TRNP Ecosystem Research and Monitoring Report 2016

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Suggested Citation:

Tubbataha Management Office. 2016. Ecosystem Research and Monitoring Report 2015. Tubbataha Protected Area Management Board. Puerto Princesa City, Philippines

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Executive Summary

Coral reefs are considered the rainforests of the ocean because of their rich biodiversity. When properly managed, coral reefs provide many goods and services to coastal communities, including fisheries, recreation, research, protection against natural hazards and climate regulation. In the Philippines, coral reefs contribute approximately 11 to 29% of the country's fisheries production (Licuanan and Gomez, 2000). However, the impacts of natural phenomena coupled with anthropogenic pressures bring our coral reefs to deterioration.

Tubbataha Reefs Natural Park is no exception to these threats. Thus, the health of the reefs and the marine life depending on it is monitored annually Tubbataha Reefs Natural Park is no exception to these threats. Thus, the health of the reefs and the marine life depending on it is monitored annually. The average fish biomass was estimated to be 218.9 grams per m^2 from 334.5 last year. The decline in the average biomass this year was influenced by the decline recorded in all five regular monitoring sites. Further analysis reveals that biomass estimates are strongly influenced by temporal variations (between years) rather than spatial variations (between sites). Tubbataha, being an oceanic reef, is often visited by schools of large, mobile pelagic fishes. This greatly influenced the biomass results in some of the years, making the data series fluctuate erratically. Excluding sharks and schools of large-bodied fishes greater than 100 individuals, the average fish biomass was estimated to be 189.2 grams per m^2 from 223.4 last year. This decline was observed in all monitoring sites. Despite the huge decline in biomass, average fish density has increased to 2,079 individuals per 500 m^2, or 24% higher than last year. Four out of the five monitoring sites have increased density outputs which suggests that the increase in the average was true of all sites.

Fish populations were categorized based on their commercial and ecological importance and their associations to the reefs. Pelagic fishes accounted for 46% of the fish biomass while demersal fishes comprised the remaining 54%. Further classification of the fish population was also made – indicator, target and major groups. Indicator fish biomass dropped to 1.9 grams per m^2 from 3.3 in 2015. Their occurrence also dropped to 17 individuals per 500 m^2 from 23 last year. Biomass of target species dropped to 189.2 grams per m^2, quite far from last year's 283.3. Thisgroup made up 81% of the average biomass. The density of these fishes increased to 408 individuals per 500 m^2 from only 294 in the previous year. However, an increase in density does not result in an increase in biomass. Large-bodied target fish were more abundant and dominant in 2015 compared to this year's survey. Like the indicators, major species showed declines in both biomass and density compared to the previous monitoring. Their biomass was down to 42.3 grams per m^2 from 56.3 last year, and their density to 1,654 individuals per 500 m^2 from 1,955. This group comprised 79% of the fish density.

The threatened and near threatened species recorded this year are bumphead parrotfish (*Bolbometopon muricatum*), napoleon wrasse (*Cheilinus undulatus*), grey reef sharks (*Carcharhinus amblyrhynchos*) and whitetip reef sharks (*Triaenodon obesus*). Fish populations in the two grounding sites were also surveyed. The USS Guardian grounding site continues to yield improving fish biomass. It slightly increased to 473 grams per m^2 from 469.2 in 2015. However, fish density in the same area was almost halved. From 3,393 in 2015, only 1,759 individuals were present per 500 m^2 this year. The case in Min Ping Yu is the opposite of what happened in the USSG. Here, fish biomass decreased with increasing fish density. From 177.3 grams per m^2 in 2015, fish biomass fell to 140.8 grams per m^2 while density improved by five percent to 2,132 individuals per 500 m^2.

The results of the monitoring of the benthic community is presented according to depths to be able to describe the conditions and changes in benthic compositions at two different zones in the park – shallow sites on the reef flat and deep sites located in the walls. In general, the mean live coral cover (64%) of the deep sites are in 'good' condition, while the shallow sites are in excellent condition based on the classifications of Gomez et al. (1994). For both depths, the live coral cover did not deviate much from last year's results. Hard coral cover of the deep sites this year (38.76%) is less than last year's (40.9%), but the difference is not significant. The highest hard coral cover was recorded at Station 7B, while the lowest was recorded in Station JBB. Hard coral cover of the shallow sites decreased from 75.22% in 2015 to 70.81% this year, but the decrease in not significant. Looking at the general trends of the benthic components at both depths, we can tell that the condition of the reefs in Tubbataha continue to improve. This is evident in the generally increasing hard and soft coral cover, and decreasing cover of algae, mortalities, other invertebrates and abiotic components. In conclusion, the fish biomass and live coral cover in Tubbataha are still beyond what is considered a healthy reef ecosystem in the country. Efforts to protect this fragile marine ecosystem should be continued, for it to be able to give the ecosystem services it provides.

The land area of Bird islet has decreased by nearly17% from 18,760% in 1981, and 10% since 2004, when GPS was first introduced. Erosion started along sections of the northeastern coastline in 2012. Also, the sandbars located to the southeast of the islet have been substantially reduced in size. Measures to mitigate the erosion of the islet are recommended. The South islet has not significantly decreased in size due to the seawall constructed around it. However, the partial collapse of the seawall and continued deterioration of the remaining wall is likely to hasten the erosion of the islet.

A minimum of 38,511 adult individuals of the six breeding seabird species were recorded; 28,011 on Bird Islet and 10,500 on South Islet (Table 5). Bird Islet hosted about 73% of the population (78% in 2015) while South Islet hosted 27 % (22% in 2015). The total result of the May 2016 count is almost the same as in 2015 (38,911 individuals) and represents, together with 2015, the highest count ever. The high count result is mainly due to the presence of a substantial number of both Great Crested Terns and of Sooty Terns. A decrease in the number of adult and pulli Red-footed Booby was observed in 2016 since the species started to occupy Bird Islet in 2004. Brown Booby population continue to increase to the highest number of adults and nests recorded since regular inventories started in 1997. However, the species had the lowest reproduction rate - as seen in the number of eggs, pulli and 1st year juveniles, - since 2009. Despite the increase this year, the population is still 17% lower than in the baseline year of 1981. There was a 19% reduction in the population of Brown Noddy compared to 2015. However, the population is still at the same level as in the baseline year of 1981. Similar to 2015, a very early start of breeding was observed as evidenced by the presence of pulli during the inventory period. A marked decrease of over 1/3 of the number of nests of Black Noddy was noted this year. The largest nesting decline on Bird Islet corresponds to the decline in vegetative cover. The very low breeding activity may be caused by the lack of leaves used as nesting materials. A similar decrease was observed on South Islet where only 40% of the population was breeding. The number of Black Noddy breeding on the ground and inside the Lighthouse and in the hut in the South Islet increased. After 21 years, an adult male Masked Booby was found in the main colony of Brown Booby at 'Plaza". It remained there until 10 June 2016 and occupied a territory of Brown Booby where it incubated an egg together with a female Brown Booby.

A total of 200 green turtles *(Chelonia mydas)* were captured via rodeo jumps. Of these, 49 turtles were recaptures. As in the previous years, females account for a substantially high percentage (76%) compared to the captured males (24%). This equates approximately to a 1Male:3Female ratio. Juvenile turtles this year account for 52% of the total captures. This number is lower compared to 2015 where juveniles made up 78% of the captured turtles. The 73 sub-adults comprise 37% of the turtles captured this year, while the 22 adults constitutes 11%. As with the previous years, given the variation in growth rates, there was overlap in sizes amongst the differing age-classes, particularly between the 55cm and 80cm. During laparoscopy, two turtles, both not previously captured in the park, were determined to be adult males that were ready to find partners and breed this year. Both of them were installed with satellite trackers. Dr. Pilcher noted that these are probably the only male green sea turtles with satellite trackers in the Southeast Asian region. Satellite trackers previously deployed in the region have been on nesters (females) which were conveniently caught on land as they laid eggs. One turtle caught in South Islet came from Malaysia (left tag MYS27963; right tag: MYS27964). This is the first time that a foreign tagged turtle has been documented in the park. This nester from Malaysia measured 99.5 cm and was the largest caught this year.

Water quality was monitored for 20 stations in the park. Results were compared against the highest standards for marine protected areas in the Philippines (CLASS SA) as stipulated in DENR Admin. Order No. 34, Series of 1990. TRNP passed in almost all parameters except for total coliform, fecal coliform and oil and grease. Temperature readings during this survey range from 26.9^{o}C to 31.7^{o}C, which are within the surface temperature readings of Villanoy et al. (2007), which from range from 28^{o}C to 32^{o}C. For oil and grease, 15 sites failed to meet the standard for Class SA. Of these, 11 sites even exceeded the maximum for Class SC which is only suitable for recreational activities such as boating. This year, 10 sites exceeded the 70 MPN/100mL maximum total coliform level for Class SA, while eight sites were in exceedance to the fecal coliform level. It is recommended that the south/southwestern side of both atolls be designated for the greywater discharge.

INTRODUCTION

CHAPTER 1

1 INTRODUCTION

1.1 Overview

Up to half a billion people globally are believed to depend economically on coral reefs (Beaudoin and Pendleton, 2012).In the Philippines, coral reefs contribute approximately 11 to 29% of the country's fisheries production (Licuanan and Gomez, 2000).

The conservation of the Tubbataha Reefs Natural Park is therefore imperative because it contributes to the fisheries productivity of the country. The legal basis for its protection is Republic Act 10067 or the Tubbataha Reefs Natural Park Act of 2009. RA 10067 provides for more stringent penalties for violations and extended the area of the park, adding a 10-nautical mile buffer zone to the existing 97,030-hectares no take area. Four programs are employed in managing TRNP: Conservation Management, Conservation Awareness, Sustainable Resource Management, and Research and Monitoring.

The goals of Ecosystem Research and Monitoring (ERM) are:

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

The results of monitoring activities conducted in the park reflects the effectiveness of management programs, where anthropogenic pressures are concerned. They also serve as guide for the Tubbataha Protected Area Management Board (TPAMB) to arrive at science-based management decisions and policies.

This year marks the 20th year of consistent biophysical monitoring of TRNP, specifically the fish, benthos and seabird populations. Regular monitoring was previously spearheaded by World Wildlife Fund (WWF) – Philippines beginning in 1997. 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 2016 and provides an analysis of temporal and spatial trends of the benthic community, fish and seabird populations.

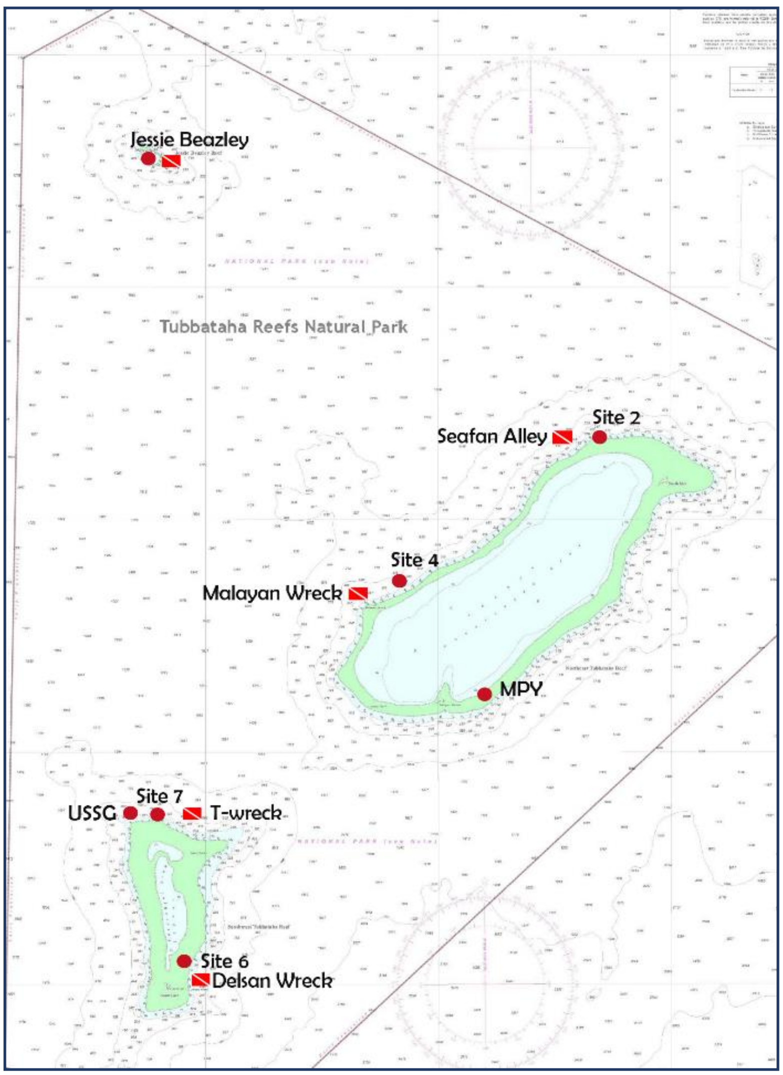

Figure 1. Location map of the monitoring sites.

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 coral community using the photo-transect method.

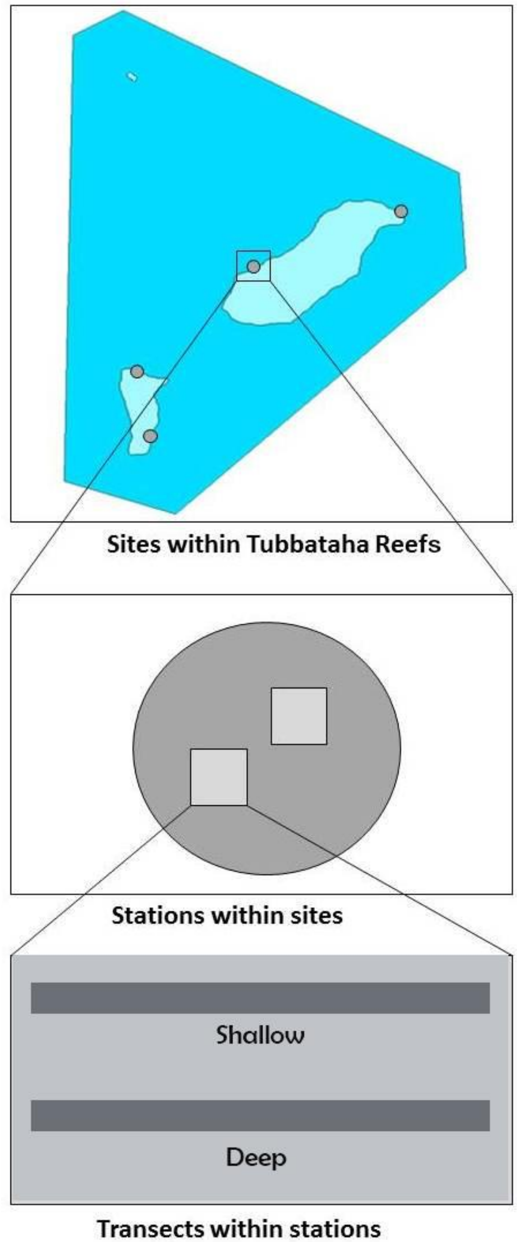

Figure 2. Hierarchical sampling design (Modified from Licuanan et al 2015 unpublished).

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 and Limitations

The fish and benthos survey were conducted on 18 – 24 April while the seabirds survey was conducted on 9 – 14 May. This year, one limiting factor for both the fish and benthos surveys was the lack in manpower. Due to unforeseen circumstances, each team was short of members, that is why adjustments were made to be able to maximize the available human resources. The benthos team was assisted by one of the MY Navorca crew, while the fish team decided to drop the shallow sites. The members of the monitoring team is listed in Annex 1.

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1.3 References

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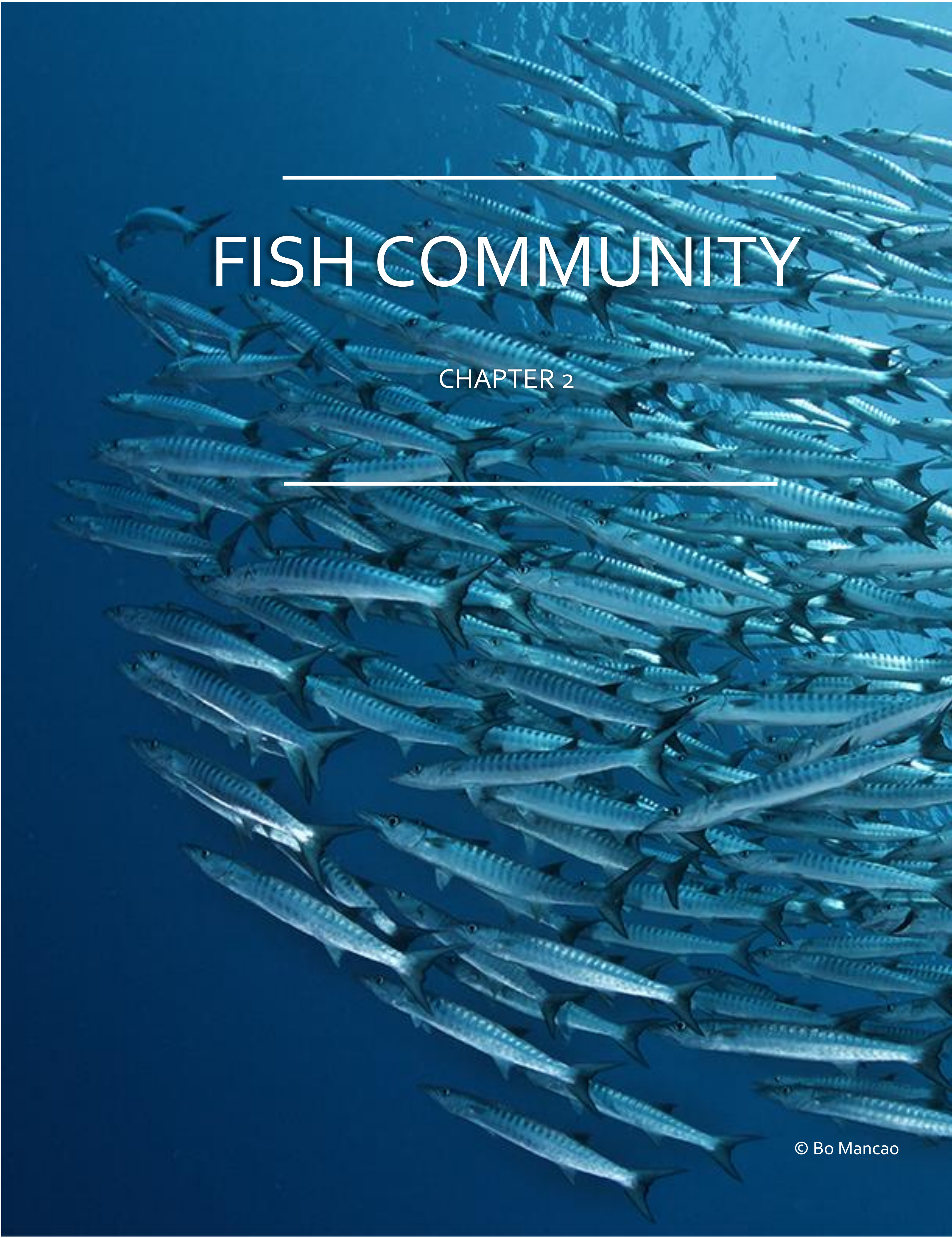
FISH COMMUNITY

CHAPTER 2



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2 FISH COMMUNITY

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2.1 Overview

Tubbataha's fish community is annually monitored since 1997 to inform management of the present condition of the reef. Fish biomass, density, and species richness are the parameters used to gauge the condition of the fish population. Results are compared to previous findings in order to establish trends.

Results show that fish biomass in Tubbataha fluctuate from year to year. This could be due to natural variations through time, changes in sampling design, and shortages in manpower. In 2013, the number of monitoring sites were reduced from 10 to five, which made comparison of results over the years difficult.

2.2 Methods

Sampling design

Because of manpower shortage during the census, the team dropped the shallow transects (five meters) and gave priority to the deep transects (10 meters). This is because the deeper transects have a longer data series than the shallow ones and are thereby more useful for establishing trends. This halved the number of surveyed transects down to 30 this year. The USS Guardian and Min Ping Yu grounding areas were also monitored.

Data collection was patterned from Fish Visual Census by English et al. (1997). Divers took note of the scientific name, count, and the estimated size/length of all fishes encountered inside the established survey areas. Each transect is 50 meters long with an imaginary 5-meter coverage on both sides (50 x 10 m or 500 m^2). Transects were divided into 5-meter segments along its length and surveyed one segment after another. Highly-mobile fish species were recorded first before the slower benthic dwellers. Four divers completed this year's survey; two worked alone in separate transects, while two divers covered the remaining transect. Each transect was accomplished within 50 minutes to an hour.

Data analysis

Raw data was collated following the format introduced by DENR through the Coral Reef Visualization and Assessment (CoRVA) system in 2014. Species richness was derived from the actual number of fish species recorded, density and abundance from the actual counts, and biomass from both counts and size estimates. A two-factor analysis of variance (ANOVA) carried out with Microsoft Excel 2013 was used to detect significant differences in overall fish biomass between monitoring sites and between years from 2013 to 2016. Density was expressed in number of individuals per 500 m^2. Biomass estimate was simplified to grams per m^2 to compensate for the variations in the sampling designs employed throughout the 19 years of reef fish monitoring in Tubbataha. Biomass was calculated using the length-weight relationship formula of Kulbicki et al. (1993)

$$W = (a \times L^b) \cdot count$$

Where:

W = weight (biomass) in grams

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

L = size estimate (total length) in centimeters

2.3 Results and discussion

Fish biomass

The average fish biomass was estimated to be 218.9 grams per m² from 334.5 last year. The decline in average biomass this year was influenced by the decline recorded in all five regular monitoring sites. Average fish biomass in Tubbataha from 1999 through 2016 was at 252.7 grams per m². A polynomial trend line was used to establish trend in Tubbataha's fluctuating average fish biomass data series (see Figure 3). A continuous downward trend was reflected by the data series from 1999 to 2004 because of the visible decrease in biomass year after year. However, the trend became upward from 2005 to 2009 because of evident improvement in the biomass yield in the course of these years. The trend seemed to plateau from 2011 to present. Although a major decline in biomass was recorded in 2014, the trend was compensated by the abrupt increase the following year, mainly due to fish seasonality. Site 7 had the highest record of fish biomass among the regular monitoring sites this year. The said area has the highest biomass yield in the last four years.

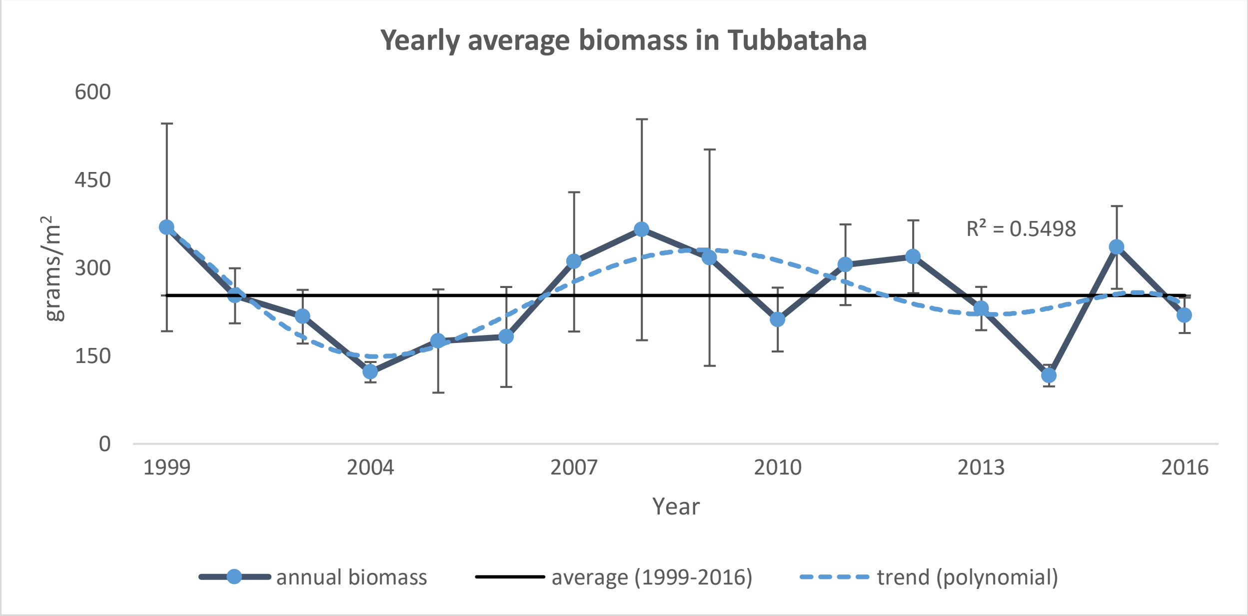

Figure 3. Average fish biomass in Tubbataha from 1999 to 2016 (2000 and 2001 data unavailable). Error bars represent the standard error of the mean.

A two-factor Analysis of Variance (ANOVA) was used to examine the biomass estimates of all sites from 2013 to determine the source and intensity of variations between values (see Table 1). The analysis showed that there is a significant difference between yearly biomass estimates (p=0.006). Like last year's analysis, the test confirmed that Tubbataha biomass estimates are strongly influenced by temporal variations (between years) rather than spatial variations (between sites).

Table 1. Results of the two-way ANOVA used to investigate fish biomass values from 2013 to 2016. Variation between years (p=0.01) is statistically significant.

Two-way ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between years	119494.31	3	39831.43	6.69	0.006	3.49
Between sites (within years)	70835.29	4	17708.82	2.97	0.063	3.25

Differing biomass values from year to year can be linked to the fact that fishes are highly mobile animals. Movement of fishes is strongly influenced by factors such as food source, avoidance to predators, mortality risk, and shifting habitats (Dahlgren and Eggleston, 2000). In the local scale, this can be associated with feeding, spawning, diver presence, and ontogenetic shifts in habitat requirements (Sale, 2002). Also, the sampling design used and effort exerted in the conduct of Fish Visual Census varied from time to time, depending heavily on availability of manpower and existing national protocols.

Separate biomass results for deep (10-12 meters) and shallow transects (4-6 meters) is provided in Figure 4. Deep transects have remarkably greater fish biomass outputs than shallow ones. Also, it is comparatively more unstable. Since 1999, biomass in this depth averaged to 361.3 grams per m^2. The trend in the last four monitoring years seems to be decreasing. The decline from last year could have been manifested by the stabilization of fish biomass values in 2016. A remarkably high yield was recorded last year due to evident prominence of big fishes. Fish biomass in shallow transects on the other hand are seen to be increasing. Except in 2008, results remained to be stable and close to the average of 121.3 grams per m^2 from 2002 to 2015.

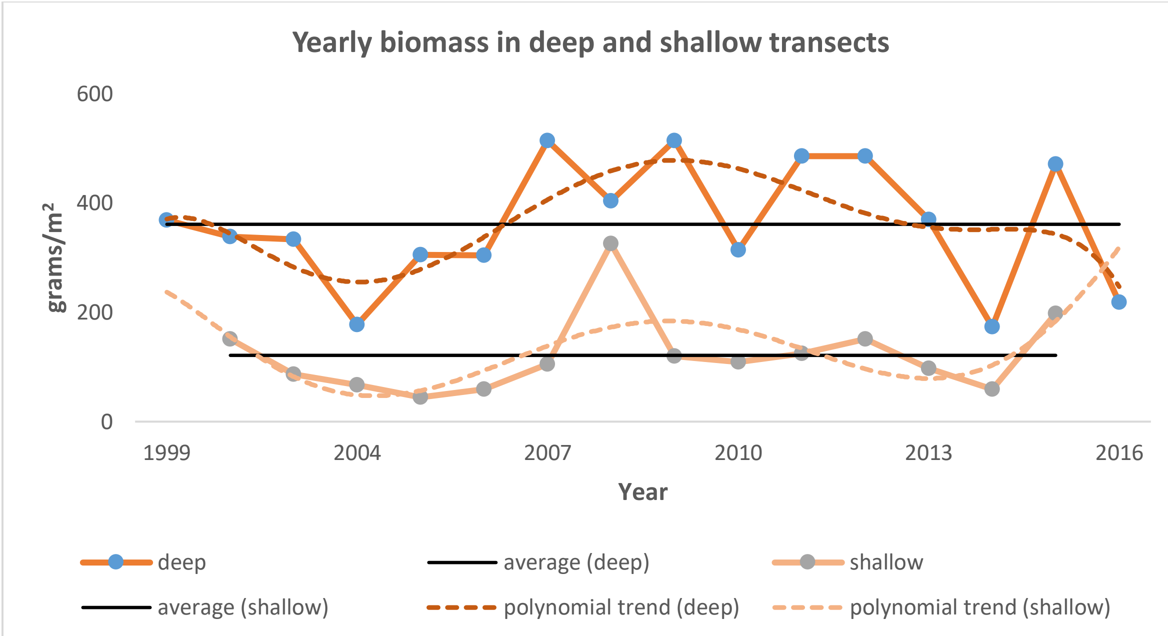

Figure 4. Average fish biomass in deep and shallow transects in Tubbataha from 2002 to 2015.

Tubbataha, being an oceanic reef, is often visited by schools of large, mobile pelagic fishes. This greatly influenced biomass results in some of the years, making the data series fluctuate erratically. To get a clearer picture of the biomass of reef fishes, biomass of sharks and large-bodied, schooling fishes greater than 100 individuals were removed from the biomass computation below. In this report, schooling large-bodied fishes include some unicornfishes (Nasinae), fusiliers (Caesionids), jacks and trevallies (Carangids), emperors (Lethrinids), snappers (Lutjanids), bumphead parrotfishes (*Bolbometopon muricatum*), and barracudas (Sphyraenids). Excluding these fishes, the average fish biomass was estimated to be 189.2 grams per m^2 from 223.4 last year. The decline in biomass this year was observed in all five regular monitoring sites.

The average fish biomass in Tubbataha from 1999 through 2016 was at 186.3 grams per m^2. Biomass yields in each year (except 2007, 2008, and 2014) were close to the 17-year average. A polynomial trend line was used to establish trend in Tubbataha's fluctuating average fish biomass data series (see Figure 5). Again, the trend line did not vary much even though there was an evident increase in 2007 because it was compensated by the abrupt decrease the year after. A similar scenario happened in 2014 to 2015. The behavior of the trend line only affirms that seasonality of fishes plays a big role in the biomass yields in Tubbataha. Site 7 had the highest record of fish biomass among the regular monitoring sites this year. The said area has the highest biomass yield in the last four years.

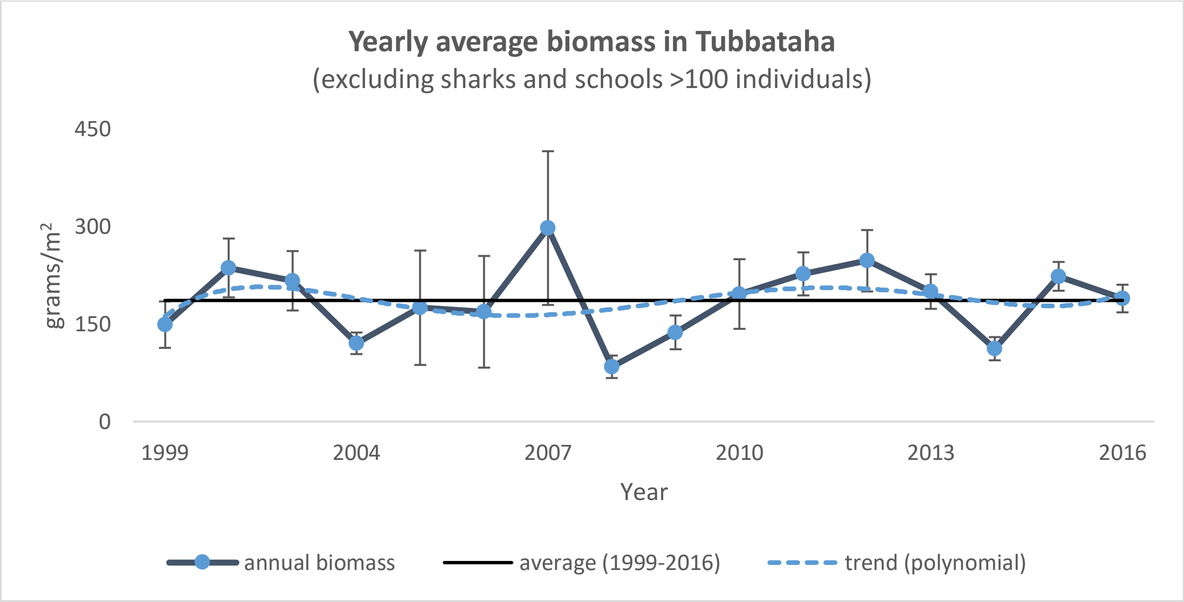

Figure 5. Average fish biomass in Tubbataha from 1999 to 2016 (2000 and 2001 data unavailable). Error bar represent standard error of the mean.

A separate biomass results for deep and shallow transects (excluding sharks and large-bodied fishes aggregating to schools greater than 100 individuals) is provided in Figure 6. Deep transects have remarkably greater fish biomass outputs than shallow ones. Also, it is comparatively more unstable. Since 1999, biomass in this depth averaged to 269.3 grams per m^2. The trend in the last four monitoring years seems to be decreasing. The decline could have been manifested by the stabilization of fish biomass values in Tubbataha which produced a remarkably high yield in 2015 due to the prominence of big fishes. Fish biomass in shallow transects on the other hand are seen to be increasing. Results remained to be stable and close to the average of 92.3 grams per m^2 from 2002 to 2015.

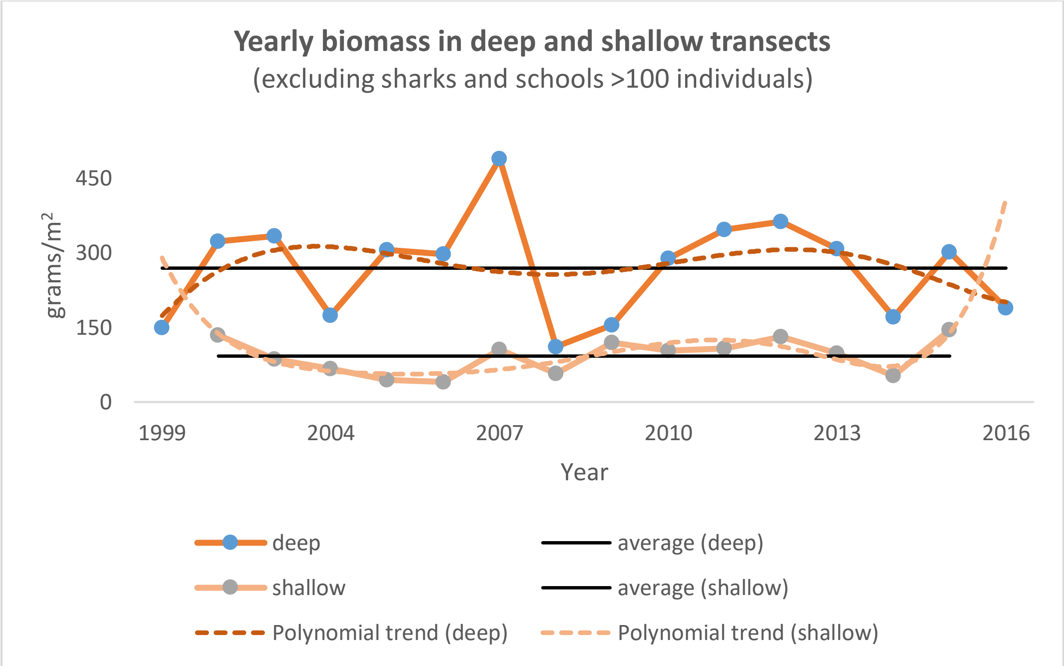

Figure 6. Average fish biomass in deep and shallow transects in Tubbataha from 2002 to 2015.

Unicornfishes (Family Acanthuridae subfamily Nasinae) accounted for 23% of the average biomass this year, the highest of all fish families. Seven out of the top 10 families in terms of biomass are considered commercially important.

Fish density and species variety

Despite the huge decline in the resulting biomass, average fish density increased to 2,079 individuals per 500 m^2, 24% greater than last year. Four out of the five monitoring sites have increased density outputs. Only two families made up three fourths of the fish density. Damselfishes (Family Pomacentridae) were the most numerous comprising 38% of the counts, while the anthiases (Family Serranidae subfamily Anthiinae) made up 36%. A summary of fish biomass and density in the last four years (n=5) is shown in Figure 7. Fewer fish species were observed this year compared to the previous year. From 339, only 286 species were encountered in the survey areas. These were from 100 genera and 34 fish families.

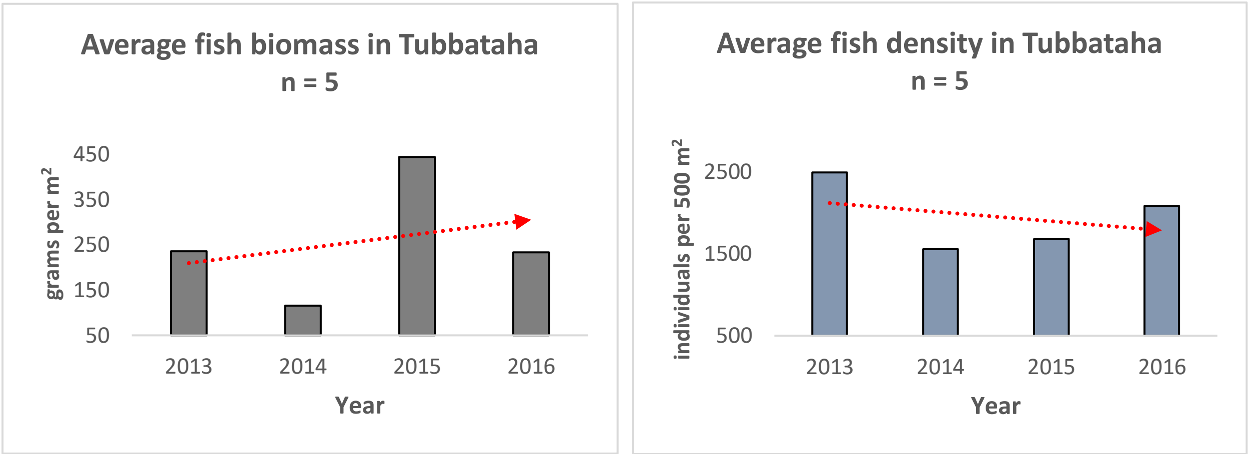

Figure 7. Fish biomass and density values in the last four years where n = 5.

Pelagic and demersal fish species

Comprising only a third of the average biomass in 2015, pelagic species accounted for 46% or almost half of the average biomass this year (see Figure 9). Families of fish which are considered pelagic are Carangidae (jacks and trevallies), Caesionidae (fusiliers), Carcharhinidae (requiem sharks), Scombridae (tunas and mackerels), Sphyraenidae (barracudas) and subfamily Nasinae (unicornfishes) from the Acanthuridae family (surgeonfishes). Demersal species are still more dominant than the pelagics in terms of number. The former made up 89% of the average fish density in the last four years. In terms of biomass, it made up 54%. Because demersals re closely associated with the reef, they are better indicators of reef health than pelagics.

Figure 8. Small but numerous damselfishes and anthiases make up 75% of the fish encountered in Tubbataha.

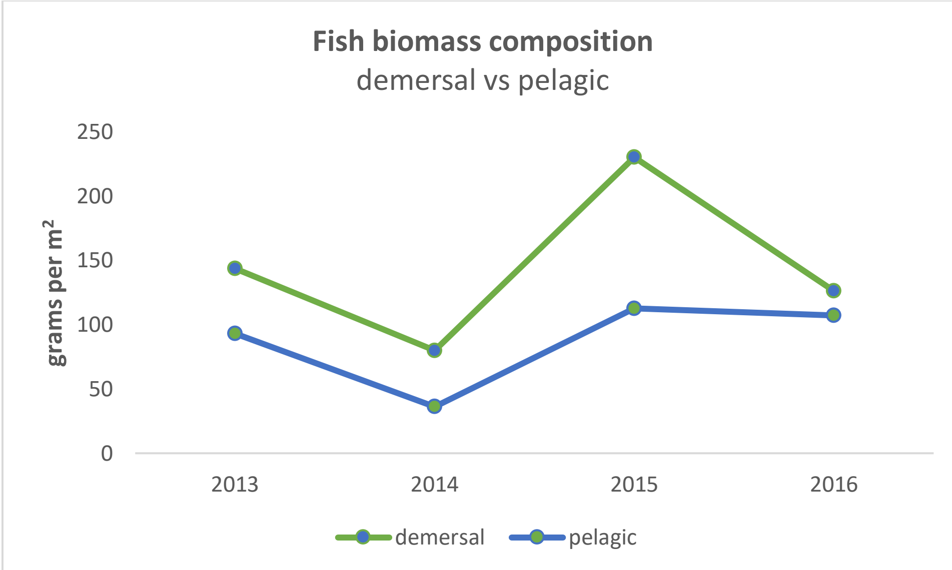

Figure 9. Comparison of demersal and pelagic species biomass from 2013 to 2016.

Fish groups: Indicator, Target, and Major

Fishes were further clustered into three different groups. The indicator group is dominated by the butterflyfishes (Family Chaetodontidae). These fishes have strong and obvious dependence on corals for food, shelter, and living space (Cole et al., 2008). Hence, fishes in this group are often associated with coral reef health (Hourigan et al., 1988)

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

Lastly, fishes which belong to the major group are the ones which occur in high numbers and concentrations. Key members of this group are the damselfishes (Family Pomacentridae), fairy basslets and anthiases (Family Serranidae subfamily Anthiinae) and some angelfishes (- Pomacanthidae). These are clustered in a group to distinguish them from other fishes that occur in low numbers.

A decline in biomass is evident in all three fish groups. Indicator fish biomass dropped to 1.9 grams per m^2 from 3.3 in 2015. Their occurrence also dropped to 17 individuals per 500 m^2 from 23 last year.

Biomass of target species dropped to 189.2 grams per m^2, from last year's 283.3 (see Figure 10). This group made up 81% of the average biomass. The density of these fishes increased to 408 individuals per 500 m^2 from only 294 in the previous year. Large-bodied target fish were more abundant and dominant in 2015 compared to this year's survey. Their prominence in 2015 greatly influenced the fish biomass output. Since they were less prominent this year, the biomass of these fishes might have returned to normal levels, hence the decrease.

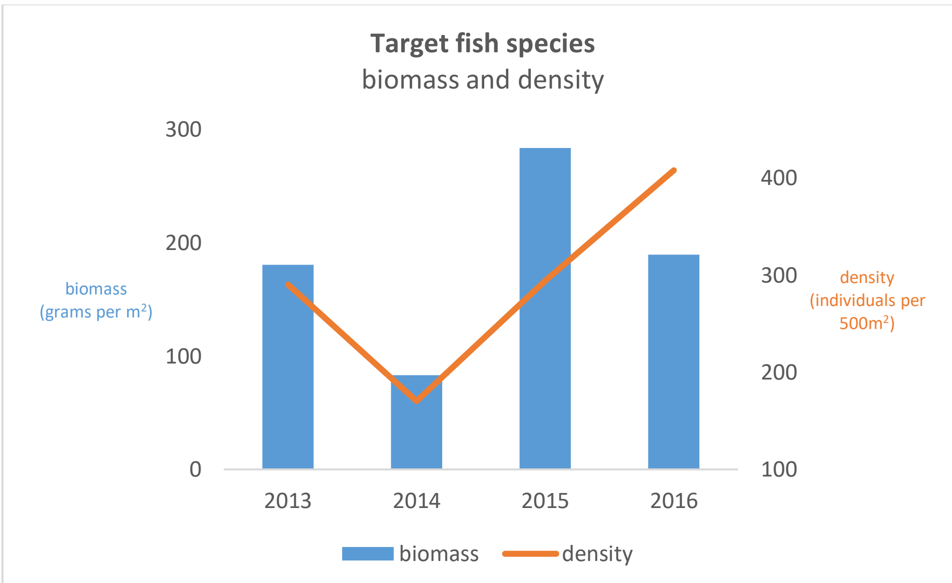

Figure 10. Biomass and density of commercially-important fish species from 2013 to 2016.

Like the indicators, major species showed declines in both biomass and density compared to the previous year. Their biomass was down to 42.3 grams per m^2 from 56.3 last year, and their density to 1,654 individuals per 500 m^2 from 1,955. This group comprised 79% of the fish density.

Threatened species

Listed as vulnerable (VU) by the International Union for the Conservation of Nature (IUCN) in its Red List of Threatened Species, one bumphead parrotfish (*Bolbometopon muricatum*) was recorded in Site 7. Last year, 106 individuals of the same species were spotted. Their very low occurrence in this year's census might have played a pivotal role in the decline of the average biomass.

The endangered (EN) Napoleon wrasse (*Cheilinus undulatus*) was again present in all monitoring sites . Although fewer than last year, 18 individuals ranging from 34 to 90 centimeters were recorded inside the survey areas. Six grey reef sharks (*Carcharhinus amblyrhynchos*) and six whitetip reef sharks (*Triaenodon obesus*) were also spotted inside the survey areas. Both species are listed as near threatened (NT) in the IUCN Red List.

Grounding sites: USS Guardian and Min Ping Yu

Results of this year's census show that fish communities in both of the grounding sites are continuously recovering (see Figure 11). The USS Guardian grounding site continues to show improving fish biomass. Biomass slightly increased to 473 grams per m^2 from 469.2 in 2015. However, fish density decreased from 3,393 in 2015, only 1,759 individuals 500 m^2 this year. Fish biomass, however, not only depends on the number of fishes observed within an area. Species variety and size estimates also dictate the biomass output for a site. This might explain why fish biomass increased while density decreased. Despite fewer fish, species variety increased by two to 124 this year. Demersal species made up 74% and 98% of the biomass and density in this site respectively.

The development in Min Ping Yu grounding site is opposite to that of the USS Guardian. Here, fish biomass decreased while fish density increased. From 177.3 grams per m^2 in 2015, fish biomass fell to 140.8 grams per m^2 while density improved by five percent to 2,132 individuals per 500 m^2. Fish diversity and size might have influenced this development. Species variety however slightly decreased to 121 from 125 last year. Demersal species made up 59% of the biomass and 98% of the density.

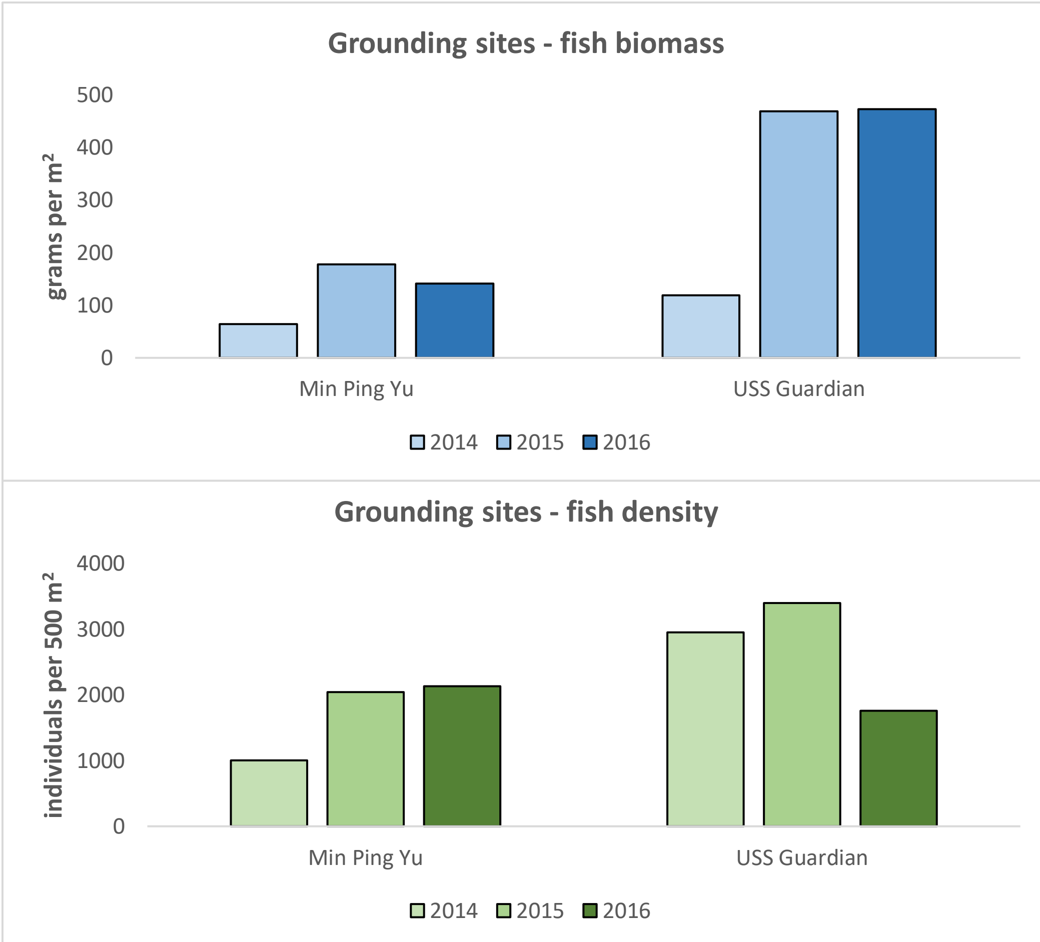

Figure 11. A summary of fish biomass and density at the two grounding sites from 2014 to 2016.

2.4 Conclusions

Even with the significant decline in fish biomass estimates, Tubbataha still exceeds the 40 grams per m^2 that is believed to be the minimum yield for a protected area (Nañola et al., 2006). This year's biomass estimate is only 52% of last year's. Large-bodied fishes were not as predominant in this year's census compared to 2015, when more than a hundred bumphead parrotfishes (*Bolbometopon muricatum*) were recorded. That encounter alone made the 2015 biomass estimate exceptionally higher than usual. Data also show that smaller fishes were prevalent in this year's census.

Both the USS Guardian and Min Ping Yu grounding sites continue to show positive development since it was monitored in 2014. The improving state of the two grounding sites may be attributed to the contribution of the surrounding healthy reefs to their recovery.

As an offshore atoll, Tubbataha is expected to have naturally higher fisheries potential compared to fringing or barrier reefs (Dantis et al., 1999). But this alone cannot justify the outstanding records of fish biomass, density, and species richness in the park. Tubbataha's protected status, regarded as the best in the country (ADB, 2014), appears to be the main reason why fish populations prosper despite numerous threats.

2.5 Recommendations

This year's census suffered from lack of manpower, thereby the shallow transects were not surveyed this year. It would also help to add one personnel dedicated to laying and reeling in the transect lines for added efficiency.

It is also likely that changing observers with varied levels of expertise each year impinges on the results of the FVC. Employing the same observers as much as possible would eliminate bias in survey results. It is also critical to carry out the survey methods precisely for accurate and robust results.

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BENTHIC COMMUNITY

CHAPTER 3

3 BENTHIC COMMUNITY

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Tubbataha Management Office

3.1 Overview

The results of the annual benthos monitoring serve as a gauge to determine the status of the reefs and the efficacy of conservation measures. A decrease in the quality of the reefs due to anthropogenic impacts would signify that law enforcement is weak, thereby requiring a redirection of efforts towards compliance management. In this manner, survey results become critical to management decision-making.

3.2 Methods

Sampling Design

In the past, various modifications of methods were used to measure the benthic cover and assess coral health of TRNP. After rigid statistical analysis of all available data, a hierarchical monitoring design was adopted for the area, which would better capture changes at different spatial scales and better infer the drivers of such changes (Licuanan et al., 2014). This was done to be able to produce data that reflects the actual benthic cover, and might also allow the detection of changes in coral cover over time and space.

The researchers followed the life form categories in English et al. (1997) in the benthos point intercept method. 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.

Data Analysis

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.

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.

Condition Index

Based on the above results of benthic categories, condition index was computed to provide additional information on the condition of the reef. These was computed as follows:

Condition Index = LOG Live coral / dead coral + algae+ other fauna

Paired t-test

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

3.3 Results and Discussion

A total of seven sites were monitored during the five-day trip to TRNP. Four sites were surveyed in the Tubbataha atolls, plus the Min Ping Yu and USS Guardian grounding sites, and one in Jessie Beazley. This year the benthos point intercept and photo transect methods were applied in the two grounding sites generate further insights on the response and recovery of the reef from such incidents.

Results are presented per depth to be able to describe the conditions and changes in benthic compositions at two different zones in the park – shallow sites on the reef flat and deep sites located along the walls.

Deep sites (10 meters)

Table 2. Overall mean percentage cover at 10 meters in TRNP.

	2015	SE	2016	SE
HARD CORALS	40.9	3.50	38.76	4.27
SOFT CORALS	22.51	2.11	26.16	7.42
MORTALITIES	0.60	0.21	0.91	0.3
ALGAE	18.08	2.86	17.26	3.51
ABIOTIC	11.22	5.31	7.96	2.82
OTHERS	6.71	0.41	8.94	1.94

A summary of the benthic cover of the five sites surveyed show that the mean live coral cover (hard and soft corals) in the deep sites in TRNP this year is at 64.93% (Table 2). This figure is within the average live coral cover for Tubbataha from 1997-2015. Using the quartile scaling of reef condition established by Gomez et al. (1994) live coral cover in deep sites falls under 'good' category. A paired t-test value of p= 0.42 showed no significant difference between 2015 and 2016 in hard coral cover at deep sites.

Figure 12 shows that hard and soft coral cover remain stable over the years. Conversely, mortalities, abiotic and other fauna show decreasing trends. Over the last three years, a slight increase in algal cover was observed. Algal composition in deep sites were composed mainly of coralline algae, and not algal assemblages and fleshy-macro algae. Coralline algae are an important part of the reef system because they help build the reef by depositing calcium carbonate, resisting wave, and by cementing sediments (Dethier, 1994, Castro and Huber, 2012). Thus, it may allow other benthic organisms to thrive in in the area (Gherardi and Bosence, 1999, Vermeij et al., 2011). Generally, benthic cover in TRNP remains the same at this depth.

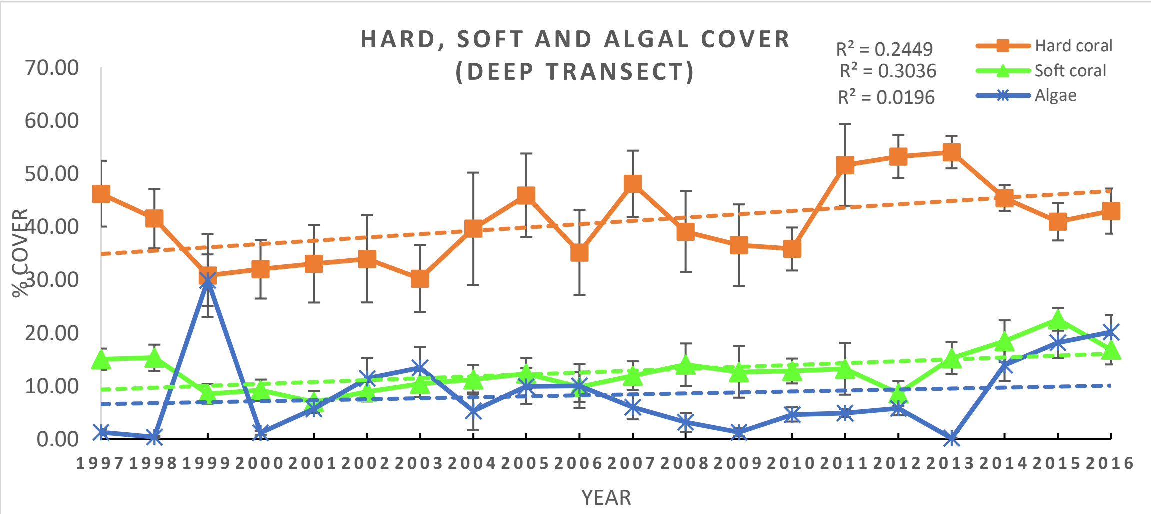

Figure 12. Mean percentage cover of hard corals (orange), soft corals (green) and algae (blue) at 10 meters depth. Error bar represent standard error of the mean.

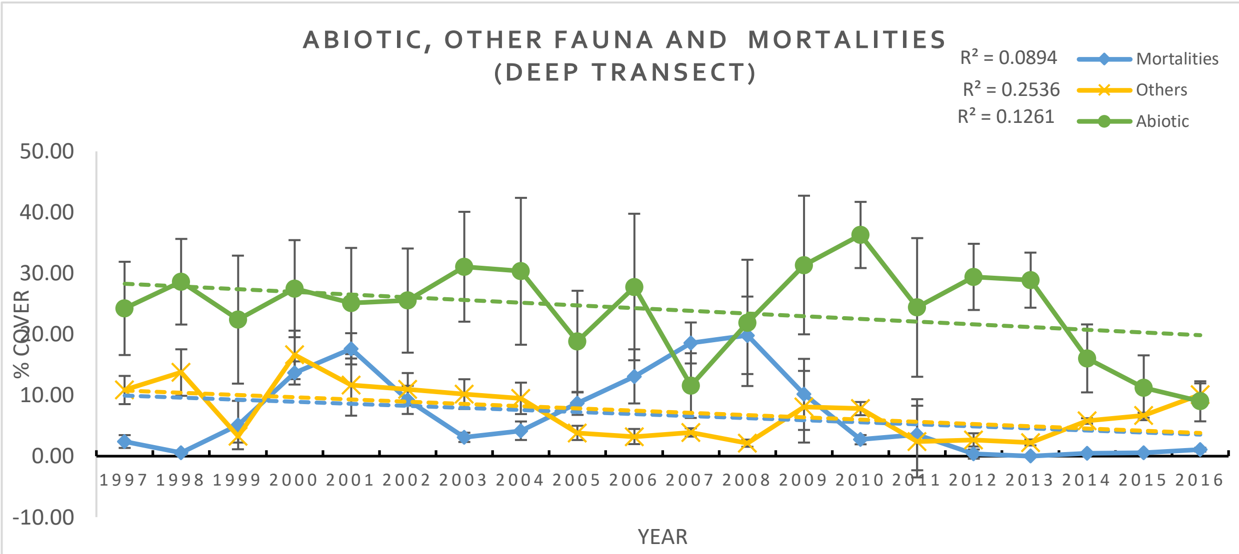

Figure 13. Mean percentage cover of abiotic (green), others (yellow) and mortalities (blue) at 10 meters. Error bar represent standard error of the mean while trendline determine the trajectory of benthic cover through time.

The mean hard coral cover for the deep sites this year (38.76%) is a little less than last year's (40.9%). Paired t-test p= 0.42 reveals that this decrease in hard corals is not significant. Hard coral cover was recorded highest in Station 7B at 59.38% followed by Station 2B at 56%. A notable increase was observed in Station 6A at 42% this year compared to 30% in 2015. Station 6A is composed of fast growing branching type of corals that may have contributed to the increase of hard coral cover in this area. The lowest hard coral cover was recorded in JBB at 17.25% (Table3). Sites 7 and 2, located at the northern tip of both atolls, are exposed to the monsoons, but interestingly obtained the highest hard coral cover among the sites. The deep sites, particularly in Site 7, was dominated by 45% encrusting corals and 12% massive and non-Acropora branching corals. Massive and encrusting corals are slow growing, yet they can withstand wave action, contrary to the Acropora-branching type which are fast growing but more prone to breakage (Piquero et al., 2015).

Table 3. Mean percentage cover per site at 10 meter depth.

	S2A	S2B	S4A	S4B	S6A	S6B	S7A	S7B	JBA	JBB
HARD CORALS	48.13	56.00	44.63	22.88	41.62	32.13	38.63	59.38	27	17.25
SOFT CORALS	21.25	19.25	12.5	17.25	17.5	3.625	30.38	12.5	63.13	64.25
MORTALITIES	0.50	1.00	0.25	0	0.75	2	2.5	1.5	0	0.625
ALGAE	23.75	13.50	21.63	36.5	10.37	28.13	12.5	14.63	2.75	8.875
ABIOTIC	0.25	2.50	5.25	3.125	19.25	26.88	9.375	5.375	6.875	0.75
OTHERS	6.13	7.75	15.75	20.25	10.5	7.25	6.625	6.625	0.25	8.25

A decrease in hard coral cover was noted in the Jessie Beazley stations this year. There appears to be an ongoing phase shift from hard corals to soft corals, which may have started last year. Soft coral cover in JBA doubled from 34.25% last year to 63.13% this year.

Figure 14. Stitched images of the first 20 meter transect in Station JBA. Image showed the proliferation of soft coral at this site.

Mortalities, on the other hand, remain very low across the stations. Algae increased in Sites 2 and 7, and in stations 4A and JBB, but the results were not significant (paired t-test p=0.70). Other invertebrates generated higher cover than normal for most of the stations. This category was particularly high in the two stations of Site 4, where sponges dominated. This can be seen in the stitched images of the transect (Figure 15). However, paired t-test results (p = 0.63) revealed that the increase is not significant.

Figure 15. Stitched images of the first 20 meter transect of Site 4B showing the area dominated by sponges.

Shallow sites (5 meters)

Table 4. 2016 overall mean percentage cover at 5 meters in TRNP.

	2015	SE	2016	SE
HARD CORALS	75.22	12.76	70.81	6.406
SOFT CORALS	12	8.18	13.91	6.439
MORTALITIES	0.69	1.09	0.138	0.06
ALGAE	0.93	1.12	0.638	0.153
OTHER INVERTS	6.25	4.92	4.413	1.24
ABIOTIC	4.91	2.46	10.09	2.096

Mean live coral cover (hard and soft corals) in the shallow sites (5 meters) is estimated at 84.72%, less than last year's 87.23% (Table 4). This puts the shallow sites in the "excellent" category based on the quartile scaling of reef health by Gomez et al. (1994). The decrease in hard coral cover from 75.22% in 2015 to 70.81% this year was not significant (paired t-test = 0.61). Although the shallow reefs are known to be more vulnerable to anthropogenic impacts and natural perturbations (Myers and Ambrose, 2009), the shallow sites in TRNP appear to be in better condition than the deep sites as shown in Figure 16, where the trend of hard corals continued to escalate since 2012.

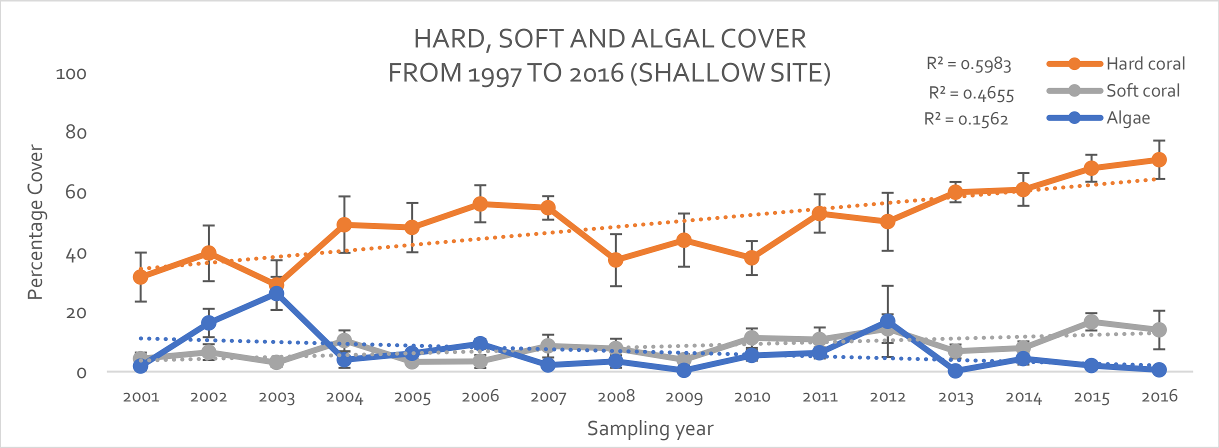

Figure 16. Mean percentage cover of hard corals (orange), soft corals (grey) and algae (blue) at 5-meter depth. Error bar represent standard error of the mean, while trendline shows the trajectory of benthic cover through time.

Benthic cover throughout the years were then plotted to determine the general trend of the six benthic categories through time. The overall trend for hard coral cover is increasing. Compared to the baseline data, hard corals in shallow sites doubled in the 15-year period, from 32% in 2001 to 70.80% this year. Soft corals showed a slight increase over the years. The algal cover remained the lowest in most of the sites and showed a decline through time (Figure 16.).

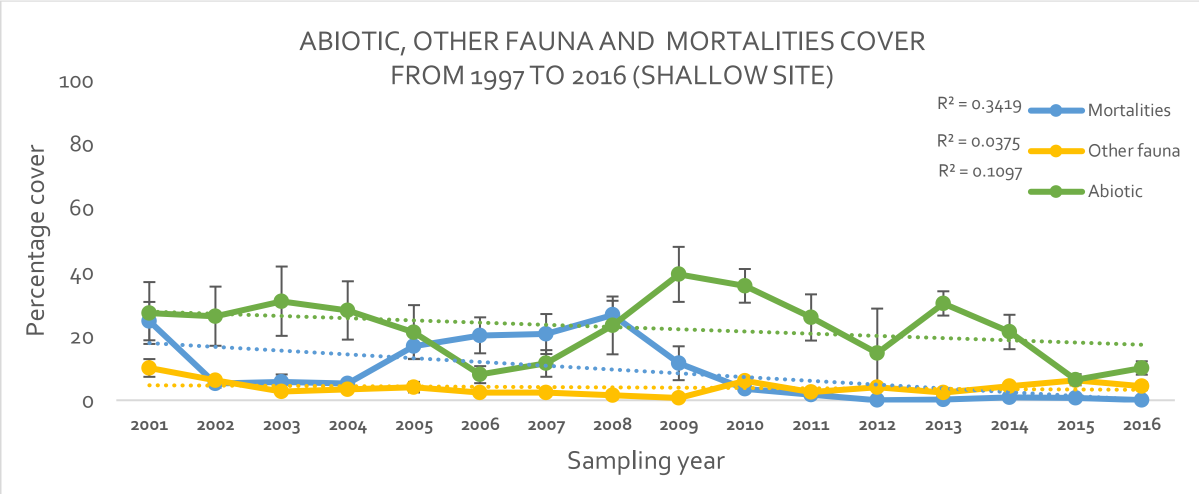

Figure 17. Overall mean percentage cover of hard corals (orange), soft corals (grey) and algae (blue) at 5-meter depth. Error bar represent standard error of the mean, while trendline was plotted to determine trajectory of benthic cover through time.

Abiotic components displayed an erratic change through time (Figure 17). Major peaks were observed in 2008 until 2010 and again in 2013. These values were even higher compared to 2003 and 2004 when coral bleaching was observed in most of the sites. Mortalities were particularly high from 2005 to 2009. In 2008, it peaked to 26%, possibly due to the storm which hit the park in April (Ledesma et al., 2008). After a year, the reef started to recover from disturbances and mortalities gradually declined. Lastly, other fauna remained stable through time. The high hard coral cover and low level of mortalities, the presence of other fauna and abiotic components suggest a generally healthy reef ecosystem.

Table 5. Mean percentage cover per site at five meter depth.

	S2A	S2B	S4A	S4B	S6A	S6B	S7A	S7B	JBA	JBB
HARD CORALS	84.00	56.38	58.25	74.50	86.13	88.63	62.88	71.63	28.25	97.5
SOFT CORALS	7.875	33.63	18.75	4.00	0.50	0	7.12	2.375	63.63	1.25
MORTALITIES	0	0	0.50	0.25	0.25	0	0	0	0.375	0
ALGAE	1.25	0.50	0.88	0.50	0.25	0.50	1.50	0.875	0.12	0
ABIOTIC	3.875	6.125	17.50	18.00	9.25	9.00	20.5	11.13	4.25	1.25
OTHERS	3.00	3.375	4.13	2.75	3.62	1.875	8.00	14.00	3.37	0

Figure 18. Image of Station 6B at 5 meter depth showing the dominant species of Isopora branching at the reef edge.

Table 5 presents the benthic cover per monitoring station. Hard coral cover remains highest in station JBB (97.5 %). This station is mainly composed of plate-like coral formations (approximately 80%). Other coral formations in this station include tabulate, branching, and sub-massive. Hard coral cover in both stations of Site 6 is also high (86.13% in station 6A and 88.63% in station 6B). Beds of Isopora branching corals flourish in these stations (Figure 18). Almost all the stations were documented to have high hard coral cover except station JBA where it was only 28.25%. Soft corals, on the other hand, increased in some stations, but not significantly (paired t-test p= 0.41). Substantial increase in soft corals was observed in the shallow and deep stations of JBA.

Correlation of both depths

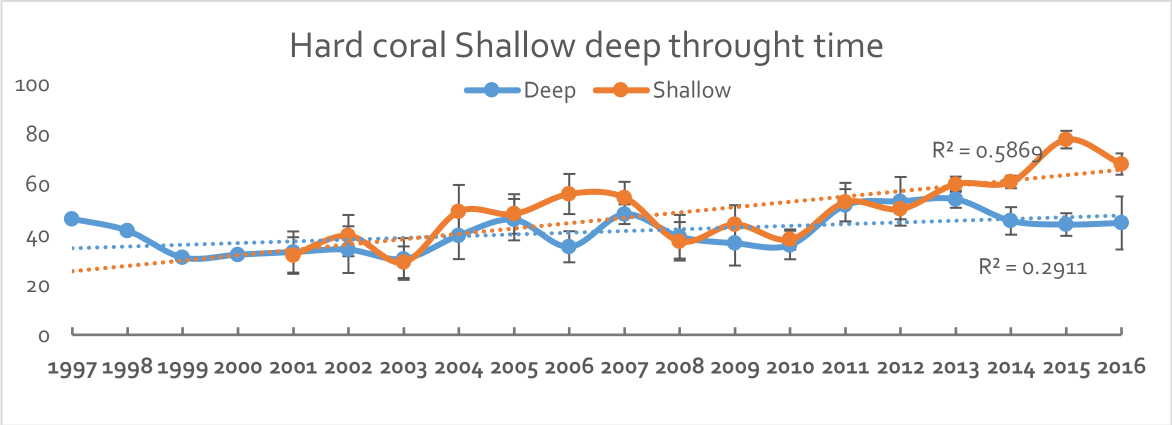

Figure 19. Correlation of hard corals at 5 meter and 10-meter depth from 1997 to 2016.

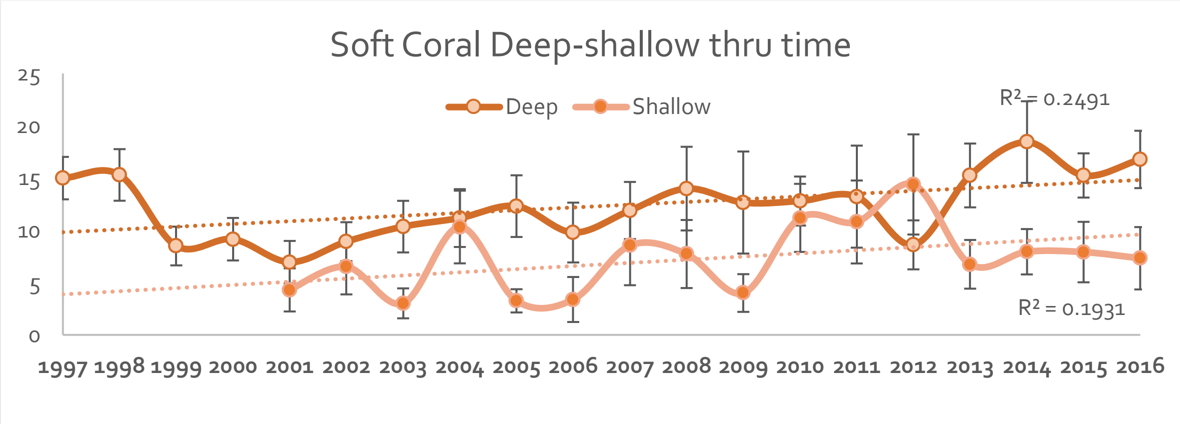

Figure 20. Correlation of soft corals at five and 10-meter depth from 2001 to 2016.

The percentage cover of hard corals and soft corals in the two depths are summarized in Figure 19 and Figure 20. This was done in order to see the changes in hard and soft coral communities at different depths. Hard corals correlation coefficient remains moderately positive at r = 0.60 suggesting that the increase in hard corals occurs simultaneously at both depths. It can be observed in Figure 19 that from 2013 onwards shallow sites had increasing hard coral cover compared to deep sites. In the case of soft corals, the correlation coefficient is r = 0.45 representing a weak relationship. This suggests that the increase and decrease of soft corals at both depths do not coincide in most years.

Condition Index

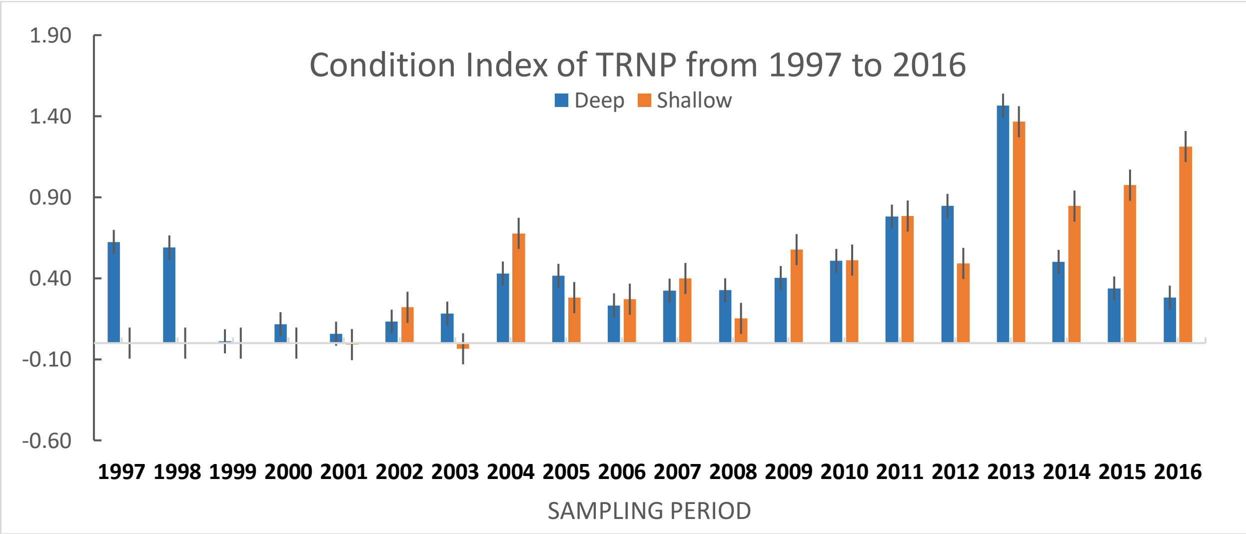

Figure 21. Condition index in TRNP. Error bar represent standard error per year.

The condition index provides insights on how the reef responds to certain stressors. It represents the ratio of hard corals to the total benthic cover sampled (Figure 21). In most of the years the condition index was positive. For the shallow sites, condition indices were negative in 2001 and 2003, at -0.01 and -0.4 respectively. On the other hand, the condition index in the deep site was nearly zero in 1999. During the years 1999 to 2001 and 2003, hard coral cover was observed to be lowest while algae took over most of the sites (Ledesma et al., 2009). From 2004 to the present, the condition index for both depths remained positive.

Coral bleaching incident

Figure 22. Images of the 2015 occurrence of coral bleaching in TRNP.

In July 2015, marine park rangers reported the occurrence of coral bleaching in TRNP. Coral bleaching was documented in Shark airport at the northern tip of North atoll. Massive corals under the Genus *Pavona* (left picture in Figure 22) were mostly affected. The area affected was around seven to eight meters. Bleaching in this area seemed to affect only a small portion of the reef. Another bleaching observation was reported in August 2015 at the Delsan Wreck and a small area southwest of the South Atoll. Bleaching occurred in a few species of branching and table corals within an area estimated to be 20 square meters. In Jessie Beazley Reef, a few species of branching corals were bleached. The bleaching incident occurred in different parts of the reef, and the occurrence was intermittent. This incident was not reflected in the 2015 ERM report since the bleached areas not within the monitoring stations and further observation was conducted.

3.4 Conclusions

The generally increasing trend of hard coral cover both in the deep and shallow sites affirm that the park is in good condition. Reef building corals continue to thrive while the abiotic components decrease in cover. Furthermore, mortalities were minimal since 2010.

Over the last two decades, TRNP surpassed many challenges including illegal fishing, ship groundings, storms, and coral bleaching. To date it remains healthy, as shown by the results of benthic monitoring. The deep sites are in 'good' condition while the shallow sites are 'excellent' in terms of live coral cover. Through the decades, the remote location of TRNP, coupled with efficient management allowed it to be a model of a pristine reef environment and of MPA management. This is supported by the effectiveness of the management programs and the no-take policy implemented in the park since 1988.

3.5 Recommendations

Based on the results of this year's survey, we suggest that the sampling stations be permanently marked to ensure the same sections of the reefs are monitored every year. Embedment using stainless steel pin at the start of transect, which will serve as markers, should be prioritized at the deeper sites.

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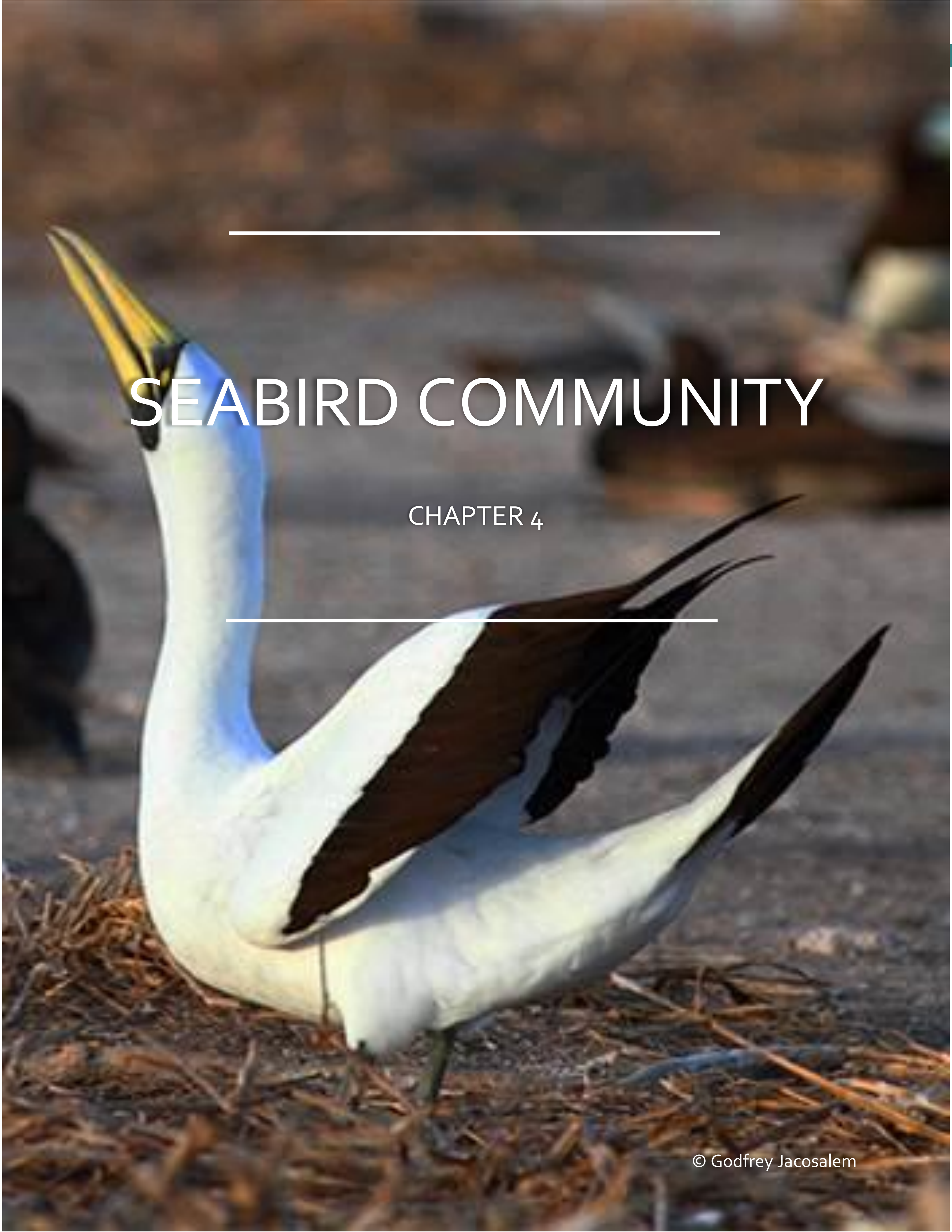

SEABIRD COMMUNITY

CHAPTER 4

4 SEABIRD COMMUNITY

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4.1 Overview

Once every quarter, TRNP marine park rangers conduct an inventory of seabirds breeding and roosting in the islets of TRNP. During the second quarter monitoring, the team is joined by a consultant, ornithologists, TMO staff and volunteers. This chapter presents the results of the second quarter monitoring with some notes on the rangers' data from the previous three quarters. Adult population and breeding data are presented in a timeline to compare inter-annual variations and describe long-term trends.

4.2 Methods

The field work followed methods laid out in 2004 and used since (Annex 10 and Annex 11). The team camped overnight at Bird Islet in order to carry out optimal work. South Islet was visited in the afternoon of 13 May for a three-hour period. Consequently, three thematic inventory teams worked in parallel. 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.

In order to determine the total seabird population, an afternoon count of birds flying in to roost was conducted from 4:30PM to 6:30PM on 11 May at Bird Islet (Annex 12) and on 13 May on South Islet (Annex 13). Monitoring of the number of dead birds and autopsies were carried out on sample individuals. Plastic and other debris such as fish hooks, posing a potential threat to the breeding populations, were systematically removed by the team.

Calculation of breeding populations

The methods used to calculate the adult seabird populations are:

- the average distance monitoring results of the birds present at day time;
- day time direct counts of birds, nests and eggs;
- in-flight data of Red-footed Booby *Sula sula*, Brown Booby *Sula leucogaster*, Brown Noddy *Anous stolidus*, Common Noddy *Anous minutus* and Sooty Tern *Onychoprion fuscata*;
- early morning (5 am) count of Brown Boobies at the 'Plaza';
- count of Great Crested Tern *Thalasseus bergii* along the shoreline at high tide;
- count of Sooty Terns at the breeding colonies in late afternoon and early evening

The combined results of these methods are used for comparison with the total result of the standardized day-counts and in-flight counts.

The result of the fieldwork is compared with data sets from the second quarter of the previous years; mainly data sets gathered by TMO staff from 2004 to 2015 and by WWF Philippines from 1998 to 2004. These data sets are analyzed in detail in the 28-year seabird population development report released in 2009 and in the 2004 to 2006 and the 2010 to 2015 seabird field reports (see Jensen 2004 to 2006 and 2009 to 2015). In addition, relevant literature and published data on seabirds were used as references.

Calculation of land area and vegetative cover

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

Vegetative cover is monitored by conducting a census of the condition of trees on the islets. Trees, mostly of *Argusia argentia and Pisonia alba (grandis)*, are classified as either in optimal (good), moderately deteriorating (fair) or severely deteriorating (bad) condition and lastly, as dead. The inventory of 2016 was carried out using the same methodology as all other years, except in 2013, and the trend over time is therefore comparable.

4.3 Results and Conclusion

Monitoring of Changes in Land Areas

Independent sets of measurements were taken using two separate GPS instruments. The measurements were taken at high tide along the shoreline as the previously used vegetation line along most of the shoreline has disappeared. Because of this, the data from 2016 may not be comparable to the previous years'.

Bird Islet: Overall, the land area has decreased by nearly 17%; from 18,760 m^2 in 1981(Kennedy 1982) to less than 15,649m^2 in 2016 (Table 6). From 2004, the first year when GPS measurement was introduced, the decline in the land area is more than 10%.

Plate 1. Severe erosion of the Bird Islet's core of calcite sandstone and topsoil at the northeastern shoreline has continued since 2012. Photo shows the entrance to "Plaza". Photo: Arne E. Jensen.

The circumference of the islet is 590 meters measured along the high tide line on 11 May 2016. The land area was measured to be 15,690 m^2 of which the area of the 'Plaza' was 4,513 m^2. While the GPS data suggests that the land area of Bird Islet is increasing, this does not appear to be the case. Erosion that started along sections of the northeastern coastline in 2012 has continued (Plate 1). In addition, the long sandbar towards the northwest has largely disappeared. Also, the sandbars located to the southeast of the islet have been substantially reduced in size. Further details, conclusions and recommendations for piloting land restoration activities on Bird Islet are found in Annex 16.

Table 6. Approximate changes in the land area of Bird Islet from 1911 to 2016. Source: Worcester 1911, Kennedy 1982, Heegaard and Jensen 1992, Manamtam 1996, WWF Philippines 2004 and Tubbataha Management Office 2004 to 2016.

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

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.

South Islet: South Islet was originally part of a large sandbar but a circumferential concrete seawall was constructed in the 1980s (Kennedy 1982). 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).

Plate 2. South Islet showing the exposed southeastern shoreline where the seawall has collapsed. Photo: Arne E. Jensen

The circumference of the islet was measured to be 247 meters in 2016. Based on a GPS-reading using the new GPS equipment from the TMO, the land area was 2.981 m² or about the same as previous years. However, the partial collapse of the seawall and continued deterioration of the remaining wall is likely to hasten the erosion of the islet (Plate 2).

Monitoring of Changes in Habitats

Bird Islet: In 2010 the dense congregation of mature trees in good condition on Bird Islet, first recorded in 1991 (Heegaard and Jensen 1992) had died. Other vegetation also deteriorated as a result of the intensive nesting density of the Red-footed Booby since 2004 (Jensen 2010). From 2014 to 2016 the deterioration of trees was further accelerated by drought-like conditions caused by the El Niño.

The vegetation in 2016 consisted of 110 trees of bush-height including 25 seedlings less than one foot tall. In 2006, the first year when vegetation was counted, there were about 245 trees and seedlings (Figure 23). The vegetation in 2016 included just 62 bush-size trees and bushes in good or fair condition. Twenty-three percent of the total vegetation is now severely deteriorating with a limited likelihood of survival. However, despite the El Niño, the number of seedlings increased by 92 percent or 35 seedlings compared to just 13 seedlings in 2015.

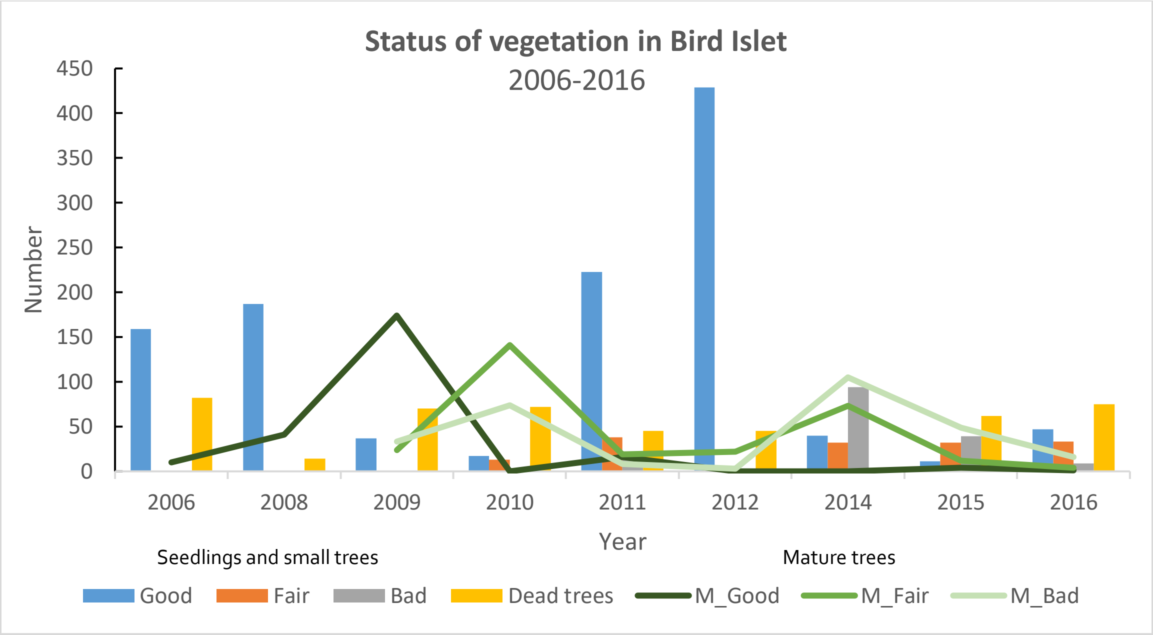

Figure 23. Status of vegetation on Bird Islet from 2006 to 2016. Bars represent seedlings and small trees while lines represent mature trees.

The presence of seedlings and small trees, one to three feet tall, that were in good condition spiked in 2012 but have since decreased. Although the number of seedlings increased this year, most are used as roosts by the Ref-footed Booby, therefore, the chances of these trees growing into maturity are very low. The decrease in mature trees in fair and bad condition resulted in the increase in the number of dead trees.

South Islet: Until 2009 beach forest vegetation of about 125 trees were in good condition and several trees were up to about 30 feet tall. In 2016, a total of 60 trees or 20% fewer than in 2015 were recorded (Figure 24). Of these 60 trees, 40 were in bad condition. No trees were found to be in good condition compared to 75 trees in 2010 (baseline year), and no seedlings were found. Colonization by Red-footed Booby and extremely dry weather conditions caused by the ongoing El Niño event since 2014 appear to be the main factors causing the rapid decline in the vegetation cover.

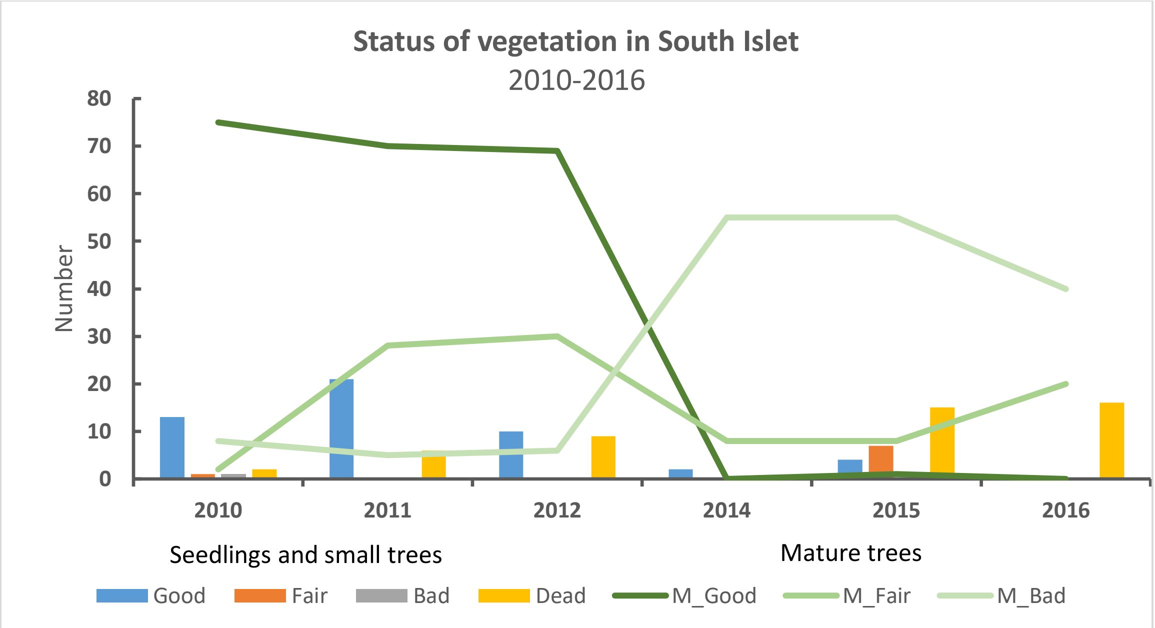

Figure 24. Status of vegetation on South Islet from 2010 to 2016.

Avifauna

Review of Park Rangers' Monitoring Data

Since the inventory of May 2015, the TMO Park Rangers made three inventories using the direct count methods (Annex 14). The inventories included in-flight count on Bird Islet in November 2015 and in February 2016 (Annex 14). The counts did not include the breeding population of Pacific Reef Heron *Egretta sacra,* Barred Rail *Gallirallus torquautus* and Eurasian Tree Sparrow *Passer montanus.*

A total of seven distance count estimates of the seabirds of Bird islet and South Islet were carried out from October 2015 to April 2016. A single count estimate was also undertaken at Jessie Beazley Reef in December 2015. Estimates of unidentified frigate birds and of white egret species were included in the distance counts.

The data reported were consistent with the previous year's results and, overall, is of high technical quality. However, there is room for some improvement in terms of:

a) data accuracy and completeness in terms of date of the records, name of recorder, etc.;
b) the symbols '–'and 'o' are used to mean the same even when no data

was collected; and

c) incomplete back-up of data file at TMO.

The results of the Park Rangers' counts of seabirds revealed important observations. One of these is an unusual congregation of Brown Noddy, Black Noddy and Sooty Tern at Jessie Beazley Reef at a time when these species are normally absent from TRNP (Plate 3 and Table 7).

Plate 3. More than 2,200 Brown and Black Noddy and 800 Sooty Tern were recorded by TMO Park Rangers in December 2015, when these species are normally absent from TRNP. Photo: TMO

Table 7. Selected results of TMO Park Rangers distance monitoring and inventories from August 2015 to April 2016.

Species	Bird Islet	South Islet	Jessie Beazley Reef
Brown Booby	High number of adults, eggs and pulli in February 2016 (2,150 individuals, 223 eggs and 463 pulli/1st year juveniles. The result is consistent with previous year's data sets for the month of February.	No breeding population	No breeding population
Sooty Tern	Presence of 2,708 adults with 2,280 juveniles and 212 pulli in November 2015, suggests a second breeding population in 2015. 2,270 adults were counted in January 2016. Normally the species is absent from December to March.	No breeding population	800 adults were present at the reef in December 2015
Brown Noddy	A relatively high number, 805 individuals, were already present in early February 2016	Present before April 2016, earlier than in most years	400 adults present in December 2015

Black Noddy	Already present from February 2016. This is nearly two months earlier than normal arrival of this species.	3,450 adults already present from March 2016. This is about one month earlier than its normal arrival time.	An unusual gathering of 1,800 adults at the reef in December 2015

Avifauna Inventory Results May 2016

A total of 26 different bird species were identified during the inventor (Annex15). Ten of the species can be classified as pelagic or coastal-living seabirds. Of these, six species breed in TRNP. These are the 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.* One species was formerly breeding in the Park, the Masked Booby *Sula dactylatra*. Other breeding species are the Pacific Reef Heron, Barred Rail, and Eurasian Tree Sparrow.

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

A minimum of 38,511 adult individuals of the six breeding seabird species were recorded; 28,011 on Bird Islet and 10,500 on South Islet (Table 8). Bird Islet hosted about 73% of the population (78% in 2015) while South Islet hosted 27 % (22% in 2015).

The total result of the May 2016 count is almost the same as in 2015 (38,911 individuals) and represents, together with 2015, the highest count ever (Annex 8). It is substantially higher than the previous highest count in 2012 of 30,159 adults. The combined total population of all breeding seabirds in 2016 was 185% higher than the first inventory conducted in 1981 (Kennedy 1982). The high count result is mainly due to the presence of a substantial number of both Great Crested Terns and of Sooty Terns. In summary, the count results for 2016 showed:

A decrease in the number of adult and pulli Red-footed Booby to the lowest number recorded in May since the species started to occupy Bird Islet in 2004;

A continued increase in the population of Brown Booby to the highest number of adults and nests recorded since regular inventories started in 1997. However, the species had the lowest reproduction rate - as seen in the number of eggs, pulli and 1st year juveniles,

- since 2009. Despite the increase this year, the population is still 17% lower than in the baseline year of 1981;

A 19% reduction in the population of Brown Noddy compared to 2015. However, the population is still at the same level as in the baseline year of 1981. Similar to 2015, a very early start of breeding was observed as evidenced by the presence of pulli during the inventory period;

A marked decrease of over 1/3 of the number of nests of Black Noddy. The largest nesting decline on Bird Islet corresponds to the decline in vegetative cover. The very low breeding activity may be caused by the lack of leaves used as nesting materials. A similar decrease was observed on South Islet where only 40% of the population was breeding. An increase in Black Noddy population breeding on the ground and inside the Lighthouse and in the hut in the South Islet;

Increased breeding population of Great Crested Tern to the highest number ever recorded;

Third highest breeding numbers of Sooty Tern since regular recording started and with a late start of the breeding season compared to 2015 (start in February).

Table 8. Total count of adult resident seabirds on Bird and South Islet 10-13 May 2016.

Species/ Number	Bird Islet	South Islet	Total
Masked Booby *Sula dactylatra*	1	0	1
Red-footed Booby *Sula sula*	615	1,526	2,141
Brown Booby *Sula leucogaster*	3,058	64	3,122
Brown Noddy *Anous stolidus*	1,350	746	2,096
Black Noddy *Anous minutus*	795	7,921	8,716
Great Crested Tern *Thalasseus bergii*	13,637	243	13,880
Sooty Tern *Onychoprion fuscata*	8,555	0	8,555
Total	**28,011**	**10,500**	**38,511**

Species Account

Data on the number of immature, juvenile and pulli populations and on the number of eggs and nests recorded since 2004 on Bird Islet and South Islet are presented in Annex 7. The combined results of the adult populations and their development over time at the two islets are shown in Annex 8.

Masked Booby: On 11 May an adult male was found in the main colony of Brown Booby at 'Plaza". It remained there until 10 June 2016 and occupied a territory of Brown Booby where it incubated an egg together with a female Brown Booby (Plate 4).

In the Philippines, the species is known to have been breeding only in Bird Islet, where 150 adults were recorded in 1981 (Kennedy 1982). It was last recorded breeding in May 1991 when two fledglings were confiscated from a fishing vessel at Bird Islet (Palaganas and Perez 1993). The last adult individual was reportedly observed on 23 June 1995 (Manamtam in communication 1996).

Plate 4. Adult male Masked Booby at a territory of Brown Booby at 'Plaza' in May 2016. Photo: TMO

Red-footed Booby: The increasing scarcity of optimal breeding and roosting habitats may have resulted in the very low number of adult birds recorded this year. It is the lowest count of adult birds recorded since it established itself in large numbers on Bird Islet. There were only 2,141 individuals in 2016 compared to 2,435 individuals in 2004 (Figure 25). Of these, more than 70% were found on South Islet, which has most of TRNP's remaining vegetation necessary for this tree-breeding species. In comparison, only around 40% of the adults were recorded at South Islet during the previous two years.

The scarcity of breeding materials and of roosting habitats appears to have reduced both the number of adults and the number of pulli and juveniles to the lowest number since the main population arrived 2004. The number of nests in 2016, 315 nests, is the lowest since 2009 and reproduction expressed as number of pulli and 1st year juveniles was the lowest since the baseline year (Figure 26). On South Islet, the number of nests decreased from 190 nests in 2015 to 171 in 2016.

Plate 5. Adult Red-footed Booby with nesting material; now a scarce commodity as a result of inadequate vegetation. Photo: TMO

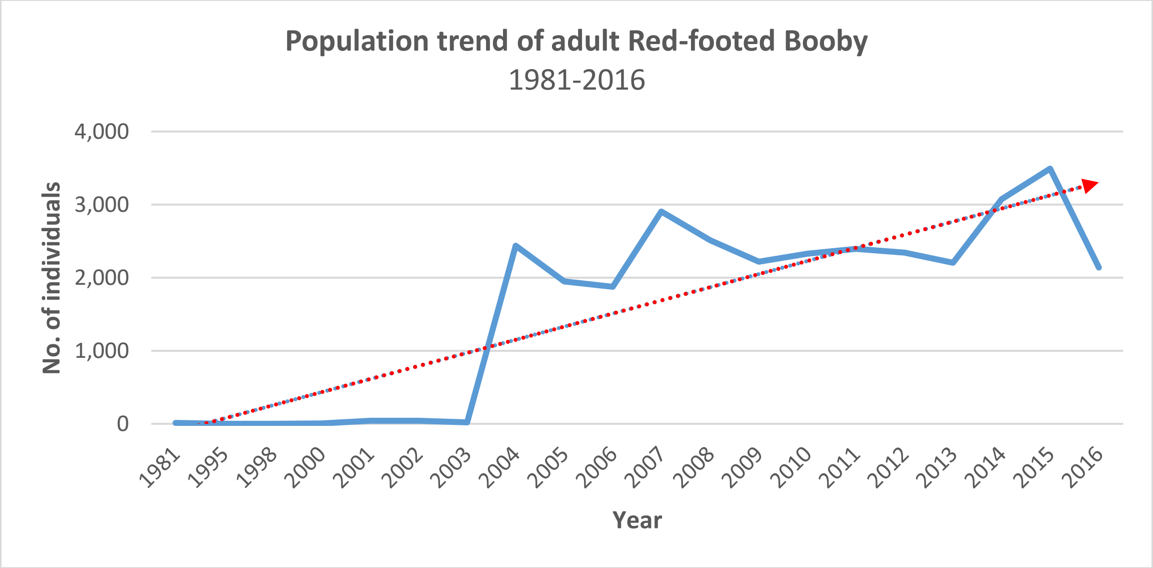

Figure 25. Population trend of adult Red-footed Booby in TRNP from 1981-2016.

On Bird Islet, eight samples of dead birds - four pulli, three 1st year juveniles and one adult - were examined. None of them contained plastic debris. The total number of dead birds on the islet, were assessed to be low and within natural mortality rates.

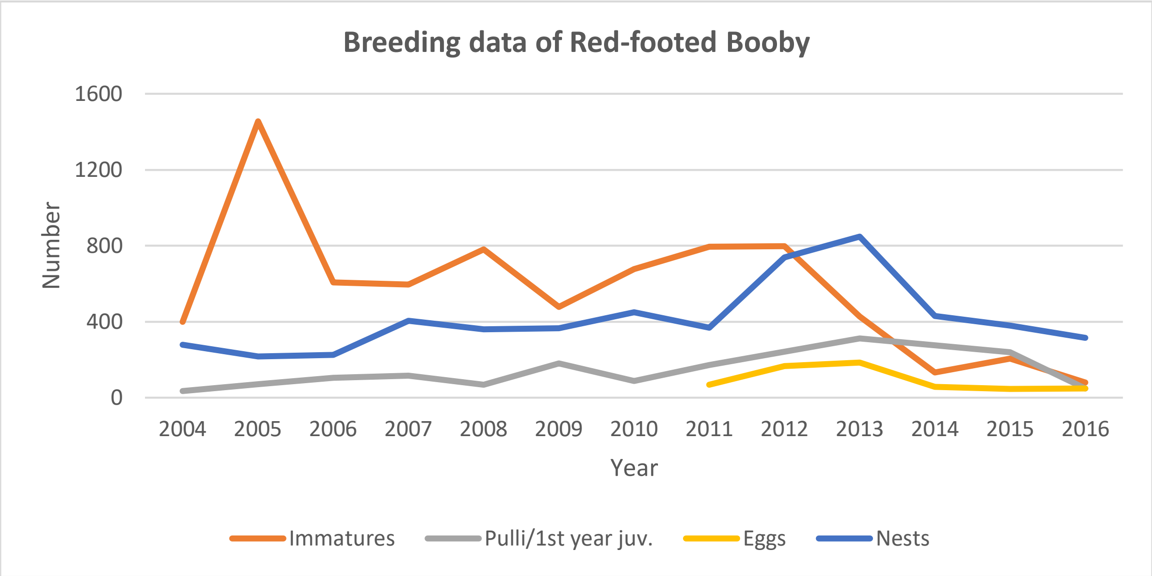

Figure 26. Breeding data of Red-footed Booby from 2004 to 2016.

Brown Booby: The May inventory showed in a total of 3,122 adults. It is the highest number counted since the baseline year of 1981 (Kennedy 1982). Although 30% higher than in 2015, the population it is still lower by 17% than in 1981 (Figure 27). High numbers of 2,700 adult individuals, including extrapolated in-flight numbers in December 2015 and 2,150 individuals in February 2016, were also observed by the TMO Rangers. Of the birds observed in South Islet, 64 individuals, and one pair with an egg was found. It is the first breeding evidence on South Islet since 1981 when Kennedy reported nine breeding pairs (Kennedy 1982).

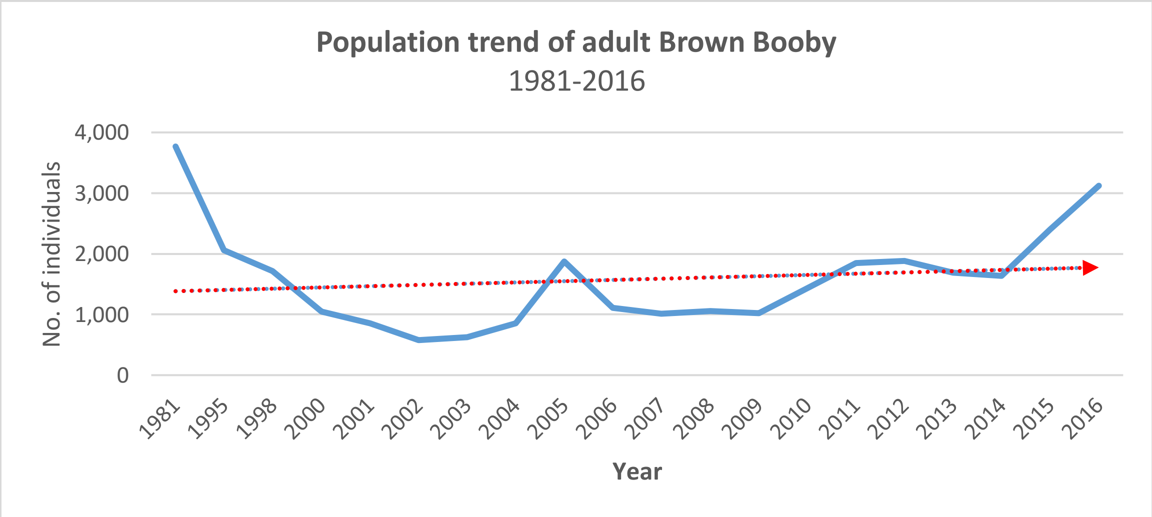

Figure 27. Population trend of adult Brown Booby from 1981 to 2016.

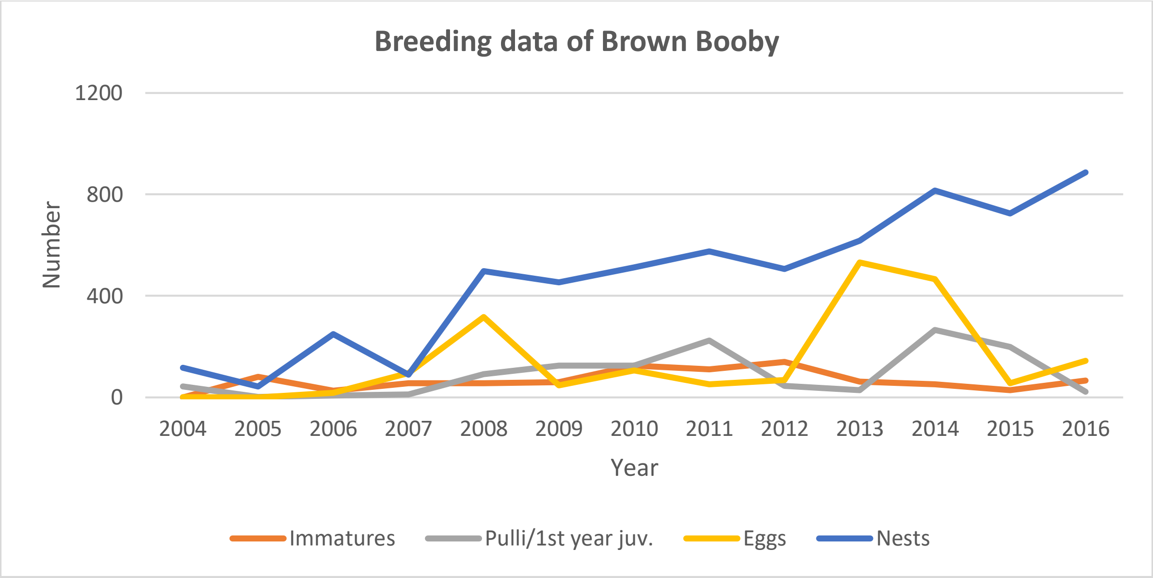

Figure 28. Breeding data of Brown Booby from 2004 to 2016.

Plate 6. The May 2016 survey yielded the highest number of Brown Boobies recorded in 35 years. Photo: Arne E. Jensen

The species continues to be highly reproductive as indicated by 887 nests, the highest number of nests counted over time (Figure 28). However, the number of pulli and juveniles, 22 individuals were the lowest since 2008 indicating a very late start in the breeding cycle.

Fourteen samples of dead birds - eight pulli, five1st year juveniles and one adult - were examined (See Annex 9). Similar to the result for Red-footed Booby, none of the birds contained plastic debris. The total number of dead birds found were assessed to be low and within natural mortality rates.

A total of 104 birds banded with color bands in 2007 to 2009 were recaptured in September 2015. This year, 138 different individuals banded in the same period were recaptured (Table 9). Of the total for two years, 126 individuals were banded as adults and 114 as pulli. The pulli banded in 2007 are now adults, 14 years or older, while the birds that were banded as downy youngs in 2007 are 10 years old. The lifespan of a Brown Booby is known to be 25 years (Hennicke *et al* 2012). Also, a bird banded as pulli in July 2008 was caught in Puerto Princesa in March 2016 and was later released in TRNP.

Table 9. Ring readings of Brown Booby on Bird Islet on 15 Sept 2015 and 11 May 2016 banded from 2006 to 2009.

	15 September 2015				11 May 1016		
Year	Adult	Pulli	No Data	Total	Adult	Pulli	Total
2006	13	9	2		12	8	20
2007	28	14			32	30	62
2008	4	18			12	26	38
2009	12	4			13	5	18
Total	57	45	2	104	69	69	138

Brown Noddy*:* The population of 2,096 individuals was 19% lower than in 2015 but at the same level as the baseline year of 1981 (Kennedy 1982) (Figure 30). The largest population reduction of 36% occurred on South Islet.

Despite the lower number in adult birds in 2016, the number of nests, (1,048) was the highest ever counted as is the number of eggs (620) and pulli (109) (Figure 29). It was only in 2015 when six pulli were found for the first time during a May inventory. In 2016 an even higher number of the breeding population had pulli in their nests, 66 on South Islet and 43 on Bird Islet. Interestingly, and apparently undescribed by science, the pullus occur both in a white and a dark phase or variation (Plate 7).

An unusual record of 400 Brown Noddy at Jessie Beazley Reef on 6 December 2015, is only the 4th December record from TRNP since regular seabird counting started in 1995 (Plate 3). The species was also present in December 2005, 2006, and 2011. Normally they are absent from TRNP from the end November to February.

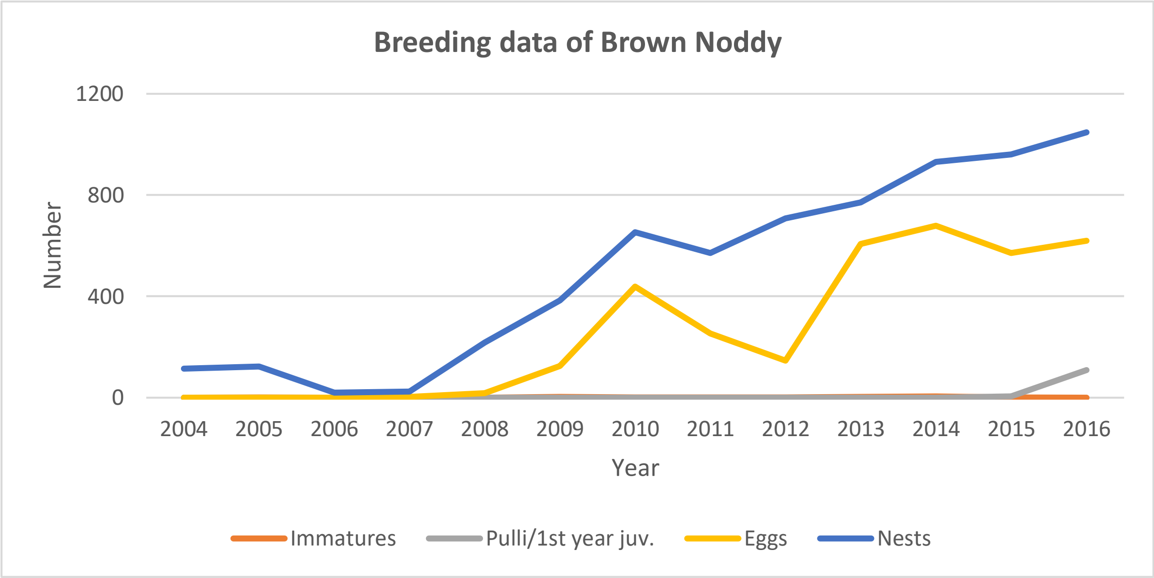

Figure 29. Breeding data of Brown Noddy from 2004 to 2016.

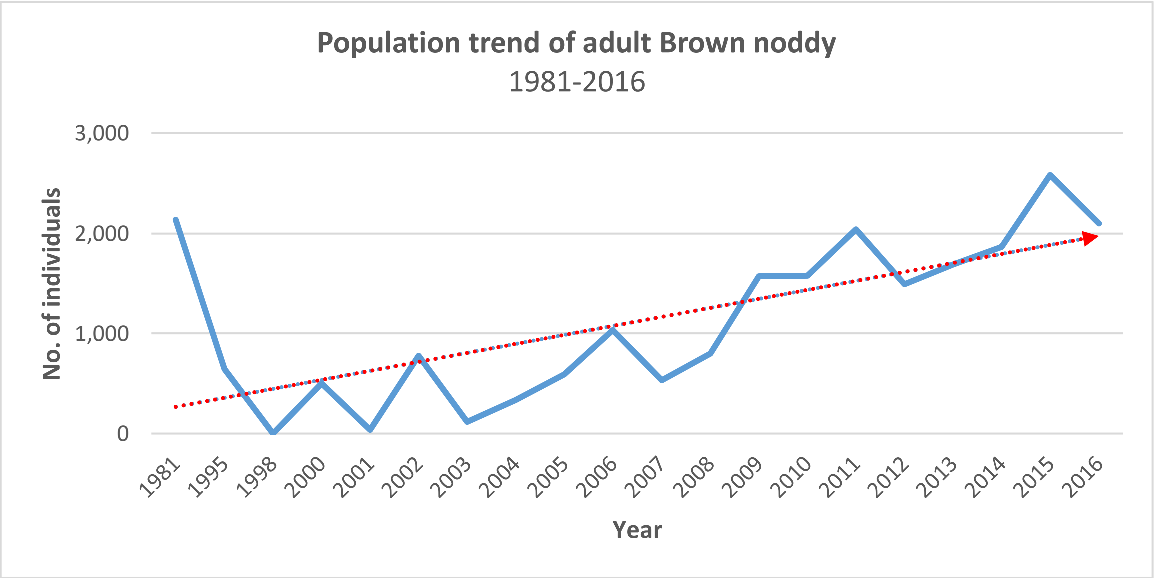

Figure 30. Population trend of adult Brown Noddy from 1981 to 2016.

Plate 7. Pullus of Brown Noddy occur in variations of black and white. Photo: Arne E. Jensen

Five carcasses of adult birds were checked and were found to be free of plastic debris.

Black Noddy: A total of 8,716 adults were counted. This is close to the average five-year population from 2012 to 2016 of 8,918 individuals (Figure 31). The populations were distributed between the South Islet, where 91% of the birds were found, and the Bird Islet, with only 9% on. This is the lowest number ever recorded in Bird Islet. In 2014, 24 % and in 2015 31% of the population was found on Bird Islet.

The decline in the Black Noddy population on Bird Islet mirrors the decline of the vegetative cover (Figure 23). All of the vegetation is almost without leaves, apparently due to the over-fertilization of the trees with guano from the Red-footed Booby. This is exacerbated by the El Niño-induced drought since 2014. The leaves are used as nesting materials by the Black Noddy, Plate 8. Consequently, about 5,450 adult birds had no nests and remained inactive.

As in 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 and at the roof and stairs of the Lighthouse on South Islet. Birds were also observed breeding inside the hut in the Islet. A total of 73 nests were found in these unusual locations, Plate 9.

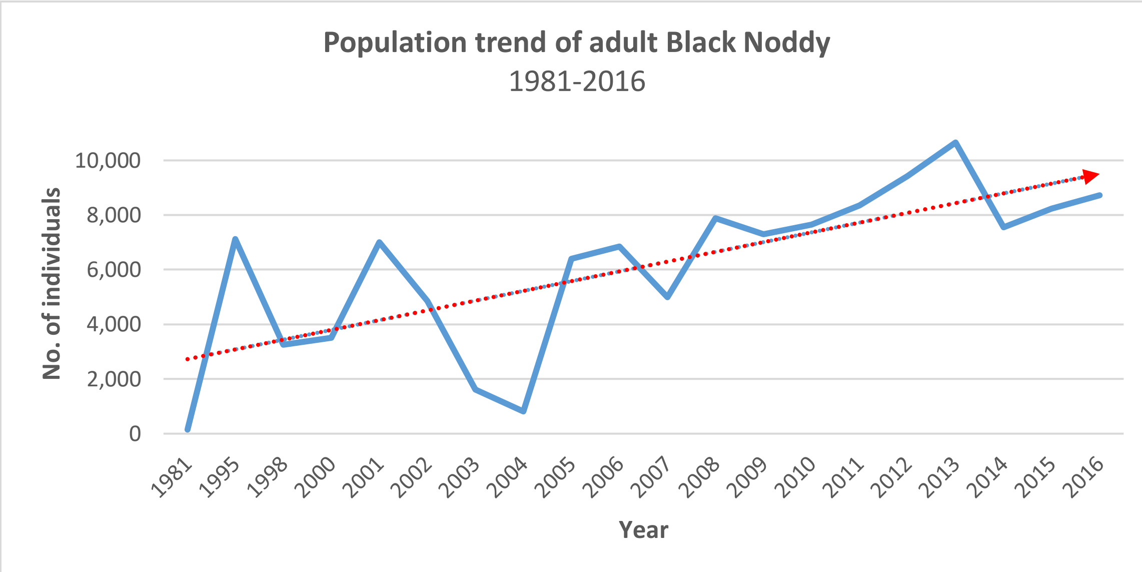

Figure 31. Population trend of adult Black Noddy from 1981 to 2016

The TMO Park Rangers observed 1,800 Black Noddy at Jessie Beazley Reef on 6 December 2015, Plate 3. Normally, the species is absent from the end November to February. The only other time it was observed in December was in 2006.

One carcass of an adult bird was inspected. It did not contain plastic debris.

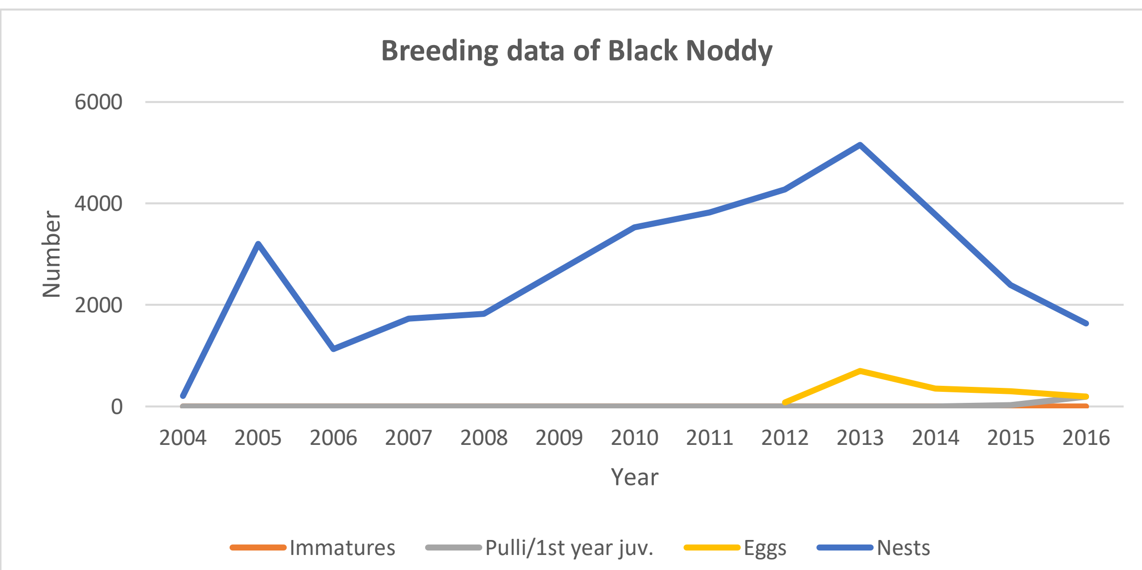

Figure 32. Breeding data of Black Noddy from 2004 to 2016


Plate 8. The decline in breeding habitats together with lack of leaves for nesting material resulted in a very low breeding rate of Black Noddy in May 2016. Photo: Arne E. Jensen


Plate 9. The number of Black Noddy breeding on the ground and other alternative areas, this nest in the hut at South Islet, continued to increase due to the absence of more suitable natural breeding areas. Photos: Arne E. Jensen.

Great Crested Tern: The breeding population on Bird Islet reached 13,880 individuals. This is the highest number ever recorded (Figure 34, Plate 10). The population increase from 2015 to 2016 was 12%. Similar to May 2015 the population was in the egg-laying stage. A small number of adult birds, 243 individuals, were found on South Islet. Although some of these showed breeding behavior, no eggs were found. It was last observed breeding in South Islet in 2003.

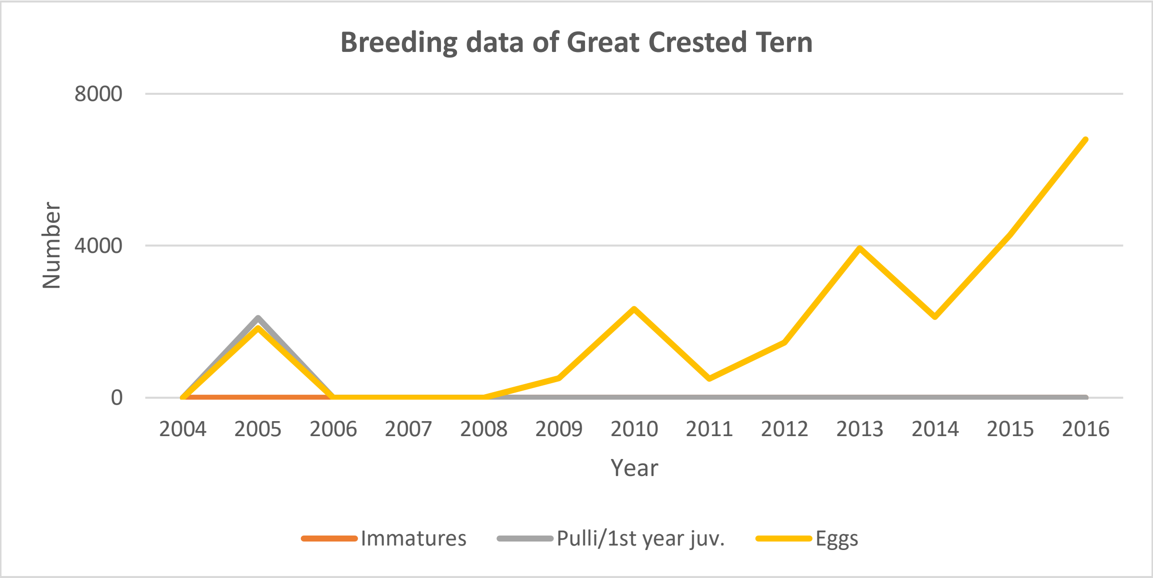

Figure 33. Breeding data of Great Crested Tern from 2004 to 2016

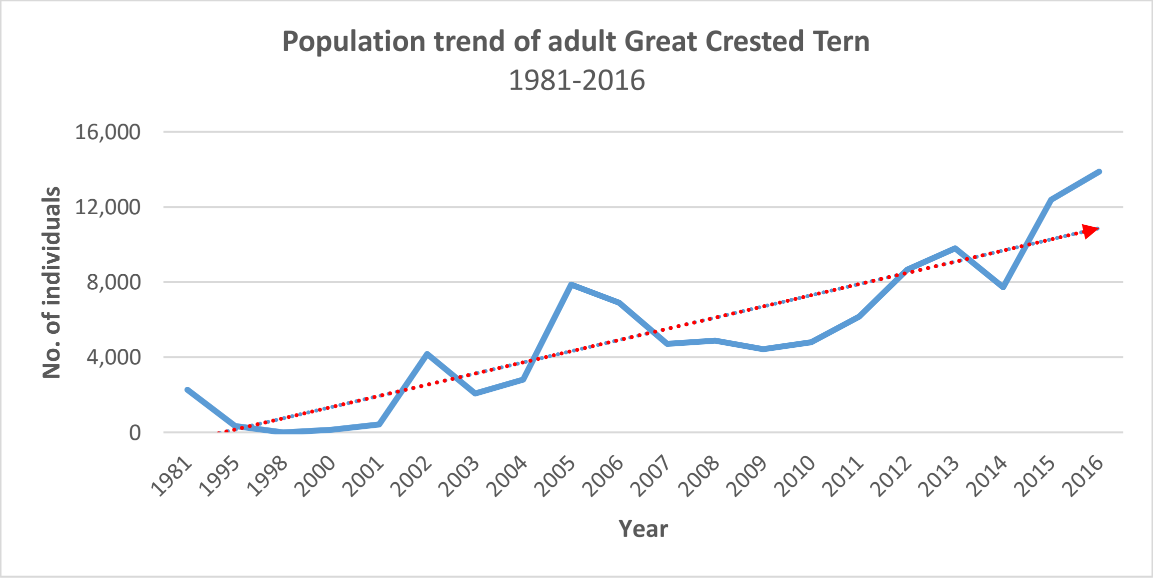

Figure 34. Population trend of adult Great Crested Tern from 1981 to 2016

Plate 10. Great Crested Terns and their eggs covered vast tracts in the periphery of the 'Plaza' on Bird Islet in May 2016. Photo: TMO

Sooty Tern: A total of 8,555 adults were counted on Bird Islet (Figure 36). Of these, only up to 855 individuals were observed at daytime. The vast majority arrived in Bird Islet in large flocks starting around 16.30pm until the early evening. The population in 2016 was about 23% higher than the average for the five-year period of 2012 to 2016. Compared to 2015, the number of adults in May 2016 was 13% lower. However, it was 69% higher than in the baseline year of 1981 when 5,070 individuals were recorded.

Only 166 eggs were found indicating the very beginning of the species' breeding cycle (Figure 35). In comparison, on 27 May, the TMO Park Rangers counted 3,999 adults with 1,713 eggs, again suggesting that the egg-laying period had not ended.

The TMO Park Rangers observed 800 Sooty Terns at Jessie Beazley Reef on 6 December 2015 (Plate 3). Normally the species is absent from the end of November to February. This is only the second time Sooty Tern have been recorded in TRNP in December. The first record was from December 2005.

Immatures have been recorded to return to their natal colonies only after six years of absence as they disperse far away from their breeding grounds (del Hoyo *et al.*1996). Yet at Jessie Beazley Reef, an immature bird, probably born in 2015, was observed on 10 May. This would be the first record of an immature Sooty Tern in TRNP.

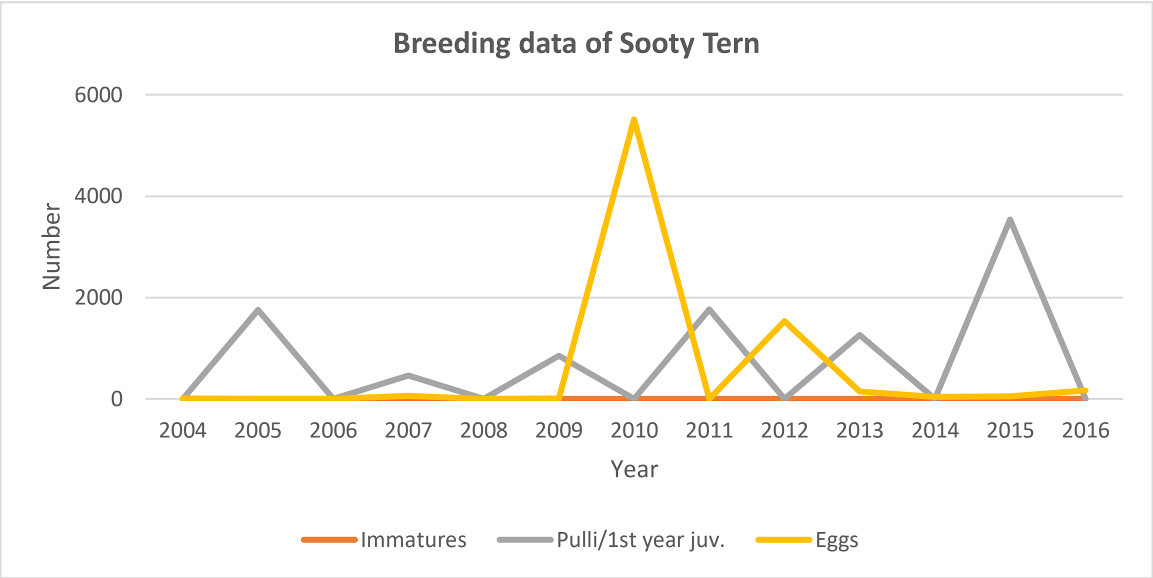

Figure 35. Breeding data of Sooty Tern from 2004 to 2016.

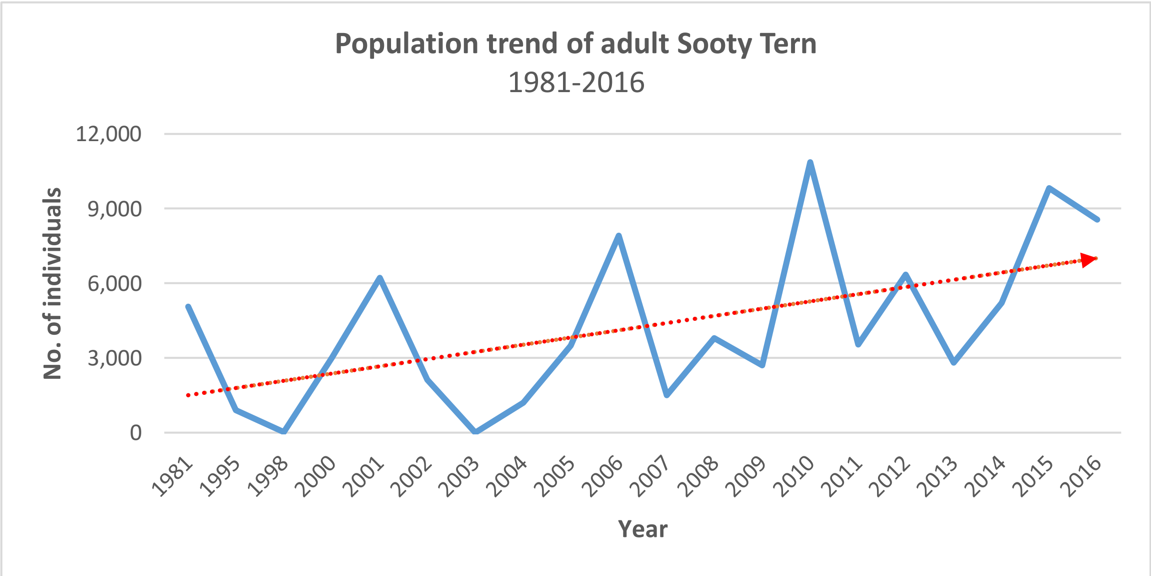

Figure 36. Population trend of adult Sooty Terns from 1981 to 2016.

Plate 11. On May 2016, the Sooty Tern population was in the very beginning of its breeding cycle and only a few birds were present in Bird Islet during the daytime. Photo: Arne E. Jensen

Pacific Reef Heron: The total adult population in May 2016 was around 19 individuals (14 in 2015). Seventeen adults were found on South Islet together with two empty nests and one juvenile bird. Based on the TMO data sets since 2004, the population is increasing on South Islet but decreasing on Bird Islet.

Plate 12. Nearly the entire breeding population of Pacific Reef Heron belongs to the dark phase. The photo shows two adults and two juvenile birds. Photo: J.L. Tan

Plate 13. Despite massive drought and currently very limited vegetation on Bird Islet the Barred Rail remains one of the breeding bird species in TRNP. Photo: Lanze A., Wild Bird Photographers of the Philippines.

Barred Rail: Two adults were observed on Bird Islet in May 2016. The species was last time recorded on the islet in 2007. Barred Rail was first found in TRNP in May 2003 and it used to occur in both Bird Islet and South Islet.

Plate 14. The Eurasian Tree Sparrow has been observed in TRNP every year since 1991. Photo: Lisa Paguntalan.

Eurasian Tree Sparrow: Five individuals were recorded in Bird Islet. It was last found in the islet in 2012. The highest number was recorded in 2013 when a total of 16 birds were found in both Bird Islet and South Islet.

4.4 Recommendations

Methodology

1. Ensure adherence to inventory methodologies and accurate reporting.

2. Ensure that outgoing rangers from TRNP encode their distance count and direct count data for uploading in TMO avifauna database. The TMO researchers and the Park Ranger together validates that the encoding is accurate.

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

Habitat

4. Increase planting of beach forest seedlings on both Bird Islet and on South Islet. The seedlings must be protected against the Red-footed Booby population.

Land area

5. No studies have been done on the sea 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 it results contribute to decisions to halt the loss of the land areas at Bird Islet.

6. Explore environmentally friendly, soft-engineering solutions to mitigate loss of land area on Bird Islet with a goal to increase it. Initially, experiment with land expansion methods at two smaller areas in Bird Islet: at the coastline at the entrance of "Plaza" at the islet's northwest coast and along a portion of the southeast coast.

Species

7. Continue population and habitat monitoring, which includes monthly distance count estimations and three seasonal inventories in the months of January, August and October. Include counts of other species such as Pacific Reef Egret, Barred Rail, and of the migratory Ruddy Turnstone and Grey-tailed Tattler.

8. Include in the inventories, counts of the number of dead seabirds categorized into pulli, juvenile and adult birds.

9. When it has least impact on the breeding birds, increase recapture of banded Sooty Tern and Black Noddy to gain more knowledge on life expectancies, etc.

10. Include in the annual budgeting, a budget for satellite-transmitter tacking and tracking of the adult and juvenile seabird species. Use then the TRNP budget to seek external co-funding.

11. Construct an enclosure in Bird Islet that enables the Black Noddy to enter but excludes the Red-footed Booby.

Public awareness raising

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

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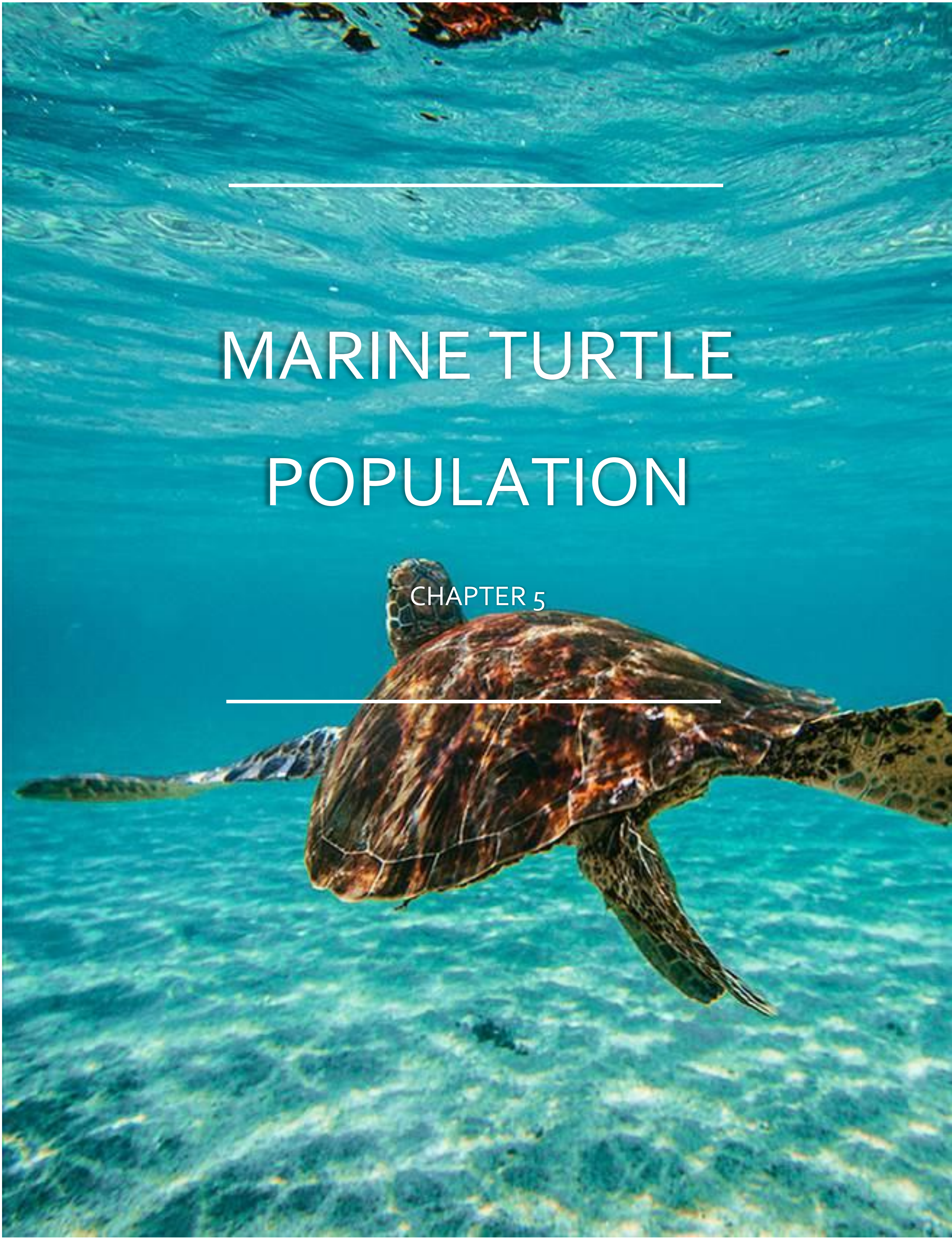

MARINE TURTLE POPULATION

CHAPTER 5

5 MARINE TURTLE POPULATION

5.1 Overview

Marine turtles have been monitored in the Tubbataha Reefs Natural Park (TRNP) since 2005, with assistance from the Department of Environment and Natural Resources. In 2010, with the help of Dr. Nicolas Pilcher of the Marine Research Foundation, more comprehensive studies on the population dynamics of turtles were conducted. Tubbataha Management Office (TMO) Staff and partners were trained in the proper measurement of the curved carapace length (CCL), lagging, laparoscopy and extracting tissue samples for DNA Analysis. This report presents preliminary findings of the marine turtle survey in 2016.

5.2 Methods

Methods for the marine turtle survey followed the methods used by marine turtle consultant, Dr. Nicolas Pilcher of the Marine Research Foundation. These methods were based on the principles outlined by the IUCN SSC Marine Turtle Specialist Group, Pendoley Environmental, Dr. Colin Limpus and colleagues, and Dr. Nicolas Pilcher.

Rodeo-style captures (Figure 37) were conducted from two fiberglass dinghies with rear steering and 25-30 hp outboard engines weaving in and out across sandy shallows at three key sites (Ranger Station, North Islet, South Islet). Three to four catchers positioned at the front and sides of the boats searched for turtles, and when a turtle was seen, it was chased until it was either captured or lost. Capture selections were made without regard to the size or location of the turtle. When the dinghies were full (10-20 turtles) they unloaded their catch at the Ranger Station or on the MV Navorca and continued catching.

Figure 37. Marine Park Ranger attempting to capture a turtle using the rodeo method. Photo: Tommy Schultz.

Turtles were also carefully measured for curved carapace length (CCL) using a fiberglass tape measure (+/-2mm) – measured over the curve of the carapace along the midline from the anterior point at the midline of the nuchal scute to the posterior tip of the supracaudal scutes. Turtles were checked for the presence of tags on the flippers. Those without were tagged on their two front flippers, with Inconel tags containing unique numbers for their identification.

Through laparoscopy, a form of surgery, the turtle's sex and reproductive status were determined by the appearance of gonads (oviduct size and shape, color of ovaries) in females, and testes (size, shape and color, and shape of epididymis) in males. Laparoscopy uses a miniature telescope to directly view the inside of the peritoneal cavity (see Figure 38).

Figure 38. Dr. Rizza Salinas, DENR-BMB, performing laparoscopy. Photo: TMO

5.3 Results and Discussion

Laparoscopy investigations revealed a wealth of information on population structure, sex ratios, nesting activity, spatial distribution, residence times, growth rates and size structure. In several instances the data from past surveys allowed calculations of residence periods and growth rates. A total of 200 green turtles *(Chelonia mydas)* were captured via rodeo jumps. Of these, 49 turtles were recaptures from past seasons (identified via tags applied previously).

Population Structure and Male : Female Ratio

As in the previous years, females account for a substantially high percentage (76%) compared to the captured males (24%). This equates approximately to a 1Male : 3Female ratio.

Juvenile turtles this year account for 52% of the total captures. This number is lower compared to 2015 where juveniles made up 78% of the captured turtles. Of the 102 juvenile turtles this year, five were new recruits, based on a white scratch-less plastron and small size. The proportion of new recruits to the juvenile class is 5%. This is close to the 2015 data which is 6.4%. New recruits only accounted for 1% of the juvenile green sea turtles in 2010 and 2014.

The 73 sub-adults comprise 37% of the turtles captured this year, while the 22 adults constitutes 11%. These values are higher compared to 2015 where sub-adults accounted for 17% and adults 4.9% of the turtles. A breakdown by age class and sex ratio is provided in Figure 40.

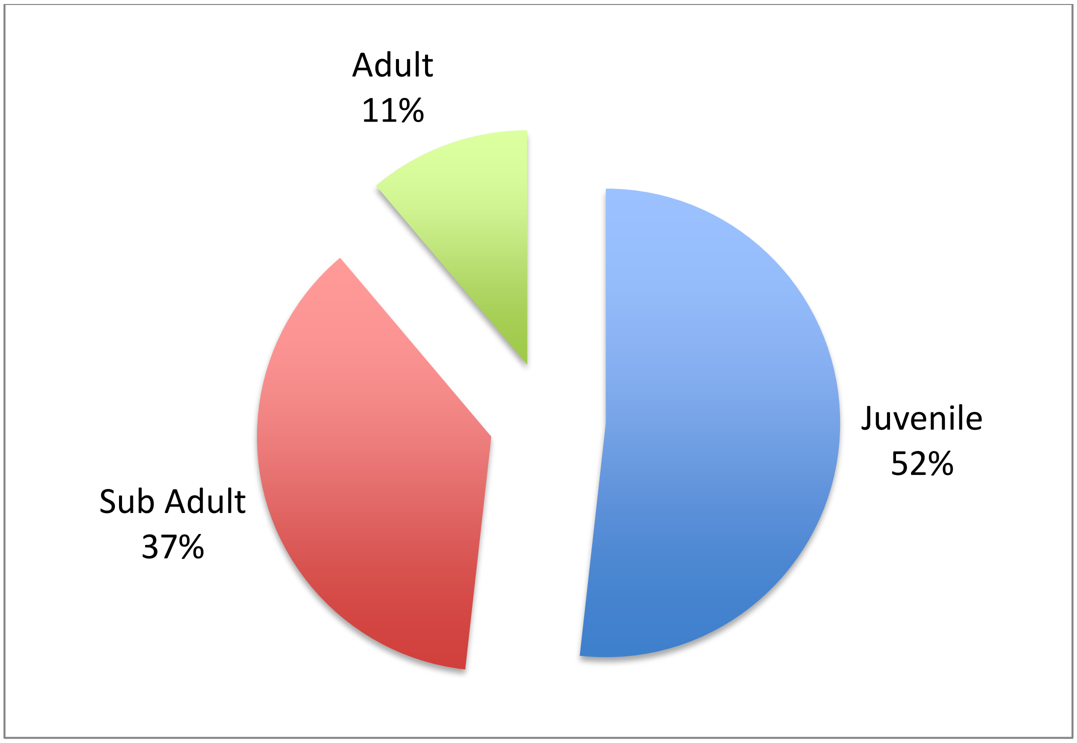

Figure 39. Age class structure of rodeo captures in TRNP, June 2016.

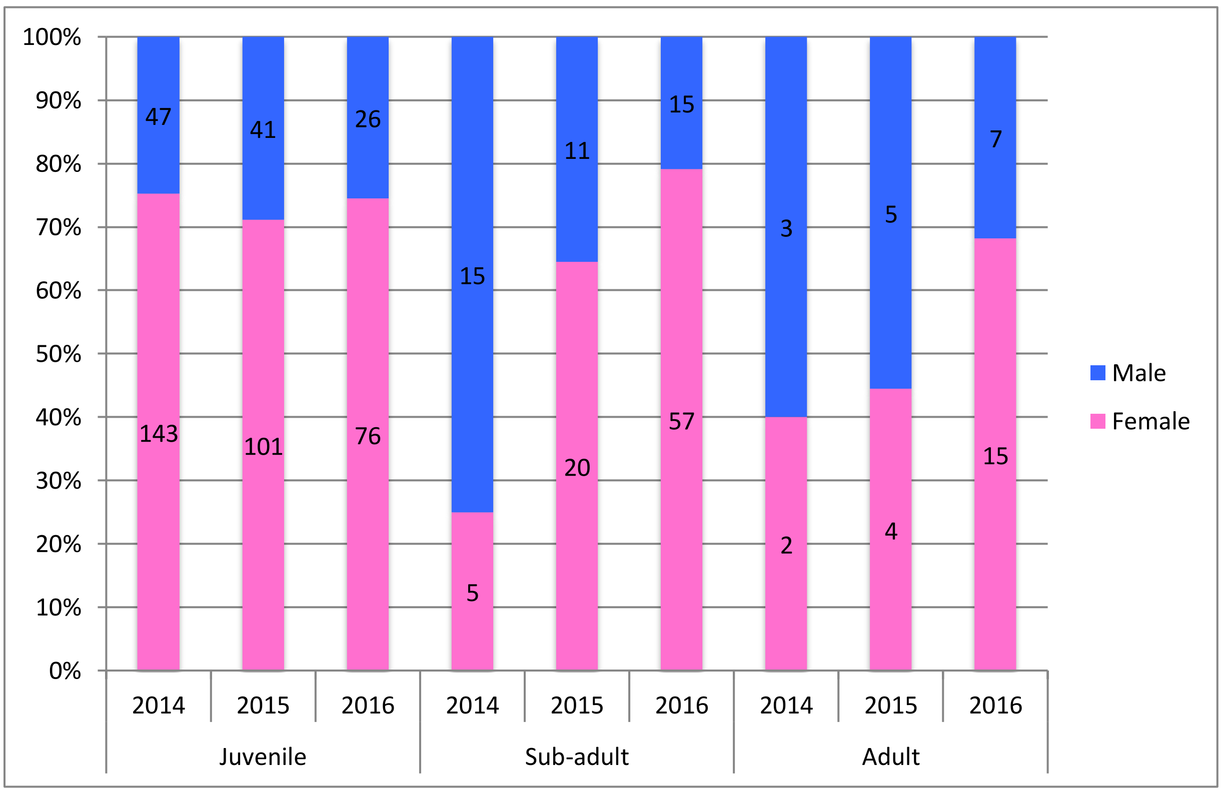

Figure 40. Age class structure broken down by sex for turtles captured in TRNP, 2014 to 2016.

Size Distribution

As with the previous years, given the variation in growth rates, there was overlap in sizes amongst the differing age-classes, particularly between the 55cm and 80cm. A breakdown of size characteristics by sex and age class is presented in Table 10.

Table 10. Size characteristics (CCL in cm) for turtles encountered in TRNP, June 2016.

	Male			Female		
	Juvenile	Sub-adult	Adult	Juvenile	Sub-adult	Adult
Ave	54.4	70.1	89.4	54.9	68.5	80.5
SD	10.5	6.9	4.9	10.6	5.0	8.1
Min	41.7	58.3	81.9	35.8	56.9	72.5
Max	78.6	87.1	97.1	72.7	81.3	99.5
n	26.0	15.0	7.0	76.0	58.0	15.0

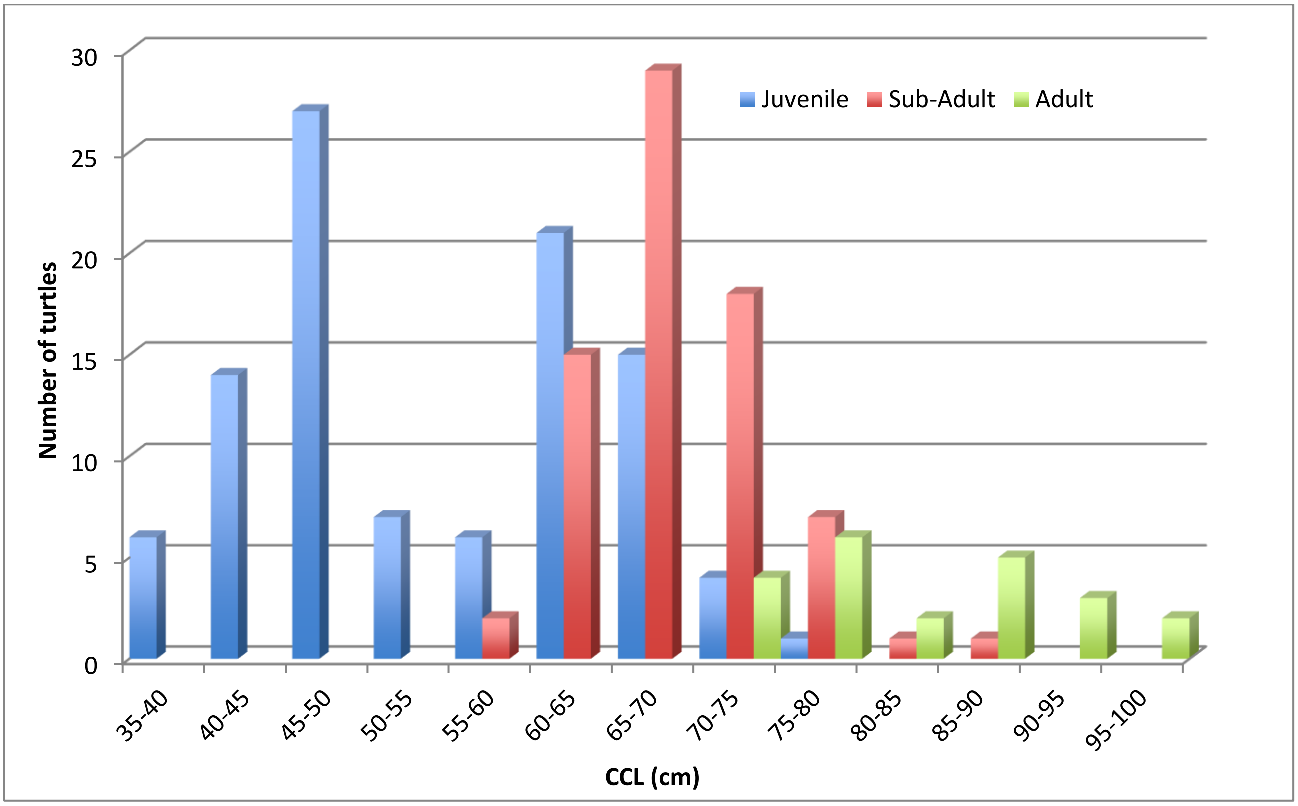

Figure 41. Size distribution broken down by age class for turtles captured in TRNP, June 2016.

There were seven juvenile turtles captured at the Ranger Station, with sizes ranging from 46.05cm to 68.8cm. More than half of the turtles captured this year were taken from Bird Islet (133 individuals or 66.5%). Of these turtles, 63 individuals were juveniles, 53 were sub-adults and 15 were adults. Their sizes range from 35.8cm to 91cm. In South Islet, there were 32 juveniles, 20 sub-adults and 7 adult individuals. Sizes of turtles captured in this area range from 36.05cm to 99.5cm.

Mark-Recapture, Intervals and Growth

Capture-mark-recapture studies allow assessments of growth rates, residence periods, migrations and age-specific mortality. All data gathered by TMO personnel and by the DENR were used in the analysis.

In 2016, data were available for 84% (41 individuals) of all recaptures. Four individuals (10%) were recaptured at the Ranger Station, 29 individuals (70%) from Bird Islet and 8 individuals (20%) from South Islet. Of the 41 turtles, 15 were first tagged in 2015, 16 turtles first captured in 2014, two in 2010 and 2009, three in 2007 and one in 2005.

Nine of the 41 turtles were recaptured more than once. One turtle was recaptured five times (2005, 2010, 2014, 2015 and 2016) and has grown 19.8cm (49cm in 2005 to 68.8cm in 2016).

Satellite Tagging

During laparoscopy, two turtles, both not previously captured in the park, were determined to be adult males that were ready to find partners and breed this year. The decision was made to fix satellite trackers on these adult males to find out more about the breeders who normally do not stay long at the park. Dr. Pilcher noted that these are probably the only male green sea turtles with satellite trackers in the Southeast Asian region. Satellite trackers previously deployed in the region have been on nesters (females) which were conveniently caught on land as they laid eggs.

Figure 42. Dr. Pilcher installing a satellite tag on an adult male turtle caught in South Islet. Photo: TMO

One turtle caught in South Islet came from Malaysia (left tag MYS27963; right tag: MYS27964). This is the first time that a foreign tagged turtle has been documented in the park. This nester from Malaysia measured 99.5 cm and was the largest caught this year.

5.4 Conclusion

As with the previous years, juvenile turtles still represent the most number of turtles caught in the park. This supports earlier statements made that Tubbataha is a juvenile developmental ground for green sea turtles. As in 2014 and 2015, there were still more females than males, with a ratio of approximately 1Male : 3Females.

Compared to previous years (2010, 2014 and 2015), there was an increase in the number of sub-adults, specifically in Bird Islet. Sub-adults accounted for 53% of the turtles caught in this area. Since the training in 2014, there were improvements on the precision of measurement data (curved carapace length). This year, the team was able to maintain a maximum of 2mm difference in their measurements.

WATER QUALITY

CHAPTER 6

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6 WATER QUALITY

6.1 Overview

Water quality is a limiting factor to biological processes within organisms and is therefore a key determinant of overall community health and viability. Due to logistical and financial constraints, it has only been monitored in the Tubbataha Reefs Natural Park since 2014, with the assistance of the Palawan Council for Sustainable Development Environmental Laboratory. In the past two years, TRNP passed in almost all water quality parameters when compared against the highest standards for marine protected areas in the Philippines (CLASS SA) as stipulated in DENR Admin. Order No. 34, Series of 1990. Parameters where the park failed to meet the Class SA levels are oil and grease, total coliform and fecal coliform. This report presents the monitoring results from 2014 to 2016.

6.2 Methods

Collection of water samples

In 2014, twenty (20) monitoring stations were established for water quality (Figure 43). Seven (7) water quality (WQ) stations are located in North Atoll, nine (9) WQ stations are distributed in South Atoll, and one (1) in Jessie Beazley Reef. Three (3) stations are located outside the park boundaries, near the North Atoll (WQ18), South Atoll (WQ08) and Jessie Beazley Reef (WQ20). Parameters such as temperature, dissolved oxygen, pH, salinity, and conductivity were measured *in situ* using Hach Multi-probe meter. Grab water samples were taken from each monitoring station, and brought to the PCSDS Environmental Laboratory for analysis of oil and grease, fecal coliform and total coliform concentrations.

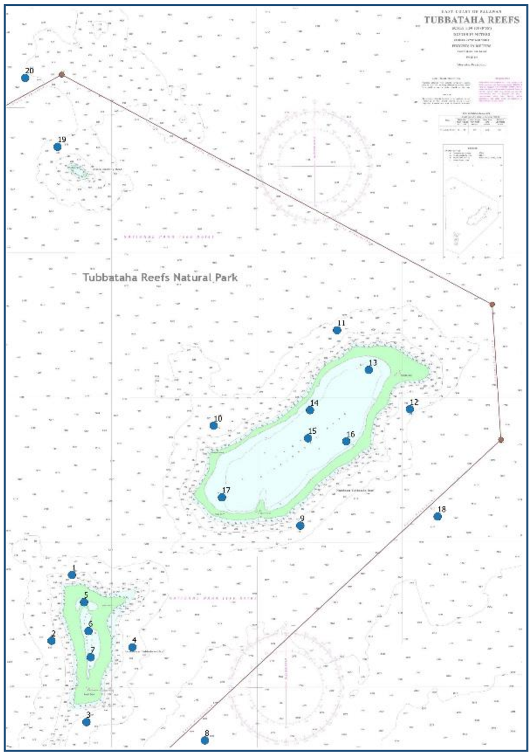

Figure 43. Water quality monitoring sites in TRNP.

Laboratory analyses

Collected water samples were taken to PCSD Environmental Laboratory for laboratory analysis. Prescribed and approved methods of analyses were used based on DENR Admin. Order No. 34, Series of 1990. These methods of laboratory analyses, summarized in Table 11, were taken from the Standard Methods for Examination of Water and Wastewater Analysis, 21st Edition, published by American Public Health Association and American Water Works Association (APHA-AWWA). Colorimetric methods with the use of Hach DR 3000 were utilized for analysis of nitrates and phosphates.

Table 11. Methods of laboratory analysis.

Parameter	Method of Analysis
Physico- chemical parameters	
pH	Glass Electrode Method
Temperature	Multi-probe Meter
Dissolved Oxygen (DO)	Membrane Electrode Method (DO Meter)
Salinity	Multi-probe Meter
Conductivity	Multi-probe Meter
Total Suspended Solids (TSS)	Gravimetric dried at 103 - 105°C
Total Dissolved Solids (TDS)	Gravimetric dried at180°C
Color	Visual Comparison Method (Platinum Cobalt Scale)
Settleable Solids	Imhoff Cone
Biochemical Oxygen Demand (BOD)	Alkali Iodide Azide
Nitrogen as Nitrates	Colorimetric using Hach Nitrate Powder Pillows
Phosphorus as Phosphates	Colorimetric using Hach Phosphate Powder Pillows
Chromium hexavalent (Cr^{6+})	Diphenyl Carbazide Colorimetric Method
Oil and Grease (O&G)	Gravimetric Method (Petroleum Ether Extraction)
Microbiological Parameters	
Total Coliform (TC)	Multiple Tube Fermentation Technique
Fecal Coliform (FC)	Multiple Tube Fermentation Technique

6.3 Results

pH

pH is the measure of acidity ranging from 0 – 14. The lower the value the more acidic is the water. Neutral pH stands at 7 while seawater is generally at 8, which is a little basic. Acids and bases are extremes like hotness and coldness (Addy et al. 2004), thus changing pH levels will influence all forms of life within an environment. Most aquatic organisms prefer pH levels of 6.5 to 8.5. Outside of this range, organisms become physiologically stressed (Addy et al. 2004).

The three-year average pH level in TRNP is at 8.24. Values within the three-year period ranged from 7.74 to 8.89. With an exception to the 2014 pH level in Site WQ10, overall, the pH levels of sites monitored in TRNP are within the limit for Class SA (Figure 44).

Dissolved oxygen

Dissolved oxygen (DO) refers to the amount of oxygen available in the water column. It is an important requirement for the maintenance of a balanced populations of fish, shellfish, and other marine organisms. DO concentrations of all stations in TRNP ranged from 6mg/L to 7.29mg/L in 2014, 6.2mg/L to 8.51mg/L in 2015, and 6.1mg/L to 8.9mg/L in 2016 (Figure 44). These concentrations are well above the 5mg/L minimum for Class SA.

Salinity and temperature

Salinity is the measure of all the salts dissolved in water. Geographical location and time influence ocean salinity. The salinity of saltwater is about 35 parts per thousand (ppt). In 2014, salinity levels in TRNP ranged from 30.9 ppt to 36.8 ppt, 35.2 ppt to 35.7 ppt in 2015 and 33.4 ppt to 35.5 ppt in 2016. Salinity level of TRNP and its surrounding waters ranges from 34.5 psu (Practical Salinity Unit) to 35 psu (Villanoy et al., 2007).

Sea surface temperature in TRNP ranged from 25.4°C to 38.4°C in 2014, 28.2°C to 29.8°C in 2015 and 26.9°C to 31.7°C in 2016. Except for some sites (Sites 4, 8, 9, 10, 17) in 2014, temperature data in the past three years were within the surface temperature readings of Villanoy et al. (2007), which from range from 28°C to 32°C.

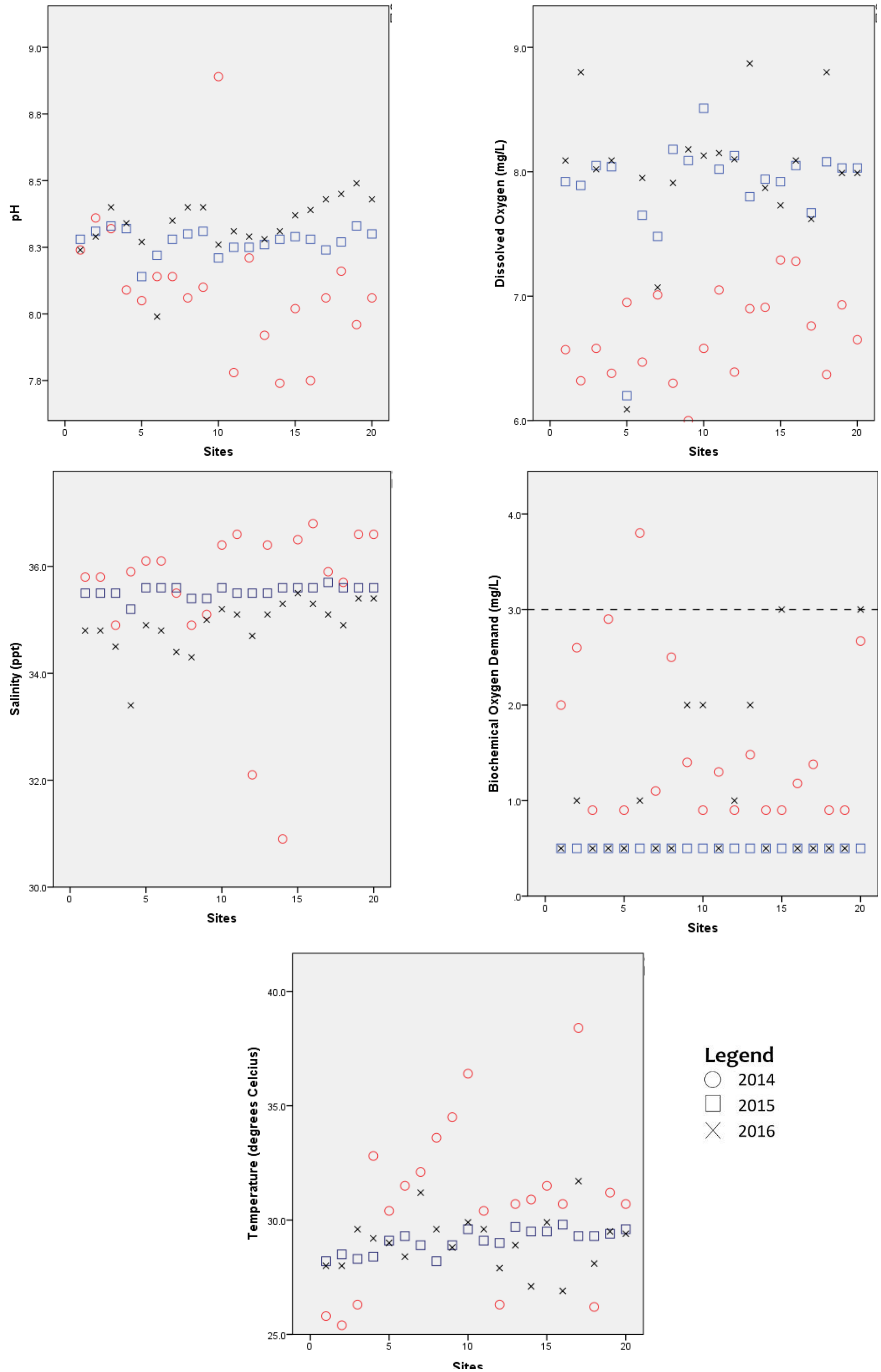

Figure 44. Scatterplot of pH, dissolved oxygen, salinity, biochemical oxygen demand and temperature from 2014 to 2016.

Biochemical Oxygen Demand

Biological Oxygen Demand (BOD) is a measure of the quantity of oxygen used by microorganisms (e.g., aerobic bacteria) in the oxidation of organic matter.

All of the sites, except WQ6 in 2014, passed in the acceptable level of BOD for Class SA, which is 3 mg/L. BOD level in WQ6 (in 2014) is at 3.75 mg/L, is below the maximum BOD level for Class SB, which suggests that BOD levels in TRNP are still within acceptable level. The average BOD for all sites is 1.58 mg/L in 2014, 0.5 mg/L in 2015 and 1.1 mg/L in 2016.

Aesthetic characteristics: Color, Turbidity and Solids

Parameters such as color, turbidity, total suspended solids, and settleable solids are related to the aesthetic quality of water. Water clarity is an essential environmental factor for phototrophic organisms that dominate coral reefs, seagrass meadows and the seafloor microphytobenthos. Good aesthetic quality is important in providing maximum enjoyment for recreational purposes in the Tubbataha Reefs Natural Park. It also indicates that the surrounding water is free from suspended matter from unnatural sources or causes. The suspended or colloidal matter contributing to the color and turbidity in water are captured in the analysis of total suspended solids and total dissolved solids.

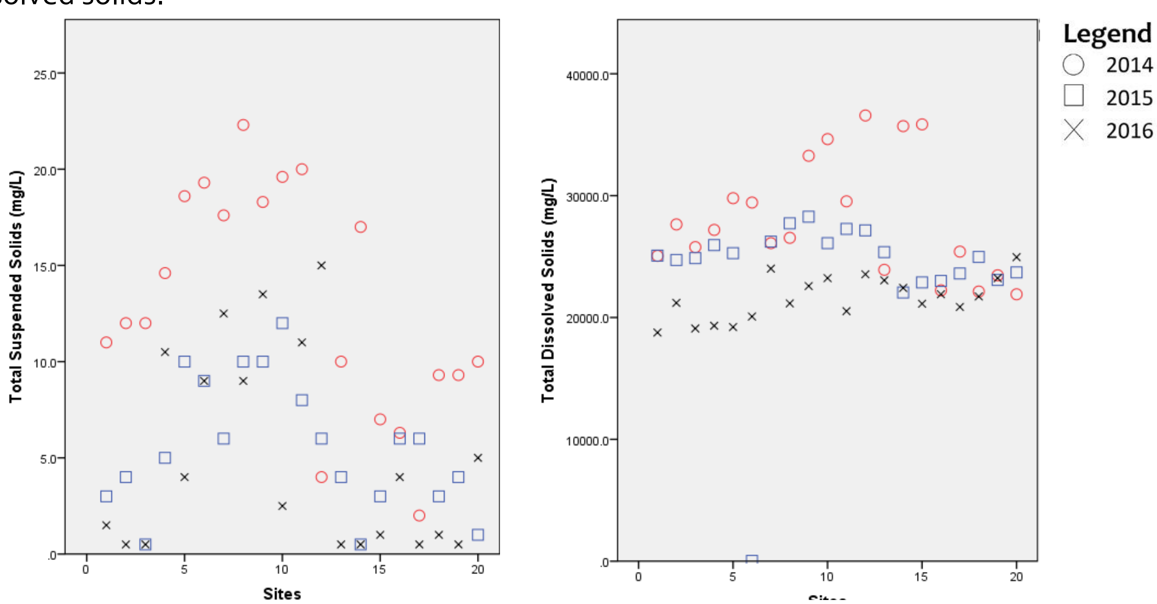

Figure 45. Scatterplot showing total suspended and dissolved solids from 2014 to 2016.

Overall, the total suspended solids (TSS) collected from the 20 stations in TRNP during the summer month varied from 0.69 mg/L to 22.3 mg/L in 2014, 0.5 mg/L to 12.0 mg/L in 2015 and 0.5 mg/L to 15.0 mg/L in 2016. These values are within the standards of Class SA. No numerical value is established as water quality criteria for color and TSS, aside from the provisions that there should be no abnormal discoloration from unnatural causes in the color of seawater and not more than 30% increase in total suspended solids of the water compared to its baseline concentration. Total dissolved solids (TDS) of highly saline water may range from 10,000 mg/L to 35,000 mg/L. In the last three years, TDS levels in TRNP ranged from 18,700 mg/L to 36,500 mg/L.

Oil and grease

On a world-wide scale, marine transportation activities are often responsible to inputs into the oceans (Tong S.L. et al., 1999). Oil and grease refers to the chemicals containing organic compounds derived from diverse sources ranging from crude petroleum and industrial derivatives to edible oil and fats and their oleo-chemical derivatives (Eaton et al., 2005). The microorganisms such as phytoplankton, zooplankton and benthic algae also provide biosynthetic hydrocarbon mixtures, and its input at a global scale may exceed that of petrogenic origin, but its impact is balanced by the degradative capacity of hydrocarbon-consuming microorganisms (Tong, et al., 1999).

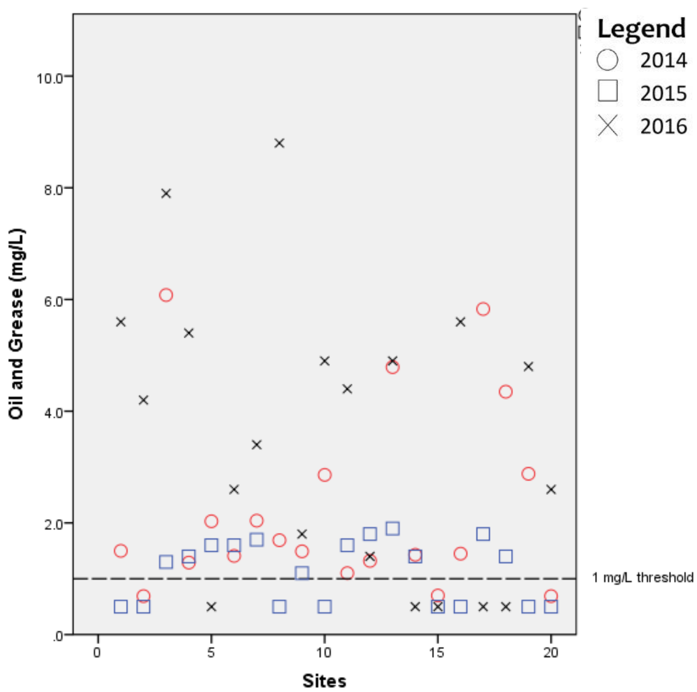

Figure 46. Scatterplot showing the concentrations of oil and grease in the monitoring sites from 2014 to 2016. Broken line marks the 1mg/L maximum oil & grease level for Class SA.

In the case of TRNP, oil and grease concentrations have been a concern since every year, most of the sites have exceeded the 1mg/L threshold for Class SA. In 2014, 17 sites were more than the 1mg/L threshold , while in 2015, 12 sites were in exceedance. In 2016, 15 sites failed to meet the standard for Class SA.

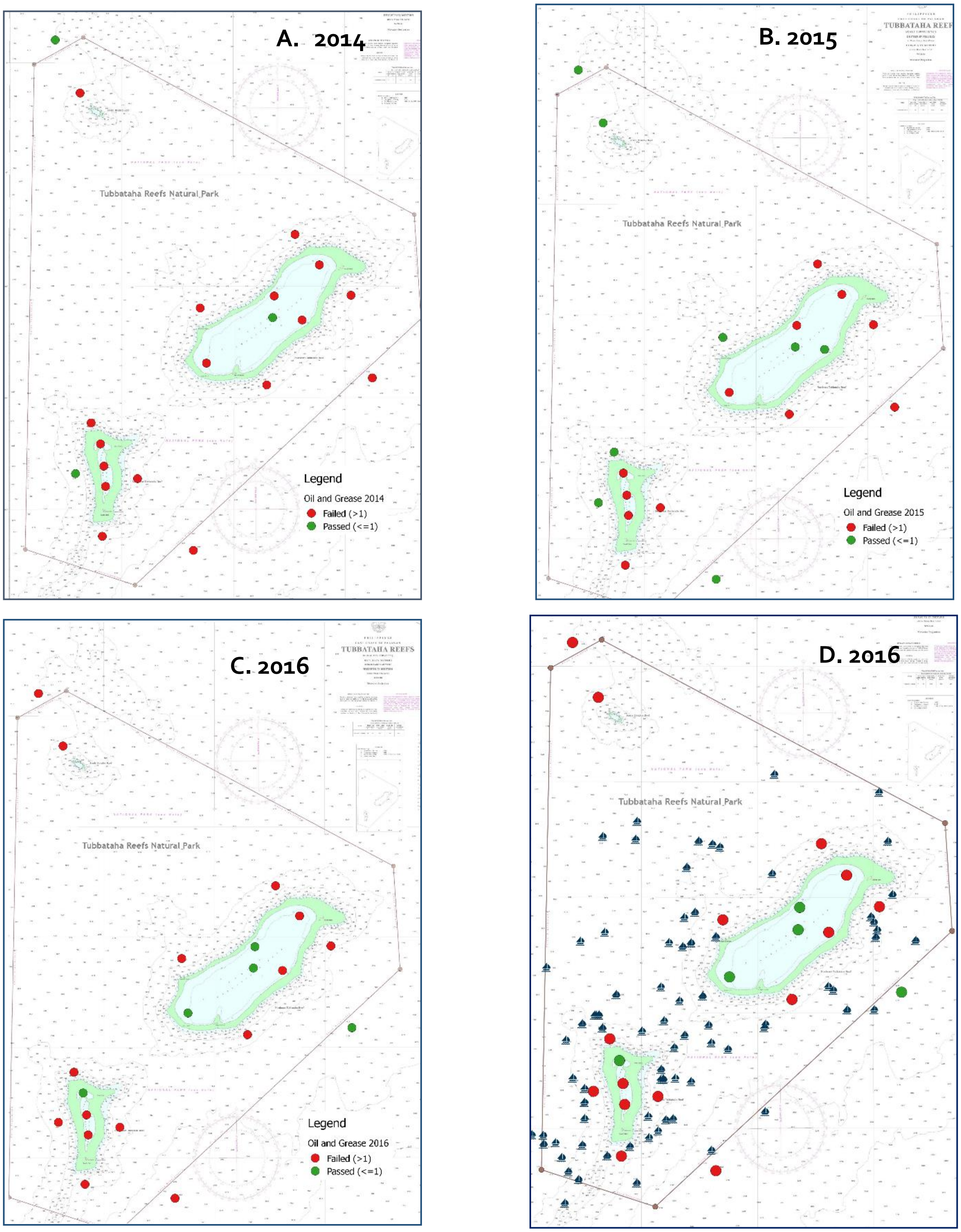

Figure 47. Oil and grease levels from 2014 to 2016 (a-c), with the greywater discharge locations in 2016 (d).

Nutrients: Phosphates and Nitrates

All living organisms require nitrogen and phosphorus for their growth, metabolism and reproduction. According to studies, phytoplankton productivity in the surface ocean is often limited by the amount of available fixed nitrogen, and in some cases, phosphorus (Patey et al., 2008).

In TRNP, the concentration of phosphates range from 0.09 mg/L to 1.43 mg/L in 2014, 0.35 mg/L to 1.43 mg/L in 2015 and 0.02 mg/L to 1.47 mg/L in 2016. The concentration of nitrate range from 0.6 mg/L to 1.8 mg/L in 2014, 1 mg/L to 1.7 mg/L in 2015 and 0.7 mg/L to 1.5 mg/L in 2016. There is no stipulated standard concentration for phosphates and nitrates in Class SA, DAO 34 S. 1990.

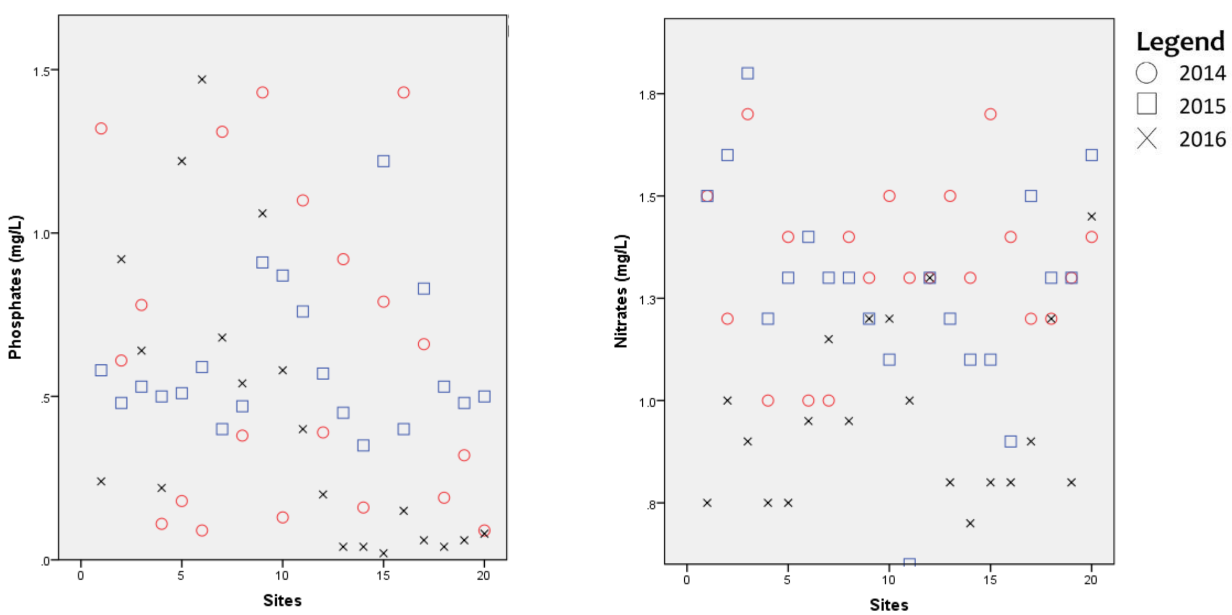

Figure 48. Scatterplot of phosphates and nitrates concentration of from 2014 to 2016.

Microbiological Analysis: Total Coliform and Fecal Coliform

Coliform bacteria include a large group of many types of bacteria that occur throughout the environment. They indicate potential presence of disease-causing bacteria in water. It should be noted that total coliform does not only include fecal coliform, although it can be one component. Thus, a separate analysis was made particularly for fecal coliform.

Total coliform has been monitored in TRNP for three years, while fecal coliform levels were taken only in 2015 and 2016 (See Figure 49). Five sites exceeded the 70 MPN/100mL maximum for Class SA in 2014, seven sites in 2015 and 10 sites in 2016 (See Figure 50).

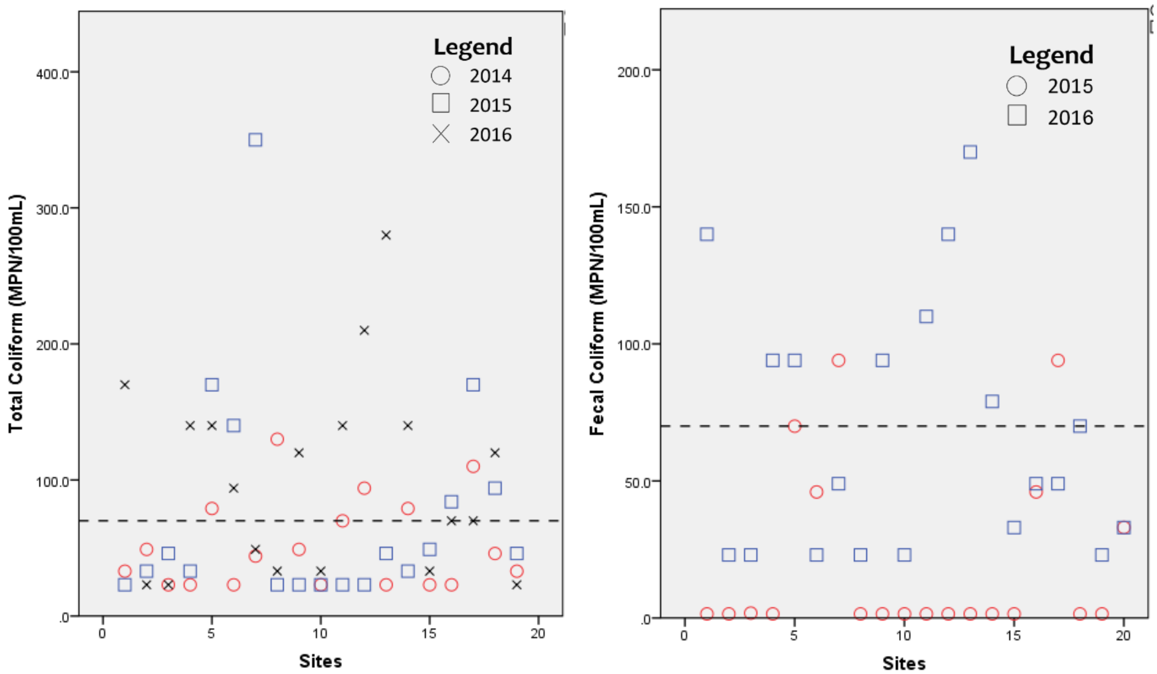

Figure 49. Scatterplot of total coliform (2014-2016) and fecal coliform levels (2015-2016).

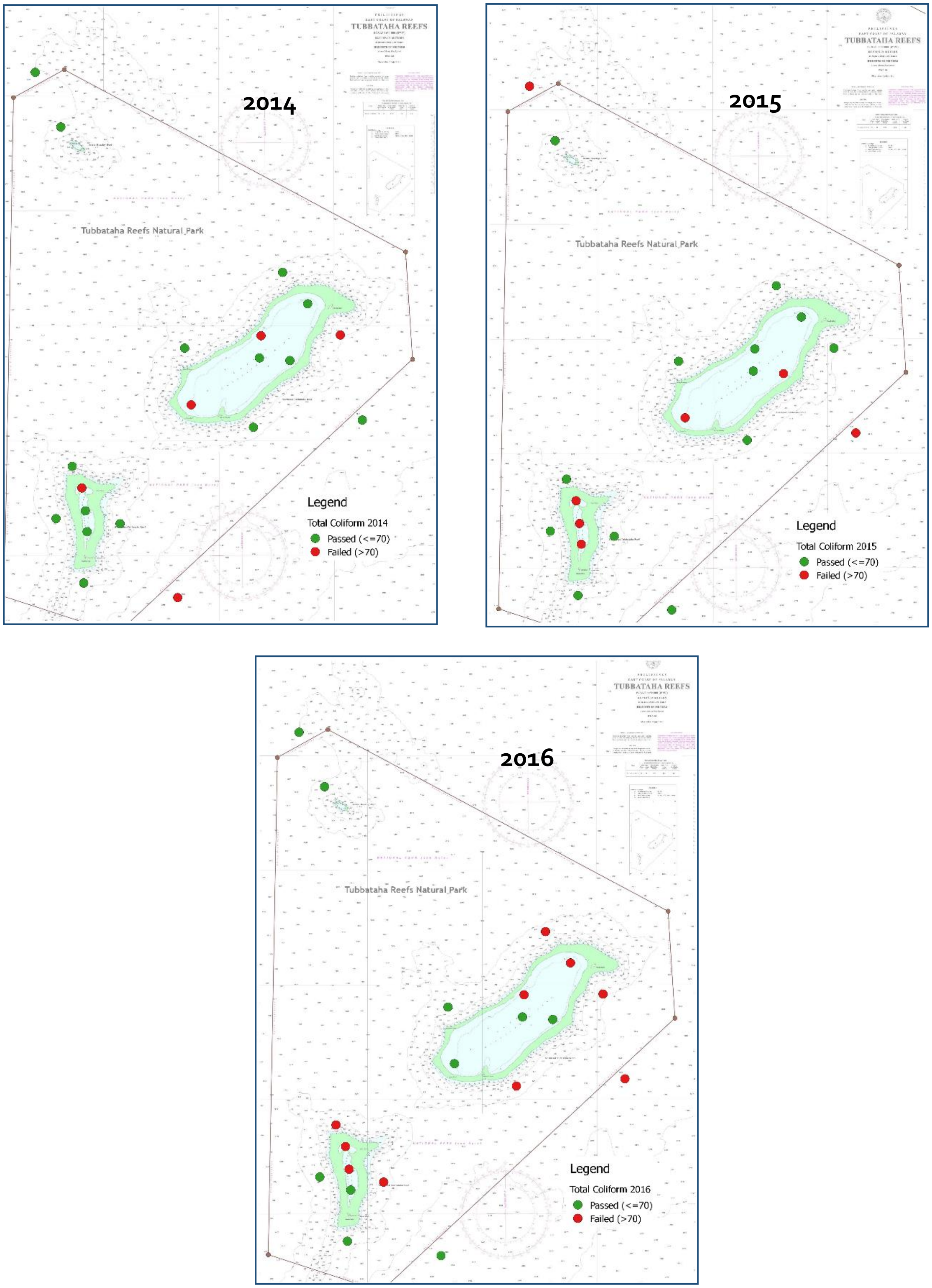

Figure 50. Total coliform levels in TRNP from 2014 to 2016.

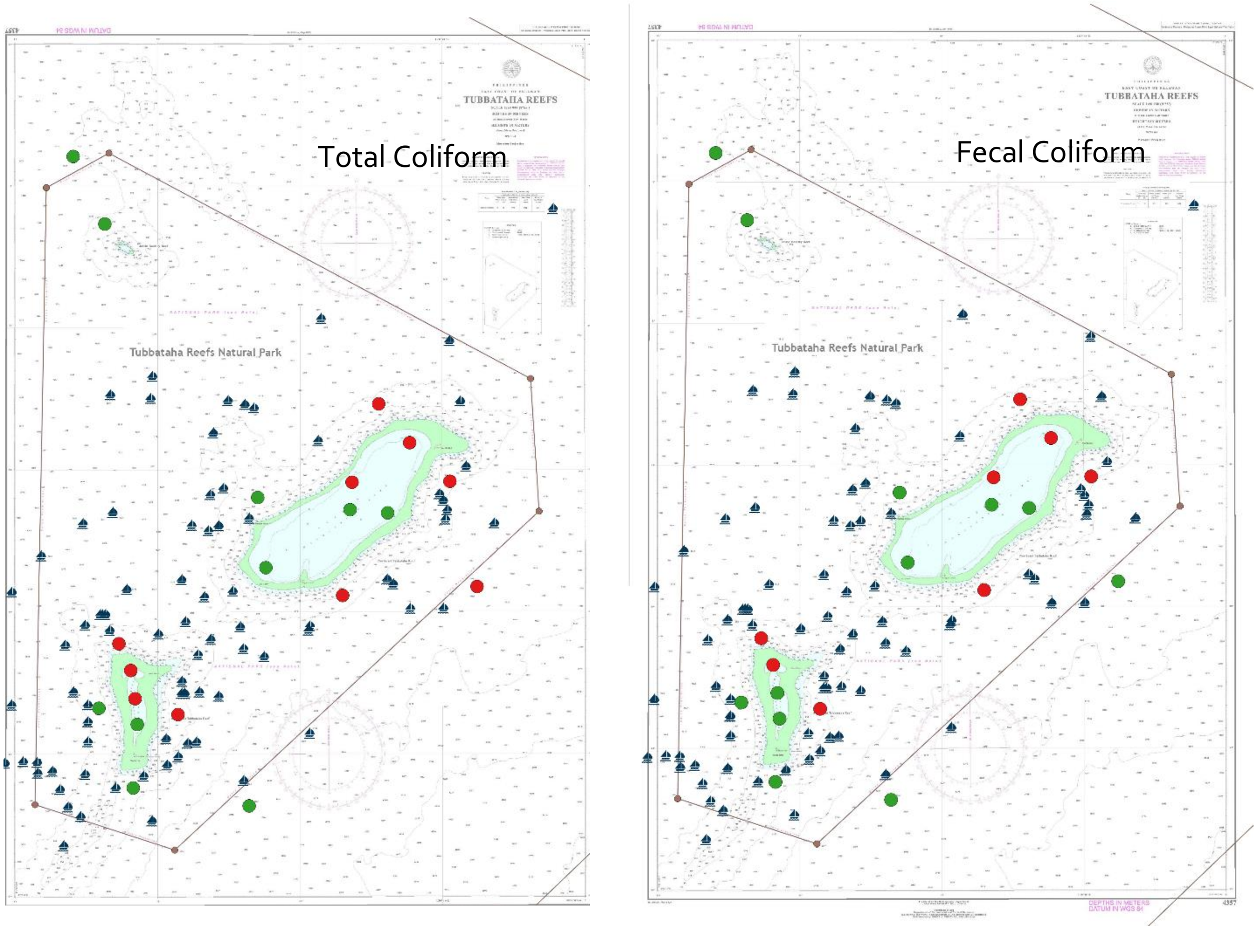

Figure 51. Total coliform and fecal coliform with greywater discharge locations in 2016.

Although inconclusive, the discharge of greywater in these locations may have contributed to the fecal and total coliform levels in the monitoring sites. Rule 18.J of the TPAMB Administrative Order No. 01 Series of 12 stipulates that disposals of the holding tank shall be allowed beyond one (1) nautical mile distance away from the reef, but not within the channel. As presented in Figure 51, some vessels were within the channel when disposing their greywater.

6.4 Recommendations

TRNP passed in almost all parameters except for total coliform, fecal coliform and oil and grease. The results of the 2014 and 2015 monitoring were both presented during the Annual Consultation for Dive Operators and last year. It was suggested that the south/southwestern aide of both atolls shall be designated for the greywater discharge (See Figure 52). This should strictly be imposed to dive boats as a measure in trying to decrease the coliform and oil and grease to levels acceptable to Class SA. Options to treat greywater in dive boats prior to disposal must also be studied.

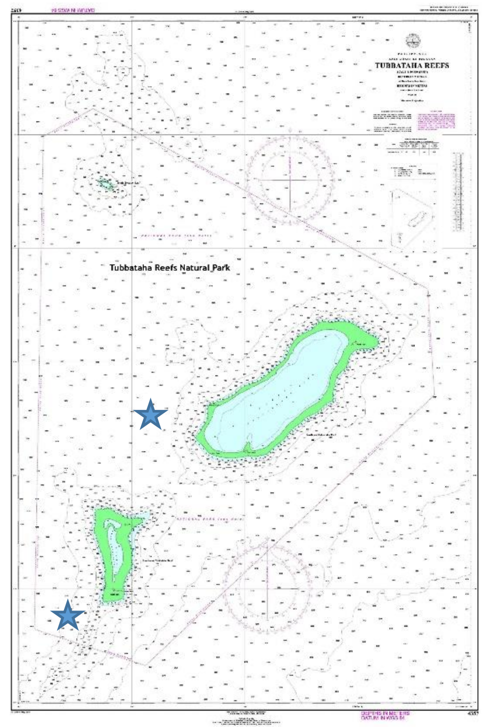

Figure 52. Recommended locations for greywater discharge in TRNP.

It is also recommended that water samples be taken in the fish and benthos monitoring sites. Water quality stations can be adjusted to the nearest fish and benthos monitoring sites.

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ANNEXES

Annex 1 Research Teams

Fish Monitoring

Segundo Conales Jr. (TMO)
Jeric Dejucos (TMO)
Dr. Hazel Arceo (UP-MSI)
Prof. Jerome Benedict Cabansag (UP-Tacloban)
Joseph Benedict Garcia (UP-MSI)

Benthos Monitoring

Rowell Alarcon (TMO)
Retchie Pagliawan (TMO)
Noel Bundal (TMO)
Jeffrey David (TMO)
Eznaira Jeung Narida (UP-MSI)
Regine Robles (DLSU)
Darwin John Raymundo (DLSU)

Seabirds Monitoring

Angelique Songco (TMO)
Arne Erik Jensen (Wetlands International)
Rowell Alarcon (TMO)
Theresa Aquino (MWWP)
Noel Bundal (TMO)
Cresencio Caranay Jr (TMO)
Segundo Conales Jr (TMO)
Jeffrey David (TMO)
Jeric Dejucos (TMO)
Gerlie Gedoria (TMO)
Maria Retchie C. Pagliawan (TMO)
Darius Cayanan, (M/Y Navorca)
Ronald de Roa (M/Y Navorca)
Gilbert Umali (PCG)

Lemuel de Salva (PN)
Jason delos Santos (PN)
Erik Florez (PN)
Narciso Cayaw (LGU Cagayancillo)
Dennis Favila (LGU Cagayancillo)
Armado Bajarias (WBCP)
Juan Carlos Gonzales (UP-Los Baños)
Godfrey Jakosalem (PBCF, Inc.)
Lisa Paguntalan (PBCF, Inc.)

Annex 2 Monitoring Sites

Site Name	Stations	Location	Latitude (N)	Longitude (E)
Site 2 (Sea Fan Alley)	Station 2A	North of north atoll	8.93532 °	120.01302 °
	Station 2B	North of north atoll	8.93781 °	120.00851 °
Site 4 (Malayan Wreck)	Station 4A	West of north atoll	8.89236 °	119.90627 °
	Station 4B	West of north atoll	8.89128 °	119.90453 °
Site 6 (Delsan Wreck)	Station 6A	Southeast of south atoll	8.75591 °	119.82881 °
	Station 6B	Southeast of south atoll	8.75186 °	119.82784 °
Site 7 (T-wreck)	Station 7A	North of south atoll	8.80850 °	119.81907 °
	Station 7B	North of south atoll	8.80656 °	119.82169 °
Jessie Beazley	Station JBA		9.04393 °	119.81599 °
	Station JBB		9.04557 °	119.81348 °
Grounding sites	USSG	North of south atoll	8 49.297°	119 48.187°
	MPY	Southeast of north atoll	8 51.183°	119 56.188°

Annex 3 Top 10 fish families in terms of biomass

Family	Common name	% in average BIOMASS
Acanthuridae sub. Nasinae*	Unicornfishes	21.5
Caesionidae*	Fusiliers	10.2
Carangidae*	Jacks and trevallies	8.9
Lutjanidae*	Snappers	8.5
Scaridae*	Parrotfishes	7.8
Carcharhinidae*	Requiem sharks	7.5
Pomacentridae	Damselfishes	7.2
Balistidae	Triggerfishes	3.8
Labridae*	Wrasses	3.2
Chaetodontidae**	Butterflyfishes	3.1

***commercially important/target fishes**

**coral indicator fishes

Annex 4 Top 10 families in terms of density

Family	Common name	% in average DENSITY
Pomacentridae	Damselfishes	38.0
Serranidae sub. Anthiinae	Anthiases	36.0
Caesionidae*	Fusiliers	7.7
Labridae*	Wrasses	4.0
Acanthuridae*	Surgeonfishes	2.8
Chaetodontidae**	Butterflyfishes	2.3
Acanthuridae sub. Nasinae*	Unicornfishes	1.7
Lutjanidae*	Snappers	1.2
Balistidae	Triggerfishes	1.2
Pomacanthidae	Angelfishes	1.0

*commercially important/target fishes

**coral indicator fishes

Annex 5 Average biomass of fish families per site and per station

Biomass (grams/m²)	Site 2		Site 4		Site 6		Site 7		Jessie Beazley		TRNP
	A	B	A	B	A	B	A	B	A	B	Ave.
Acanthuridae	8.53	3.50	3.38	2.26	4.73	3.78	8.15	4.12	3.20	3.27	4.49
Anthiinae	7.82	5.53	4.70	2.71	10.97	1.82	4.69	5.59	5.76	3.90	5.35
Apogonidae	--	--	0.01	--	0.05	--	--	--	--	--	0.03
Aulostomidae	--	--	--	--	--	--	--	--	0.53	--	0.53
Balistidae	6.98	7.24	4.81	1.42	8.68	2.57	10.49	3.69	3.70	33.46	8.30
Blenniidae	0.00	0.00	0.07	0.00	0.00	--	0.00	0.01	0.00	--	0.01
Caesionidae	1.74	27.56	34.54	32.72	5.85	0.82	7.92	106.8	1.19	4.46	22.36
Carangidae	13.56	71.41	7.06	12.77	2.20	20.40	9.00	52.09	4.03	2.11	19.46
Carcharhinidae	13.63	107.0	--	11.50	--	--	--	9.83	--	22.12	32.81
Chaetodontidae	17.31	10.39	2.91	9.47	1.95	1.37	7.67	4.27	2.86	9.07	6.73
Cirrhitidae	0.16	0.02	0.07	0.04	0.08	0.04	0.04	0.12	0.06	0.04	0.07
Ephippidae	19.33	3.07	--	--	--	5.24	--	1.11	--	--	7.19
Fistulariidae	--	0.13	--	--	--	--	--	--	0.02	--	0.07
Haemulidae	--	--	--	--	0.69	6.87	2.75	14.99	--	1.24	5.31
Holocentridae	2.03	0.63	2.78	5.35	3.53	2.49	2.33	7.03	--	14.23	4.49
Kyphosidae	--	--	--	--	--	0.41	--	14.33	--	--	7.37
Labridae	5.74	7.79	8.30	25.23	1.68	3.07	2.84	1.69	0.75	12.03	6.91
Lethrinidae	10.26	5.72	3.50	5.16	9.67	1.73	3.62	5.81	0.84	2.26	4.86
Lutjanidae	5.14	10.21	20.46	20.24	8.31	8.84	52.35	32.61	13.18	14.14	18.55
Monacanthidae	--	0.01	--	--	--	--	--	--	0.01	--	0.01
Mullidae	0.76	0.62	0.65	0.84	--	--	0.21	--	0.12	0.25	0.49
Muraenidae	--	--	0.00	2.21	--	--	--	18.27	--	2.33	5.71
Nasinae	19.17	38.92	69.98	44.78	59.55	19.64	36.59	55.82	46.36	80.42	47.12
Ostraciidae	--	0.08	--	--	--	--	--	0.83	--	2.85	1.25
Pomacanthidae	4.49	3.87	1.67	1.48	4.34	0.29	3.88	2.63	0.42	2.22	2.53
Pomacentridae	14.32	19.53	19.96	13.68	19.60	13.15	10.61	19.33	11.71	15.63	15.75
Ptereleotridae	0.05	0.00	0.02	--	0.01	--	--	0.00	0.04	--	0.02

Scaridae	10.38	8.59	3.67	16.85	60.33	10.47	23.46	32.53	1.24	3.44	17.10
Scombridae	--	--	--	--	--	--	6.84	--	12.65	--	9.74
Scorpaenidae	--	--	0.02	0.02	--	--	--	--	--	--	0.02
Serranidae	7.08	8.75	13.26	3.60	5.32	1.84	2.61	2.86	2.50	5.89	5.37
Siganidae	--	0.64	0.07	0.07	--	0.46	1.60	0.23	--	--	0.51
Tetraodontidae	0.35	0.47	0.30	0.39	0.23	--	0.13	0.36	0.13	0.27	0.29
Zanclidae	0.84	0.52	0.54	0.80	0.79	0.87	0.74	0.89	0.38	0.81	0.72

Annex 6. Condition of vegetation on Bird Islet and South Islet.

Condition of vegetation on Bird Islet, May 2006 (baseline year) and 2015 to 2016.

Trees/ Condition	Good (optimal)			Fair (moderately deteriorating)			Bad (severely deteriorating)			Total (live trees)			Dead trees		
	2006	2015	2016	2006	2015	2016	2006	2015	2016	2005	2014	2016	2006	2015	2016
Dead trees													82	62	75
Mature,live trees (> 3 feet)	10	4	1	49	12	4	11	49	16	70	65	21			
Small, live trees (2- 3 feet)	109	4	33	0	28	24	0	37	7	109	69	64			
Seedlings (< 1 feet)	50	7	14	0	4	9	0	2	2	50	13	25			
Total	**169**	**15**	48	**49**	**44**	37	**11**	88	25	**229**	**147**	110	82	62	75

Condition of vegetation on South Islet May 2011 (baseline year) and 2015 to 2016.

Trees/ Condition	Good (optimal)			Fair (moderately deteriorating)			Bad (severely deteriorating)			Total (live trees)			Dead		
	2011	2015	2016	2011	2015	2016	2011	2015	2016	2011	2015	2016	2011	2015	2016
Dead trees													6	>15	16
Mature, live trees (> 3 feet)	70	1	0	28	8	20	5	55	40	103	64	60			
Small, live trees (2- 3 feet)	2	0	0	0	7	0	0	0	0	2	7	0			
Seedlings (< 1 feet)	19	4	0	0	0	0	0	0	0	19	4	0			
Total	**91**	**5**	0	**28**	**15**	20	**5**	**55**	40	**124**	**75**	60	**6**	**>15**	16
Note: Coco Palms 2011: 13, 2015: 3, 2016: 6															

Annex 7. Seabird breeding data from Bird Islet and from South Islet, April to June 2004-2016. Source: WWF Philippines 2004 and TMO 2004 to 2016.

Species/Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Red-footed Booby													
Immatures	398	1,455	606	597	780	477	677	795	799	426	134	206	80
Pulli/1st year juv.	> 35	71	105	116	69	180	88	171	243	312	277	240	49
Eggs	+	+	+	+	+	+	+	68	>166	>185	>57	>46	> 49
Nests	279	217	225	404	361	367	451	369	739	848	431	379	315
Brown Booby													
Immatures	0	81	26	55	55	61	126	110	140	62	51	28	66
Pulli/1st year juv.	43	2	7	12	91	126	125	225	46	28	266	200	22
Eggs	1	0	18	95	317	48	106	52	69	532	466	55	144
Nests	117	43	250	89	497	453	513	575	507	618	816	726	887
Brown Noddy													
Immatures	0	2	0	0	0	4	1	1	2	3	5	2	0
Pulli/1st year juv.	0	0	0	0	0	0	0	0	0	0	0	6	109
Eggs	0	0	0	3	17	126	438	253	>147	>607	679	571	620
Nests	115	124	20+	25+	218	384	653	571	709	771	931	960	1,048
Black Noddy													
Immatures	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
Eggs	ND	+	0	+	+	430	+	+	>80	>700	>351	>299	>191

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
Great Crested Tern													
Immatures	0	1	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
Eggs	0	1,829	0	0	0	515	2,341	498	1,456	3,939	2,120	4,280	6,800
Sooty Tern													
Immatures	0	0	0	0	0	0	0	0	0	0	0	0	1
Pulli/1st year juv.	0	1,750	0	458	0	846	0	1,764	0	1,258	0	3,538	0
Eggs	9	0	0	63	2	3	5,515	2	1,534	146	37	52	166

Annex 8. Population results and population trend of breeding seabirds in TRNP, April to June 1981 – 2016. Source: Kennedy 1982, Manamtam 1996, WWF Philippines 1998-2004 and TMO 2004-2016.

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	Trend (%)
Ground-breeders Sub-total	10,534	9,721	18,669	13,592	18,383	15,988	16,448	27,193	27,654	+ 104
Masked Booby	0	0	0	0	0	0	0	0	1	- 99
Brown Booby	1,059	1,018	1,438	1,846	1,879	1,690	1,632	2,403	3,122	- 17
Great Crested Tern	4,875	4,433	4,790	6,160	8,653	9,794	**2)** 7,730	<12,387	13,880	+ 511
Sooty Tern	3,800	2,700	10,866	3,544	6,359	2,816	**3)** 5,224	**4)** 9,820	8,555	+ 69
Brown Noddy	800	1,570	1,575	2,042	1,492	1,688	1,862	2,583	2,096	- 2
Tree-breeders Sub-total	10,403	9,525	9,975	10,746	11,776	12,858	10,630	11,718	10,857	+7,010
Red-Footed Booby	2,513	2,220	2,331	2,395	2,340	2,202	3,074	3,492	2,141	- 12
Black Noddy	7,890	> 7,305	7,644	8,351	9,436	10,656	7,556	8,226	8,716	+ 22
TOTAL	20,937	19,246	28,644	24,338	30,159	28,846	27,078	38,911	38,511	+ 185

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. Baseline years are underlined.

Annex 9. 2016 Necropsy Report for Seabirds in Bird Islet

A total of 33 dead birds were retrieved from all over the Bird Islet although this number did not account for all the mortalities. The breakdown according to species are presented below:

Species	Pullus	Juvenile	Adult	Total per species
Brown booby	8	5	1	14
Red-footed booby	4	3	1	8
Black noddy	0	0	1	1
Brown noddy	0	0	3	3
Sooty tern	0	0	5	5
Crested tern	0	0	2	2
Total	12	8	13	**33**

Most carcasses were already desiccated with organs missing. Five specimens still possessed organs, three of which were in an advanced decomposition state while two others were relatively fresher.

Two mortalities, one great crested tern and one brown booby were trapped by the same nylon string tied to a piece of Styrofoam. The string was found threaded through the wing feathers of the tern which obviously died first while the booby, suspected to have died only hours prior to discovery, had one of its leg securely wrapped in the nylon.

Annex 10. Inventory and population calculation methods per breeding species.

<table>
<tr><th>Species</th><th>Calculation methods</th></tr>
<tr><td rowspan="2">Red-footed Booby</td><td>The active adult breeding population size is expressed as the number of nests multiplied by two = the minimum number of 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 in order 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 highly disturbing to the birds.</td></tr>
<tr><td>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.</td></tr>
<tr><td rowspan="3">Brown Booby</td><td>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.</td></tr>
<tr><td>Although the species only irregularly breeds at South Islet, the count result from this islet is included in the calculation of the total population of the species present at TRNP in May.</td></tr>
<tr><td>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.</td></tr>
</table>

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 in May.
	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 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. The results from South Islet are added to the result for North Islet in order to express the total population.
	Reproduction rate is expressed as the number of nests, eggs and/or pulli and juveniles found during the inventory. Because 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 in May.
	Since the species is not breeding at either Black Rock, Amos Rock or Ranger Station, the count result from these localities are not included in the population calculation.
	Reproduction rate is expressed as the number of eggs and/or pulli and juveniles found.
Sooty Tern	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 11. 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 done.
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 12. In-flight to roost statistics of boobies and noddies on Bird Islet May 2005 to May 2016

Species/ Numbers	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	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	
Red-footed Booby													
Adult: Daytime	823	655	631	1,241	686	982	1,011	382	830	950	1,499	248	
In-flight	960	1,171	2,082	1,272	1,534	1,259	1,259	1,680	779	813	602	367	
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	
%-in-flight population	55%	65%	78%	51%	69%	56%	55%	81%	48%	46%	29%	60%	**57.8%**
Immature: Daytime	514	>205	275	239	179	194	106	174	125	61	111	8	
In-flight	588	401	295	541	298	483	483	249	149	5	37	17	
Adjusted to 2-hour period	941	419	322										
Total	1,455	>606	597	780	477	677	589	423	274	66	148	25	
%-in-flight population	65%	69%	54%	69%	63%	71%	82%	59%	54%	8%	25%	68%	**57.3%**
Brown Booby													
Adult: Daytime	629	405	660	691	650	930	1,338	1,060	968	834	1,505	1,920	

In-flight	360	225	326	368	368	508	508	819	722	798	848	1,202	
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	
%-in-flight population	48%	37%	35%	35%	36%	35%	28%	44%	43%	49%	36%	39%	**38.8%**
Immature: Daytime	22	20	21	20+?	22	30+	96	81	30	13	1	25	
In-flight	37	6	31	34	39	96	14	59	32	39	25	41	
Adjusted to 2-hour period	59	6	34										
Total	81	26	55	54	61	126	110	140	64	51	26	66	
%-in-flight population	73%	23%	62%	63%	64%	76%	13%	42%	50%	76%	96%	62%	**58.3%**
Brown Noddy													
Adult: Daytime							618	607	1,004	1,045	1,031	992	
In-flight							1,124	525	142	239	378	358	
Total							1,742	1,132	1,146	1,284	1,409	1,350	
%-in-flight population							65%	46%	12%	19%	27%	27%	**32.7%**
Black Noddy													
Adult: Daytime							421	1,098	2,243	1,506	2,412	711	
In-flight							1,334	1,124	272	318	132	84	
Total							1,755	2,222	2,515	1,824	2,544	795	
%-in-flight population							76%	51%	11%	17%	5%	11%	**28.5%**

Annex 13. In-flight to roost statistics of boobies and noddies on South Islet May 2014 to 2016.

Species/Numbers	2014	2015	2016	Species/Numbers	2014	2015	2016	Species/Numbers	2015	2016
Red-footed Booby	May 8: 16.30 – 17.30	May 8: 16.30-18.30	May 13: 16.30-18.30	**Brown Booby**	May 8: 16.30 – 17.30	May 8: 16.30 - 18.30	May 13: 16.30 - 18.30	**Noddies, unidentified** (Note 1)	May 8: 16.30 - 18.30	May 13: 18.00 - 18.30
Adult: Daytime	401	366	508	Adult: Daytime	7	22	40	Adult: Daytime	6,856	> 4,421
In-flight	910	1,020	1,018	In-flight	2	28	24	In-flight	4,678	> 3,500
Adjusted to 2-hour period	1,820			Adjusted to 2-hour period	4			Adjusted to 2-hour period (Note 2)	4,678	
Total	2,221	1,386	1,526	**Total**	11	50	64	**Total**	11,534	7,921
% in-flight population	82.0%	73.6%	66.7%	% in-flight population	18.2%	56.0%	37.5%	% in-flight population	40.6%	44.2%
Immature: Daytime	68	58	32	Immature: Daytime	0	2	0	Immature: Daytime	NA	NA
In-flight	1	Not counted	21	In-flight	0	Not counted	Not counted	In-flight	NA	NA
Adjusted to 2-hour period	2			Adjusted to 2-hour period	0			Adjusted to 2-hour period	NA	NA
Total	70	> 58	63	**Total**	0	>2	0	**Total**	NA	NA
% in-flight population	2.9	-	33.3	% in-flight population	0	-	-	% in-flight population	NA	NA

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

Annex 14. Results of Park Rangers' counts, August 2015 to February 2016 at Bird Islet and South Islet.

Bird Islet	2015				2016		
Species/Date	16 August	6 November			9 February		
	Day Count	Day Count	Inflight	Total	Day Count	Inflight	Total
Red-footed Booby							
Adult	413	492	109	601	139	257	396
Sub-adult	-	8	0	8	47	10	57
Pullus/ juvenile	8	45	0	45	25	0	25
Eggs	No data	No data		No data	No data		No data
Nests	145	225		225	306		306
Brown Booby							
Adult	574	1064	206	1270	1478	672	2150
Sub-adult	-	2	0	2	6	31	37
Pullus/ juvenile	9	81		81	464		464
Eggs	67	101		101	223		223
Nests	284	312		312	685		685
Brown Noddy							
Adult	179	425		425	805		805
Sub-adult	-	0		0	0		0
Pullus/juvenile	8	0		0	0		0
Eggs	19	0		0	0		0
Nests	276	0		0	0		0
Black Noddy							
Adult	235	347		347	330		330
Sub-adult	-	0		0	0		0
Pullus/ juvenile	-	0		0	0		0
Eggs	-	0		0	0		0
Nests	99	0		0	0		0
Great Crested Tern							
Adult	743	0		0	0		0
Sub-adult	-	0		0	0		0
Pullus/ juvenile	53	0		0	0		0
Eggs	41	0		0	0		0
Sooty Tern							
Adult	0	2708		2708	373		373
Sub-adult	0	2280		2280	350		350
Pullus/juvenile	0	212		212	0		0
Eggs	0	0		0	0		0

South Islet	2015				2016		
Species/Date	11 August	16 November			14 February		
	Day Count	Day Count	Inflight	Total	Day Count	Inflight	Total
Red-footed Booby							
Adult	550	236		236	92		92
Sub-adult	-	0		0	18		18
Pullus/ juvenile	14	0		0	41		41
Eggs	Not counted	Not counted		Not counted	Not counted		Not counted
Nests	56	218		218	196		196
Brown Booby							
Adult	53	5		5	0		0
Sub-adult	0	0		0	0		0
Pullus/ juvenile	0	0		0	0		0
Eggs	0	0		0	0		0
Nests	0	0		0	0		0
Brown Noddy							
Adult	368	1		1	0		0
Sub-adult	0	0		0	0		0
Pullus/juvenile	28	0		0	0		0
Eggs	27	0		0	0		0
Nests	61	0		0	0		0
Black Noddy							
Adult	592	0		0	0		0
Sub-adult	0	0		0	0		0
Pullus/ juvenile	0	0		0	0		0
Eggs	0	0		0	0		0
Nests	990	0		0			990
Great Crested Tern							
Adult	3	0		0	0		0
Sub-adult	0	0		0	0		0
Pullus/ juvenile	0	0		0	0		0
Eggs	0	0		0	0		0
Sooty Tern							
Adult	0	0		0	0		0
Sub-adult	0	0		0	0		0
Pullus/juvenile	0	0		0	0		0
Eggs	0	0		0	0		0

Annex 15. Systematic list of avifaunal records, Bird Islet, South Islet and Jessie Beazley Reef from 10 to13 May 2016.

Note: Breeding species are indicated in bold letters. Taxonomic treatment and sequence follows IOC/Wild Bird Club of the Philippines 2016.

Status/Abundance (within Sulu Sea)	Species name	Number of individuals	Locality	Notes
Resident/Migrant Fairly Common	Striated Heron *Butorides striata*	1	Bird Islet	
		1	South Islet	May be same individual as at Bird Islet
Resident/Migrant Locally Common	Eastern Cattle Egret *Bubulcus coromandus*	1	Bird Islet	
		1	South Islet	May be same individual as at Bird Islet
Resident/Migratory Uncommon	Great Egret *Ardea alba*	1	Bird Islet	
		1	South Islet	May be same individual as at Bird Islet
Resident Uncommon	**Pacific Reef Heron** *Egretta sacra*	Adults: 2 Nests: 0	Bird Islet	Dark phase
		Adults: 1	Ranger Station	Dark phase
		Adults: 17 Juveniles: 1 Nests: 2	South Islet	Dark phase. No eggs and pulli
Migrant Rare	Chinese Egret *Egretta eulophotes*	1	Bird Islet	
Migrant Locally uncommon	Great Frigatebird *Fregata minor*	Adults: 2	Bird Islet	2 males
		Adults: 3 Immatures: 2	South Islet	2 males + 1 female + 2 immatures
Migrant Locally uncommon	Lesser Frigatebird *Fregata ariel*	Immatures: 4	Bird Islet	4 -1 2nd year female + 3 juvenile/ 2nd y immatures North Islet
	Unidentified Frigatebirds *Fregata sp.*	Immatures: 13	South Islet	
Extirpated Rare	Masked Booby *Sula dactylatra*	Adult: 1	Bird Islet	Male. First record since 23 June 1995
Resident Locally uncommon	**Red-footed Booby** *Sula sula*	Adults: 615 Immatures: 17	Bird Islet	

		Pulli/juv.: 23 Nests: 246 Eggs: 39		
		Adults: 1,526 Immatures: 66 Pulli/juv.: 26 Nests: 171 Eggs: >10	South Islet	
Resident Rare	**Brown Booby** *Sula leucogaster*	Adults: 3,122 Immatures: 66 Pulli/juv.: 22 Nests: 886 Eggs: 143	Bird Islet	
		Adults: 64 Nest: 1 Eggs: 1	South Islet	Not breeding
Resident Common	**Barred Rail** *Gallirallus torquatus*	Adults: 2	Bird Islet	
Resident Fairly Common	Watercock *Gallicrex cinerea*	1	South Islet	Female
Migratory Common	Grey-tailed Tattler *Heteroscelus brevipes*	2	Bird Islet	
		5	Ranger Station	One in breeding plumage
Migrant Fairly common	Ruddy Turnstone *Arenaria interpres*	2	Bird Islet	
		2	Ranger Station	Breeding plumage
Migrant Uncommon	Sanderling *Calidris alba*	1	Ranger Station	Breeding plumage
Migrant Common	Red-necked Stint *Calidris ruficollis*	1	Bird Islet	
Resident Locally rare	**Brown Noddy** *Anous stolidus*	Adults: 1,350 Pullus: 43 Nests: 675 Eggs: 442	Bird Islet	2nd time with pulli in May. Pullus occur in both a white and a dark plumage
		Adults: 746 Pullus: 66 Nests: 373 Eggs: 178	South Islet	2nd time with pulli in May
Resident Rare	**Black Noddy** *Anous minutus*	Adults: 795 Pullus: 3 Nests: 298 Eggs: 34	Bird Islet	2nd time with pulli in May
		Adults: 7,921 Pullus: 190 Nests: 1,336 Eggs: 157	South Islet	2nd time with pulli in May

Resident Fairly common	**Great Crested Tern** *Thalasseus bergii*	Adults: 13,637 Eggs: 6,800	Bird Islet	Largest number ever counted
		Adults: 243	South Islet	Not breeding
		Adults: 150	Jessie Beazley	Not breeding
Resident Rare	**Sooty Tern** *Onychoprion fuscata*	Adults: 8,555 Eggs: 166	Bird Islet	Nearly all adults only present at night
		Adults: 5 Immature: 1	Jessie Beazley	The only record ever of a 2nd year old bird
Resident Uncommon	Black-naped Tern *Sterna sumatrana*	1	Bird Islet	
		1	South Islet	
Migrant Fairly common	White-winged Tern *Chlidonias leucopterus*	1	Bird Islet	Migrating north
		2	South Islet	Migrating north
Migrant Common	Arctic Warbler/ Kamchatka Leaf Warbler *Phylloscopus borealis/ examinandus*	1	Ranger Station	
Resident Common	**Eurasian Tree Sparrow** *Passer montanus*	5	Bird Islet	
		0	South Islet	
Migrant Uncommon	Pechora Pipit *Anthus gustavi*	1	South Islet	
Migrant Common	Eastern Yellow Wagtail *Motacilla tschutschensis*	2	Bird Islet	

Annex 16. Possible solution to mitigate land erosion on Bird Islet

Background: The land area of Bird Islet is reduced from 18,000 hectares in 1981 to about 13,400 hectares in 2015. Based on an agreement with TMO in 2015, communication has been undertaken with foreshore restoration ecologists of Wetlands International, the global engineering firm Royal Haskoning DHV and the independent Dutch institute Deltares in formulating sound recommendations for the unique ecosystem of Bird Islet. The specialists consulted have been working with applied research and biodiversity – sensitive conservation activities in the field of mitigation using soft engineering approaches in response to phenomena such as sea-level rise, land subsidence and wave velocity impacts on coastlines.

Although globally there is substantial and positive experiences on how to secure and expand coastlines in areas with high level of mud sediment loads, experiences are less from areas with sandy substrates, including areas composed of coralline sands.

Mitigation of land erosion at Bird Islet: The continued erosion of the core of Bird Islet may further increase due to a combination of sea-level rise and the increase in the frequency of storms with corresponding increase in wave velocity and in likely changes in the sea current patterns. As the stabilizing sandbars adjacent to the islet have disappeared or are largely reduced since 2015, the risk of further reduction in the land areas of Bird Islet intensifies (Plate 1).

Plate 1. *The northwest-end of Bird Islet where the stabilizing sandbar extension has disappeared since 2015. The second photo (below) shows where the sandbar used to be located. Photo: Arne E. Jensen*

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 it results contribute to decisions to halt the loss of the land areas at Bird Islet.

The coastline reduction is different along the south coast and at the northwest coast where the erosion since 2012 has been very active (Plate 2 and Plate 3). At the south coast a substantial layer of sand has covered the eroded coastline since 2011 but this may rapidly change as the sandbars east and west of the islet I have disappeared since 2015.

Plate 2. *Development stages of erosion along the south coast of Bird Islet from 2006 to 2015. Photo: Arne E. Jensen*

Plate 3. *Erosion at the northwest coast of Bird Islet. Photo: Arne E. Jensen*

The use of semi-permeable structures placed both perpendicular and parallel to the coastline has proven to be effective in halting erosion. In Boracay, Philippines, bamboo poles have been used as an experiment (Plate 4).

Plate 4. *Experimental use of bamboo poles to halt erosion of the sandy beach of Boracay. Photo: Arne E. Jensen*

Based on Wetlands International's and other organizations successful experiences in securing and expanding eroding coast lines e.g. at Java, Indonesia and in Vietnam the bamboo poles need to be hammered at the least 1.5 meter down into the sand to withstand the impact of tides and currents (Albers et al, Cuong and Brown 2013, Schmitt et al 2013, Thao et al 2014, and Winterwerp et al 2016). Small tree branches are intertwined with the poles in order to absorb and deposit particles moved during the process of high tide and low tide (Plate 5).

Plate 5. *The process of establishment of semi-permeable structures with natural membranes perpendicular and parallel to an eroding coastline. Photo: Wetlands International and Deltares.*

Conclusion and Recommendation: Any intervention at Bird Islet will have to be carried out in an experimental basis. Based on the initial results of experiments, the approaches will have to be further fine-tuned until the best solution is gleaned. Hence, it is proposed that the experiment focus on two smaller areas in Bird Islet: at the coastline at the entrance of "Plaza" at the islet's northwest coast (Area I) and along a portion of the southeast coast (Area II) (Plate 6).

Plate 6. *Proposed experimental areas for coastline restoration at Bird Islet. Photo: Teri Aquino.*

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Annex 17. Comparison of the landscape and habitats seen from the permanent photo documentation sites on Bird Islet and South Islet, May 2004 and May 2016.

Bird Islet

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

Photo name code: B1 01 Comments: 3 shots (Stitched by Microsoft ICE) Date: May 11, 2016

Photo nos.: DSC_4731-4733 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: 6 shots

Photo nos.: DSC_4680-4685

Date: May 11, 2016

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

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

Photo name code: BI 03 Comments: 14 shots stitched (Microsoft ICE) Photo credit: Teri Aquino

Viewing angle for photo: facing E 067º

Film no: 14

Photo no (negative):

Photo name code: BI 04

Photo no (camera):

Comments: 1 shot plaza

Date: May 7, 2004

Photo Doc Site NI No. 04 - 2004

Photo name code: BI 04

Comments: 1 shot plaza

Date: May 11, 2016

Photo nos.: DSC_4674

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 13, 2016

Comments: single shot including parola at the background