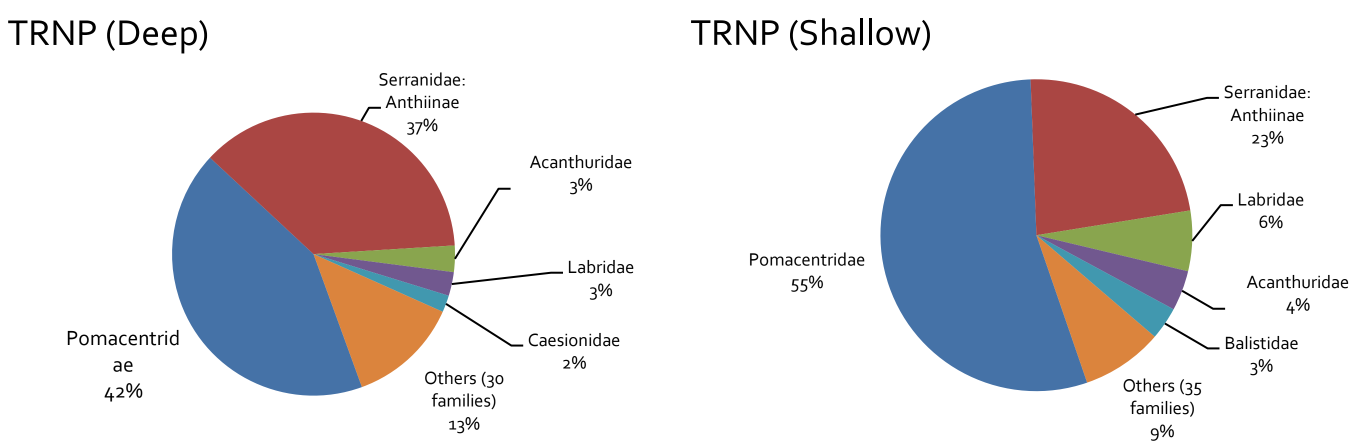

Figure 9. Relative contribution of fish density per Family in deep and shallow stations in TRNP.

Biomass of Reef Fishes

Reef fish biomass in deep stations of Tubbataha Reefs Natural Park (TRNP) is mainly represented by Family Acanthuridae (Surgeonfishes) and Carangidae (Trevallies), while shallow stations are represented by Family Balistidae (Triggerfishes) and Carangidae (Figure 10). Mean biomass of fish community in deep stations (179 mt/km^2) is relatively higher than in shallow stations (124 mt/km^2) of TRNP (Annex 6). In addition, the estimated fish biomass in both deep and shallow stations fall in very high level (>40 mt/km^2) based on categories suggested by Nañola et al. (2004) (Annex 3).

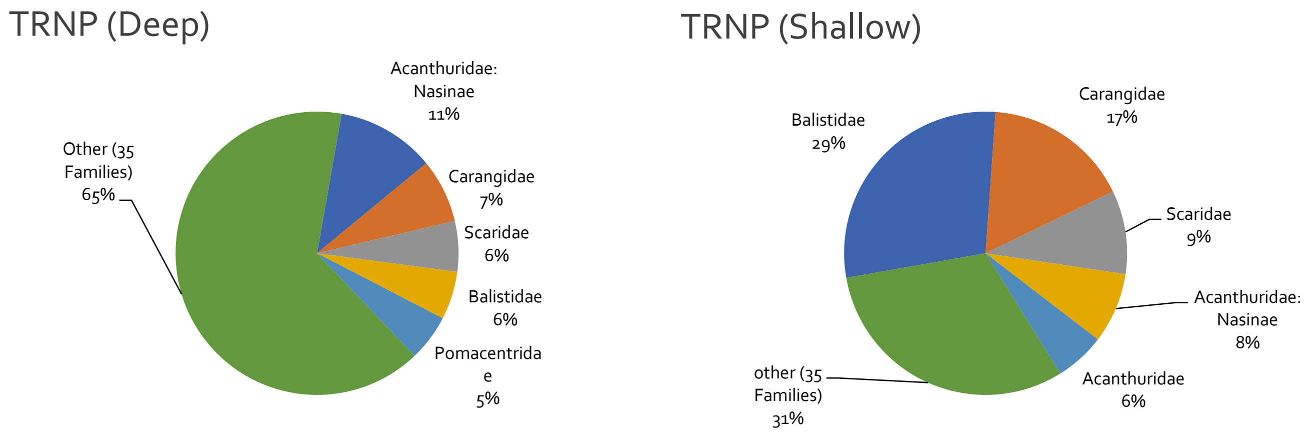

Figure 10. Relative contribution of fish biomass per Family in deep and shallow stations of TRNP.

Temporal Patterns of Fish Community

Annual Patterns of Fish Biomass

Changes in fish biomass were noted annually from 1999 to 2017 to detect fluctuations of mean biomass. Figure 11 shows that temporal patterns in mean biomass of reef fishes were variable, with annual mean biomass lower than the overall average biomass (black line) observed in the year 2003 to 2006, 2010, 2013 to 2014, and 2016 to present. In general, all sites in the present survey exhibited a declining pattern with reference to 2016 estimates, with sites in Malayan Wreck, Seafan Alley and Ko-ok contributed greatly to the observed decline.

Sources of fluctuations of annual mean reef fish biomass may be due to observer biases since data readers across the years were variable and may not have the opportunity to standardize size and count estimates, thus, the observed significant difference and high deviation values as reflected in error bars. Another is the presence or absence of highly mobile transient species (e.g. Caesionidae, Carangidae, subfamily Nasinae) in the reef which can be associated with feeding and spawning (Sale, 2002), and in some instances diver presence (Hawkins et al., 1997). In addition, a significant difference (two-factor ANOVA; $p<0.05$) in the observed fluctuations of mean reef fish biomass in TRNP is influenced by temporal variations rather than spatial or between sites (Annex 8).

Mean reef fish biomass in TRNP is largely represented by reef fishes observed in deep stations (red line) as opposed to shallow stations (Figure 12). Polynomial trend line was used to identify annual patterns of reef fish biomass between depths in TRNP, and it shows that both deep and shallow stations follow the same fluctuating patterns with lowest mean biomass recorded in the year 2004 and 2014. In general, fish biomass observed in shallow stations is relatively lower than in deep parts of the reef.

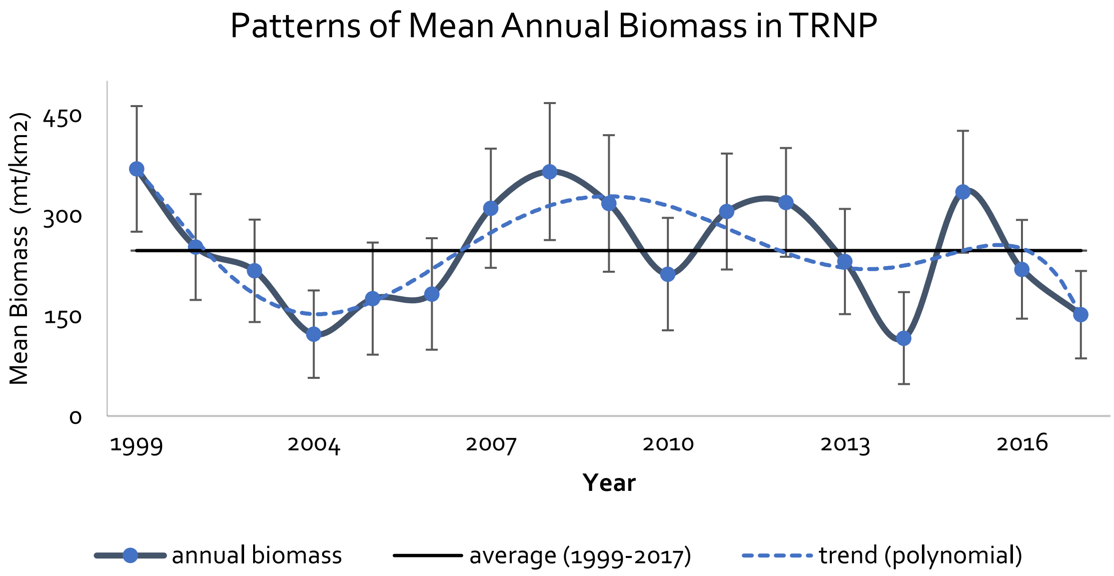

Figure 11. Temporal patterns of reef fish mean biomass (mt/km2) in TRNP.

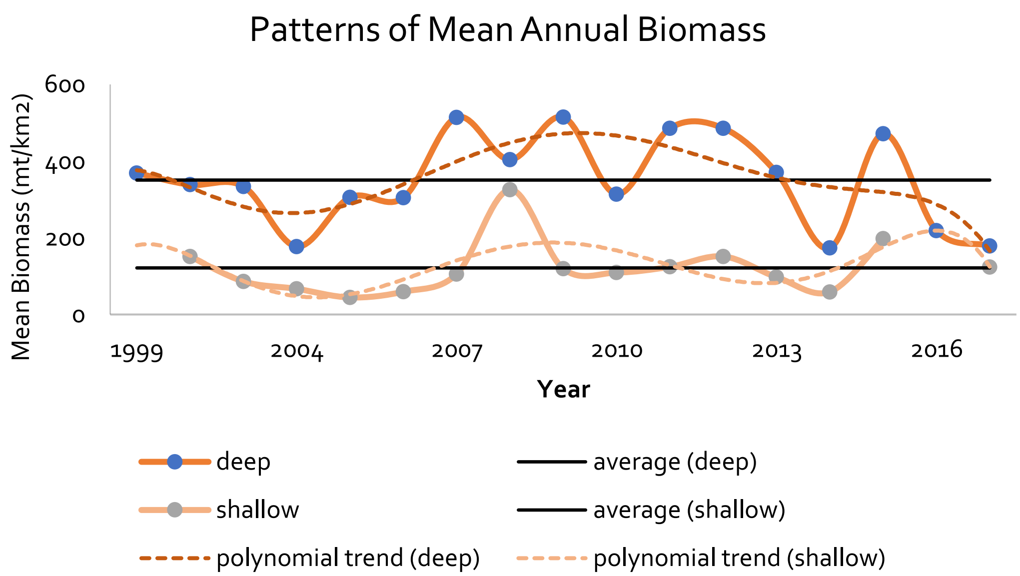

Figure 12. Temporal patterns of reef fish mean biomass (mt/km2) in deep and shallow stations in TRNP.

Patterns of Fish Biomass and Density

There is an observed declining pattern in fish mean biomass (mt/km^2) and mean density (ind/500m^2) since the year 2013 as indicated by a linear trendline (Figure 13). The lowest mean fish biomass was recorded in the year 2014 while the highest was observed the following year. The decline in fish biomass in the present year (2017) may be influenced by the observed decrease in abundance of large-sized (>30cm) red snappers (*Lutjanus bohar*) in most stations in the North and South atolls of TRNP where abundance of the species was recorded higher in the previous year. The observed declining pattern may be associated to feeding and predator avoidance (Helfman et. al. 2009), and in some instances, much larger seasonal migrations occur that are related to spawning and feeding that are depicted in the form of oscillatory movements (Bone and Moore 2008).

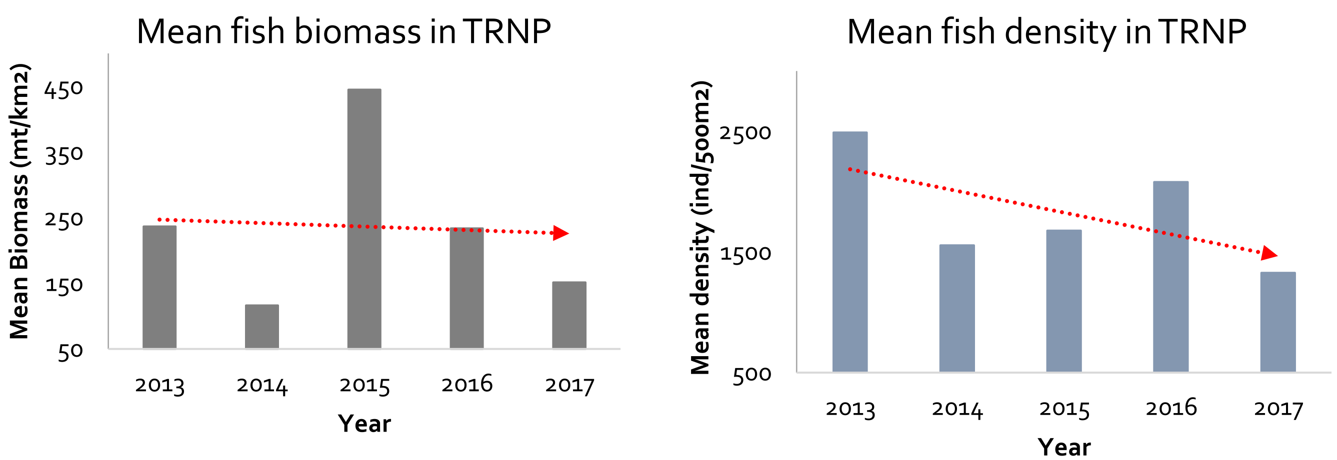

Figure 13. Patterns of mean fish biomass (mt/km2) and density (ind/500m2) from the year 2013 to 2017.

Pelagics and Demersals

Relative proportions of pelagic and demersal fish species were monitored since the year 2013. In this report, fish families that are considered pelagic species were Acanthuridae subfamily Nasinae (surgeonfishes), Carangidae (jacks and trevallies), Carcharhinidae (sharks), Caesionidae (fusiliers), Sphyraenidae (barracudas), and Scombridae (tunas and mackerels). Figure 14 shows the annual patterns of pelagic and demersal fish biomass from 2013 to 2017, and it shows an oscillating pattern with the highest projected estimate in the year 2015, particularly with demersal fish species. Estimates in the present assessment were comparable with the year 2014 for both demersal and pelagic fish groups, and is among the lowest biomass estimate.

In the present assessment, pelagic fish biomass was estimated at 35% of the total and is largely represented by families Acanthuridae subfamily Nasinae and Carangidae. This present estimate of pelagic fish biomass is relatively lower in comparison to 2015 assessment (46%). Alternatively, demersal fish biomass constitutes 65% of the total and is mainly represented by family Balistidae (triggerfishes) in the present assessment.

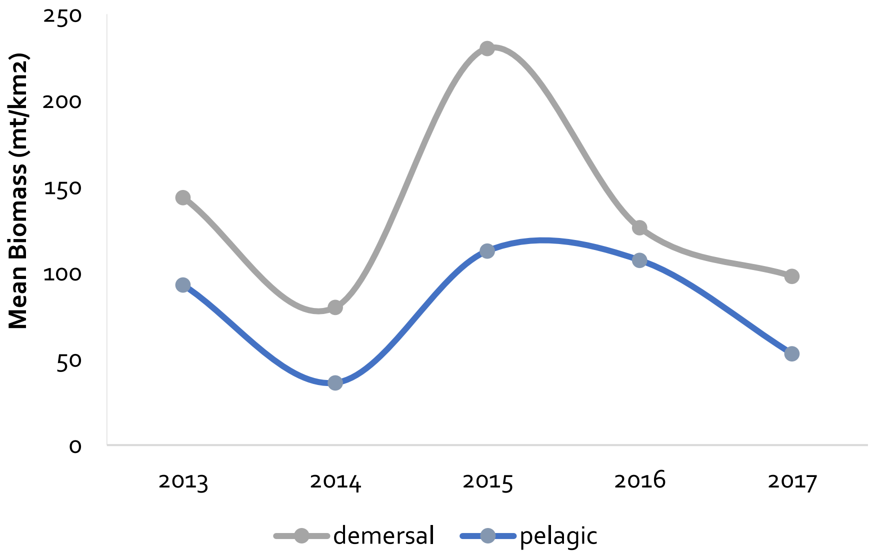

Figure 14. Mean biomass of pelagic and demersal fishes.

Fish groups: Indicator, Target, and Major

Fishing mainly decreases the biomass of target food fish or top trophic level species, after which the next dominant trophic level, such as herbivores, will be exploited in turn – a 'fishing down the web' concept popularized by Pauly et al. (1998). The establishment of no take zones or Marine Protected Areas (MPAs), such as TRNP, which are free from any form of resource extraction, is a management strategy to avoid the decreasing trend of capture fisheries by enhancing the biomass build-up of top trophic level species given years of continued reef protection (Russ and Alcala 1996).

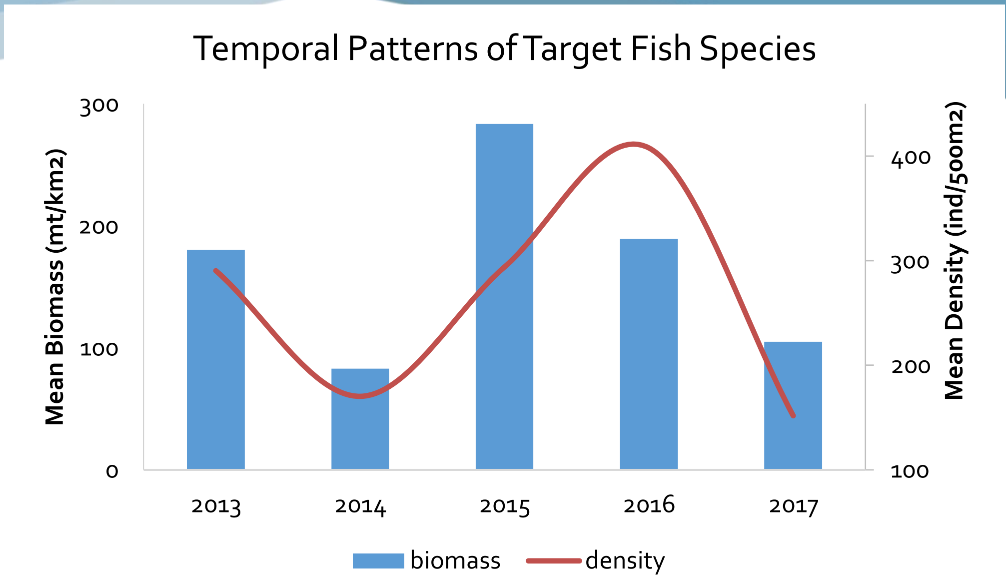

Figure 15. Temporal patterns of fishery targeted fish biomass (mt/km2) and density (ind/500m2) from 2013 to 2017.

In this light, the presence of top trophic level or fishery targeted fish species would serve as an indication of the positive impacts of reef protection. Figure 15 shows a fluctuating temporal trend of potential harvestable biomass and density of target species in TRNP from 2013 to 2017, with lowest recorded in 2014 and highest the following year (2015). In addition, differences in mean biomass estimates of reef fishes in TRNP between 2016 and 2017 assessment is not significant (t-test: $p>0.05$). The oscillating pattern in mean biomass and density of target species may be contributed by the same reasons cited above, such as: observer bias since the data have been collected by different observers thru time; and seasonal migrations associated with spawning and feeding (Bone and Moore 2008).

Target fish biomass of the present assessment constitutes 69.4% of total fish biomass and is largely represented by family Acanthuridae (Surgeonfishes) and Carangidae (Jacks and Trevallies). The relative proportion of target fish biomass estimated in the present assessment is relatively lower in comparison with the previous estimates (range: 76-81%). Despite this observation, target fish biomass in TRNP is comparatively higher than estimates of target fish biomass in a protected reef in Sablayan (61.1%), Occidental Mindoro (NACRE Report, 2015). In addition, major species constitutes 30% of the total fish biomass in TRNP and is largely represented by families Balistidae (Triggerfishes), Pomacentridae (Damselfishes), and Serranidae subfamily Anthiinae (Basslets/Anthias). Moreover, indicator species (1%) is mainly represented by Family Chaetodontidae.

Threatened Species

One of the benefits of reef protection is the restoration of ideal reef conditions of both benthic and fish communities, most notably, the presence and abundance of species listed in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Among the species of interest, the endangered (EN) Napoleon Wrasse (*Cheilinus undulatus*), was observed in all of the monitoring stations in the North and South Atolls of TRNP, with a total count of 39 individuals. However, no sightings were recorded on the mentioned fish species in Jessie Beazely Reefs. Species listed as vulnerable (VU), such as Humphead Parrotfish *Bolbometopon muricatum* (three individuals) and Blacksaddle Coral Grouper *Plectropomus laevis* (four individuals), were also observed around the survey areas of Malayan Wreck, Seafan Alley and Ko-ok. In addition, near threatened (NT) fish species observed in TRNP includes Leopard Coral Grouper *Plectropomus leopardus* (nine individuals), Brown Marbled Grouper *Epinephelus fuscoguttatus* (two individuals), Gray Reef Shark *Carcharhinus amblyrhynchos* (nine individuals), and Whitetip Reef Shark *Triaenodon obesus* (10 individuals). To mention, Highfin Grouper *Epinephelus maculatus* (one individual) was observed at Shark Airport during the 2016 census.

Other species listed in the IUCN Red List that were observed in Tubbataha Reefs during the conduct of the assessment were the endangered (EN) Green Sea Turtle *Chelonia mydas* and Whale Shark *Rhincodon typus*. The whale shark was observed in Jessie Beazley Reef.

Grounding Sites: Ming Ping Yu and USS Guardian

Reef fish density in deep stations of the grounding sites of Ming Ping Yu and USS Guardian is represented largely by Family Pomacentridae and Subfamily Anthiinae (Figure 16). The shallow station is represented largely by Families Acanthuridae and Labridae (Wrasses), while subfamily Anthiinae is not represented. This observed pattern in dominance may be due to the visually obvious poor cover of hard corals, particularly in USS Guardian. Mean reef fish density in deep (1011 ind/500m^2) is substantially higher than in shallow (707 ind/500m^2) stations (Annex 5), however, this observed difference is not significant (t-test; $p>0.05$). Alternatively, based on categories used by Nañola et al. (2014) for reef fish density, both deep and shallow stations of the grounding sites fall on moderate level (338.5-1133.5 individuals/500m^2) (Annex 3).

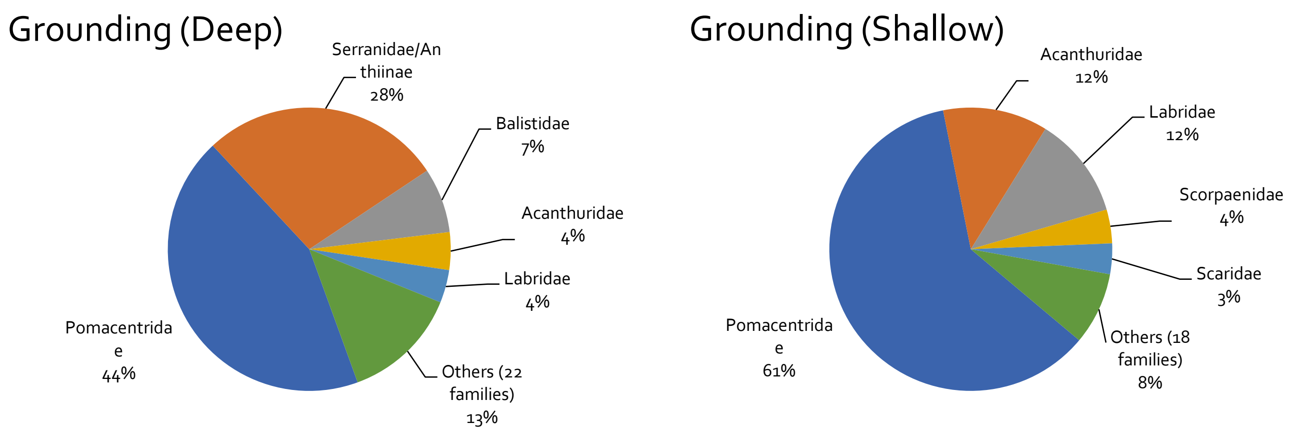

Figure 16. Relative contribution of fish density per Family in deep and shallow stations in the grounding sites (Ming Ping Yu and USS Guardian).

On the other hand, reef fish biomass in both deep and shallow stations of the grounding sites (Ming Ping Yu and USS Guardian) of TRNP is largely represented by Family Balistidae and Acanthuridae (Figure 17). Mean biomass of reef fishes in deep stations is significantly higher (t-test; $p<0.05$) than in shallow stations of the grounding sites. Further, mean biomass in shallow stations in the grounding sites (38 mt/km^2) falls under high level (21-40 mt/km^2) while deep stations (159 mt/km^2) (Annex 7) fall under very high level based in categories set by Nañola et al. (2004).

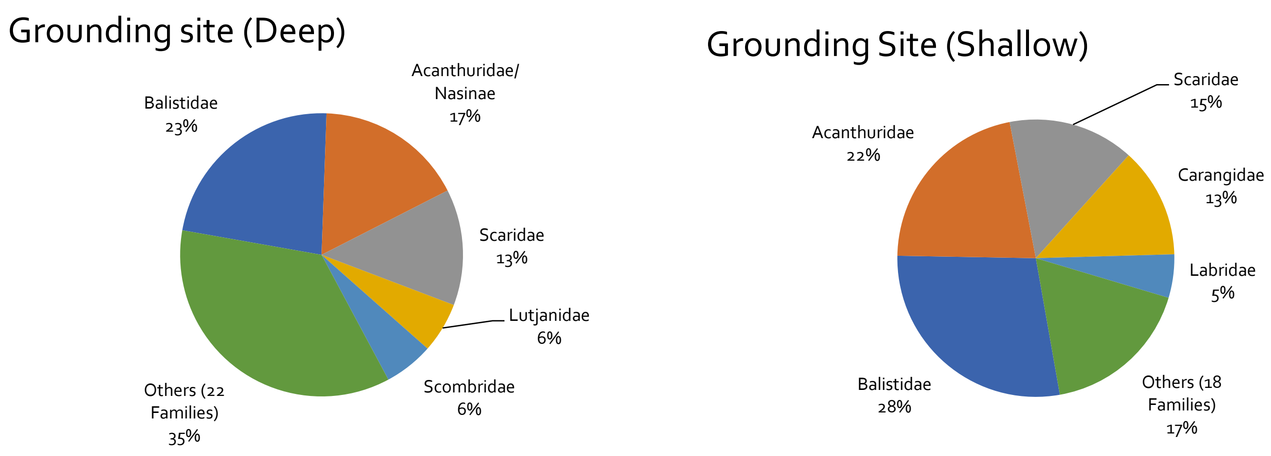

Figure 17. Relative contribution of fish biomass per Family in deep and shallow stations of grounding sites (Ming Ping Yu and USS Guardian) in TRNP.

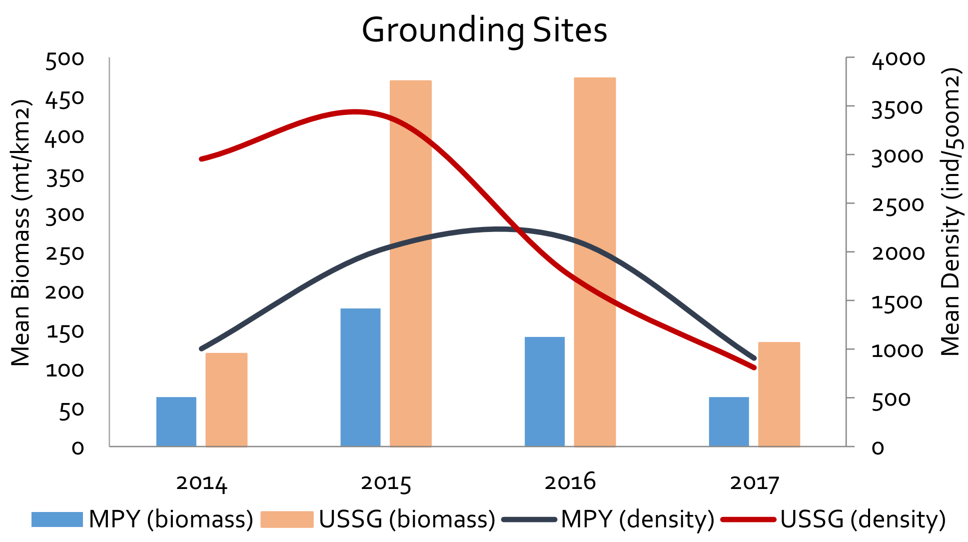

Figure 18. Temporal patterns of reef fish density (ind/500m2) and biomass (mt/km2) in Ming Ping Yu and USS Guardian.

In general, fish density (ind/500m²) and biomass (mt/km²) in USS Guardian grounding site is relatively higher than estimates in Ming Ping Yu (Figure 18). Temporal trend in these two sites follow the same pattern exhibited with the rest of the stations in TRNP. It is worth noting however, that both sites exhibit positive response to the continued reef protection as it shows an increasing trend until the year 2017. The decrease in fish density and biomass contributed by estimates in the present (2017) assessment may be due to the same factor brought about by observer bias, and migration patterns influenced by feeding and spawning (Bone and Moore 2008).

3.4 Conclusion and Recommendations

In summary, a total of 314 fish species belonging to 43 Families and Subfamilies were identified in Tubbataha Reefs Natural Park, with an estimated very high level of species density. Abundance of reef fishes was considered high, while fish biomass falls under very high level based on categories set to evaluate ecological health of coral reef fish communities. Target species biomass account for 69% of total, and is largely represented by Families Acanthuridae, Carangidae, Scaridae, Serranidae, and Lutjanidae. Oscillating trends in fish biomass is influenced by temporal rather than spatial variations. The presence of top trophic level species (sharks and jacks) in TRNP serve as indicator of the ecological balance of the reef ecosystem. A relatively high density of the endangered species *Cheilinus undulatus* was observed in North and South Atolls but not in Jessie Beazely Reef. The presence of adult sized vulnerable species of *Bolbometopon muricatum* and *Plectropomus laevis*, and the near threatened *Plectropomus leopardus* were also observed.

Temporal patterns in reef fish biomass in the grounding sites show an increasing trend until 2017, when a decrease was recorded. This trend may be influenced by observer bias or may be due to feeding and spawning patterns of reef fishes.

The observed high proportion of target fish species biomass and the presence of endangered and near threatened fish species serve as indication of the positive impacts of a strictly enforced protected reef. Ecotourism serve as integral part of the marine park project for financing operations, but should be well regulated and monitored. It is also recommended to maintain standardized assessment of the conduct of fish visual census among observers to prevent observer biases.

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4 SEABIRD COMMUNITY

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4.1 Overview

Seabirds are marine predators who occupy the upper trophic level in marine food webs. They are present in all marine ecosystems and oceans of the world, from coastline to pelagic and open seas. Seabirds feed on a wide range of marine organisms, from zooplankton to relatively large fish and squid. Thus, they are good indicators of the health of our oceans.

In TRNP, seabirds were identified as one of the biological indicators of management effectiveness. Since 2004, their population and habitat have been monitored regularly by marine park rangers, volunteers and consultants. This chapter presents the results of the 2017 second quarter monitoring, with additional discussions on data collected by marine park rangers during their quarterly monitoring and monthly distance counts.

4.2 Methods

The field work followed methods established in 2004 and used since (Annex 12 and Annex 13). South Islet was only visited in the morning of 9 May, from 8.30am to 12.00 noon, due to limitations imposed by the tides. Three inventory teams surveyed sequentially in South Islet. The team camped overnight at Bird Islet on 10 to 11 May in order to carry out optimal work.

The counts of the breeding bird populations represent a combination of count methods. These includes direct day-time inventories of adults, immatures, juveniles, pulli, eggs and nests. 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 9 May at South Islet (Annex 15) and on 10 May at Bird Islet (Anex 14). Major equipment used were handheld binoculars (10 x 50), spotting scope (20 x), GPS and cameras.

A count of dead birds and autopsies on sample individuals were done. The field team also removed debris from the islets.

Calculation of breeding populations

The methods used to calculate the seabird populations followed the previous years' approach:

- day time direct counts of birds, nests and eggs;
- in-flight data of Red-footed Booby *Sula sula*, Brown Booby *Sula leucogaster*, Brown Noddy *Anous stolidus*, and Black Noddy Noddy *Anous minutus* ;
- early morning (5 am) count of Brown Boobies at the 'Plaza';
- count of Great Crested Tern *Thalasseus bergii* along the shoreline at high tide;

The result of the fieldwork is compared with data sets from the second quarter of the previous years; data sets gathered by MPRs and the annual inventory teams from 2004 to 2017, and by WWF Philippines from 1998 to 2004. The data sets until 2013 were analyzed in detail by Jensen and Songco (2016) and published in the Journal of Asian Ornithology (FORKTAIL 32 (2016): 72–85). Other analyses are found in the 28-year seabird population development report released in 2009 and in the 2004 to 2006 and the 2010 to 2017 seabird field reports (see Jensen 2004 to 2006 and 2009 to 2015, and Jensen et al. 2016).

Calculation of land area and vegetative cover

Photos were taken of permanent photo documentation sites in Bird Islet and South Islet (Annex 18). These sites were established in 2004 in order to measure changes in land area and in vegetation. GPS readings were taken measuring the land area at high tide of both Bird Islet and South Islet.

Vegetative cover was monitored by conducting a census of the condition of trees on the islets. Trees, mostly *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 2017 was carried out using the same methodology as all other years, except in 2013, and the trend over time is therefore comparable.


Teri Aquino

4.3 Results and Discussion

Monitoring of Changes in Land Area

Independent sets of measurements were taken using two separate GPS units. The measurements were taken at high tide along the shoreline as the vegetation line previously used as reference has disappeared. Due to this shift in methodology, data sets from 2016 onwards may not be comparable to the previous years'.

Bird Islet: Overall, the land area has decreased by 18.4%; from 18,760 m^2 in 1981 (Kennedy 1982) to about 15,307m^2 in 2017 (Table 4). From 2004, the first year when GPS was used to measure the islets, the decline in the land area has been 10% each year.

The circumference of the islet measured along the high tide line is 586 meters, or about the same is in 2016. The land area was measured to be 15,307 m^2 or 342 m^2 smaller than in 2016. The area of 'Plaza' was 6,704 m^2, suggesting a substantial expansion of 2,191 m^2 compared to 2016 data (4,513 m^2). The expansion area, however, is the now denuded former beach forest area. Erosion along sections of the northeastern coastline, first noted in 2012, has continued although in a much smaller scale since 2016.

Table 4. Approximate changes in the land area of Bird Islet from 1911 to 2017. Source: Worcester 1911, Kennedy 1982, Heegaard and Jensen 1992, Manamtam 1996, WWF Philippines 2004 and Tubbataha Management Office 2004 to 2017

Year	Land area (length x width)/circumference (m)	Land area (high tide) (m^2)	Open area ("Plaza") (m^2)	Major sandbars position and condition	Erosion area
1911	400 x 150	60,000	No data	>40,000 m^2 (?)	No data
1981	268 x 70	18,760	18,000	NW, SE	South coast
1991	>220 x 60	> 13,200	>8,000 (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 SE : Decrease	South coast
2005	No data	15,987	>4,000 (est.)	NW, SE: Stable	South coast
2006	No data	14,694	7,900 (est.)	NW, SE: Stable	South coast
2007	No data	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	Northeast coast
2012	590	12,494	3,892	NW: Stable SE : Stable	Northeast coast
2013	548	10,955	4,840	NW: Decreasing SE : Stable	Northeast coast
2014	503	>10,220	4,124	NW: Decreasing SE : Stable	Northeast coast
2015 [1]	<561	<13,408	3,279	NW: Stable SE : Stable	Northeast coast
2016 [2]	590	15,649	4,513	NW: Disappeared SE : Decreasing	Northeast coast
2017 [3]	588	15,307	6,704	NW: Disappeared SE : Decreasing	Northeast coast

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

Note 2: Measurement approach changed from measurement along shore vegetation line to measurement along the high tide line. Data can therefore not be compared.

Note 3: Expansion in Area of Plaza is due to inclusion of former forested areas

South Islet: South Islet was originally part of a large sandbar until a circumferential concrete seawall was constructed in the 1980s (Kennedy 1982) to accommodate a lighthouse. Based on photographic evidence, the land area remained the same at least until 1981 (Kennedy 1982). In 1991about 1/3 of the seawall had collapsed and was partly submerged (Heegaard and Jensen 1992).

The circumference of the islet was measured to be 240 meters or about the same as previous years (247 meters in 2016). Also the land area, 2,980 m² had remained the same since May in 2016. Continued deterioration of the remaining seawall was noted.

Monitoring of Changes in Habitats

Overall, the combined baseline data (from Bird islet and from South Islet) shows a baseline around 2009 and 2006 of around 355 trees, generally in a very good condition (229 trees on Bird Islet and 125 trees on South Islet). In 2017 the number of trees had fallen to a total of 59 trees or just below 18% of the original beach forest.

Although the rapid decline in vegetation cover had continued it was also noted that a shift from El Niño to La Niña events brought more rainfall to the islet, consequently the remaining trees again had leaves in May 2017.

Bird Islet: The vegetation in 2017 consisted of 39 trees of bush-height compared to 110 trees in 2016 (Figure 19). The baseline was 229 trees measured in 2006. Only 16 seedlings were found. Of the 39 trees including seedlings found in May 2017, only 13 trees and seedlings were in a fairly good condition. Hence, the prospect of the beach forest recovering on its own within a short time period is bleak.


Steve De Neef

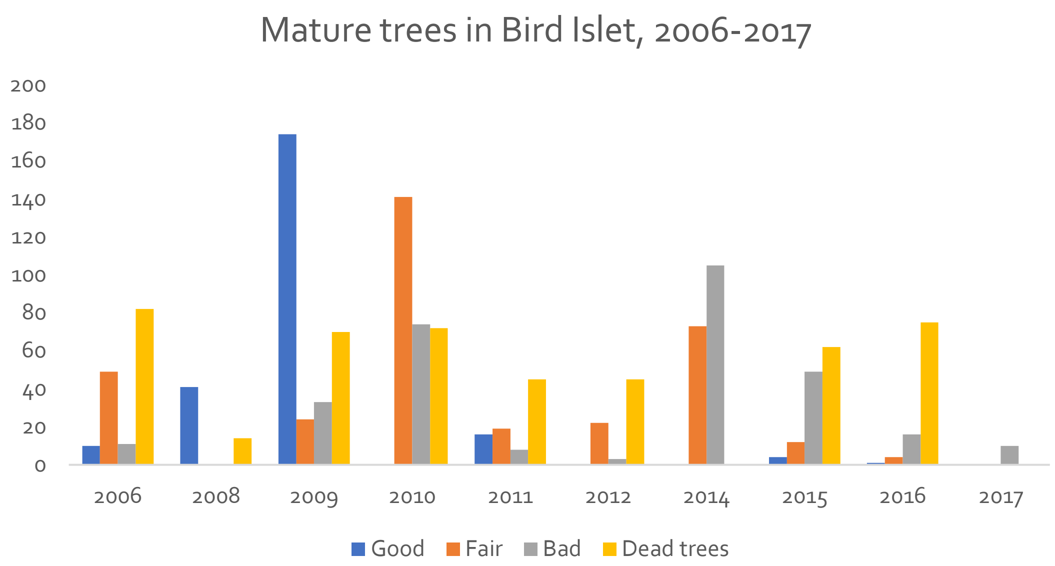
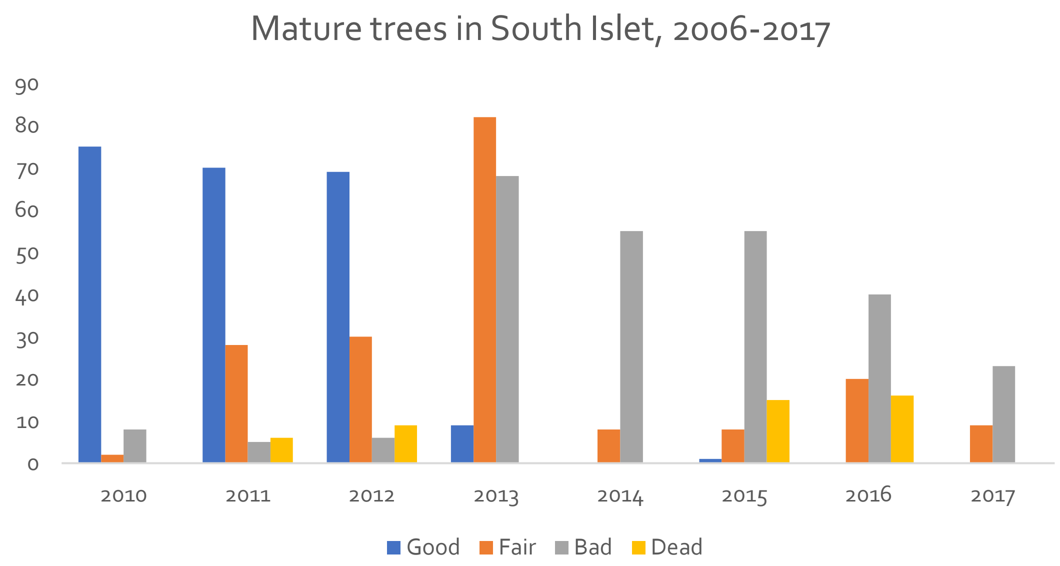


Figure 19. Status of vegetation in Bird Islet from 2006 to 2017.

South Islet: Until 2009, the beach forest comprising of about 125 trees was in an optimal condition, with several trees as high as about 30 feet.

In 2017, a total of 32 trees excluding seedlings or 27% fewer than in 2016 were recorded (Figure 20). No trees were found to be in good condition, and just eight seedlings were found. The number of trees in a severe deteriorating condition represented 61% of all vegetation surveyed.



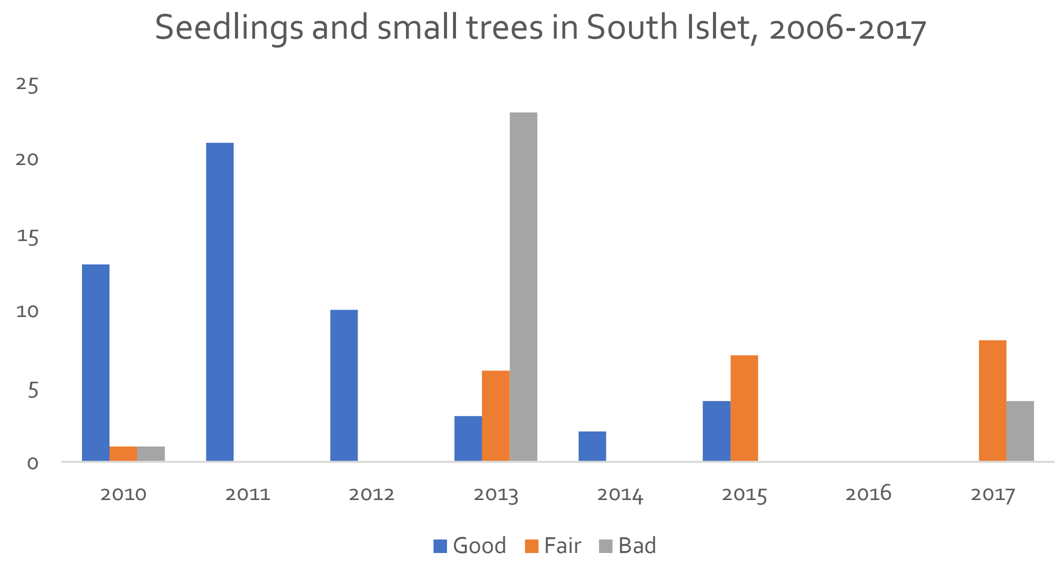


Figure 20. Status of vegetation in South Islet from 2010 to 2017.

Review of MPR Monitoring Data

Since the externally-assisted avifauna inventory in May 2016, MPRs made only two inventories using the direct count methods (Annex 16). The inventories included in-flight counts in November 2016. No direct counts were carried out in the first quarter of 2017. This is unfortunate as egg counts in the first quarter of the year often represents the most reliable data determining the annual breeding population of Sooty Tern.

Contrary to the reduced number of inventories, the MPRs had increased the number of distance counts at both Bird Islet and South Islet to 11 counts, or one count every month. One count estimate was undertaken at Jessie Beazley Reef on 27 November 2016.

The data gathered were generally consistent with the previous year's results. However, the results of the surveys revealed some important new observations (Table 5).

Table 5. Selected results of MPR distance counts from June 2016 to April 2017

Species	Bird Islet	South Islet	Jessie Beazley
Red-footed Booby	Highest count estimate of 2,500 individuals on 15 March 2017	Highest count estimate of 730 individuals on 12 October 2016	
Brown Booby	High number of nests and eggs on 17 November 2017 (737 nests and 356 eggs). Relative high estimates of adults in February (1,500) and March (2,200)	No breeding population	
Great Crested Tern	Present from 15 February 2017	No breeding population	
Sooty Tern	4,200 adults estimated on 15 February, indicating start of breeding season on January 2017	No breeding population	
Brown Noddy	A high number (1,200) of breeding population present on 15 February 2017). This is seasonally a very early presence	Present from 23 March 2017	More than 800 individuals as late as 27 November 2016
Black Noddy	300 adults on 15 February 2017. As in 2016, seasonally a very early presence.	2,300 adults present from 17 February 2017. As in 2016, a very early arrival.	1,700 individuals as late as 27 November 2016

A total of 34 species of birds were identified during the inventory (Annex 17). Of these, the Oriental Plover *Charadrius veredus*, rare in the Philippines, Common Redshank *Tringa totanus*, Terek Sandpiper *Xenus cinereus*, and Gull-billed Tern *Gelochelidon nilotica* were new records for TRNP. The total number of avifauna species recorded in TRNP is now 115 species.

Ten of the species can be classified as pelagic or coastal-living seabirds. Of these, seven species breed or attempt to breed in TRNP: the Masked Booby *Sula dactylatra*, Red-footed Booby *Sula sula*, Brown Booby *Sula leucogaster*, Great Crested Tern *Thalasseus bergii*, Sooty Tern *Onychoprion fuscata*, Brown Noddy *Anous stolidus* and Black Noddy *Anous minutus*. Other breeding species are the Pacific Reef Heron *Egretta sacra* and the Eurasian Tree Sparrow *Passer montanus*.

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

A total 37,218 adult individuals of six breeding and one attempting to breed species were recorded; 30,414 individuals on Bird Islet and 6,804 individuals on South Islet (Table 6). Bird Islet hosted about 82% (73% in 2016 and 78% in 2015), and South Islet hosted 18% (27 % in 2016 and 22% in 2015).

The total result of the May count in 2017 is about 4% lower than in 2016 and in 2015 (38,911 individuals) and represents, together with the results from these two years, the highest count of avifauna from TRNP (Annex 11). The combined population of all breeding seabirds in 2017 was 175% higher than the first inventory conducted in 1981 (Kennedy 1982). The high count result is mainly due to a substantial increase in the numbers of Great Crested. In summary, the count results for 2017 showed:

- A decrease in the number of adult Red-footed Booby to the 3rd lowest number recorded in May since the species started to breed in large numbers on Bird Islet in 2004.
- A continued increase in the population of Brown Booby to the highest number of adults since the baseline inventory by Kennedy in 1981. The adult population in 2017 was 6% lower than in the baseline (3,768 individuals).
- Increased breeding population of Great Crested Tern to the highest number ever recorded.
- As in 2015, the breeding season of Sooty Tern started in February.
- An extraordinary increase in the population of Brown Noddy, both on Bird Islet and South Islet, to the highest number of adults ever counted. A very early breeding start, on February or March, took place as evidenced by the presence of more than 200 pulli during the inventory period.
- A continued decrease in number of Black Noddy nests corresponding to the decline in the number and condition of trees.

- On South Islet, about 27% of all nests were found on the ground or at ledges. Despite this remarkable change in breeding behavior, without the trees the species may largely be wiped out from TRNP.

Table 6. Total count numbers of adult resident seabirds present on Bird Islet and South Islet 8 to 12 May 2017.

	Bird Islet	South Islet	Total
Masked Booby *Sula dactylatra*	1	0	1
Red-footed Booby *Sula sula*	870	1,217	2,087
Brown Booby *Sula leucogaster*	3,535	(42)	3,535
Great Crested Tern *Thalasseus bergii*	17,097	(39)	17,097
Sooty Tern *Onychoprion fuscata*	5,098	0	5,098
Brown Noddy *Anous stolidus*	3,004	1,205	4,209
Black Noddy *Anous minutus*	809	4,382	5,191
Total	**30,414**	**6,804**	**37,218**

Species Account of Breeding Birds

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 Annex 10. The combined results of the adult populations and their development over time at the two islets are shown in Annex 11 and percentages of in-flight populations of Red-footed Booby, Brown Booby, Brown Noddy and Black Noddy are shown in Annex 14 and Annex 15.

Masked Booby: On 11 May an adult male was again found in the main colony of Brown Booby at the 'Plaza". It is assumed to be the same bird that was recorded on the very same date in 2016. Since 2016 the species has occupied at least one patch within the territory of the Brown Booby, where it first incubated a Brown Booby egg alternately with a female Brown Booby. Later it was observed feeding the off-spring.

Red-footed Booby: The total population in May 2017 was 2,087 adult individuals and just slightly lower than in 2016 (Figure 21). However, compared to 2014, the baseline year for this species, the population is lower by over 14% which correlates with the reduced breeding habitat due to the massive decline in available nesting and roosting trees. Correspondingly, the number of nests, pulli and juveniles recorded were the lowest since the 2014 baseline year (Figure 22).

Of the population found in May 2017, about 42% where found on Bird Islet and 58% on South Islet compared to 70% that were found on South Islet in 2016. The reduction in South Islet reflects the decrease in vegetation necessary for breeding and roosting.

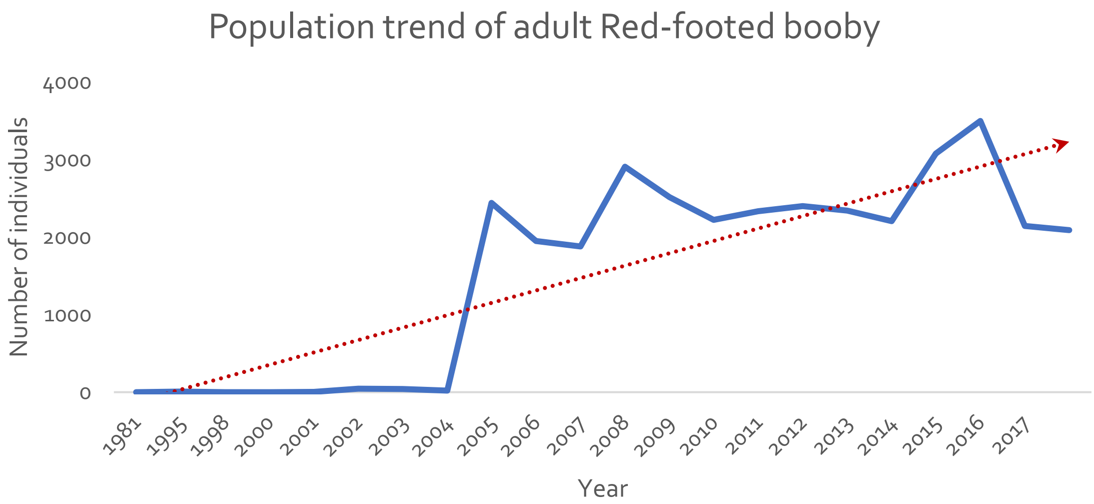


Figure 21. Population trend of adult Red-footed Booby from 1981 to 2017

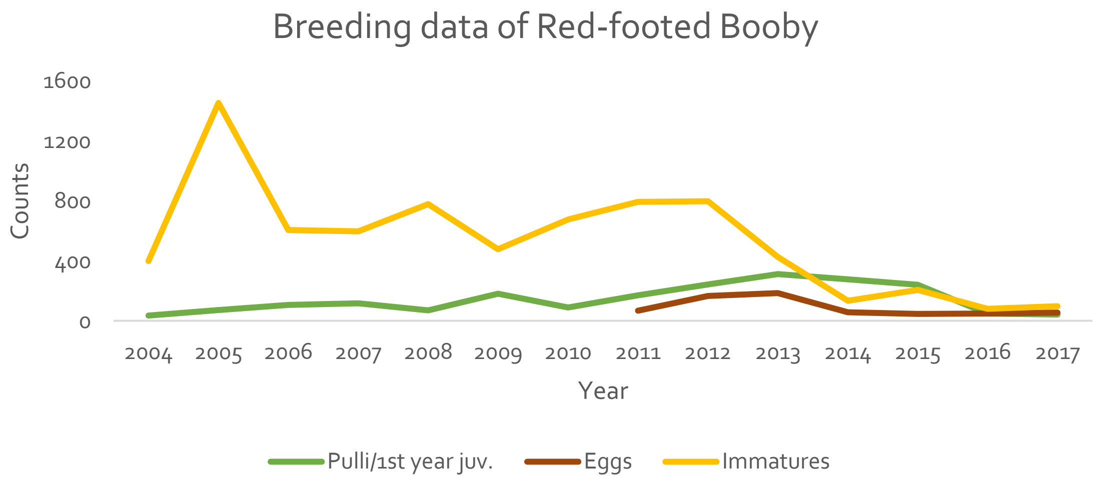


Figure 22. Breeding data of Red-footed Booby from 2004 to 2017

Brown Booby: The May inventory resulted in a total count of 3,535 adults or 13% higher than in 2016 (Figure 23). It is the highest number counted since the baseline year of 1981 (Kennedy 1982) and just 6% lower than the baseline figure of 3,768 individuals (Annex 11). A high number of adults was also observed by MPRs in March and April 2017. In 2017, the species was found breeding only on Bird Islet.

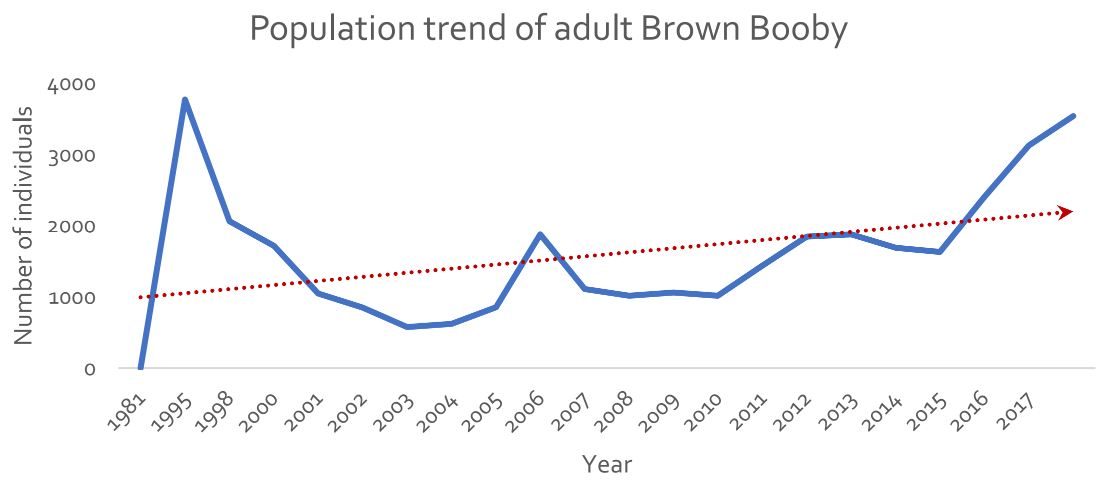


Figure 23. Population trend of adult Brown bobby from 1981 to 2017.

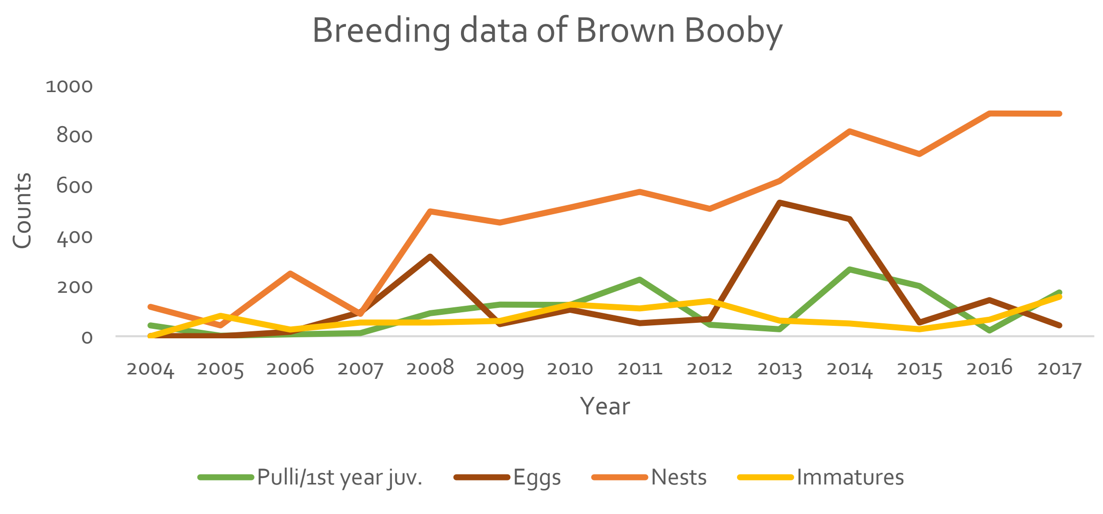


Figure 24. Breeding data of Brown booby from 2004 to 2017.

The species continues to be highly reproductive as evidenced by the presence of 887 nests, the highest number of nests counted over time (Figure 24). The number of nests was at par with the counts of 2016, which showed the highest number of nests recorded since regular inventories started in 1997.

Also, the number of pulli was high compared to the previous years. 2017 yielded the highest number of immatures ever recorded as well. The number of eggs, however, was were very low, and combined with the number of eggs, pulli and first years juveniles (215 individuals) is lower by 41% compared to 2016 (Figure 24).

From 13 August to 22 December 2016, a total of 331 Brown Booby banded on Bird Islet from 2006 to 2009, were recaptured. Of these, 195 were banded as adults and 133 individuals as pulli. The birds banded as pulli are now from eight to eleven years old. The lifespan of a Brown Booby may reach 25 years (Hennicke et al. 2012).

Table 7. Results of ring readings of Brown Booby on Bird Islet from 13 August to 22 December 2016

Year	Adult	Pulli	No Data	Total
2006	51	24	3	
2007	82	43		
2008	25	57		
2009	37	9		
Total	195	133	3	331

Brown Noddy*:* The population in May 2017 showed an unprecedented increase of over 100% from May 2016 - from 2,096 to 4,209, or an increase of 2,113 adults (Figure 25). The May 2017 population represents the highest number ever recorded and was 97% higher than the baseline population of 2,136 individuals counted in 1981 (Kennedy 1982) (See Figure 25). The largest population increase of 1,654 individuals or 123% occurred on Bird Islet. In South Islet, a significant population increase took place, from 746 individuals in 2016 to 1,205 individuals in May 2017.

The 1,917 nests and correspondingly eggs were also the highest number ever counted. Likewise, with the number of pulli (Figure 26). As in May 2016, an unusually high number of pulli were found in May 2017 totaling 223 pulli, or more than double the numbers in 2006 (Figure 26). It would therefore be the third consecutive year where the start of the breeding season was early, starting in March.

The presence of more than 800 Brown Noddy at Jessie Beazley Reef on 27 November 2016 falls within the normal departure period for this species from TRNP.

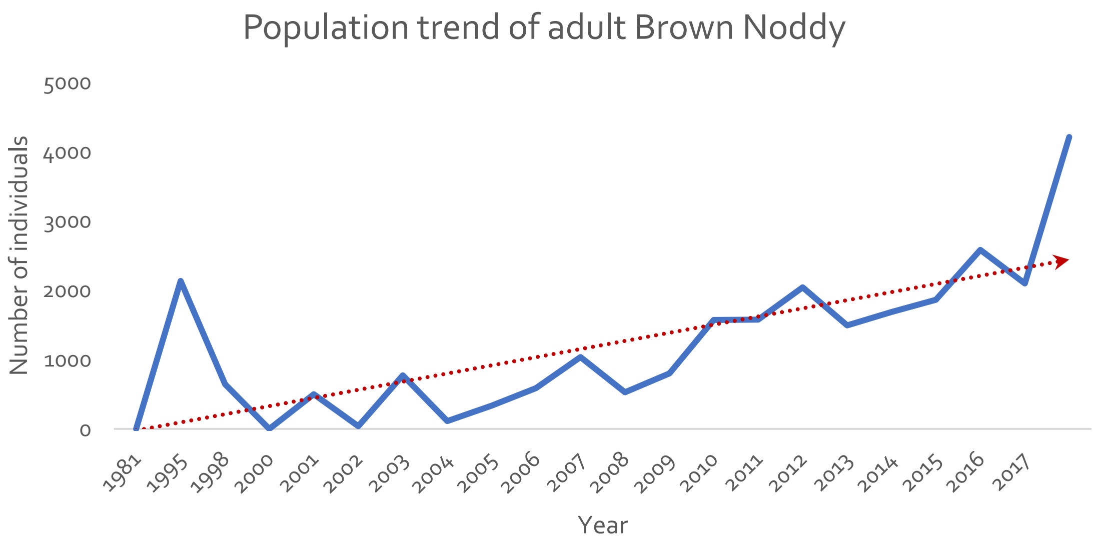


Figure 25. Population trend of adult Brown noddy from 1981 to 2017.

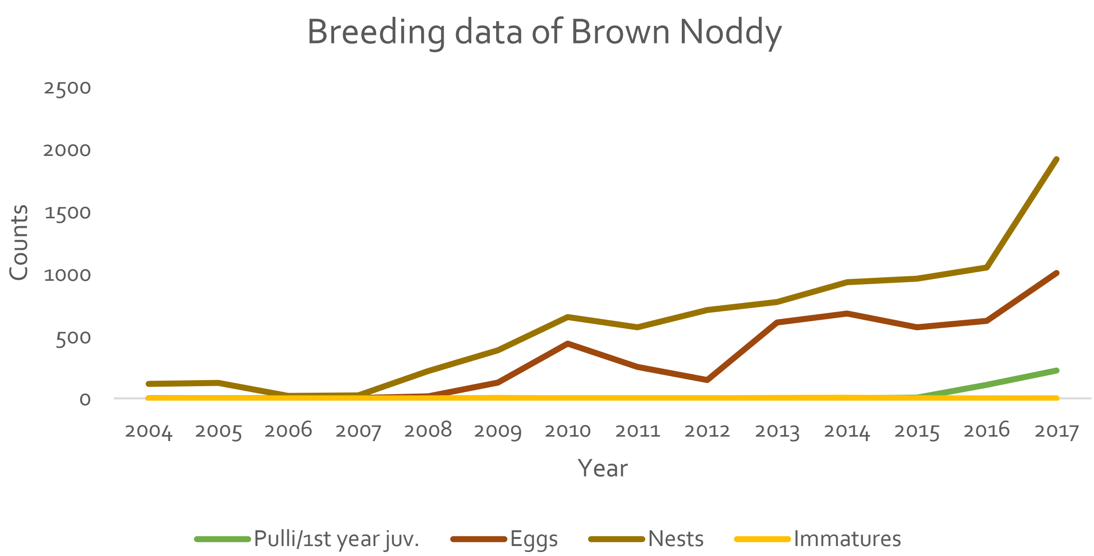


Figure 26. Breeding data of Brown noddy from 2004 to 2017.

Black Noddy: A total of 5,191 adult individuals were counted compared to 8,918 birds in 2016. This represents a 42% decline in the adult population of this species. Compared to the peak count in 2013 (10,656 adults), less than 52% of the breeding population was present in May 2017 (Figure 27). The populations were distributed between the South Islet, where more than 84% of the birds were found (91% in 2016), and the Bird Islet, with 16% present. This remains among the lowest number ever recorded in Bird Islet. In 2014, 24 % and in 2015 31% and in 2016 9% of the population was found on Bird Islet. The decline in the Black Noddy population on both islets corresponds to the decline of the vegetative cover (Figure 19). The number of nests, 152 nests on Bird Islet and 1,053 nests on South Islet, were similarly the lowest since 2006 (Figure 28).

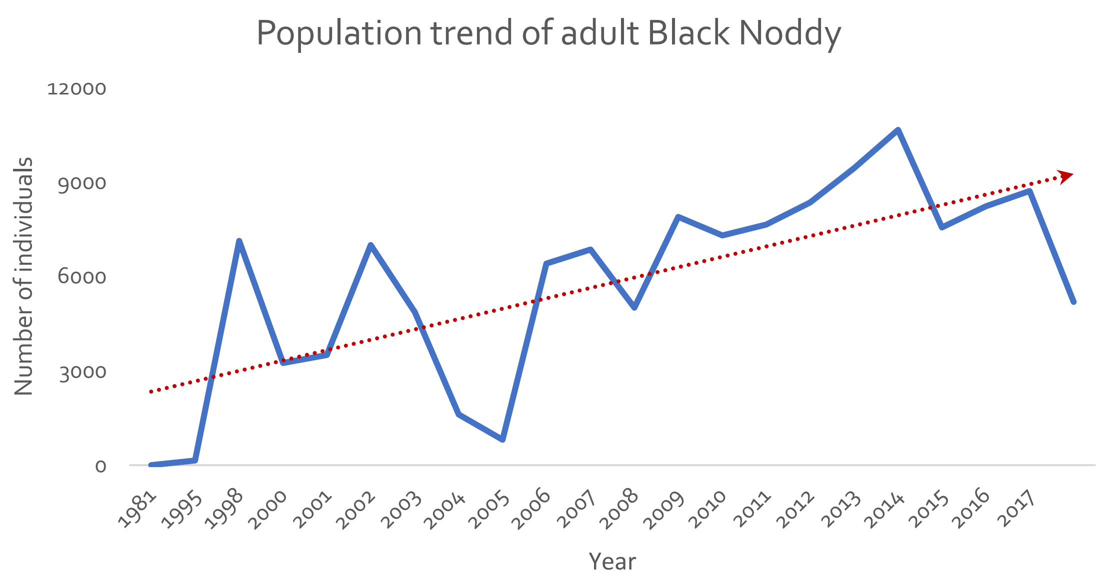


Figure 27. Population trend of adult Black noddy from 1981 to 2017.

Since May 2015, the first time the species was recorded breeding on the ground on both islets, an increasing number of nests were found on the ground around and at the roof and stairs of the Lighthouse on South Islet. A total of 287 nests were found in these locations, which are not normally preferred by this species.

In 2016 and 2017 only 19 % and 25%, respectively, of the adult population present, could breed due to lack of breeding trees and foliage for nesting materials. As most of the remaining trees are projected to die within a few years, only a fragment of the adult population could continue to reproduce. Consequently, with an average life span of about 10 years (Dewey 2009), the continued breeding failure could lead to a 75% decline in population over the next 10-year period. However, this projection is based on current vegetative conditions and with no further decline in vegetation and on other factors that impact the number of mature individuals.

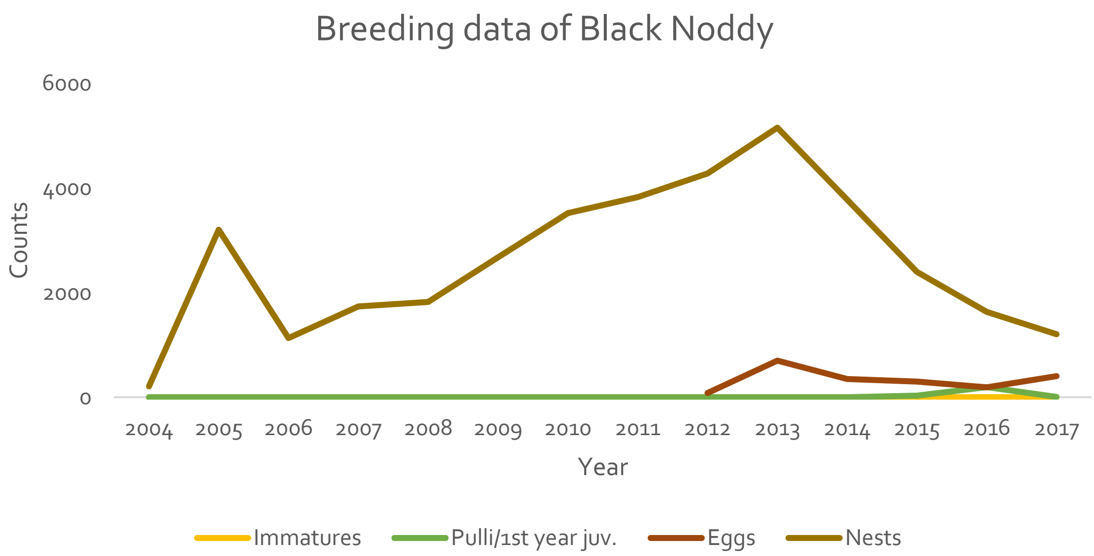


Figure 28. Breeding data of Black noddy from 2004 to 2017.

As in 2016, a very early presence of the species, e.g. 2,300 adults present on 17 February, was observed in 2017. However, in May only eggs were found, indicating that active breeding started only in April. As late as 27 November 2016, the end of the breeding season, 1,700 individuals were recorded. Normally, nearly the entire breeding population would have left TRNP at this late date.

Great Crested Tern: The population growth noted since 2011 continued in 2017. The breeding population on Bird Islet reached a new high of 17,098 adult birds. There was a 25% (3,460 individuals) increase in the population compared to 2016. This is higher than the 12% increase observed from 2015 to 2016 (Figure 29). As in May 2015 ,the population was in an active egg-laying stage. More than 8,600 eggs were counted on Bird Islet (Figure 30). No birds were found breeding on South Islet.

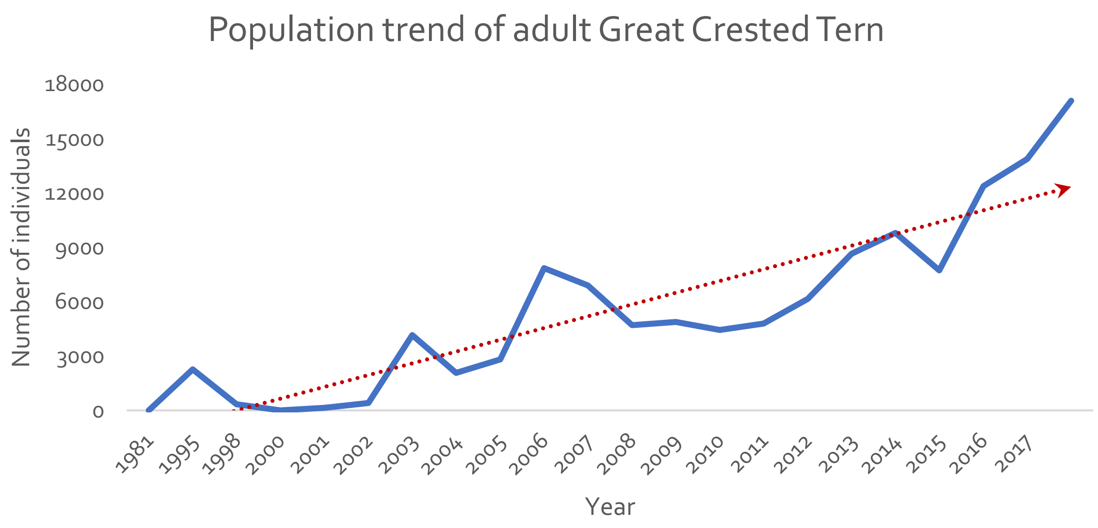


Figure 30. Population trend of adult Great crested tern from 1981 to 2017.

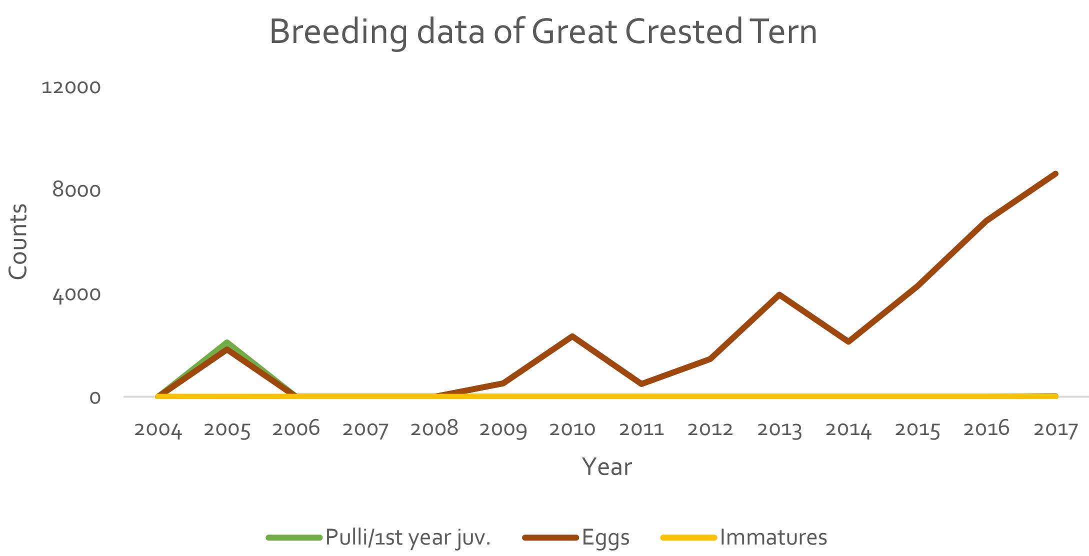


Figure 29. Breeding data of Great crested tern from 2004 to 2017.

Sooty Tern: A total of 2,549 juveniles corresponding to 5,098 adults, or over 40% fewer adult birds than in 2016, were found on Bird Islet (Figure 31 and Figure 32). No eggs were observed. However, distance counts of 26 April 2017 showed about 4,200 juvenile birds, indicating that a substantial number of the juveniles left Bird Islet prior to the May inventory. Therefore, it is likely that the inventory result does not reflect the total adult population breeding in 2017.

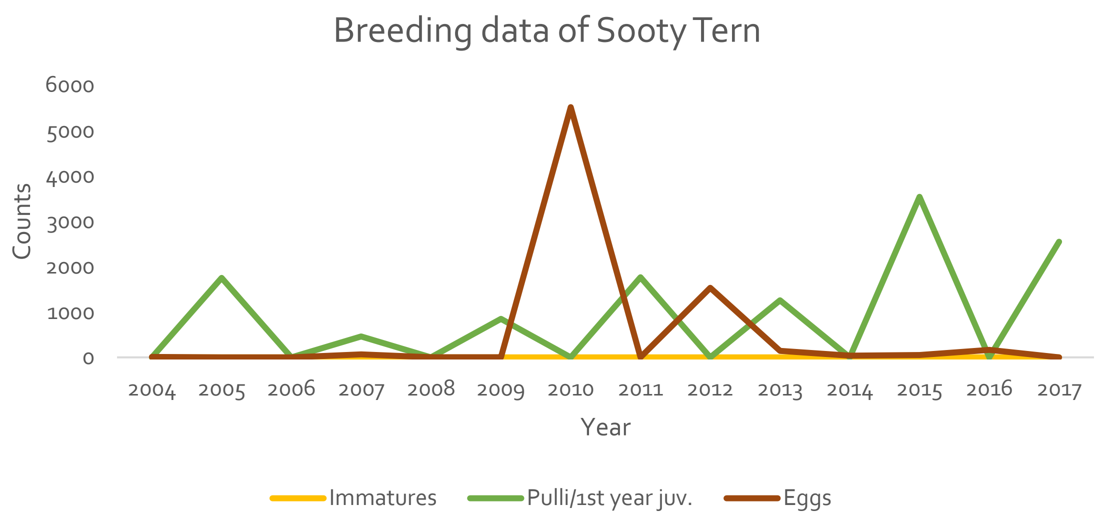


Figure 31. Breeding data of Sooty tern from 2004 to 2017.

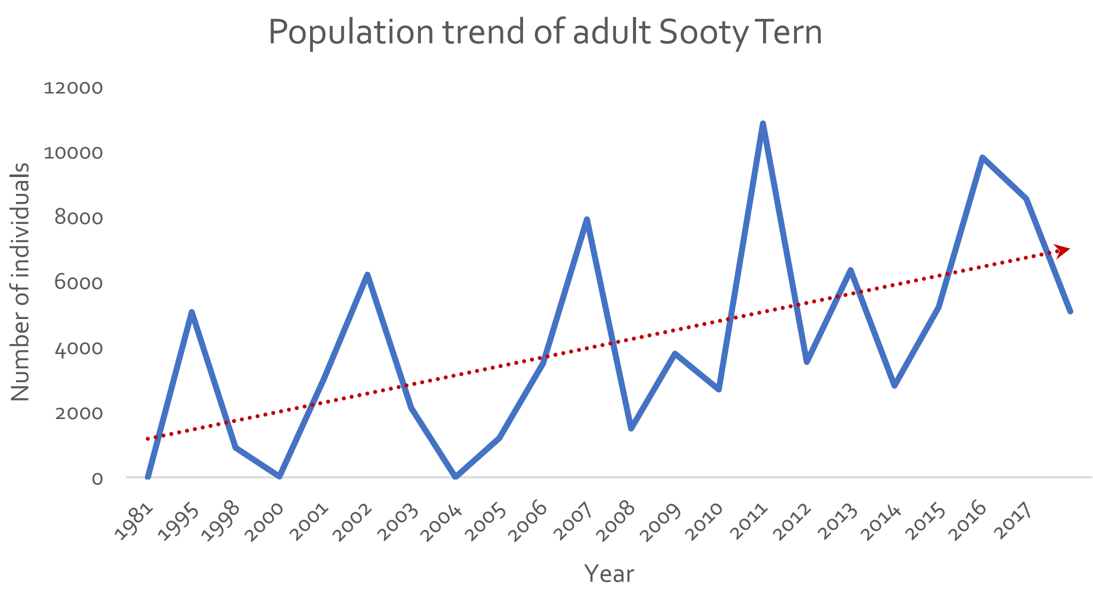


Figure 32. Population trend of adult Sooty tern from 1981 to 2017.

Pacific Reef Heron: The total adult population in May 2017 was 16 individuals (19 in 2016). Eleven adults were recorded on South Islet together with three empty nests. On Bird Islet five adult birds were observed. All birds recorded in May 2017 were in the dark phase.

Barred Rail: No birds were observed since May 2016, when two were found on Bird Islet. It used to occur on both Bird Islet and South Islet.

Eurasian Tree Sparrow: Eight individuals were recorded in South Islet and two birds in Bird Islet. The presence of the species in May 2017, confirms its permanent presence in TRNP since 2004.

Results of examination of dead birds and species identification of ectoparasites and scavengers in Bird Islet

Dead seabird specimens were presented for post-mortem examination. The breakdown of the specimens and their condition compared with the totals per species found in 2016 is found in Table 8.

Table 8. Summary of dead birds found in May 2017, age classification, and specimen condition compared to number of dead birds found in 2016.

Species	Age Classification	Specimen Condition
Red-footed booby	Pullus	Desiccated
	Pullus	Desiccated
	Juvenile	Desiccated
	Juvenile	Desiccated
	Adult	Putrefied
	Adult	Desiccated
Total 2017	**6**	
Total 2016	8	
Brown Booby	Juvenile	Desiccated
	Juvenile	Desiccated
Total 2017	**2**	
Total 2016	14	
Great Crested Tern	Adult female	Fresh
Total 2017	**1**	
Total 2016	0	
Sooty Tern	Adult, sex unknown	Desiccated; lower half missing
	Immature	Fresh
Total 2017	**2**	
Total 2016	0	
Brown Noddy	Adult	Desiccated
Total 2017	**1**	
Total 2016	5	

Black Noddy		
Total 2017	**0**	
Total 2016	1	
Grand Total 2017	**12**	
Grand Total 2016	28	

Only 12 dead specimens were found in Bird Islet compared to 28 in 2016. Considering that the Brown Booby is known to rear only one out of two pulli born, and with records showing several Brown Booby with two eggs, the absence of dead pulli specimens is noteworthy.

Most of the specimens found were dried up or mummified, which limited the post-mortem findings. Only two of the specimens were fresh enough to examine for possible cause of death: the first, a female adult Great Crested Tern was observed to have a nest of arthropods on its chest concentrated at the base of the feathers. Internal examination revealed linear hemorrhages on the mucosal surface of the stomach which was empty apart from a few sandy particles. The intestines (both small and large intestines) were gas-filled. All other organs were unremarkable. The other specimen, a juvenile Sooty Tern, also exhibited an empty digestive tract and an otherwise unremarkable necropsy.

The highlight of the necropsy findings was a high prevalence of external parasites collected from the 12 specimens. Parasitism in wild populations may be an indication of overstocking or a decrease in available habitat space per individual. In addition, University of the Philippines – Museum of National History conducted identification of 36 ectoparasites (ticks, biting lice and louse flies) and 13 scavengers (beetles, chiggers, and cockroaches) collected from Bird Islet in May 2017. The results are presented in Table 9.

Table 9. Results of species identification of ectoparasites and scavengers collected from Bird Islet in May 2017.

Common name	Order	Family	Genus	Remarks	No. of Ind.
Soft Tick	Ixodidae	Argasidae	Argas?	Ectoparasite	8
Louse flies	Diptera	Hippoboscidae		Ectoparasite	4
Skin beetles	Coleoptera	Dermestidae		Sarcophagous	6
Click beetle	Coleoptera	Elateridae		Sarcophagous	1
Cockroach	Blattodea	Blaberidae	Pycnoscelus	Sarcophagous	1
Biting lice	Psocodea: Mallophaga			Ectoparasite	10
Skin beetles	Coleoptera	Dermestidae		Sarcophagous	5
Chiggers	Trombidiformes	Trombiculidae		Ectoparasites	14

4.4 Recommendations

Habitat

1. It is recommended that a nursery of beach forest trees be established, perhaps at Cavili Island, Cagayancillo, to serve as a source of seedlings for planting in Bird Islet and South Islet. This is in response to the bleak prospect of the beach forest recovering within a short timeline of three to five years.

Species

2. Black Noddy: As a top priority, replenish lost breeding habitats for the noddy population by constructing bio-degradable, artificial ledges for nesting. The aim is to construct ledges for 4,000 adult birds of the 8,000 birds that are currently unable to reproduce.

Continue to assist the population by providing substantial quantities of nesting materials, in form of e.g. seagrass, sea weed or even dried leaves brought from Puerto Princesa.

3. Sooty Tern: Encourage the Park rangers to conduct inventories also in February/ March as egg counts in the first quarter of the year often represents the most reliable or only data determining the annual breeding population.

4. Include in the annual budgeting and fund-raising, a budget for satellite-transmitter tacking and tracking of adult and juvenile seabird species.

5. When it has least impact on the breeding birds (before egg-laying), conduct recapture of banded Sooty Tern and Black Noddy to gain more knowledge on life expectancies, etc.

Land area

6. No studies have been done on the current patterns around Bird Islet, thereby there is little understanding of its influence on the erosion of the islet. A study needs to be made and its results used to contribute to decisions to halt the decrease in the land area of Bird Islet.

Methodology

7. Continue monthly distance counts, and conduct three direct counts in January/February, August/September and October/November. Include counts of other species such as Pacific Reef Heron, Barred Rail, and of the migratory Ruddy Turnstone and Grey-tailed Tattler.

8. As a standard protocol, agree with outgoing rangers from TRNP to encode their distance count and direct count data for uploading in the TMO avifauna database. TMO researchers and MPRs must work together to validate the accuracy of data encoding.

Public awareness raising

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

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5 SEAGRASS COMMUNITY

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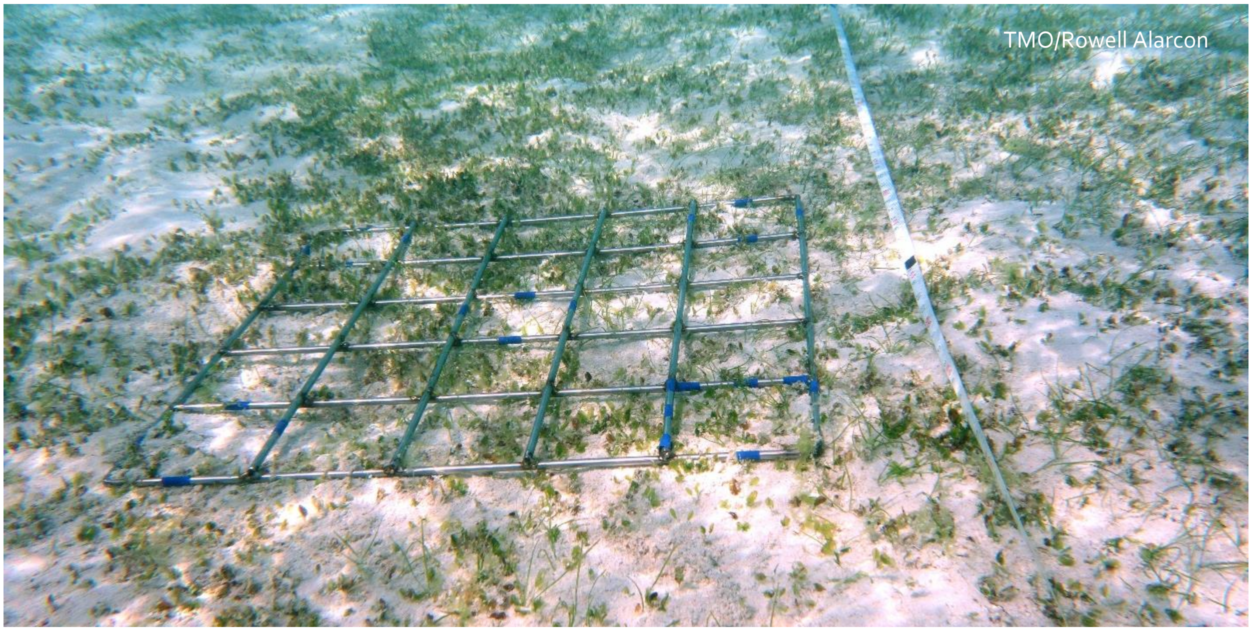
Tubbataha Management Office

5.1 Overview

Seagrasses are marine flowering plants which grow in shallow coastal waters. A total of 60 seagrass species have been identified in the world and 16 are found in the Philippines. A total of nine species have been recorded in Tubbataha. These are: *Cymodocea serrulata, Cymodocea rotundata, Enhalus acoroides, Halodule pinifolia, Halodule uninervis, Halophila ovalis, Halophila spinulosa, Syringodium isotefolium and Thalassia hemprichii*. Some ecosystem services they provide include food for associated species, habitat for invertebrates and nursery for juvenile marine species, water purification, and carbon sequestration. According to Conservation International (2008), the economic value of seagrass beds amounts to 105,990 USD per year.



In Tubbataha, seagrasses cover is sparse and is relatively dense only around the Ranger Station, Bird Islet and South Islet. Seagrass beds have been monitored in the Bird and South Islets from 2002 to 2004, while the ranger station was included in this assessment. Dominant seagrass species differed during these years. Bird Islet has fewer seagrass species compared to South Islet. Bird Islet was dominated by *Halodule uninervis* in 2002, and Halophila ovalis in 2003. In 2004, *Halodule pinifolia* and H. ovalis were the most dominant, with very few of the larger seagrasses like *Cymodocea rotundata*. South Islet, on the other hand, was dominated by *C. rotundata* and *C. serrulata* in 2002, but it was overtaken by *Thalassia hemprichii* in 2003. In 2004, South Islet was dominated (by the number) by *Thalassia hemprichii* followed by *Cymodocea serrulata* and *Cymodocea rotundata*. The difference in the intensity of currents in the two islets was one of the factors which may have influenced the change in dominant species as well as the number of species (Sabater and Ledesma 2004). This year, the assessment was focused on the Ranger Station, Bird Islet and South Islet in determining species composition and their relative density.

5.2 Methods

The assessment of seagrass was conducted in the three areas where seagrass beds are relatively dense – around the Ranger Station, Bird Islet and South Islet. Two sites were established at the Ranger Station and Bird Islet and one in South Islet. In each site, three 50-meter transects were laid perpendicular to the coastline, at depths between 1-2 meters. Following the methods described by Saito and Atobe (1970), a quadrat measuring 50cm x 50cm was laid every 5 meters at both sides of the transect. Seagrass species inside the quadrat were identified and their shoots counted. The location of each site was marked using a GPS and is shown below.

Site	Coordinates
1	N8.93069° E119.99560°
2	N8.92879° E119.99671°
3	N8.85163° E119.91849°
4	N8.85066° E119.91666°
5	N8.74861° E119.81894°

5.3 Results and Discussion

The seagrass assessment this year covered a total sampling area of 750m^2. A total of five seagrass species were recorded in the assessed sites - *Cymodocea rotundata, Halodule pinifolia, Halophila minor, Halophila ovalis* and *Thalassia hemprichii.* All species except *H. minor* were previously recorded in TRNP (Sabater and Ledesma 2007, Tiquio and Villanueva 2007). The two species previously documented in TRNP that were not observed in this study are *Cymodocea serrulata and Enhalus acoroides.* Of the five species recorded, *Halophila ovalis* and *Halodule pinifolia* were found to be the dominant species in terms of shoot density (Table 10 and Figure 33). Both species were recorded in all the sites. Interestingly, *Thalassia* *hemprichii* was only recorded in Ranger Station 2 (in front of the ranger station). The highest seagrass density was recorded in Ranger Station 2 while the lowest was in South Islet (Table 10).

Table 10. Shoot density (# of shoots/ m²) and relative percentage per species in the five sites in TRNP.

Sites / Shoot density (# of shoots/m²)						Relative percentage (%)
Species	Bird Islet_1	Bird Islet_2	Ranger Station_1	Ranger Station_2	South Islet_1	
Cymodocea rotundata	0	0	29	116	0	5
Halodule pinifolia	256	251	132	388	199	41
Halophila minor	132	0	136	0	0	9
Halophila ovalis	296	296	300	252	121	43
Thalassia hemprichii	0	0	0	68	0	2
Relative percentage	23%	18%	20%	28%	11%	

In the previous assessments of Sabater and Ledesma in 2002 to 2004, they reported a shift in the dominant seagrass species in Bird Islet, that is *Halodule uninervis* in 2002 to *Halophila ovalis* and *Halodule pinifolia* in 2003 and 2004. This year, Bird Islet was still dominated by *Halophila ovalis and Halodule pinifolia*. Bird Islet is located in the northeastern part of the north atoll which is exposed to the northeast monsoon. The strong waves in this area create movements in the sand where the seagrass beds are located. This movement inhibits the colonization of large seagrasses which are slow growing and are often uprooted during shifts of the monsoon.

South Islet, which was previously dominated by thick beds of *Thalassia hemprichii* is now also dominated by *Halophila ovalis* and *Halodule pinifolia.* In 2004, Sabater and Ledesma described South Islet to be relatively sheltered compared to Bird Islet, allowing for the slow-growing species such as *Thalassia hemprichii* to thrive. However, this year the dominant species in Bird and South Islets are the same, which suggests that stronger waves might be hitting the South Islet as well.

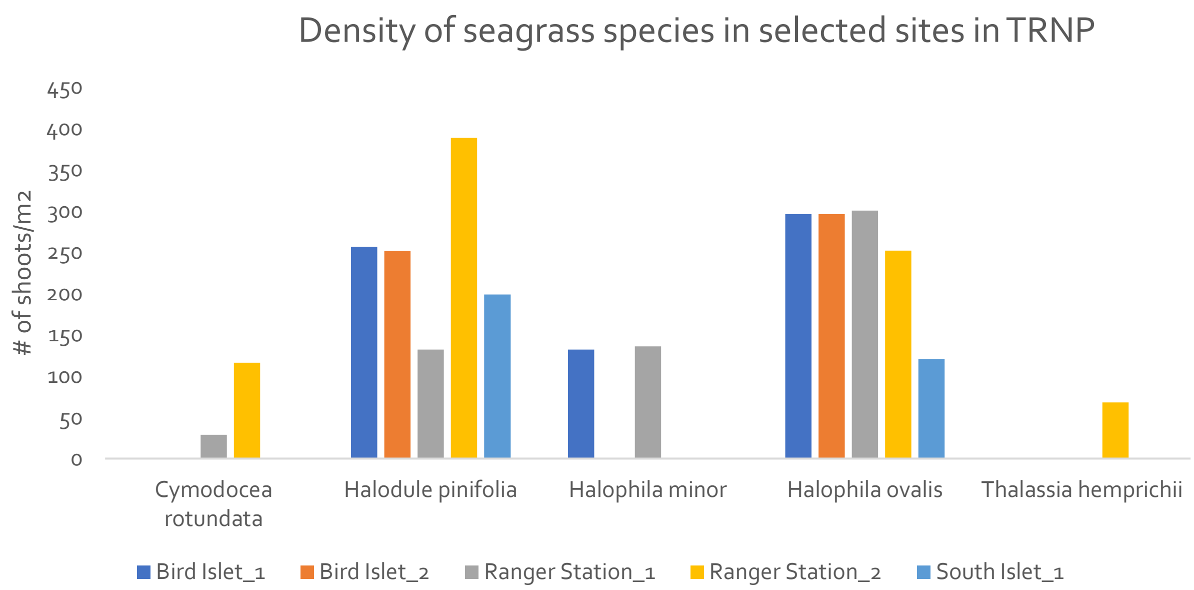


Figure 33. Density of seagrass species in the five sites in TRNP.

5.4 Conclusion and Recommendations

Seagrass beds are important in maintaining the ecological processes in TRNP. They serve as food for marine life such as turtles, as well as habitat for smaller species. The seagrass beds, especially those near the islets, help in keeping the substrate intact, therefore, providing habitat for other benthic organisms. A survey of the extent and biomass of seagrass beds in TRNP may give information on its productivity, and could be related to the ecosystem services it provides.

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6 *TECTUS NILOTICUS* POPULATION

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6.1 Overview

Tectus niloticus is a topshell that is widespread in the Indo-pacific region. It has been massively harvested in the Philippines for its mother-of-pearl shell, which is valued at a high price. In 2001, the *Tectus niloticus* was included in the Bureau of Fisheries and Aquatic Resources Fisheries Administrative Order No. 208 as a threatened species, not to be taken in the wild. Due to the depleting wild population of this species, some conservation measures have been taken by research institutions and the academe, such as translocation and stock enhancement (Dolorosa et al. 2013; Gonzales et al. 2006).

Tectus are considered herbivorous feeding on filamentous algae attached to rocks and rubbles in shallow reefs. They become sexually mature when they are between 5 cm and 7 cm that are attained in two to three years (Nash, 1985). They can be found in both intertidal and subtidal reef areas, generally in high energy sections of the reef (Lorrain et al. 2015). Tectus are believed to spawn once or twice each year, being more active in the summer months. Female spawning is induced by the presence of sperm in the water. Embryos develop into free-swimming planktonic marine larvae and later into juvenile planktons that drift with currents before settling on a rocky surface. After 2 or more years they may become adults. In their juvenile stage, Tectus are very cryptic because of their small size and the complexity of the reef surface where they live (Castell et al. 1996). This study aims to have an update on the population density of *T. niloticus* in the Tubbataha Reefs.

6.2 Methods

Nine sites were selected for the assessment of *Tectus niloticus*. Seven of these nine sites coincide with those surveyed in 2006 and 2008 (Dolorosa et al. 2010; Jontila et al. 2014). The two additional sites established in this survey are in Jessie Beazley and Black Rock. Two 100-meter transects were laid in each site, at depths between 1 to 2 meters. Researchers surveyed the transects following the Reef Check method, where the transect is divided in four segments, with 5-meter intervals between each segment. All *T. niloticus* within the 2.5-meter imaginary corridor on both sides of the transect were counted and its basal diameter measured. Sampling was done from 26 - 31 March 2017, covering a total area of 6,800 m^2.

Site	Coordinates
1	N8.92786° E120.01252°
2	N8.92318° E119.99562°
3	N8.84815° E119.91726°
4	N9.04393° E119.81599°
5	N8.87317° E119.88678°
6	N8.74951° E119.81232°
7	N8.78537° E119.82962°
8	N8.74432° E119.82717°
9	N8.80827° E119.80652°

6.3 Results and Discussion

Tectus niloticus is a species of special interest to the Tubbataha Reefs because it was the target of illegal fishers from 2006 to 2008 due to its high commercial value. Illegal collection of this species from 2006 to 2008 reduced the density from 6,000 individuals/hectare (120 ind/200 m^2) in 2006 to 2,000 individuals/hectare (40 ind/200 m^2) in 2008 (Jontila *et al.* 2014). In this survey, the average density of *T.*

niloticus is 31 individuals/200 m². This value is lower than the previous survey. The decrease in density may have been influenced by the very low density in Site 4 (Jessie Beazley Reef) with only 1 ind/200m². The total area surveyed for the assessment is 6,800 m². The highest density was recorded in Site 2 (Elbow Mac) with 142 individuals/200 m², while the lowest was in Site 4 (Jessie Beazley) with 1 individual/200 m². The average basal diameter of *T. niloticus* in this study is 79mm ± 19.4mm, higher than the result of the baseline assessment in 2006 (Dolorosa et al. 2010) which is 67mm ± 14.6mm. However, it is slightly lower than the last survey conducted in 2008 which is 82mm ± 16mm (Dolorosa and Jontila 2012). Majority of the *T. niloticus* measure 51mm to 110mm in basal diameter (Figure 34).

Table 11. Density and basal diameter of T. niloticus in the nine sites.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
Density (# of ind/200 m²)	3	142	45	1	10	14	29	19	18
Average basal diameter (mm)	77	74	86	94	89	80	77	84	92
Minimum basal diameter (mm)	41	23	20	81	68	26	20	35	51
Maximum basal diameter (mm)	97	121	118	106	115	105	130	115	118

Figure 35 presents the size classification of *T. niloticus* based on its basal diameter (mm) per site. *T. niloticus* with a basal diameter <50mm can be classified as juveniles while those measuring >50mm are classified at sexually mature (Ponia *et al.* 1997 and Jontila *et al.* 2014). In general, sexually mature individuals are distributed across all sites (Figure 35). However, juveniles were sighted in very few numbers in Sites 1, 4, 5, and 9 (Near Shark airport, Jessie Beazley, Wall Street and Kook, respectively). The limited number of juveniles could be a result of predation on individuals that settled on the subtidal habitats, the difficulty in finding them because of their small size and cryptic nature, and their nocturnal habit (Nash et al. 1993; Castell et al. 1997). During this survey, juveniles were found hiding under rocks, which is in conformity with the observation of Dolorosa et al. (2016).

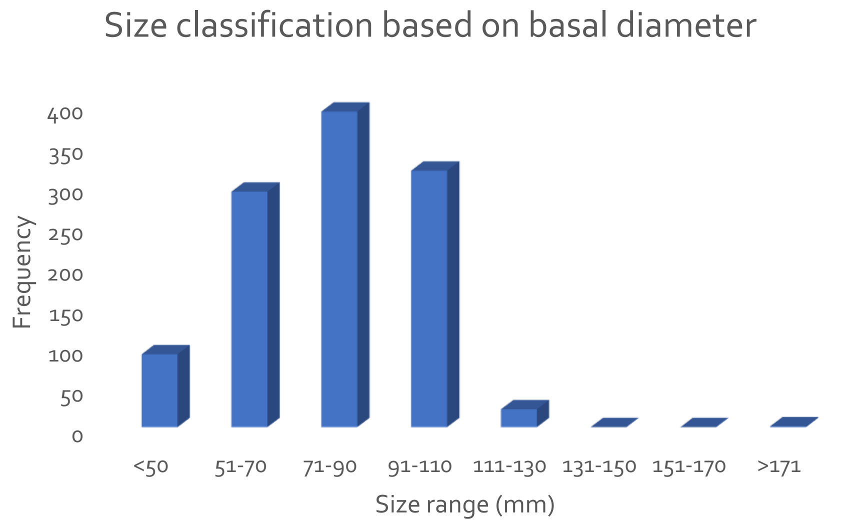

Figure 34. Size frequency distribution of T. niloticus.

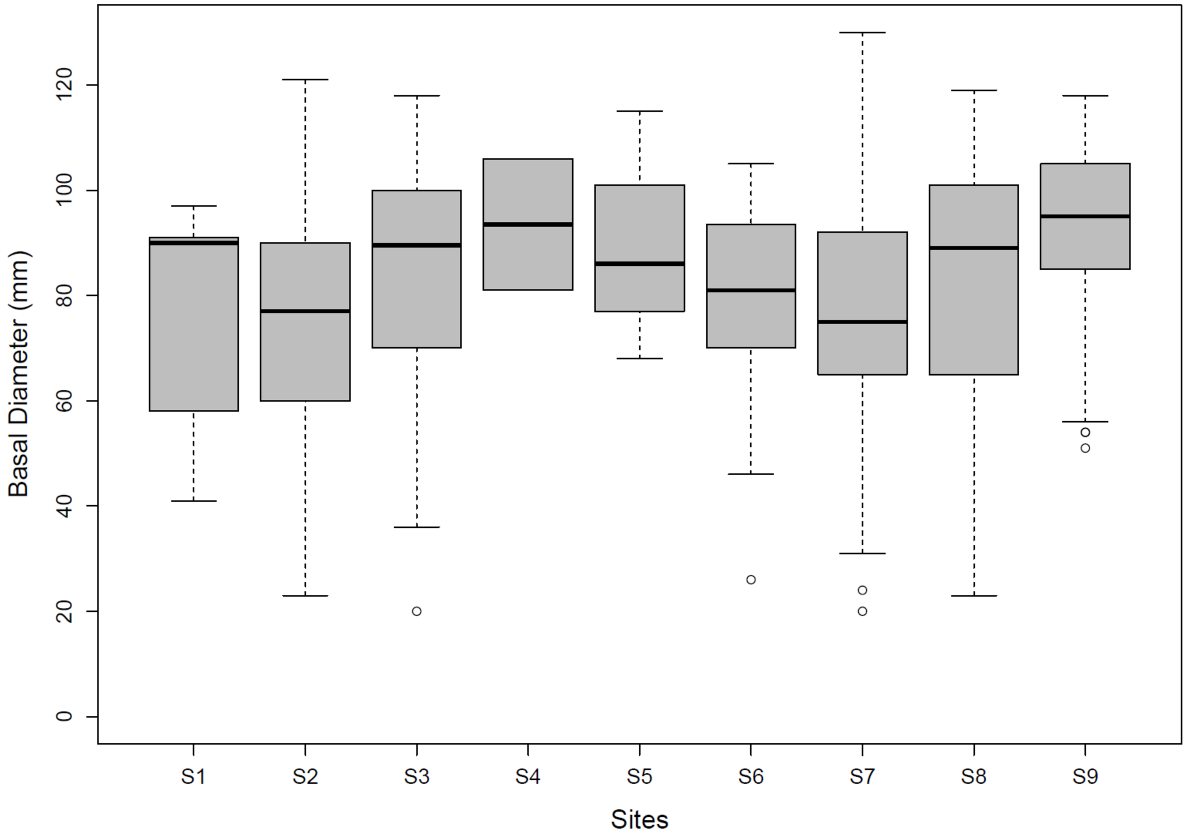

Figure 35. Box plot of sizes of T. niloticus from 9 sampling sites in TRNP.

6.4 Conclusion and Recommendations

T. niloticus continue to thrive in the park, however, the present density is still lesser than in 2008 because population recovery from heavy poaching may take several decades. A regular monitoring for the *T. niloticus* is needed to document the progress in population growth.

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7 *HIPPOPUS HIPPOPUS* POPULATION

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[2] Western Philippines University

7.1 Overview

Hippopus hippopus is one of the species of giant clams, the largest living marine bivalves which typically inhabit tropical reefs in coastal regions throughout the Indo-Pacific (NOAA Fisheries). In the past, giant clams were heavily harvested in the Philippines, causing depletion of their population (Juinio et al. 1989). Efforts to restore depleted populations have been undertaken by research institutions such as the UP-MSI, which distributed more than 50,000 cultured giant clams to more than 40 sites in the Philippines (Gomez and Licuanan 2006). In 2005, Dolorosa and Schoppe recorded 3,300 individuals per square kilometer in TRNP's seven original monitoring stations. This study was only able to cover the area around the Ranger Station, where dense *Hippopus hippopus* populations were observed.

7.2 Methods

Hippopus hippopus was surveyed around the Ranger Station. Seven 100-meter transects were laid and all *Hippopus hippopus* species within the 5-meter imaginary corridor on either side of the transect were counted. The sampling was conducted by the marine park rangers on June 16, 2017. The coordinates of the sampling sites are presented below.

Site	Coordinates
1	N8.85186° E119.91922°
2	N8.85173° E119.91927°
3	N8.85150° E119.91929°
4	N8.85122° E119.91931°
5	N8.85089° E119.91928°
6	N8.85059° E119.91928°
7	N8.85024° E119.91948°

7.3 Results and Discussion

The total area surveyed for the assessment of *Hippopus hippopus* is 7,000 m^2. A total of 157 individuals of *Hippopus hippopus* were recorded at the seven transects around the Ranger Station. The average density of *Hippopus hippopus* is 22 individuals/1000m^2. This value, however, is not comparable to the 3.3 individuals/1000m^2 recorded by Dolorosa and Schoppe (2005) because of the difference in sites surveyed.

Table 12. Density (# of individuals/1000m²) of H. hippopus around the Ranger Station.

Site	Density (# of individuals/1000m²)	Relative percentage
Transect 1	19	12%
Transect 2	20	13%
Transect 3	20	13%
Transect 4	53	34%
Transect 5	27	17%
Transect 6	11	7%
Transect 7	7	4%

7.4 Conclusion and Recommendations

This study was only able to cover the areas around the ranger station because of the limited time of the marine park rangers to conduct the survey. Nevertheless, it is good to note the high density of *H. hippopus,* indicating that the species are protected in this area. However, the other sites around the North and South Atolls must also be surveyed to be able to determine their current population density. Shell measurements during the next surveys is suggested to obtain size classification of the population. Furthermore, the sites around the Ranger Station can be visited once a year for population density and size structure monitoring.

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8 REEF BENTHOS MONITORING

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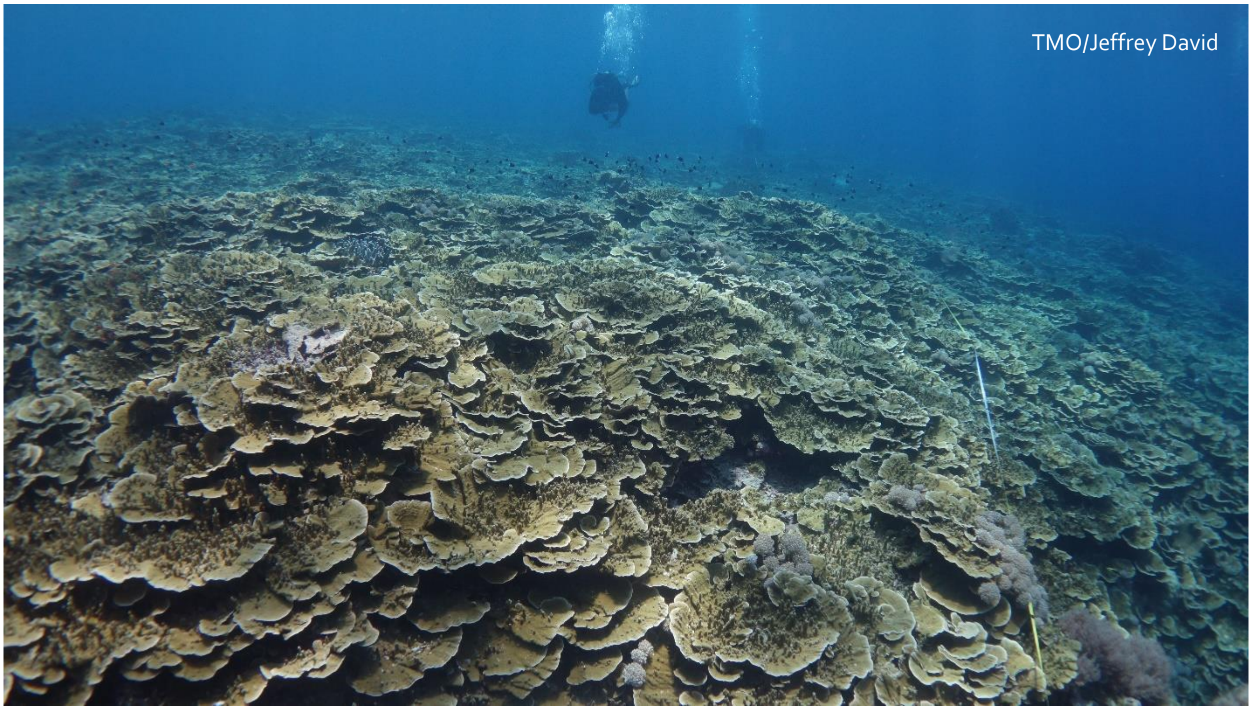
8.1 Overview

The annual monitoring of reef benthic communities in Tubbataha Reefs Natural Park was done on April 29 to May 4, 2017. This was done as part of the continuing monitoring program by the staff of Tubbataha Management Office and researchers from Shields Ocean Research Center of De La Salle University. The sites, stations visited and the field and analytical methods used follow those described in Licuanan et al. (2017).



8.2 Methods

Data collection for sites 1-4, and Jessie Beazley was done by using five replicate 50-m transects that were positioned randomly within a 25x75m station (see the Appendix of this report). There were two stations per site. Every meter of these transects was photographed using a digital camera (Sony RX100 Mk.II) in an underwater housing (Ikelite) mounted on an aluminum monopod with 1.1m distance bar and 1x1m image "foot print". The photos taken were analyzed in the laboratory using Coral Point Count with Excel extensions (CPCe) (Kohler and Gill 2006). The latter software overlaid ten random scoring points per image, and benthos under each point was identified to standard taxonomic amalgamation units (TAUs) which correspond roughly to common coral genera (see the Appendix of this report)

For the monitoring of the grounding sites of the USS Guardian and F/B Min Ping Yu, three 4x4m fixed monitoring plots were established. Of the three plots that were established in the USS Guardian impact site, one is in the middle ("Ground zero") and the second just inside the deeper boundary ("Impact border") of the area where all the corals and other benthos were scraped off by the grounded warship, leaving bare bedrock. Substrate in Min Ping Yu was mainly sand, unsuitable for coral settlement. The impact plots were set up on the fragments of corals left behind by the vessel. One plot was established on the piles of small fragments (20-40 cm diameter) while the other plot was on the base and large fragments (~ 1m diameter) of corals shattered by the rudder. These fixed plots were demarcated by metal pegs driven into the reef at the corners and midway along the sides. All fixed plots were imaged in a zig-zag shooting pattern, with at least 50% overlap between adjacent images. This meant at least 90 images, each covering a 1x1m area, are available per plot. Thirty (30) of these images were chosen randomly, and scored using CPCe with ten random scoring points per image.

8.3 Results and Discussion

Hard coral cover (HCC) and generic diversity of Tubbataha Reefs continued to show resistance to prevailing environment challenges. Average HCC from 2012-2017 is 34%, with no statistically significant change over the same period (see Table 13). This lack of significant change in HCC is despite the changes at smaller scales, as described in the following paragraph.

Table 13. ANOVA repeated measures of hard coral cover and generic diversity for 2012-2017 time periods.

ANOVA Repeated Measures

		Df	SumSq	MeanSq	Fvalue	Pr(>F)
HCC	YEAR	5	263	52.61	0.452	**0.808**
	SITE:YEAR	20	2322	116.12	0.997	**0.499**
	Residuals	23	2679	116.46		
TAU	YEAR	5	27.13	5.426	1.56	**0.211**
	SITE:YEAR	20	70	3.5	1.007	**0.490**
	Residuals	23	79.97	3.477		

An overall 4% decline in HCC (41% on 2016 to 37% on 2017) was observed between the 2016 and 2017 monitoring data. Changes in HCC were also observed at the site level. There were declines in Site 1 (12% decline from 2016) and Site 3 (10% decline from 2016), and a 4% increase in Site 2. The changes were larger at the station level for Site 1 and Site 3 (Figure 36).

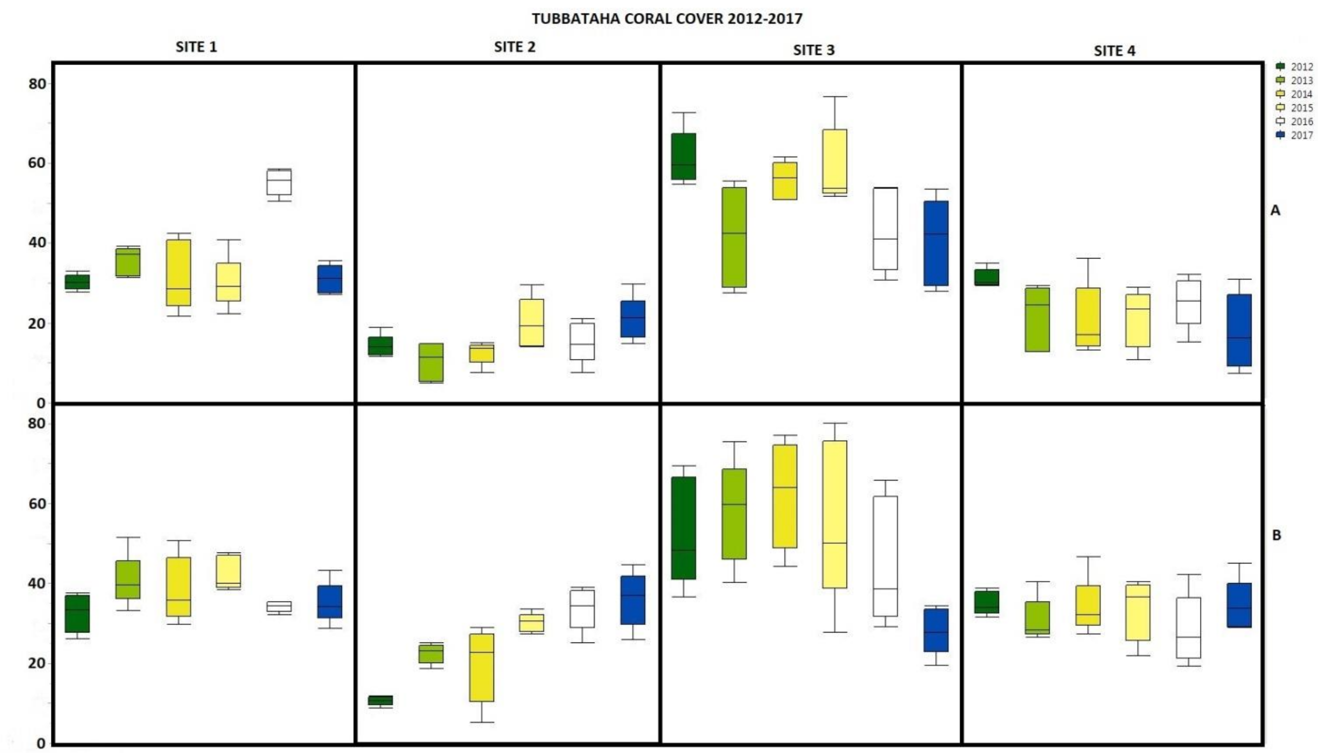


Figure 36. Box and whiskers plot of coral cover for Tubbataha stations monitored from 2012-2017. Plotted values are the median, lower and upper quartiles (25% and 75%), and the minimum and maximum values (denoted by the whiskers).

Results of linear regression indicate the changes in HCC in Site 2 and Site 3 are statistically significant (with p-values <0.001). The decline that was reported during 2016 in Site 3 was attributed to damage from logs and *payao* floats. Log damage was again observed during 2017 monitoring (Figure 37). On the other hand, HCC in Site 2 has been increasing slightly over time. The increasing trend coral cover in here might be caused by new coral recruits or the yearly growth of dominant corals. The latter might be a reasonable explanation for the increase since the dominant corals in the site are mostly fast-growing branching corals.

Table 14. Linear regression showing significant change in HCC per year for all sites/stations. Green highlight shows significant increase and red highlight shows significant decrease per year. Sites 1 and 4 show no significant change.

SITE	Term	Estimate	Std. Error	t Ratio	Prob > [t]
Site 1	Intercept	33.5805	2.4707	13.591	<2e-16
	Year	0.8352	0.6344	1.316	0.193
Site 2	Intercept	9.1827	2.3342	3.934	0.000226
	Year	3.2516	0.5994	5.425	1.18E-06
Site 3	Intercept	63.49	4.005	15.854	<2e-16
	Year	-3.767	1.028	-3.663	0.000541
Site 4	Intercept	31.1865	2.5743	12.115	<2e-16
	Year	-0.9488	0.661	-1.435	0.157
Jessie Beazley A	Intercept	64.94782	2.770037	23.450	<.0001
	YR	4.32128	0.711278	6.080	<.0001

Sampling artifacts can explain most of the changes in HCC described. Note that statistical power analyses revealed that the current monitoring can only detect 3% change in HCC at the location level, up to 9% HCC at the site level and up to 15% at the station level (see Licuanan et al. 2017).

During the 2017 monitoring, it was observed that some low arborescent *Acropora* that used to dominate Site 1 (Station A) appeared to have diminished in number. The appearance of the crater-like damage (Station B) that might be due to strong wave action was also observed. These disturbances are probably the reasons behind the HCC declines in Site 1, Station A (from 55% on 2016 to 31% in 2017). Furthermore, the monitoring team found pieces of assorted garbage in almost every station, with some entangled in corals.

Figure 37. Photo on the left showing damage probably caused by logs in Site 3 and photo on the right showing crater like damage with rubbles from branching Acropora on Site 1. These were taken at a depth of 5-6 meters.

Unlike HCC, the coral composition did not change significantly over the years. The average generic diversity per site was 18, the same number observed in 2016. Site 1 still had the highest number of TAUs it 2017 (Figure 38). Even the top ten dominant corals species per site did not change significantly.

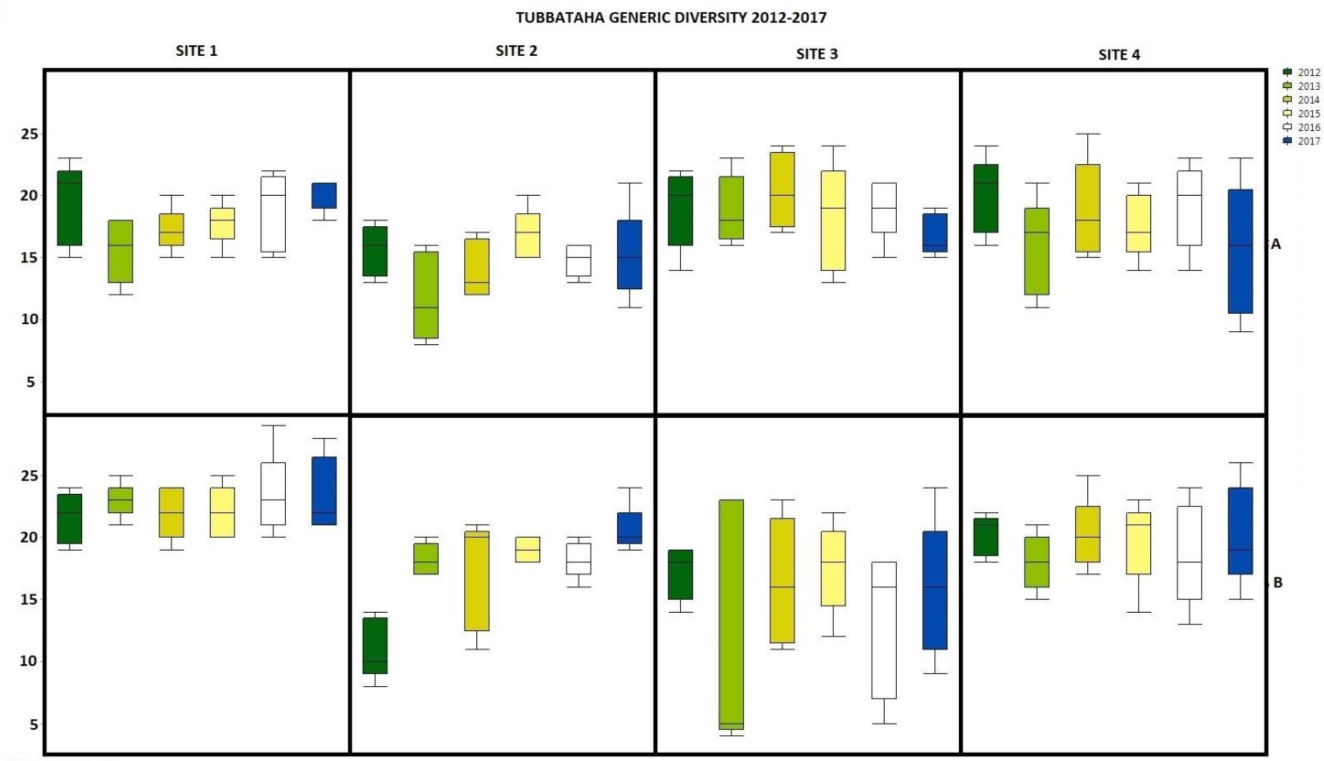


Figure 38. Box and whiskers of generic diversity for all Tubbataha stations monitored from 2012-2017. Plotted values are the median, lower and upper quartiles (25% and 75%), and the minimum and maximum values (denoted by the whiskers).

The monitoring data of Jessie Beazley has gaps, precluding detailed analysis in previous monitoring reports. As of 2017 though, using one-way ANOVA, a statistically significant increase of 4% per year in HCC was found in Station A (See Table 15). This is mainly due to the coral *Montipora* which dominated the reef since the present monitoring was initiated in 2012 (Figure 39). In addition, Jessie Beazley Station B maintained its high HCC over time, with no significant changes since 2015 (Table 15).

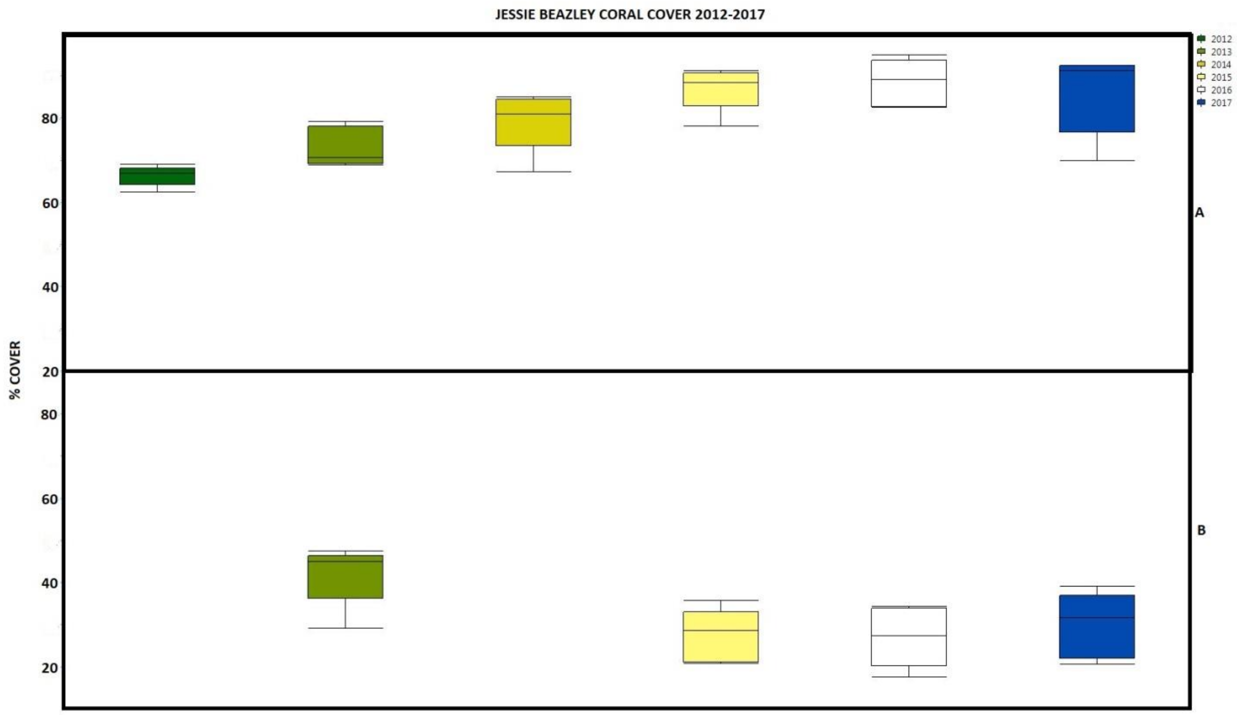


Figure 39. Box and whiskers of coral cover for stations A and B of Jessie Beazley monitored from 2012-2017. Plotted values are the median, lower and upper quartiles (25% and 75%), and the minimum and maximum values (denoted by the whiskers).

Table 15. One-way ANOVA of hard coral cover for Jessie Beazley A (2012-2017) and B (2015-2017).

Jessie Beazley A (2012-2017)

Source	DF	Sum of Squres	Mean squares	F-ratio	Prob>F
Model	1	1636.839	1636.84	36.9759	<.0001
Error	28	1239.496	44.27		
C.Total	29	286.3355			

Jessie Beazley B (2015-2017)

Source	DF	Sum of Squres	Mean squares	F-ratio	Prob>F
Model	2	23.17552	11.5878	0.2324	0.7961
Error	12	598.3173	49.8598		
C.Total	14	621.4929			

On the other hand, the results of the monitoring of fixed 4x4m plots showed an increasing hard coral cover (HCC) at the USS Guardian plots. HCC steadily increased from the marked declines on second year of the monitoring onwards (Figure 40). This was the case in the Adjacent control plot, the Impact border, and the Ground zero plots, although the increase in HCC was statistically significant only in the latter. Coral recruits, mainly *Pocillopora*, were observed in the plots as early as the first monitoring, 16 months from the grounding and 14 months since the vessel was removed from the reef. However, these early recruits did not persist into the subsequent monitoring periods and rapid turnover was apparent up to the present. The 2017 plots, nonetheless, had other coral taxa (mainly faviids*)* growing to appreciable size. This indicates slower-growing, longer-lived corals are beginning to have a larger role in the recovery of coral cover. It is projected that HCC in the Ground zero plots will approximate that of the Adjacent control plot in five years.

In contrast, no trend in HCC can be seen at the two Min Ping Yu (MPY) impact plots (i.e., the "fine" and "coarse" coral fragment plots) from 2014-2017 (Figure 41). HCC in the MPY Adjacent control plot did increase in the first three years of the monitoring, indicating that recovery is possible in the area despite the predominantly sandy substrate. Note that the impact plots had fragments of massive coral skeletons which mean that these had more colonizable space than the control plots. However, it appears the smaller (less than 15 cm) loose rubble also found in the same plots could have led to higher injuries and mortality among small corals that may have settled in the area. The coral recruits, mostly colonies of *Pocillopora*, seen in these plots were too few to lead to measurable recovery in coral cover.

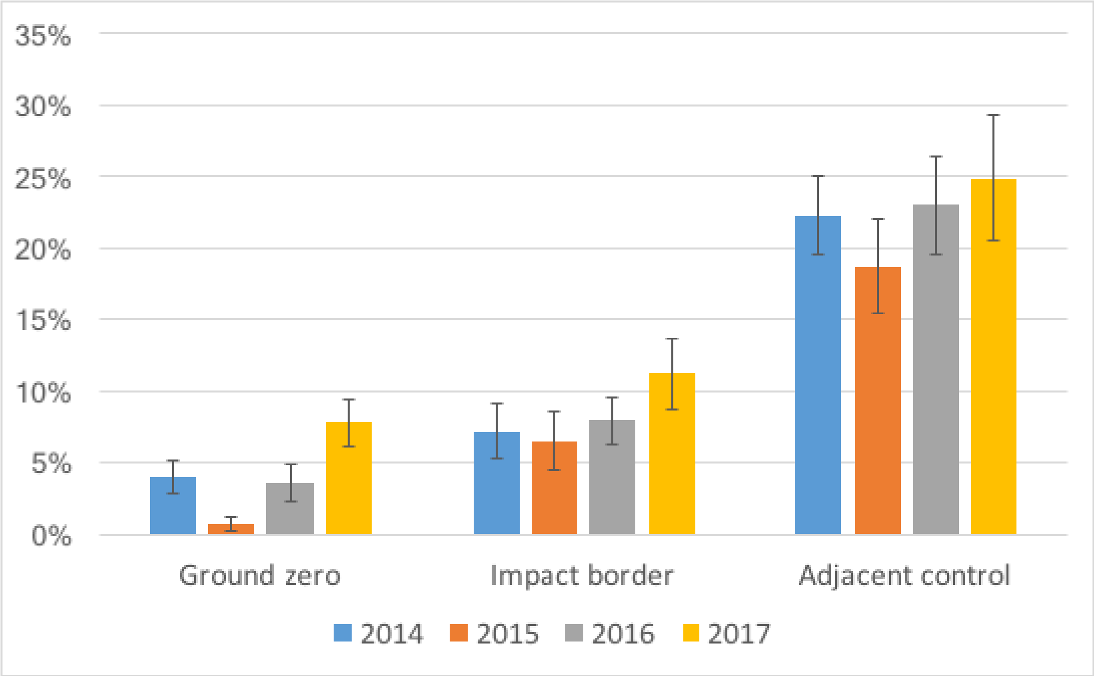


Figure 40. Hard coral cover (HCC) at and around the grounding site of the USS Guardian at the South Atoll of the Tubbataha Reefs. Error bars represent standard errors of the mean.

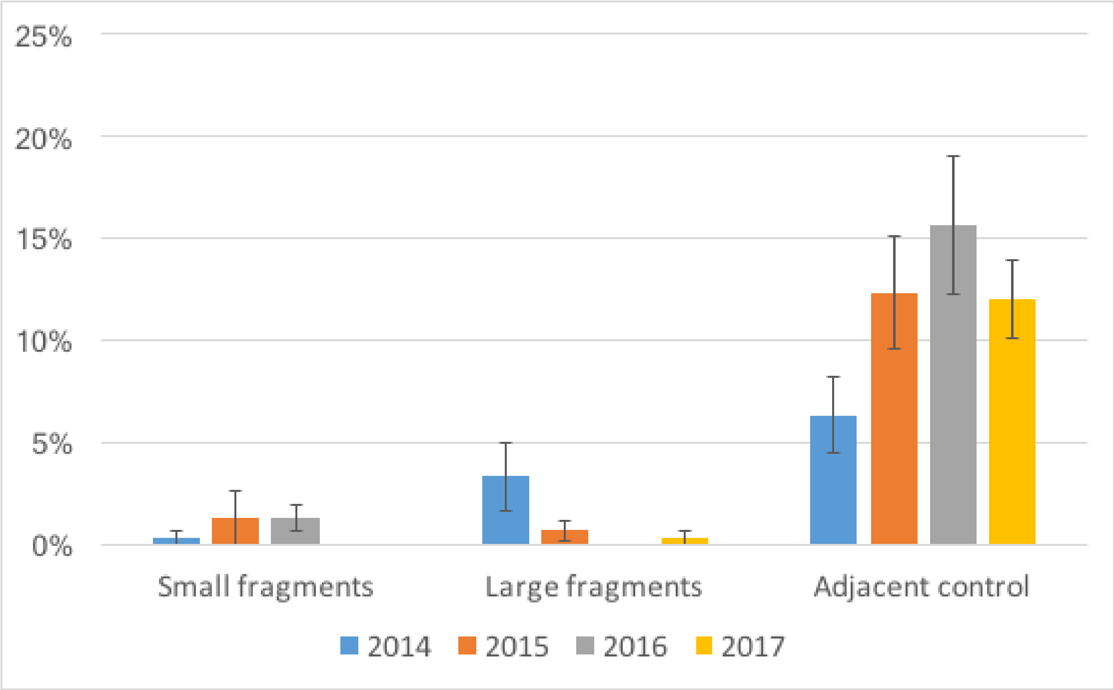


Figure 41. Hard coral cover (HCC) in fixed plots at and around the Ming Ping Yu grounding site at the North Atoll of the Tubbataha Reefs. Error bars represent standard errors of the mean.

8.4 Recommendations

The slow increasing trend in Site 2 should be examined further to determine its cause. A coral recruitment study might prove useful in the next monitoring.

It is also recommended for the quadrat data of Sites 1-4 to be processed and analyzed the same way as those in the grounding sites for comparison with the sites' transect data. This is to see the difference in coral cover between quadrats and transects, and to confirm which method will have less error.

Some monitoring markers (pegs) especially for the fixed plots were missing so the monitoring team tried to replace the missing markers. Some were replaced, but due to the very hard substrate others could not be re-established. We suggest that the missing markers of the fixed plots be replaced by long concrete nails during the 2018 monitoring.

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9 NAPOLEON WRASSE BASELINE ASSESSMENT

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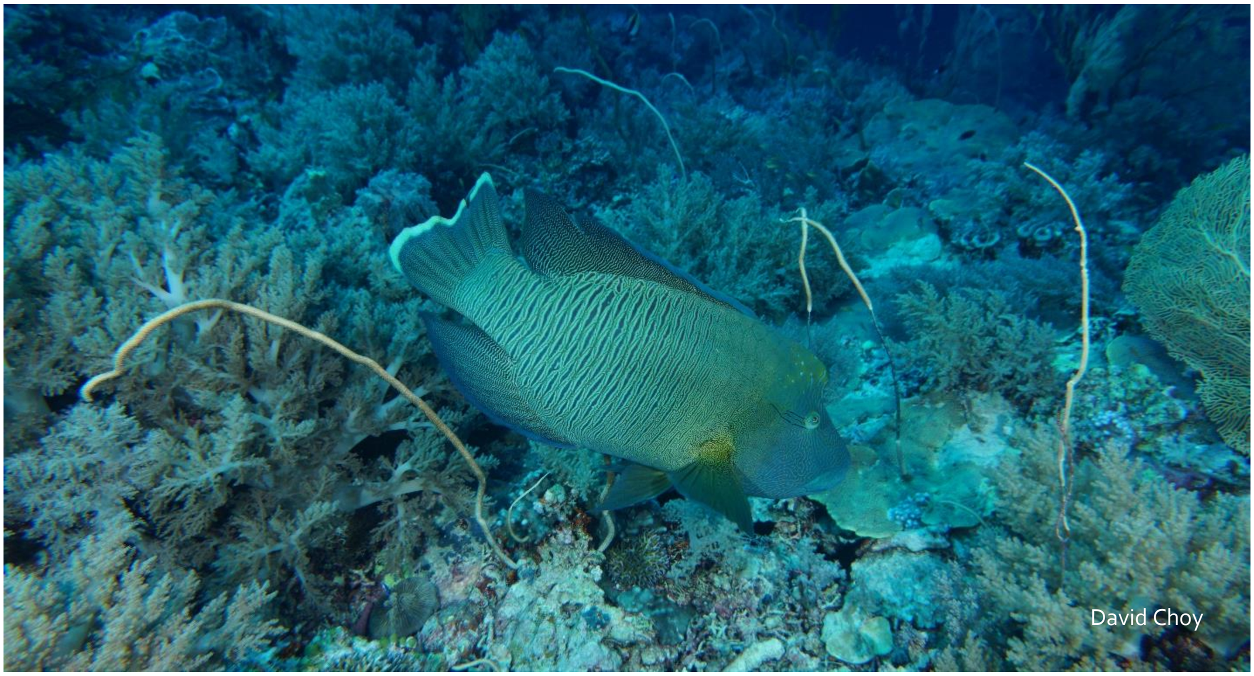
9.1 Overview

Napoleon Wrasse (*Cheilinus undulatus*) locally known as *Mameng* (Figure 1) belongs to the Labridae Family or wrasses, one of the most diverse families under Class Osteichthys, with 70 genera and 504 species (Parenti and Randall 2011). It is widely distributed in the Indo-Pacific Region from the Red Sea, East Africa, Indian Ocean, Western Pacific Ocean, Ryukyu Islands, Melanesia, including Great Barrier Reef (Australia), Micronesia, Line Island and the French Polynesia (Allen and Erdmann 2012) (Figure 43).

It is listed as Endangered in the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. The Convention on the International Trade on Endangered Species has listed the Napoleon wrasse under Appendix II – or those 'species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled.' In the Philippines, the species is protected under Section 102 of Republic Act 10654, 'An Act to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing, Amending Republic Act No. 8550, Otherwise Known as "The Philippine Fisheries Code Of 1998," and for Other Purposes'.



It is by far the largest reef fish reaching up to 229 cm total length (TL) (Randall et al. 1978). The known density for this species does not exceed more than 10 individuals/ha (Chateau and Wantiez 2006; Russell 2004). The Napoleon wrasse is protogynous; females turn into males upon reaching a certain age (Sadovy et al. 2003). Longevity, based on sagittal otolith and length data, is around 32 years old and sexual maturity is attained between the ages of 5 to 7 years at an approximate size of 55 cm fork length (FL[1]) (Choat et al. 2006; Sadovy et al. 2004). Moreover, being protogynous, males attain sizes in the order of 100 cm TL at the age of around 16 years (Choat el al. 2006). The Napoleon wrasse are known to form spawning aggregations of up to a hundred individuals (Sadovy et al. 2004). They are residential spawners, spawning only in a particular area of the reef, and may spawn as often as every day (Colin 2010).

Juveniles greater than three cm TL were found in thickets of staghorn corals in lagoonal reefs (Sadovy et al. 2003). Individuals ranging from 2.5 to 120 cm in size were also observed on seagrass beds and coral reefs (Dorenbosch 2006; Romero and Injaki 2015). The main diet of adults consists of molluscs such as trochus and turbo shells, and other invertebrates such as crustaceans, echinoids, brittle starts and sea stars (Sadovy et al. 2003) including crown-of-thorns-starfish (Randall et al. 1978).

Figure 42. Live underwater shot of Mameng taken in Tubbataha in 2010.

In 1996, the species was classified as 'vulnerable'. By 2004 it was listed as 'endangered' in the IUCN Red Listing assessment (Russell 2004). Booth (2017) believes that two major factors led to the decline in its population. First, it becomes sexually mature only between 5 to 7 years of age (Choat et al. 2006; Sadovy

[1] For *Mameng*, fork length or FL has similar measurement with total length or TL because *Mameng's* tail is rounded

et al. 2004); and second, it forms spawning aggregations (Sadovy et al. 2004), making it more vulnerable to fishing activities. Considering the above, and compounded by the high demand for *Mameng* by the live reef fish food trade (LRFFT), (Donaldson and Sadovy 2001), the species is susceptible to overexploitation. Juveniles and 'plate size' individuals are not the only sizes targeted by the LRFFT but also larger individuals. These are highly saleable because of their taste and size; more meat means more profit.

Being clandestine in nature, very little is known about the trade in Napoleon wrasse in the Philippines except in Tawi-Tawi province, where a study was conducted by Romero and Injaki (2015).

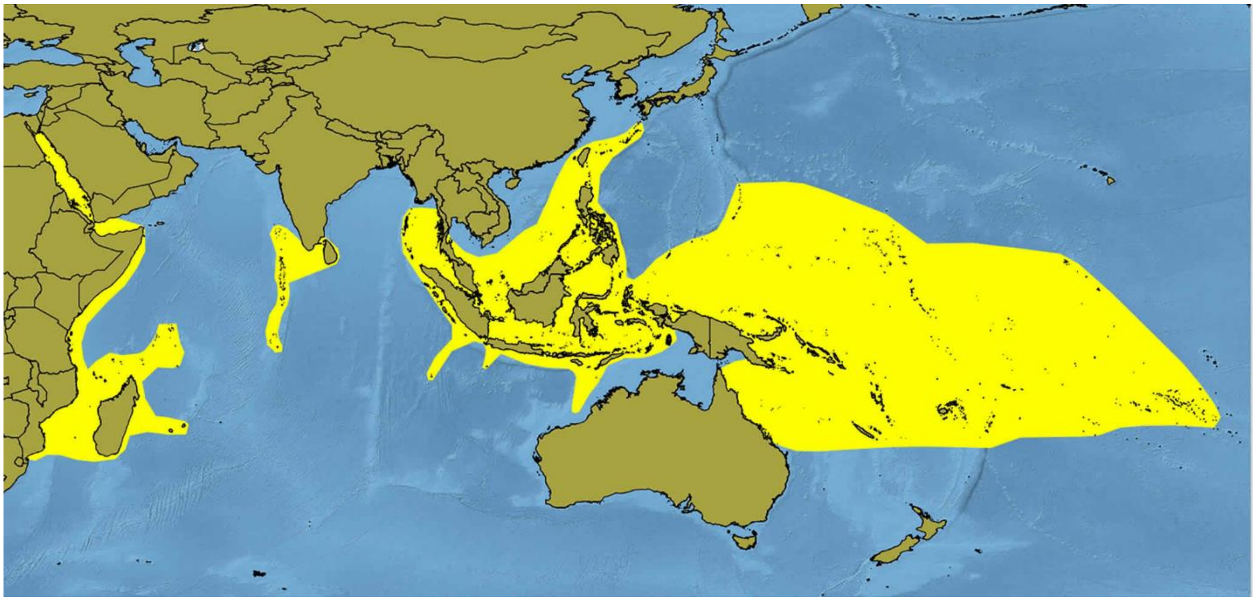


Figure 43. Distribution of Napoleon Wrasse (Allen and Erdmann 2012).

In the Philippines, there is no country level status report regarding the density and abundance of *Mameng* in the wild. Surveys in the country from 1996 to 2010 (Nañola et al. 2011, Nañola 2012), including recent surveys conducted by CL Nañola, resulted in rare encounters with Napoleon Wrasse. These encounters were mostly along the western side of the country from Basco (Batanes), Mindoro (Puerto Galera), northern Palawan, Cordova (Cebu), Tubbataha, Turtle Islands, and Kiamba (Sarangani Province). The species was also observed in Apo Reef (Mindoro) and in the island chain of Cagayancillo (R. Murray, pers. com.). Fishnet.net reports that it occurs in Gubat (Sorsogon). Moreover, the recent publication of Lavides et al. (2016) indicates that there are many areas in the country such as in Danajon Bank, Lanuza Bay, Honda Bay, Polilio Islands and Verde Island Passage, where the species is nearly, or has been, extirpated. So far, relatively high densities of Napoleon wrasse were observed only in Tawi-Tawi (Romero and Injaki 2015).

This study aims to determine the density and size class distribution of Napoleon wrasse in the Tubbataha Reefs. In addition, the study investigated the presence of the juvenile stages of this species in the Park.

9.2 Methods

The study was conducted in the two atolls of the Tubbataha Reefs, the North and South Atolls, with an aggregated reef area of approximately 100 km^2 (WWF 2006). The size of South Atoll is less than half of the North Atoll. Jessie Beazley Reef was not included in the survey. The entire TRNP, which includes the Jessie Beasley Reef, has a total area of 970 km^2 (TNC-WWF-CI-WCS 2008), the largest marine protected area in the country. Being an atoll, Tubbataha has steep slopes that descend to over 100 m in depth. Tourists and researchers report a high number of sightings of *Mameng* in the area. More details about TRNP can be found in Dygico et al. (2013) and WWF (2006).

The density assessment of *Mameng* was conducted for five days in both atolls, from May 15 to 19, 2017, using the fish visual census technique. However, instead of using a transect line, the length of the survey was obtained by measuring the distance at the start and end of the dive using GPS coordinates. A day before the survey, all observers involved, mostly from the Tubbataha Management Office (TMO) and researchers from the Western Philippines University, WWF-Philippines, and the Bureau of Fisheries and Aquatic Resources, were trained on fish size estimation using fish dummies. Fish dummies of the Napoleon Wrasse were constructed out of a thin (~1cm) rubber mat with the following sizes in TL: 30 cm, 50 cm and 100 cm. The dummies, supported with bamboo sticks to prevent folding, were deployed underwater at the end of 30-m transect lines deployed approximately two meters apart. To keep the dummies from moving around, they were anchored to the bottom using lead weights. Observers calibrated their size estimation of the dummies starting at a 30m distance, and moving closer to the 5m mark, the nearest possible distance of encounter with a live Napoleon wrasse underwater. After calibrating the size of the dummies from different distances, the sizes of live Napoleon wrasse in the wild were estimated. After the dive, the size estimations of the observers were calibrated to increase proficiency.

Two teams composed of five to seven divers each conducted the survey. Divers were scattered across the reef from the shallowest at 2 to 6 m, to the reef crest at 8 to 10 m, and along the reef wall at 10 to 12 meters. The team members moved at the same pace, in effect approximating the swath method technique described by Sadovy and Suharti (2008). The designated team leader ensured that each diver estimated the size of the same fish by calling the team's attention using a tank banger and pointing to the fish. Entries on the slate carried by each diver were numbered. Divers that heard the signal but did not see the fish marked the number of the entry with a dash. At the end of the dive, each team gathered to align their counts on a spread sheet. Before obtaining the average size per individual observed, all outliers (estimates either too small and too big compared with the ranges of individual size estimates) were excluded from the computation.

All dives were drift dives as in most cases it is impossible to dive against the current in Tubbataha. The teams aimed to cover a stretch of reef one kilometer long during each dive. At this distance, the chance of re-counting the same group or individual *Mameng* was avoided. This species, particularly the large individuals, is known to be sedentary (Sadovy et al. 2003). The density reporting was made after each dive and expressed as total count over the stretch of reef that was covered multiplied by the approximate width of 50 m. To standardize the reporting, density value was translated into number of individuals/10,000 m^2 or individuals/ha following Chateau and Wantiez (2005) and Sadovy et al (2003). Density differences were tested using non-parametric Mann-Whitney U test.

9.3 Results and Discussion

The aggregated total length surveyed was 19.44 km (13.91 km in the North Atoll and 5.53 km in the South Atoll) (Table 16). Based on a conservative width estimate of 50 m, the approximate area covered is 972,100 m^2 (or 97.21 ha).

A total of 633 individuals were counted with sizes ranging from 25 to 150 cm TL (Figure 44). This translates to a density of 7 individuals/ha. This record is about twice the density counts reported from Queensland, Australia (Choat in Pogonosky et al. 2002) and is close to the highest projection of 9 individuals/ha observed by Chateau and Wantiez in 2005 and by Russell in 2004. A study of the raw data showed that distribution was very patchy (Table 16).

Although density exceeded 10 individuals with a size range of 30 to 120cm TL (see Table 16) in a small patch of reef at the western side of the North Atoll, further investigation is needed to determine whether it was a spawning aggregation or not. So far records showed that spawning aggregations can be as small as 10 to 15 females per male individual (Sadovy et al. 2003). They were mostly observed to be in groups of three to six individuals during the survey. In contrast, there were occasions when only one or two individuals were observed over a stretch of more than 1000 m. The patchiness of distribution of the *Mameng* in Tubbataha is consistent with the observation of Donaldson (1995).

The size frequency distribution indicated that majority (68%) of the adults observed fell within the size class from 40 to 80 cm TL (Figure 4). According to Sadovy et al. (2011), *Mameng* within the 40 to 60 cm TL size class are sexually mature and are aged from 5 to 7 years old. Furthermore, around 14% of the individuals observed belonged to the size class range of more than 100 cm TL (Figure 44). Marshall (1964), Choat and Robertson (2002), and Choat et al. (2006) all report that this species can reach up to more than 2 m TL with a life span of 30 years. The largest so far recorded was at 229 cm TL in North Queensland, Australia (Marshall 1964).

Juveniles (<50cm TL) were also observed in the Tubbataha Reefs. After 20 minutes of snorkel survey in the lagoon of the North Atoll, several juveniles measuring 8 to 10 cm TL were observed hiding amongst colonies of staghorn corals.

Considering the number of sexually mature individuals (526 individuals or 82%) and the presence of juveniles, it can be inferred that both atolls in Tubbataha Reefs may be both a source and sink for *Mameng*. This could be one of the reasons why there is a high density of *Mameng* along the island chain of Cagayancillo (R Murray, pers. com.) Tubbataha's closest neighbor.

On a per unit basis, the number of *Mameng* individuals in the South Atoll (9.77 individuals/ha) is more than half of the North Atoll (6.10 individuals/ha). However, Mann-Whitney U test showed that the difference was not statistically significant (P = 0.0913). On the other hand, comparing the density outputs between western (9.54 individuals/ha) and the eastern (4.67 individuals/ha) side of the reefs, the result was significantly different (P = 0.0465). This could illustrate that *Mameng* prefer to stay in sheltered environments, explaining why it was seldom seen along the eastern Pacific Seaboard of the country. This habitat preference was also observed in the large data set used by Nañola (2012). However, the hypothesis needs to be further evaluated.

Table 16. Napoleon Wrasse density per dive in North and South Atolls.

Site Description	Start Lat	Start Long	End Lat	End Long	Length (m)	counts	area in ha	density/ ha
South Park to RS	8.84691	119.93117	8.84610	119.92364	833	48	4.165	11.52
Elbow Mac to Kanto	8.92353	119.99735	8.92556	120.00618	998	25	4.99	5.01
Elbow Mac to Kanto	8.92353	119.99735	8.91590	119.99277	987	16	4.935	3.24
Elbow Mac to Kanto	8.91590	119.99277	8.90815	119.98763	1030	11	5.15	2.14
Elbow Mac to Kanto	8.90815	119.98763	8.89846	119.98393	1150	20	5.75	3.48
Elbow Mac to Kanto	8.89846	119.98393	8.88965	119.98216	1000	10	5	2.00
Terraces to Malayan Wreck	8.94650	119.97923	8.94724	119.98625	775	75	3.875	19.35
Terraces to Malayan Wreck	8.94168	119.96585	8.93842	119.96005	734	40	3.67	10.90
Terraces to Malayan Wreck	8.92351	119.94758	8.93230	119.95222	1100	27	5.5	4.91
Terraces to Malayan Wreck	8.91166	119.93727	8.91877	119.94348	1050	41	5.25	7.81
Terraces to Malayan Wreck	8.89761	119.91293	8.90145	119.92178	1060	18	5.3	3.40
Terraces to Malayan Wreck	8.88596	119.89002	8.87859	119.88862	835	23	4.175	5.51
Ko-ok to Southwest Wall	8.80002	119.80594	8.79541	119.80690	524	47	2.62	17.94
Ko-ok to Southwest Wall	8.77685	119.81046	8.76852	119.81244	953	31	4.765	6.51
Ko-ok to Southwest Wall	8.75241	119.81341	8.74410	119.81143	950	48	4.75	10.11
Ko-ok to Southwest Wall	8.75878	119.82990	8.75219	119.82768	773	42	3.865	10.87
Ko-ok to Southwest Wall	8.77076	119.83348	8.78024	119.83358	1060	44	5.3	8.30
Ko-ok to Southwest Wall	8.78580	119.83122	8.79586	119.83669	1270	31	6.35	4.88
Kanto to South Park	8.85728	119.94310	8.84961	119.93481	1250	16	6.25	2.56
Kanto to South Park	8.87012	119.95730	8.86338	119.94982	1110	20	5.55	3.60
					19,442	633	4.86	7.20

Figure 44. Density and size class distribution of Napoleon Wrasse observed in the Tubbataha Reefs.

In general, it could be concluded that the population of Napoleon wrasse in the Tubbataha Reefs is stable because of very high density (7 individuals/ha) and the high percentage (82%) of sexually mature individuals encountered. With effective conservation of fished areas around the Tubbataha Reefs, there may still be hope for the recovery of the *Mameng* fishery in the country.

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Annexes

Annex 1. Monitoring team

Reef fish

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Seabirds

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Juan Carlos Gonzales, Professor and Curator, University of the Philippines, Los Baños
Godfrey Jakosalem, Ornithologist, Philippines Biodiversity Conservation Foundation, Inc.
Lisa Paguntalan, Director, Philippines Biodiversity Conservation Foundation, Inc.
Bonifaco Ganotice Jr., Field Assistant

Seagrass, *Trochus niloticus* and *Hippopus hippopus*

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Cedella Morato, TMO Volunteer
Mudjikeewis Santos, BFAR-NFRDI
Francisco Torres, Jr., BFAR-NFRDI

Annex 2. Monitoring sites

Fish and Benthos

Sites	Stations	Latitude (N)	Longitude (E)
Site 2	Station 1A	8.93532 °	120.01302 °
	Station 1B	8.93781 °	120.00851 °
Site 4	Station 2A	8.89236 °	119.90627 °
	Station 2B	8.89128 °	119.90453 °
Site 6	Station 3A	8.75591 °	119.82881 °
	Station 3B	8.75186 °	119.82784 °
Site 7	Station 4A	8.80850 °	119.81907 °
	Station 4B	8.80656 °	119.82169 °
Jessie Beazley	Station JBA	9.04393 °	119.81599 °
	Station JBB	9.04557 °	119.81348 °
Grounding sites	USSG	8 49.297°	119 48.187°
	MPY	8 51.183°	119 56.188°

Seagrass

Sites	Latitude (N)	Longitude (E)
1	N8.93069°	E119.99560°
2	N8.92879°	E119.99671°
3	N8.85163°	E119.91849°
4	N8.85066°	E119.91666°
5	N8.74861°	E119.81894°

Tectus niloticus

Sites	Latitude (N)	Longitude (E)
1	N8.92786°	E120.01252°
2	N8.92318°	E119.99562°
3	N8.84815°	E119.91726°
4	N9.04393°	E119.81599°
5	N8.87317°	E119.88678°
6	N8.74951°	E119.81232°
7	N8.78537°	E119.82962°
8	N8.74432°	E119.82717°
9	N8.80827°	E119.80652°

Hippopus hippopus

Sites	Latitude (N)	Longitude (E)
1	N8.85186°	E119.91922°
2	N8.85173°	E119.91927°
3	N8.85150°	E119.91929°
4	N8.85122°	E119.91931°
5	N8.85089°	E119.91928°
6	N8.85059°	E119.91928°
7	N8.85024°	E119.91948°

Annex 3. Categories for evaluating ecological health of coral reef fish communities according to Hilomen *et al.* (2000) and Nañola *et al.* (2004).

Parameter	Measure	Category
	Number of species	
Species Richness	per 1000m²)	
	<26	Very poor
	27-47	Poor
	48-74	Moderate
	75-100	High
	>100	Very High
	Number of fish	
Abundance	per 1000m²)	
	< 201 fish	Very Poor
	202-676	Low
	677-2267	Moderate
	2268-7592	High
	> 7592	Very High
Biomass	mt/km²	
	0-10	Very Low to Low
	11-20	Moderate
	21-40	High
	>40	Very High

Annex 4. Mean reef fish density (individuals/500m2) of Family and Subfamily in deep (n=30) and shallow (n=30) stations of Tubbataha Reefs Natural Park.

Family	Common Name	Shallow (ind/500m2)	Deep (ind/500m2)
Acanthuridae	Surgeonfish	50.77	43.33
Acanthuridae: Nasinae	Surgeonfish	9.93	18.63
Apogonidae	Cardinalfish		0.03
Aulostomidae	Trumpetfish		0.03
Balistidae	Triggerfish	41.50	19.23
Belonidae	Longtom	0.37	
Blenniidae	Blenny	0.27	0.17
Caesionidae	Fusilier	0.47	27.73
Carangidae	Trevally	7.37	5.23
Carcharhinidae	Shark	0.10	0.20
Chaetodontidae	Butterflyfish	16.03	26.67
Chanidae	Milkfish	0.03	
Cirrhitidae	Hawkfish	3.10	1.40
Diodontidae	Porcupinefish	0.10	
Ephippidae	Batfish	0.20	0.07
Fistulariidae	Cornetfish	0.53	
Gobiidae	Goby	0.33	8.70
Haemulidae	Sweetlip	0.93	1.80
Holocentridae	Squirrelfish	0.30	20.40
Kyphosidae	Rudderfish	1.27	0.23
Labridae	Wrasse	76.47	38.97
Lethrinidae	Emperor	2.20	12.17
Lutjanidae	Snapper	1.53	18.20
Malacanthidae	Tilefish	0.03	
Monacanthidae	Filefish	1.00	0.10
Mullidae	Goatfish	2.33	1.57
Muraenidae	Moray Eel	0.03	0.07
Nemipteridae	Coral Bream	0.03	0.03
Ostraciidae	Boxfish	0.20	
Pinguipedidae	Sandperch	0.03	
Pomacanthidae	Angelfish	19.07	17.60
Pomacentridae	Damselfish	667.30	610.20
Pseudochromidae	Dottyback	0.20	0.10
Ptereleotridae	Dartfish	2.07	0.73
Scaridae	Parrotfish	14.70	11.87
Scombridae	Tuna and Mackerel	0.10	0.13
Serranidae	Grouper	15.03	12.33
Serranidae: Anthiinae	Anthias	281.30	532.60
Siganidae	Rabbitfish	0.47	1.33
Sphyraenidae	Barracuda	0.03	0.03
Tetraodontidae	Pufferfish	0.37	0.67
Zanclidae	Moorish Idol	2.87	3.53
Total		**1220.97**	**1436.10**

Annex 5. Mean reef fish density (individuals/500m²) of Family and Subfamily in deep (n=4) and shallow (n=4) stations in the grounding sites (Ming Ping Yu and USS Guardian) of TRNP.

Family	Common Name	Shallow (ind/500m²)	Deep (ind/500m²)
Acanthuridae	Surgeonfish	84.75	43.50
Acanthuridae: Nasinae	Surgeonfish	2.00	19.25
Balistidae	Triggerfish	24.50	75.00
Belonidae	Longtom	1.75	
Blenniidae	Blenny	0.00	0.25
Carangidae	Trevally	2.25	4.50
Carcharhinidae	Shark		0.50
Chaetodontidae	Butterflyfish	5.25	23.00
Cirrhitidae	Hawkfish	0.25	0.25
Gobiidae	Goby	0.50	0.75
Haemulidae	Sweetlip		0.25
Holocentridae	Squirrelfish		8.50
Labridae	Wrasse	82.25	38.00
Lethrinidae	Emperor	0.75	15.00
Lutjanidae	Snapper	0.50	6.50
Malacanthidae	Tilefish	0.50	
Monacanthidae	Fielfish		0.25
Mullidae	Goatfish	6.00	1.25
Nemipteridae	Coral Bream	0.50	
Ostraciidae	Boxfish	0.50	0.75
Pinguipedidae	Sandperch	1.50	
Pomacanthidae	Angelfish	1.50	9.25
Pomacentridae	Damselfish	429.50	441.00
Ptereleotridae	Dartfish	0.00	0.50
Scaridae	Parrotfish	24.75	22.50
Scombridae	Tuna and Mackerel		0.50
Scorpaenidae	Scorpionfish	27.25	
Serranidae	Grouper	8.25	14.75
Serranidae: Anthiinae	Anthias		279.00
Siganidae	Rabbitfish		2.25
Tetraodontidae	Pufferfish	0.50	0.50
Zanclidae	Moorish Idol	1.50	3.50
Total		**707.00**	**1011.25**

Annex 6. Mean reef fish biomass (mt/km2) of Family and Subfamily in deep (n=30) and shallow (n=30) stations.

Family	Local Name	Shallow (mt/km²)	Deep (mt/km²)
Acanthuridae	Surgeonfish	7.07	4.88
Acanthuridae: Nasinae	Surgeonfish	9.95	31.03
Apogonidae	Cardinalfish	0.01	
Aulostomidae	Trumpetfish	0.12	
Balistidae	Triggerfish	35.70	15.11
Belonidae	Longtom	0.04	
Blenniidae	Blenny	0.002	0.001
Caesionidae	Fusilier	0.03	8.42
Carangidae	Trevally	20.64	20.08
Carcharhinidae	Shark	5.00	8.67
Chaetodontidae	Butterflyfish	1.57	3.81
Chanidae	Milkfish	0.21	
Cirrhitidae	Hawkfish	0.04	0.03
Diodontidae	Porcupinefish	0.36	
Ephippidae	Batfish	0.53	0.22
Fistulariidae	Cornetfish	0.31	
Gobiidae	Goby	0.03	0.85
Haemulidae	Sweetlip	2.41	4.26
Holocentridae	Squirrelfish	0.10	7.68
Kyphosidae	Rudderfish	2.27	0.48
Labridae	Wrasse	3.35	3.71
Lethrinidae	Emperor	2.08	6.05
Lutjanidae	Snappe	2.99	11.57
Malacanthidae	Tilefish	0.01	
Monacanthidae	Filefish	0.07	0.01
Mullidae	Goatfish	0.34	0.45
Muraenidae	Moray Eel	0.05	0.29
Nemipteridae	Coral Bream	0.01	0.01
Ostraciidae	Boxfish	0.02	
Pinguipedidae	Sandperch	0.00	
Pomacanthidae	Angelfish	1.03	2.76
Pomacentridae	damselfish	6.75	14.58
Pseudochromidae	Dottyback	0.01	0.003
Ptereleotridae	Dartfish	0.01	0.003
Scaridae	Parrotfish	11.78	15.87
Scombridae	Tuna and Mackerel	0.05	0.64
Serranidae	Grouper	6.05	10.97
Serranidae: Anthiinae	Anthias	1.39	3.20
Siganidae	Rabbitfish	0.31	0.81
Sphyraenidae	Barracuda	0.48	1.18
Tetraodontidae	Pufferfish	0.12	0.40
Zanclidae	Moorish Idol	0.39	0.56
Total		**123.54**	**178.72**

Annex 7. Mean reef fish biomass (mt/km2) of Family and Subfamily in deep (n=4) and shallow (n=4) stations of grounding sites (Ming Ping Yu and USS Guardian) in TRNP.

Family	Local Name	Shallow (mt/km²)	Deep (mt/km²)
Acanthuridae	Surgeonfish	8.19	6.05
Acanthuridae: Nasinae	Surgeonfish	1.19	26.91
Balistidae	Triggerfish	10.60	36.19
Belonidae	Longtom	0.24	
Blenniidae	Blenny		0.000
Carangidae	Trevally	4.86	8.03
Carcharhinidae	Shark		1.67
Chaetodontidae	Butterflyfish	0.18	2.29
Cirrhitidae	Hawkfish	0.002	0.01
Gobiidae	Goby	0.03	0.01
Haemulidae	Sweetlip		0.19
Holocentridae	Squirrelfish		4.01
Labridae	Wrasse	1.91	8.80
Lethrinidae	Emperor	0.84	8.38
Lutjanidae	Snapper	0.11	9.13
Malacanthidae	Tielfish	0.04	
Monacanthidae	Filefish		0.03
Mullidae	Goatfish	0.46	0.17
Nemipteridae	Coral Bream	0.06	
Ostraciidae	Boxfish	0.07	0.24
Pinguipedidae	Sandperch	0.10	
Pomacanthidae	Angelfish	0.03	1.70
Pomacentridae	Damselfish	1.21	5.06
Ptereleotridae	Dartfish		0.00
Scaridae	Parrotfish	5.56	21.08
Scombridae	Tuna and Mackerel	8.97	
Scorpaenidae	Scorpionfish	1.00	
Serranidae	Grouper	0.88	6.78
Serranidae: Anthiinae	Anthias		1.55
Siganidae	Rabbitfish		1.07
Tetraodontidae	Pufferfish	0.01	0.11
Zanclidae	Moorish Idol	0.19	0.41
Total		**37.76**	**158.86**

Annex 8. Results of the analysis of variance (ANOVA) between spatial and temporal means of fish biomass in in TRNP.

Anova: Two-Factor Without Replication

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
2013	5	1157.179289	231.4358578	2678.99
2014	5	581.0266174	116.2053235	1002.62
2015	5	1672.349578	334.4699156	28489.9
2016	5	1094.286253	218.8572505	3390.57
2017	5	755.6273292	151.1254658	1213.75
Seafan Alley	5	1006.147473	201.2294947	3299.35
Malayan Wreck	5	1039.090914	207.8181828	16200.4
Delsan Wreck	5	890.3657002	178.07314	5126.42
T-Wreck	5	1518.895003	303.7790007	29826.2
Jessie Beazley	5	805.9699753	161.1939951	2344.4

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Temporal	141467.4103	4	35366.85259	6.60138	0.002456928	3.006917
Spatial	61383.28374	4	15345.82093	2.86437	0.057675383	3.006917
Error	85719.89166	16	5357.493229			
Total	288570.5857	24				

Annex 9. Condition of vegetation on Bird Islet and South Islet

Condition of vegetation on Bird Islet, May 2006 (baseline year) and 2015 to 2017

Trees/ Condition	Good (optimal)			Fair (moderately deteriorating)			Bad (severely deteriorating)			Total (live trees)			Dead trees		
	2006	2016	2017	2006	2016	2017	2006	2016	2017	2006	2016	2017	2006	2016	2017
Dead trees													82	75	**ND**
Mature,live trees (> 3 feet)	10	1	**0**	49	4	**0**	11	16	**10**	70	21	**10**			
Small, live trees (2- 3 feet)	109	33	**0**	0	24	**4**	0	7	**9**	109	64	**13**			
Seedlings (< 1 feet)	50	14	**0**	0	9	**9**	0	2	**7**	50	25	**16**			
Total	**169**	**48**	**0**	**49**	**37**	**13**	**11**	**25**	**26**	**229**	**110**	**39**	**82**	**75**	**ND**

Condition of vegetation on South Islet May 2011 (baseline year) and 2015 to 2017

Trees/ Condition	Good (optimal)			Fair (moderately deteriorating)			Bad (severely deteriorating)			Total (live trees)			Dead		
	2011	20166	2017	2011	2016	2017	2011	2016	2017	2011	2016	2017	2011	2016	2017
Dead trees													6	16	ND
Mature, live trees (> 3 feet)	70	0	0	28	20	9	5	40	23	103	60	32			
Small, live trees (2- 3 feet)	2	0	0	0	0	0	0	0	4	2	0	4			
Seedlings (< 1 feet)	19	0	0	0	0	8	0	0	0	19	0	8			
Total	**91**	**0**	**0**	**28**	**20**	**17**	**5**	**40**	**27**	**124**	**60**	**44**	**6**	**16**	**ND**
Note: Coco Palms 2011: 13, 2016: 6, 2017:6															

Annex 10. Seabird breeding data from Bird Islet and from South Islet, April to June 2004-2017

Source: WWF Philippines 2004 and TMO 2004 to 2017

Species/Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Red-footed Booby														
Immatures	398	1,455	606	597	780	477	677	795	799	426	134	206	80	97
Pulli/1st year juv.	> 35	71	105	116	69	180	88	171	243	312	277	240	49	43
Eggs	+	+	+	+	+	+	+	68	>166	>185	>57	>46	> 49	55
Nests	279	217	225	404	361	367	451	369	739	848	431	379	315	177
Brown Booby														
Immatures	0	81	26	55	55	61	126	110	140	62	51	28	66	157
Pulli/1st year juv.	43	2	7	12	91	126	125	225	46	28	266	200	22	175
Eggs	1	0	18	95	317	48	106	52	69	532	466	55	144	43
Nests	117	43	250	89	497	453	513	575	507	618	816	726	887	886
Brown Noddy														
Immatures	0	2	0	0	0	4	1	1	2	3	5	2	0	2

Pulli/1st year juv.	0	0	0	0	0	0	0	0	0	0	0	6	109	223
Eggs	0	0	0	3	17	126	438	253	>147	>607	679	571	620	1,005
Nests	115	124	20+	25+	218	384	653	571	709	771	931	960	1,048	1,917
Black Noddy														
Immatures	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulli/1st year juv.	0	0	0	0	0	0	0	0	0	0	0	30	193	8
Eggs	ND	+	0	+	+	430	+	+	>80	>700	>351	>299	>191	406
Nests	208	3,203	1,131	1,734	1,824	2,680	3,525	3,827	4,282	5,156	3,778	2,397	1,634	1,205
Great Crested Tern														
Immatures	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Pulli/1st year juv.	0	2,100	0	0	0	0	0	0	0	0	0	0	0	29
Eggs	0	1,829	0	0	0	515	2,341	498	1,456	3,939	2,120	4,280	6,800	8,620
Sooty Tern														
Immatures	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Pulli/1st year juv.	0	1,750	0	458	0	846	0	1,764	0	1,258	0	3,538	0	2,549
Eggs	9	0	0	63	2	3	5,515	2	1,534	146	37	52	166	0

Annex 11. Population results and population trend of breeding seabirds in TRNP, April to June 1981 – 2017. Baseline years are underlined

Source: Kennedy 1982, Manamtam 1996, WWF Philippines 1998-2004 and TMO 2004-2017

Species/ Numbers	1981	1995	1998	2000	2001	2002	2003	2004	2005	2006	2007
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**
Masked Booby	150	1	0	0	0	0	0	0	0	0	0
Brown Booby	3,768	**1)** 2,060	1,716	1,045	850	577	623	856	1,877	1,108	1,016
Great Crested Tern	2,264	335	0	150	414	4,160	2,064	2,808	7,858	6,894	4,700
Sooty Tern	5,070	**1)** 910	28	3,000	6,228	2,123	2	1,200	3,500	7,920	>1,500
Brown Noddy	2,136	643	0	500	37	775	115	336	590	1,035	530
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**
Red-Footed Booby	9	0	0	2	44	43	20	2,435	1,947	1,877	2,902
Black Noddy	147	7,128	3,250	3,500	6,998	4,860	1,610	805	6,406	6,850	> 5,000
TOTAL	**13,544**	**11,077**	**4,994**	**8,197**	**14,571**	**12,638**	**4,434**	**8,440**	**22,178**	**25,684**	**15,648**

Species/ Numbers	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Trend (%)
Ground-breeders											
Sub-total	**10,534**	**9,721**	**18,669**	**13,592**	**18,383**	**15,988**	**16,448**	**27,193**	**27,654**	**29,940**	+ 124
Masked Booby	0	0	0	0	0	0	0	0	1	1	**- 99**
Brown Booby	1,059	1,018	1,438	1,846	1,879	1,690	1,632	2,403	3,122	3,535	**- 6**
Great Crested Tern	4,875	4,433	4,790	6,160	8,653	9,794	**2)** 7,730	<12,387	13,880	17,097	**+ 655**
Sooty Tern	3,800	2,700	10,866	3,544	6,359	2,816	**3)** 5,224	**4)** 9,820	8,555	>5,098	**- 1**
Brown Noddy	800	1,570	1,575	2,042	1,492	1,688	1,862	2,583	2,096	4,209	**+ 97**
Tree-breeders											
Sub-total	**10,403**	**9,525**	**9,975**	**10,746**	**11,776**	**12,858**	**10,630**	**11,718**	**11,101**	**7,278**	**+4,550**
Red-Footed Booby	2,513	2,220	2,331	2,395	2,340	2,202	3,074	3,492	2,141	2,087	**- 12**
Black Noddy	7,890	> 7,305	7,644	8,351	9,436	10,656	7,556	8,226	8,716	5,191	**- 27**
TOTAL	**20,937**	**19,246**	**28,644**	**24,338**	**30,159**	**28,846**	**27,078**	**38,911**	**38,549**	**37,218**	**+ 175**

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

Annex 12. Inventory and population calculation methods per breeding species

Species	Calculation methods
Red-footed Booby	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 number is higher represents the daytime population. The in-flight counts of adult birds are added to the day-time results to determine the total minimum population present. 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 unfeasible and 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	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.
	The species only irregularly breeds at South Islet, the count result af adults from this islet is not included in the calculation of the total population of the species.
	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 result from South Islet is added to the result for North Islet in order to express the total population of the species present at TRNP.

	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	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
Brown Noddy	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 counts is used to express the maximum adult population present.
	At South Islet in-flight counts are normally 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	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. At South Islet in-flight counts are normally not carried out and only two data sets are used to determine the population at this islet: number of nests and number of adult birds counter. This result from South Islet is 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 the nests mostly are placed at high elevation in the vegetation, total counts of eggs and pulli is only possible at Bird Islet. Identification of immature birds is not possible as they look similar to adults.

Great Crested Tern	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.
	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	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 to the average results of two to three late afternoon/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.
Eurasian Tree Sparrow	Population size is expressed as presence of adult birds since nests have not yet been found

Annex 13. Distance count estimate: objectives and methods

Objective	Documentation of a) presence or absence of seabird species, and b) the relative population trend variation throughout the year.
Method	Distance counts include 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 show signs of being disturbed or start to fly, it may indicate 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 counts/estimates the bird population numbers, the other serves as the recorder. At least two independent counts must be made.
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 14. In-flight to roost statistics of boobies and noddies on Bird Islet May 2005 to May 2017

Species/ Numbers	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	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	May 11: 16:30 – 18.30	May 10: 16.30 – 18.00	
Red-footed Booby														
Adult: Daytime	823	655	631	1,241	686	982	1,011	382	830	950	1,499	248	343	
In-flight	960	1,171	2,082	1,272	1,534	1,259	1,259	1,680	779	813	602	367	527	
Adjusted to 2-hour period	1,012	1,222	2,271	-	-	-	-	-	-	-	-	-	-	
Total	1,835	1,877	2,902	2,513	2,220	2,241	2,270	2,062	1,609	1,763	2,101	615	870	

%-in-flight population	55%	65%	78%	51%	69%	56%	55%	81%	48%	46%	29%	25%	25%	**52.5%**
Immature: Daytime	514	>205	275	239	179	194	106	174	125	61	111	8	29	
In-flight	588	401	295	541	298	483	483	249	149	5	37	17	40	
Adjusted to 2-hour period	941	419	322	-	-	-	-	-	-	-	-	-	-	
Total	1,455	>606	597	780	477	677	589	423	274	66	148	25	69	
%-in-flight population	65%	69%	54%	69%	63%	71%	82%	59%	54%	8%	25%	25%	25%	**51.5%**
Brown Booby														
Adult: Daytime	629	405	660	691	650	930	1,338	1,060	968	834	1,505	1,920	2,257	
In-flight	360	225	326	368	368	508	508	819	722	798	848	1,202	1,278	
Adjusted to				-	-	-	-	-	-	-	-	-	-	

2-hour period	576	235	356											
Total	1,205	640	1,016	1,059	1,018	1,438	1,846	1,879	1,690	1,632	2,353	3,122	3,535	
%-in-flight population	48%	37%	35%	35%	36%	35%	28%	44%	43%	49%	36%	25%	25%	**36.6%**
Immature: Daytime	22	20	21	20+?	22	30+	96	81	30	13	1	25	74	
In-flight	37	6	31	34	39	96	14	59	32	39	25	41	78	
Adjusted to 2-hour period	59	6	34	-	-	-	-	-	-	-	-	-	-	
Total	81	26	55	54	61	126	110	140	64	51	26	66	152	
%-in-flight population	73%	23%	62%	63%	64%	76%	13%	42%	50%	76%	96%	62%	51%	**57.8%**
Brown Noddy														
Adult: Daytime							618	607	1,004	1,045	1,031	992	2,953	

In-flight							1,124	525	142	239	378	358	51	
Total							1,742	1,132	1,146	1,284	1,409	1,350	3,004	
%-in-flight population							65%	46%	12%	19%	27%	27%	2%	**28.3%**
Black Noddy														
Adult: Daytime							421	1,098	2,243	1,506	2,412	711	800	
In-flight							1,334	1,124	272	318	132	84	9	
Total							1,755	2,222	2,515	1,824	2,544	795	809	
%-in-flight population							76%	51%	11%	17%	5%	11%	1%	**24.6%**

Annex 15. In-flight to roost statistics of boobies and noddies on South Islet May 2014 to 2017

Species/Numbers	2014	2015	2016	2017	2014	2015	2016	2017	2015	2016	2017
Red-footed Booby					**Brown Booby**				**Black and Brown Noddy** (Note 1)	(Note 2)	(Note 3)
	May 8: 16.30 – 17.30	May 8: 16.30- 18.30	May 13: 16.30- 18.30	May 9: 16.30- 18.30	May 8: 16.30 – 17.30	May 8: 16.30 - 18.30	May 13: 16.30 - 18.30	May 9: 16.30 - 18.30	May 8: 16.30 - 18.30	May 13: 16.30 - 18.30	May 9: 16.30 - 18.30
Adult: Daytime	401	366	508	584	7	22	40	31	6,856	> 4,421	4,126
In-flight	910	1,020	1,018	633	2	28	24	11	4,678	> 3,500	< 2,066
Adjusted to 2-hour period	1,820	-	-	-	4	-	-	-	4,678	-	-
Total	2,221	1,386	1,526	1,217	11	50	64	42	11,534	7,921	6,192

% in-flight population	82.0%	73.6%	66.7%	52.0%	18.2%	56.0%	37.5%	26.2%	40.6%	44.2%	33.4%
									Black Noddy		
Immature: Daytime	68	58	32	27	0	2	0	4	**Adult:** Daytime		2,921
In-flight	1	Not counted	21	1	0	Not counted	Not counted	1	In-flight	(Note 4)	1,461
Adjusted to 2-hour period	2	-	-	-	0	-	-	-	Adjusted to 2-hour period		-
Total	70	> 58	63	28	0	>2	0	5	**Total**		4,382
% in-flight population	2.9%	-	33.3%	3.6%	0%	-	-	20.0%	% in-flight population		33.3%
									Brown Noddy		
									Adult: Daytime		1,205

									In-flight	(Note 4)	605
									Adjusted to 2-hour period		-
									Total		1,810
									% in-flight population		33.4%

Note 1: Majority = Predominantly Black Noddy

Note 2: From 16.30 to 17.30 more birds left the islet compared to the number of birds arriving. From 17.30 to 18.00 more birds arrived than left the islet

Note 3: 578 individuals left the islet while 2,644 flew in = 2,066

Note 4: Number extrapolated based on ratio between the numbers of the two species present during daytime

Annex 16. Results of Park Rangers' inventory counts, August and November 2016 at Bird Islet and South Islet (Note 1)

Species/Date	13 August	17 November		
Red-footed Booby	Day Count	Day Count	Inflight	Total
Adult	254	222	398	620
Sub-adult	2	25	6	31
Pullus/ juvenile	5	42	0	42
Eggs	3	103	-	103
Nests	42	181	-	181
Brown Booby				
Adult	144	396	839	1,235
Sub-adult	2	18	5	23
Pullus/ juvenile	18	62	0	62
Eggs	21	356	-	356
Nests	348	737	-	737
Masked Booby				
Adult	1	1	0	1
Great Crested Tern				
Adult	1,718	0	-	0
Sub-adult	0	0	-	0
Pullus/ juvenile	99	0	-	0
Eggs	11	0	-	0
Nests	11	0	-	0

Sooty Tern				
Adult	67	0	0	0
Sub-adult	0	0	0	0
Pullus/juvenile	50	0	0	0
Eggs	5	0	-	0
Nests	5	0	-	0
Brown Noddy				
Adult	614	5	-	5
Sub-adult	0	0	-	0
Pullus/juvenile	0?	0	-	0
Eggs	19	0	-	0
Nests	115	0	-	0
Black Noddy				
Adult	165	0	-	0
Sub-adult	0	0	-	0
Pullus/juvenile	0	0	-	0
Eggs	0	0	-	0
Nests	20	0	-	0

South Islet	2016			
Species/Date	15 August	20 November		
Red-footed Booby	Day Count	Day Count	Inflight	Total
Adult	325	181	No count	181
Sub-adult	12	7	No count	7
Pullus/ juvenile	12	2	No count	2
Eggs	1	1	-	1
Nests	37	65	-	65
Brown Booby				
Adult	149	0	No count	0
Sub-adult	0	0	No count	0
Pullus/ juvenile	0	0	No count	0
Eggs	0	0	-	0
Nests	0	0	-	0
Great Crested Tern				
Adult	11	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	370	0	-	0
Sub-adult	4	0	-	0
Pullus/ juvenile	4	0	-	0
Eggs	4	0	-	0
Nests	66	36	-	36
Black Noddy				
Adult	281	0	-	0
Sub-adult	0	0	-	0
Pullus/juvenile	0	0	-	0
Eggs	0	0	-	0
Nests	331	72	-	72

Note 1: No counts conducted in 1st quarter of 2017

Annex 17. Systematic list of avifaunal records, Bird Islet, South Islet and Ranger Station from 8 to 12 May 2017

Breeding species are indicated in bold letters. Taxonomic treatment and sequence follows IOC/Wild Bird Club of the Philippines 2017

Status/Abundance (within Sulu Sea)	Species name	Number of individuals	Locality	Notes
Accidental/Migrant Rare	White-tailed Tropicbird *Phaethon lepturus*	1 adult	09° 21'420"N, 119° 19'.197"E	Seen passing by the research vessel north of the TRNP at 10.04am, 12 May 2017
Resident/Migrant Fairly Common	Striated Heron *Butorides striata*	1	Ranger Station	
Resident/Migrant Locally Common	Eastern Cattle Egret *Bubulcus coromandus*	1	Ranger Station	Non-breeding plumage
Resident Uncommon	**Pacific Reef Heron** *Egretta sacra*	Adults: 5 Nests: 0	Bird Islet	Dark phase
		Adults: 1	Ranger Station	Dark phase
		Adults: 11 Nests: 3	South Islet	Dark phase. No eggs and pulli
Migrant Locally uncommon	Great Frigatebird *Fregata minor*	Adults: 2	Bird Islet	Males
		Adults: 1-2	South Islet	Males
Migrant Locally uncommon	Lesser Frigatebird *Fregata ariel*	1-2	Bird Islet	Immatures
		1	South Islet	Immature 2 years old

	Unidentified Frigatebird *Fregata sp.*	18	South Islet	Distance too far for identification
Extirpated Rare	**Masked Booby** *Sula dactylatra*	Adult: 1	Bird Islet	Male. Same bird as first found in May 2016. Feeding a pullus of Brown Booby and prior incubated the egg together with a female Brown Booby
Resident Locally uncommon	**Red-footed Booby** *Sula sula*	Adults: 870 Immatures: 69 Pulli/juv.: 28 Nests: 63 Eggs: 5	Bird Islet	
		Adults: 1,217 Immatures: 28 Pulli/juv.: 15 Nests: 114 Eggs: 50	South Islet	
Resident Rare	**Brown Booby** *Sula leucogaster*	Adults: 3,535 Immatures:152 Pulli/juv.: 168 Nests: 886 Eggs: 43	Bird Islet	
		Adults: 42 Immatures: 5 Juveniles: 4	South Islet	Not breeding
Migratory Common	Grey Plover *Pluvialis squatarola*	1	Bird Islet	Non-breeding plumage

Migrant Rare	Oriental Plover *Charadrius veredus*	1	Ranger Station	Breeding plumage. New record to TRNP
Migratory Common	Common Redshank *Tringa totanus*	1	Bird Islet	New TRNP record
Migratory Common	Common Greenshank *Tringa nebularia*	1	Ranger Station	In breeding plumage. First record since 2006
Migratory Common	Grey-tailed Tattler *Heteroscelus brevipes*	2	Bird Islet	
		1	Ranger Station	In breeding plumage
Migratory *Uncommon*	Terek Sandpiper *Xenus cinereus*	1	Ranger Station	Breeding plumage New TRNP record
Migrant Fairly common	Ruddy Turnstone *Arenaria interpres*	6	Bird Islet	One in breeding plumage
		2	Ranger Station	Breeding plumage
Migrant Common	Red-necked Stint *Calidris ruficollis*	1	Bird Islet	
		1	Ranger Station	
Migrant Uncommon	Sanderling *Calidris alba*	1	Bird Islet	Breeding plumage
		2	Ranger Station	1 in breeding plumage
Resident Locally rare	**Brown Noddy** *Anous stolidus*	Adults: 3,004 Pullus: 191 Nests: 1,502 Eggs: 687	Bird Islet	3rd time with pulli in May.
		Adults: 1,205 Immatures: 2 Pullus: 32	South Islet	3rd time with pulli in May

		Nests: 415 Eggs: 318		
Resident Locally Rare	**Black Noddy** *Anous minutus*	Adults: 809 Pullus: 2 Nests: 152 Eggs: 25	Bird Islet	3rd time with pulli in May
		Adults: 4,382 Pullus: 6 Nests: 1,053 Eggs: 384	South Islet	3rd time with pulli in May
Migratory Uncommon	Gull-billed Tern *Gelochelidon nilotica*	1	Bird Islet	Passing by. First record in TRNP
Resident Fairly Common	**Great Crested Tern** *Thalasseus bergii*	Adults: 17,097 Pullus: 29 Eggs: 8,620	Bird Islet	Largest number ever recorded
		Adults: 39	South Islet	Not breeding
		Adults: >190	Ranger Station	Not breeding
Migrant/Resident Uncommon	Little Tern *Sternula albifrons*	6	Bird Islet	
Resident Rare	**Sooty Tern** *Onychoprion fuscata*	Adults: 5,098 Pulll/Juv: 2,549 Eggs: 0	Bird Islet	Only few hundred adults present daytime
		Adults: 0	South Islet	Passing by

Migrant? Rare	Roseate Tern *Sterna dougallii*	1	Bird Islet	Passing by
Resident Uncommon	Black-naped Tern *Sterna sumatrana*	7	Bird Islet	
		6	Ranger Station	Pink-colored
Migrant Common	Whiskered Tern *Chlidonias hybrida*	1-2	Bird Islet	Immature
		1	Ranger Station	Immature
Migrant Fairly common	White-winged Tern *Chlidonias leucopterus*	15	Bird Islet	Migrating north
Migrant Uncommon	Indian/Himalayan/ Oriental Cuckoo *Cuculus micropterus/ saturatus/optatus*	1	Bird Islet	First record in TRNP. One brownish bird passing by but too far for species identification
Resident Common	Collared Kingfisher *Todiramphus chloris*	1	Ranger Station	
Migrant Uncommon	Lanceolated Warbler *Locustella lanceolata*	1	Ranger Station	Short roost at the research vessel
Resident Common	Asian Glossy Starling *Aplonis panayensis*	2	South Islet	Juveniles. Short roost at the research vessel
Resident Common	**Eurasian Tree Sparrow** *Passer montanus*	2	Bird Islet	
		8	South Islet	
Migrant Common	Eastern Yellow Wagtail *Motacilla tschutschensis*	6	Bird Islet	
		1	Ranger Station	

Annex 18. Comparison of the landscape and habitats seen from the permanent photo documentation sites on Bird Islet and South Islet, May 2004 and May 2017

Bird Islet

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

Photo name code: B1 01 Comments: 7 shots (Stitched by Microsoft ICE) Date: May 11, 2017

Photo nos.: DSC_5964-70 Photo credit: Teri Aquino

Viewing angle for photo: facing NE 038º

Film no: 27, 28

Photo no (camera):

Photo name code: BI 02

Photo no (negative):

Photo name code: BI 02

Comments: 5 shots

Photo nos.: DSC_5931-35

Date: May 11, 2017

Viewing angle for photo: facing S 165º

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)

Photo credit: Teri Aquino

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 name code: BI 04

Comments: 1 shot plaza

Date: May 11, 2017

Photo nos.: DSC_5946

South Islet:

Viewing angle for photo: facing S 060º

Comments: shot includes view of parola at the background

Photo name code: SI 01

Photo name code: SI 01

Date: May 9, 2017

Comments: single shot including parola at the background