The sea cucumbers (Echinodermata: Holothuroidea) of Tubbataha Reefs Natural Park, Philippines

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Abstract

Sea cucumbers are among the large macrobenthic reef invertebrates that have received little attention in Tubbataha Reefs Natural Park, Philippines. To assess the status of sea cucumbers in the park, distance and opportunistic sampling were conducted between December 2009 and April 2010. In total, 18 sea cucumber species were recorded, 12 of which were new records and three are IUCN listed. *Stichopus chloronotus* had the highest density, *Holothuria atra* ranked second, followed by *Bohadschia argus* and *Thelenota ananas*. The mean density of all species at the North Atoll was much higher than it was at the South Atoll. Jessie Beazley Reef had the lowest density and species richness. Sizes were relatively big and some species were at their maximum lengths. The present findings suggest the absence of exploitation at the park but efforts to prevent any form of extraction are needed for the continuous recovery of sea cucumber populations and for the park to serve as a significant seed source for depleted reefs. Regular population monitoring of sea cucumbers and other reef invertebrates is needed and must include those in the lagoon, which was not covered by this study.

Introduction

Sea cucumber populations in the Philippines are in serious decline because of habitat degradation and unregulated exploitation (Schoppe 2000). For this reason, the Bureau of Fisheries and Aquatic Resources drafted an administrative order to implement conservation efforts to limit and regulate the harvest of wild sea cucumber based on size limits (Pagdilao 2009). This was a response to the two most urgent conservation needs for sea cucumbers — development of national fishery management plans and harmonised trade reporting — identified during the CITES[2] international workshop, held in Malaysia in 2004, on the conservation of commercially exploited sea cucumbers (Bruckner 2006).

Management of populations in the wild, however, proved difficult because of the limited information on the ecology, biology (Pagdilao 2009) and state of stocks (Bruckner 2006) of the sea cucumbers. In response to this, a nationwide effort to monitor the status of sea cucumbers in the wild, and studies on production, sea ranching and restocking are currently being undertaken (Bruckner 2006; Pagdilao 2009).

This study on species richness, size and density of sea cucumbers serves as a success indicator in managing the Tubbataha Reefs Natural Park and complements the nationwide monitoring of wild populations.

Materials and methods

Study site

The Tubbataha Reefs Natural Park is located in the middle of the Sulu Sea, Philippines. It lies at 8°43′–8°57′N, 119°48′–120°3′E, about 150 km southeast of Puerto Princesa City, Palawan and 130 km south of the municipality of Cagayancillo. The surveyed sites were outer reef slopes and walls. A total of 15 sites were surveyed (Fig. 1), six of which were reef walls: one each at North Atoll and Jessie Beazley Reef, and four at South Atoll. The reef slopes are composed of wide patches of sand habitats among soft and hard coral colonies, while the reef walls are characterised by sudden drop-offs with deep, narrow grooves extending towards the shallow reefs.

Species richness

Methods to document the species included wading on sandy-rubble flats around the Ranger Station during day and night low tide, snorkelling in shallow reef flats and scuba diving at deeper reef slopes and walls. The sea cucumbers were identified using

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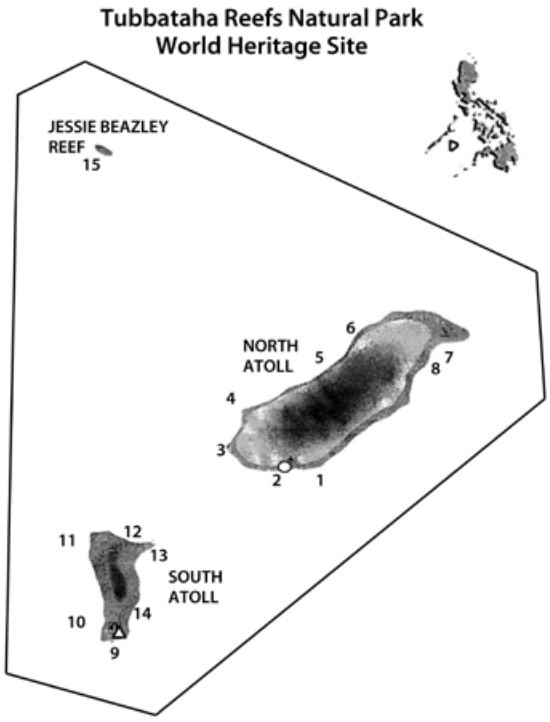

Figure 1. The 15 sampling sites in Tubbataha Reefs Natural Park.

various reference materials (Conand 1998; Schoppe 2000; Purcell et al. 2012; Kim et al. 2013).

Size

Sea cucumbers encountered close to the transect lines during the distance sampling were measured for undisturbed lengths (with a tape measure) to the nearest centimetre. The size of species encountered during the snorkelling and/or wading at the intertidal area was similarly measured.

Density

To estimate the density, distance sampling was conducted at the slope and drop-off areas in the outer part of the reef. Two scuba divers, one serving as guide, swam along the edge of the reef. The perpendicular distance of any sea cucumber species from the observer was recorded. The distance covered per dive was estimated using Garmin e Trex GPS. A total of 15 transect lines covering a distance of 11,909.16 m (Range: 370.15–1,094.35 m) were surveyed. Data were analysed using the software Distance 6.1 (Thomas et al. 2010).

Table 1. Species list of sea cucumbers in Tubbataha Reefs Natural Park.

No.	Species	North Atoll (NA)	South Atoll (SA)	Jessie Beazley Reef (JBR)
Family Holothuriidae				
1	*Actinopyga lecanora*	X		
2	*Actinopyga palauensis*	X		
3	*Actinopyga* sp. 1	X		
4	*Actinopyga* sp. 2	X		
5	*Bohadschia argus*	X	X	X
6	*Bohadschia koellikeri*	X		
7	*Bohadschia vitiensis*	X		
8	*Holothuria atra*	X	X	
9	*Holothuria fuscogilva*	X	X	
10	*Holothuria whitmaei*	X		
11	*Pearsonothuria graeffei*	X	X	X
Family Stichopodidae				
12	*Stichopus chloronotus*	X		
13	*Stichopus* sp.	X		
14	*Thelenota ananas*	X	X	X
15	*Thelenota anax*	X		
16	*Thelenota rubralineata*		X	X
Family Synaptidae				
17	*Euapta godeffroyi*	X		
18	*Synaptula* sp.	X		
Total		**17**	**6**	**4**

Results

Species composition

A total of 18 sea cucumber species belonging to eight genera and three families were recorded in the park (Table 1; Figs 2, 3 and 4). Eleven species (61.11%) belong to family Holothuriidae, five (27.28%) are under family Stichopodidae and two (11.11%) fall under family Synaptidae. The highest numbers of species were recorded at the North Atoll.

Size

Among the species sampled for total length, *S. chloronotus* and *H. atra* had the highest number of

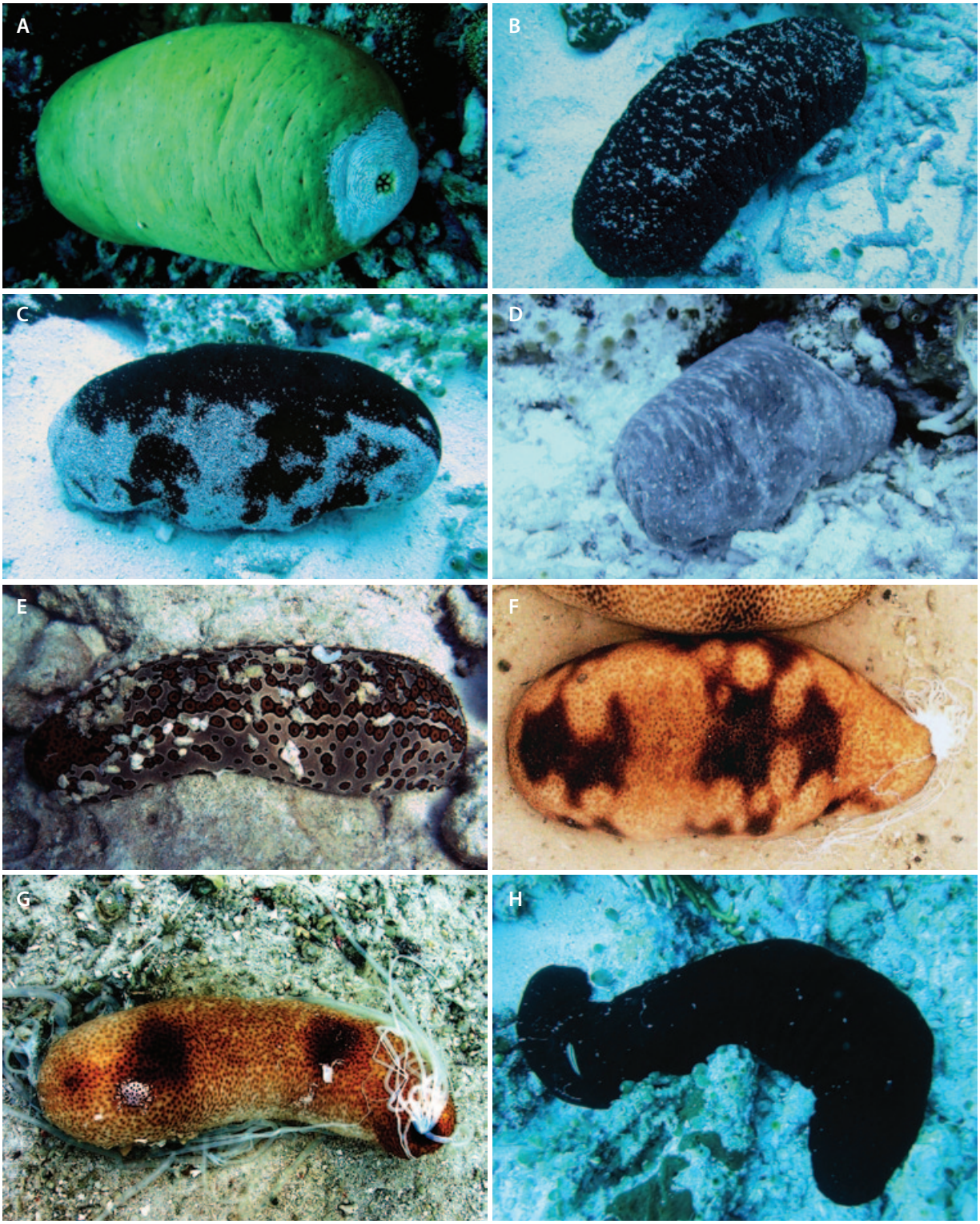

Figure 2. (A) *Actinopyga lecanora*; (B) *Actinopyga palauensis*; (C) *Actinopyga* sp. 1; (D) *Actinopyga* sp. 2; (E) *Bohadschia argus*; (F) *Bohadschia koellikeri*; (G) *Bohadschia vitiensis*; (H) *Holothuria atra*.

samples. Some species, such as *A. lecanora*, *B. koellikeri*, *B. vitiensis* and *T. rubralineata*, were quite rare so only one individual for each species was measured for total length (Table 2). The largest species were *H. atra* (100 cm), *T. ananas* (70 cm) and *T. anax* (60 cm). Among the species with length records, only *H. atra* and *S. chloronotus* were represented by small-sized individuals (min. length: 10 cm). Most of the other species were represented by large-sized individuals.

Density

The overall sea cucumber density in Tubbataha Reefs Natural Park was 41.93 ind. ha^{-1} (Table 3). The density pattern was relatively higher at the North than

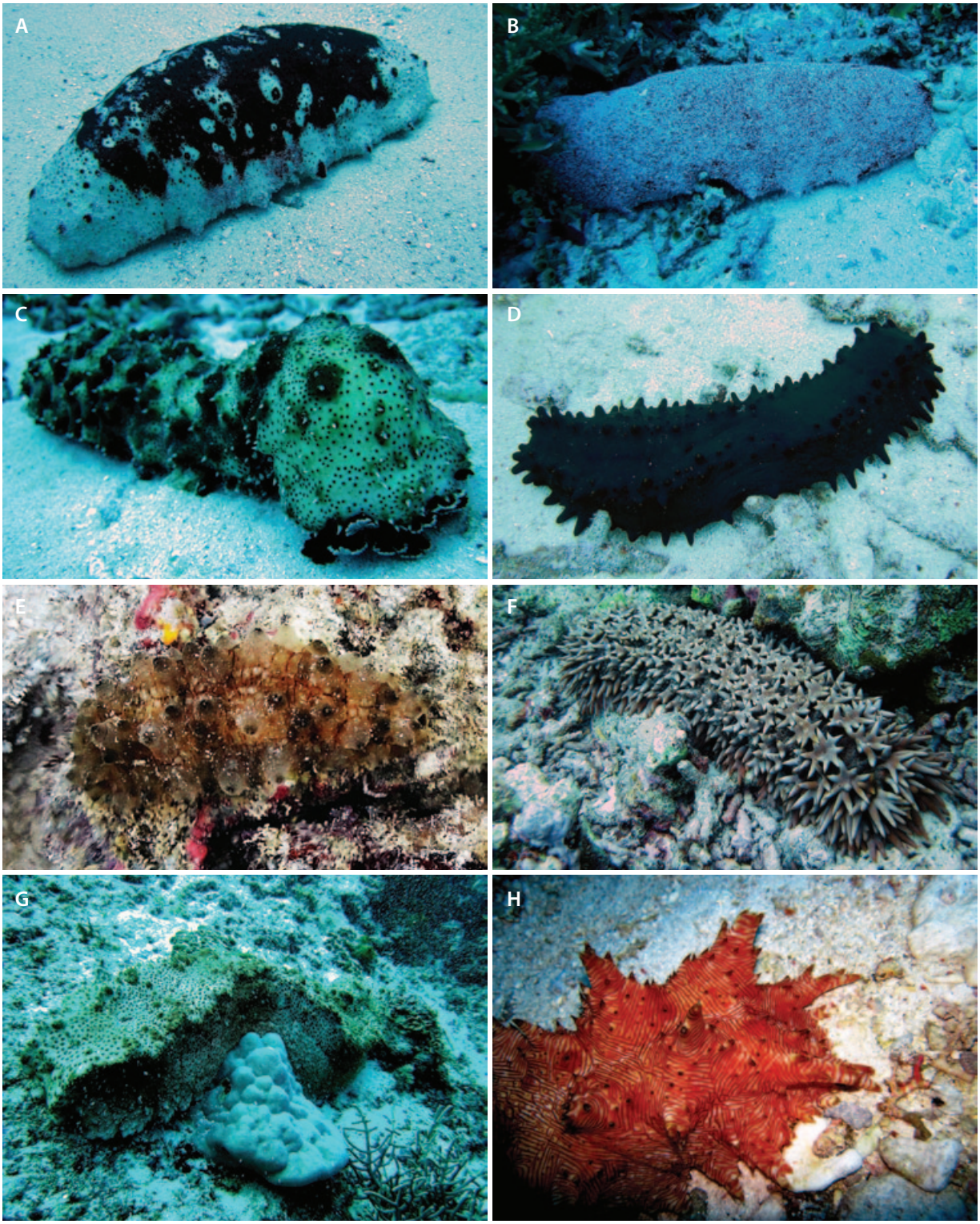

Figure 3. (A) *Holothuria fuscogilva*; (B) *Holothuria whitmaei*; (C) *Pearsonothuria graeffei*; (D) *Stichopus chloronotus*; (E) *Stichopus* sp.; (F) *Thelenota ananas*; (G) *Thelenota anax*; (H) *Thelenota rubralineata*.

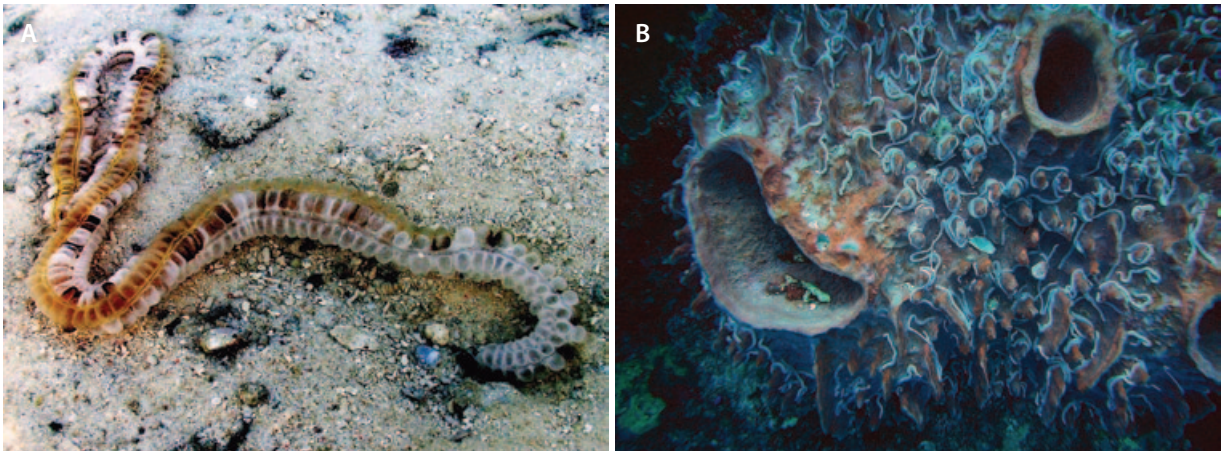

Figure 4. (A) *Euapta godeffroyi*; (B) *Synaptula* sp.

Table 2. Summary statistics for the total lengths of some sea cucumber species encountered in Tubbataha Reefs Natural Park.

Species	n	Mean length (cm)	Min. length (cm)	Max. length (cm)	Confidence level (95%)
Actinopyga lecanora	1		23.00		
Bohadschia argus	36	33.33	20.00	45.00	2.59
Bohadschia koellikeri	1		26.00		
Bohadschia vitiensis	1		24.00		
Holothuria atra	156	46.66	10.00	100.00	1.31
Holothuria fuscogilva	14	33.57	30.00	40.00	2.87
Pearsonothuria graeffei	19	33.53	30.00	45.00	2.62
Stichopus chloronotus	241	27.63	10.00	40.00	0.89
Thelenota ananas	90	53.20	40.00	70.00	1.54
Thelenota anax	2	60.00	60.00	60.00	
Thelenota rubralineata	1		50.00		
Total	**561**				

Table 3. Density (ind. ha^{-1}) of each sea cucumber species in Tubbataha Reefs Natural Park. The first three most abundant are shaded. NA = North Atoll; SA = South Atoll; JBR = Jessie Beazley Reef; LL = lower limit at 95% confidence level; UL = upper limit at 95% confidence level.

Species	NA		SA		JBR	TRNP	
	Density (ind. ha^{-1})	LL–UL	Density (ind. ha^{-1})	LL–UL	Density (ind. ha^{-1})	Density (ind. ha^{-1})	LL–UL
Bohadschia argus	7.24	5.02–10.44	0.46	0.12–1.81		4.20	2.64–6.67
Holothuria atra	16.73	9.59–29.14	4.38	1.52–12.45		9.65	5.42–17.18
Holothuria fuscogilva	1.04	0.24–4.46	0.39	0.07–2.06		0.71	0.21–2.33
Pearsonothuria graeffei	1.56	0.78–3.12	2.36	1.00–5.55	0.48	2.04	1.17–3.56
Stichopus chloronotus	42.30	24.82–72.05				22.91	12.63–41.55
Thelenota ananas	3.89	1.85–8.17	5.16	1.74–15.31	0.12	4.20	2.23–7.89
Thelenota anax	0.05	0.01–0.22				0.03	0.01–0.12
Thelenota rubralineata			0.46	0.10–2.15		0.19	0.04–0.81
Total	**70.27**	**46.37–106.48**	**10.21**	**4.11–25.37**	**0.24**	**41.93**	**27.15–64.74**

at the South Atoll and Jessie Beazley Reef (Table 3; Fig. 5). Densities at the reef slopes were much higher than at the reef walls (Fig. 5). At the North Atoll, *S. chloronotus*, *H. atra* and *B. argus* were the three most abundant species, while *T. ananas*, *H. atra* and *P. graeffei* were more common at the South Atoll. In Jessie Beazley Reef, only two individuals belonging to two species, *P. graeffei* and *T. ananas*, were encountered during the distance survey (Table 3).

Discussion

A number of reef assessments have been conducted in the park, yet only the works of Estacion et al. (1993) and Dolorosa and Jontila (2012) mention some sea cucumber species. Failure to note the number of sea cucumber species in previous studies could be related to abundance. Sea cucumbers are prone to over-exploitation and recover very slowly (Purcell et al. 2012). Prior to and even several years after its declaration as a national park in 1988, harvesting of marine resources remained uncontrolled (Arquiza and White 1999), which could have greatly reduced the sea cucumber populations. This could be why only two species were encountered by Estacion et al. (1993). In the Red Sea, Egypt, a drop in species richness of sea cucumbers was recorded after the fishing period (Hasan and Abd El-Rady 2012). Overfishing of sea cucumber is widespread, resulting in a long-term fishery closure in some countries (Uthicke 2004; Hasan 2005; Friedman et al. 2008; Kalaeb et al. 2008; Hasan and Abd El-Rady 2012; Purcell et al. 2013).

Most reef assessment studies in the park followed a permanent transect and mainly focused on coral cover and fish biomass (Ledesma et al. 2008). Only in 2005 were reef invertebrates included in the yearly monitoring, but this was limited to large gastropods and bivalves (Dolorosa and Schoppe 2005). In a 2008 survey, five species of sea cucumbers were reported as an offshoot of a survey on *Tectus* (*Trochus*) *niloticus* (Dolorosa and Jontila 2012). In the present study, 18 species were recorded, representing 33.96% of the 53 known species in Palawan (Jontila et al. 2014a). Nearly 90% of the sea cucumber species in the park are of high economic value and three species are in the IUCN Red List; *Actinopyga lecanora* and *Thelenota ananas* are listed as endangered, while *Bohadschia fuscogilva* is listed as vulnerable (Conand et al. 2014).

The maximum sizes of sea cucumbers in the park are close or even larger than their reported common and maximum lengths (Table 4). Extremely large *Holothuria atra* (measuring up to 100 cm) were encountered at the reef slope, while small individuals were common at the intertidal area within the Ranger Station. The abundance of large-size sea cucumbers suggests the possible absence of any form of exploitation, which could be attributed to the nature and depth of the habitats. Sampling sites far from the Ranger Station, where trochus were already depleted, still hold an abundance of sea cucumbers. In most cases, illegal fishers caught at the park were engaged in collecting fishery resources other than sea cucumbers. However, the rising sea cucumber price and demand in the world market (Bruckner 2006) may drive fishermen to engage in harvesting these species in the park. Measures to prevent any form of harvesting are needed because slow-growing, low-fecund and late-maturing sea cucumbers are prone to overexploitation (Bruckner 2006).

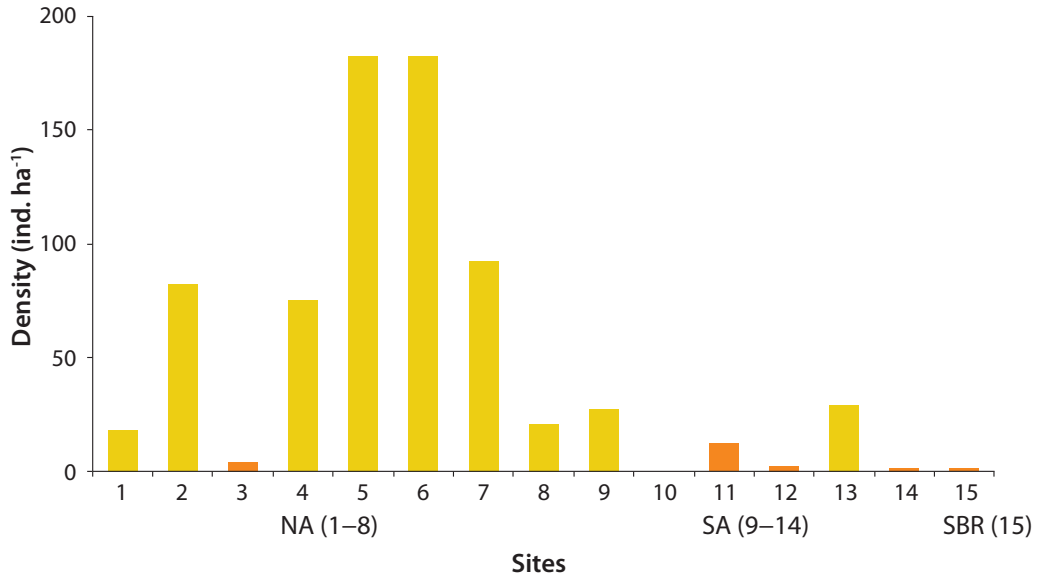

Figure 5. Density of sea cucumbers (ind. ha^{-1}) at each site. NA = North Atoll; SA = South Atoll; JBR = Jessie Beazley Reef. Sites 3, 10, 11, 12, 14 and 15 (orange bars) are reef walls. Other sites (yellow bars) are reef slopes.

Burrowing species, such as *B. koellikeri* and *B. vitiensis*, are difficult to find and only one of each species was encountered, partly buried in a sand flat surrounding the Ranger Station. One very small *Stichopus* sp. (~5 cm) was accidently found under a coral rock (Fig. 3E). Knowing the habitats of juvenile sea cucumbers essential in stock recruitment and density monitoring.

The high densities at the North compared with the South Atoll could be attributed to the sampling sites. Seven of the eight sites in the North Atoll were reef slopes, which appeared to be preferred to reef walls by many species (Fig. 5). Other factors could be the remoteness from the Ranger Station of the South Atoll and Jessie Beazley Reef. Populations of *Tectus* (*Trochus*) *niloticus* in sites far from the Ranger Station were severely affected by poaching (Dolorosa et al. 2010; Jontila et al. 2014b). The park has no record of apprehensions for sea cucumber poaching but we do not discount the possibility that poachers will collect any high value species, including sea cucumbers. Nevertheless, the present densities of some sea cucumbers species at the park are comparable with density records in other countries (Table 5). The exceptional density of *H. atra* in other reports could

Table 4. Common length and maximum length of sea cucumbers at TRNP compared with the reported data of Conand (1998).

Species	Common length (cm)		Maximum length (cm)	
	Conand (1998)	This study	Conand (1998)	This study
Actinopyga lecanora		23		
Bohadschia argus	36	33	60	45
Bohadschia koellikeri		26	40*	
Bohadschia vitiensis	32	24	40	
Holothuria atra	20	47	45	100
Holothuria fuscogilva	42	34	57	40
Pearsonothuria graeffei	35	34	45	45
Stichopus chloronotus	18	28	35	40
Thelenota ananas	45	53	80	70
Thelenota anax	55		80	60
Thelenota rubralineata			50*	50

* Kerr et al. (2006).

Table 5. Density (ind. ha^{-1} ±SE) in other localities compared with the records in Tubbataha Reefs Natural Park.

Species	Palau (Pakoa et al. 2009)	Eritrea (Kalaeb et al. 2008)	New Caledonia (Purcell et al. 2009)	Mauritius (Lampe-Randoo et al. 2014)	This study
Family Holothuriidae					
Actinopyga lecanora	1.5 ±1.1				
Actinopyga palauensis			>10		
Bohadschia argus	4.5 ±3.2		10–30		4.20
Bohadschia vitiensis	378.0 ±136.4			38	
Holothuria atra	3,770.5 ±187.3	295.0	100	424	9.65
Holothuria fuscogilva		3.0			0.71
Holothuria whitmaei			>10		
Pearsonothuria graeffei					2.04
Family Stichopodidae					
Stichopus chloronotus	6.8 ±3.5		10–100	96	22.91
Thelenota ananas		3.5	>10		4.20
Thelenota anax					0.03
Thelenota rubralineata					0.19

be habitat-related. There is an abundance of shallow water populations of small-sized *H. atra* within the Ranger Station, which could be comparable with the reports of Pakoa et al. (2009) but such densities require quantitative measurements.

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