Species composition, density and distribution of sea cucumbers (Holothuroidea) at Arreceffi Island, Honda Bay, Palawan, Philippines

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Abstract

This study was conducted to determine the species composition, distribution, density and size structure of sea cucumbers at Arreceffi Island in Honda Bay, Palawan, Philippines. Three stations covering different habitats (intertidal flats, seagrass beds, and coral reefs) were surveyed during the day and night by walking, snorkeling and scuba diving. In total, 15 species in the families Holothuriidae (11 species), Stichopodidae (3 species) and Synaptidae (1 species) were recorded. Some rare *Stichopus* and high-value species were recorded along with other aggregating species of the family Holothuriidae. Density generally ranged from 0.3 to 19.0 ind. 100 m^{-2}, and greatly varied depending on habitat.

Introduction

Sea cucumbers are among the heavily exploited invertebrates in the Philippines although their collection is unregulated due to poor implementation of pertinent laws. Information on sea cucumber populations is also very limited. Most of the earlier works focused on taxonomy and species inventories (Domantay 1934, 1960; Reyes-Leonardo 1984; Tan Tiu 1981; Schoppe 2000a; Kerr et al 2006). In recent years, sea cucumber gatherers have observed that catches are declining, and market trends also suggest this (Akamine 2005; Choo 2008b; Brown et al. 2010). In fact, since the Philippines' production peaked in the 1980s, the supply has not recovered and has shifted from a high-value and low volume focus, to a high-volume and low-value species one (Akamine 2002, 2005). Although artisanal in nature, the sea cucumber fishery has provided substantial income to meager fishermen across the country (Labe 2009). In 2012, dried sea cucumbers ranked tenth among the fishery commodities of the Philippines in terms of export value: 149 metric tons (mt) amounting to USD 1,849,230 (BFAR 2014). Despite declining production over the years (Akamine 2005), the country remains among the top suppliers of sea cucumbers in Asia (Choo 2008a), and the province of Palawan is one of its major producers (Brown et al. 2010).

Recognizing the economic and ecological importance of sea cucumbers, the Bureau of Fisheries and Aquatic Resources (BFAR) issued an Administrative Circular No. 248 in 2013, which imposed size limits and required permits for those people engaged in the sea cucumber trade. However, its implementation is still a challenge and sea cucumber gathering remains unregulated. Initial assessments in Palawan have revealed that areas open to harvesting have very little populations remaining, or populations have been depleted (Jontila et al. 2013). High-value species were seldom encountered in shallow sites of Bataraza, Quezon, El Nido and Roxas in Palawan except around Arreceffi Island in Honda Bay, Puerto Princesa City, where viable populations were noted (Jontila et al. 2014).

Sea cucumber populations are difficult to revive once they are depleted due to their limited mobility, late maturity, density-dependent reproduction, and low rates of recruitment (Uthicke and Benzie 2000; Uthicke 2004; Bruckner 2005). It is, therefore, very important to identify and protect the areas where they remain abundant. This study was therefore conducted to provide an initial assessment on the status of sea cucumber in Arreceffi Island in terms of species composition, abundance and distribution.

Methods

Study site

Arreceffi Island, also known as Dos Palmas Island Resort and Spa, is situated in the middle of Honda Bay in Palawan, Philippines. The island has thick mangrove cover, seagrass beds and coral reefs that are nearly pristine (Fig. 1). Although open to tourism, extraction of any resources is not allowed within its vicinity. The island's "no-take policy" has allowed its marine resources to flourish naturally, and sea cucumbers are abundant. They are widely distributed around the island from shallow seagrass beds, mangroves, coralline flats and coral reefs.

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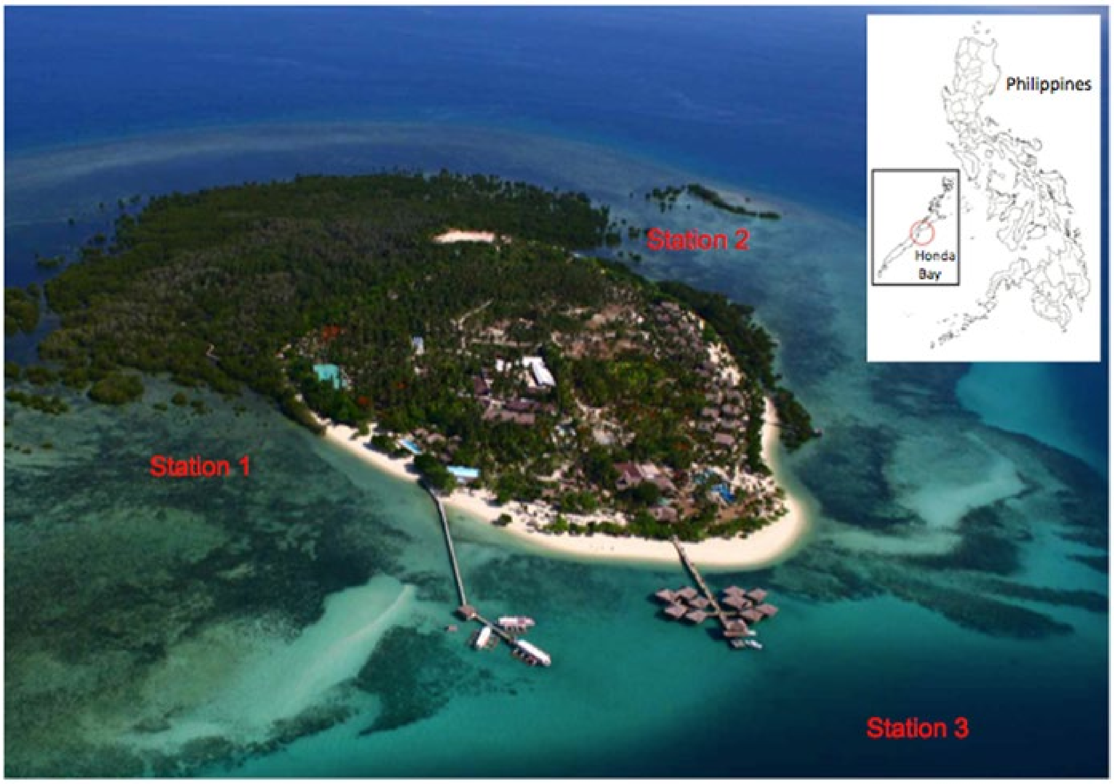

Figure 1. Aerial photograph of Arreceffi Island in Honda Bay, Palawan, Philippines showing the study's stations.

Three stations, representing different habitats, were established around the island (Fig. 1). Station 1 was mainly covered by seagrasses *Cymodocea, Halophila, Halodule, Thalassia and Enhalus.* The substrates ranged from sandy to silty. Station 2 was also covered with seagrasses but not as much as in Station 1. Its substrates were generally silty to sandy, with portions of coralline flats having patches of sand and rubble. One transect in this station was near the mangrove forest dominated by Rhizophora stylosa. Station 3 is a coral reef area, ranging in depth range from 5 to 8 m. Foreshore reef areas have mixed live corals, dead coral with algae, and sandy bottom, with little rubble. Few boulders of massive corals Porites were also present at this site.

Species identification, distribution, density and size structure

At each station, three transects measuring 50 m x 2 m were laid perpendicular to the shore at 10–15 m apart. Day and night surveys were conducted except at Station 3 where only night surveys were carried out. Snorkeling and wading were done in shallow areas while the coral reefs of Station 3 were assessed through scuba diving. Also, a timed search was done at Station 3 instead of a belt transect. This search was standardized (10 mins ± 4 mins) to cover almost the same area (100 m^2) with that of the transects surveyed through snorkeling or wading.

All sea cucumbers encountered along the transects and during the timed search were identified, counted and measured (cm), following their body contour using a bendable ruler. Care was taken during measurement so as not to touch the body to avoid constriction. In shallow areas, cryptic and burrowing species were pulled out and allowed to relax in situ before taking their measurements. A sample of each species was collected and immersed in 5% solution $MgCl_2$ for around 10 minutes to relax the body and avoid evisceration during preservation. Measurements and photographs of the dorsal and ventral sides were taken after relaxation. Specimens were then preserved in either 95% ethanol or a 10% saline formalin solution. Species were identified based on their external anatomical features and an examination of spicules using the standard protocol. Identification was based on Conand (1998), Schoppe (2000a), Massin et al. (2002), Kerr et al. (2006), and Purcell et al. (2012).

Results

Species composition and distribution

In total, 15 species of sea cucumbers, belonging to the families Holothuriidae (11 species), Stichopodidae (3), and Synaptidae (1) were recorded in this study (Table 1). Holothuriids include the genera *Actinopyga* (1 species), *Bohadschia* (2), *Holothuria* (7),

Table 1. Species composition and distribution of sea cucumbers across study sites, and substrate and habitat type at Arreceffi Island, Honda Bay, Palawan, Philippines.

Stations:	1		2		3
	Seagrass beds	Coralline flats with seagrass	Seagrass beds	Coralline flats with seagrass	Coral reefs
Family Holothuriidae					
1 *Actinopyga lecanora*	+		+		
2 *Bohadschia marmorata*	+		+		
3 *B. vitiensis*	+				
4 *Holothuria leucospilota*	+	+	+	+	
5 *H. atra*	+	+	+	+	
6 *H. coluber*	+	+	+	+	
7 *H. edulis*				+	+
8 *H. fuscocinerea*	+				
9 *H. scabra*	+		+		
10 *Holothuria gracilis*					+
11 *Pearsonothuria graeffei*					+
Family Stichopodidae					
1 *Stichopus noctivagus*					+
2 *S. rubermaculosus*					+
3 *S. vastus*					+
Family Synaptidae					
1 *Synapta maculata*	+	+	+		
Total:	9	4	7	4	6

+ means "present"

and *Pearsonothuria* (1). The other two families were only represented by genera *Stichopus* and *Synapta.*

Most of the holothuriid species (8) were encountered at Station 1. This area was mainly covered with seagrasses but coralline flats and patches of sand as well as rubble were also dominant towards the station's seaward eend. Among the commonly encountered species in seagrass areas were *Actinopyga lecanora* (Fig. 2a), *Bohadschia marmorata* (Fig. 2b), *B. vitiensis* (Fig. 2c), *Holothuria atra* (Fig. 2d), *H. leucospilota* (Fig. 2h), *H. scabra* (Fig. 2i) and *Synapta maculata* (Fig. 2o). At night, *H. fuscocinerea* was also seen in the same area together with the species mentioned. In coralline flats and the sandy seagrass parts of this station, *H. atra* and *H. leucospilota* were also encountered along with *H. coluber* (Fig. 2e).

Individuals of *H. atra undergoing fission (Fig. 2d inset) were noted also in the* sandy seagrass areas of Station 1. Variants of some species were documented as well, such as yellow *B. marmorata* with irregular brown blotches on its dorsum (Fig. 2b, inset), and the black variant of *H. scabra,* formerly named as *H. scabra* var. *versicolor* (Fig. 2i). The same species at Station 1 were also noted at Station 2, except there were no *B. vitiensis* or *H. fuscocinerea.* There were also aggregations of *H. scabra* in silty-sandy areas near the stands of mangrove *Rhizopora stylosa.* On the other hand, all *Stichopus* species and three holothuriid species that were not seen in the previous stations were encountered at Station 3, which is a coral reef area. *Stichopus* included *S. noctivagus* (Fig. 2l), *S. rubermaculosus* (Fig. 2m) and *S. vastus* (Fig. 2n). Holothuriids included *H. edulis* (Fig. 2f), *H. gracilis* (Fig. 2j), and *Pearsonothuria graeffei* (Fig. 2k). *S. vastus* (Fig. 2n) was already noted in a previous survey of Arreceffi Island (Jontila et al. 2014) but a different variant was encountered in this survey. Within the reef area, *H. edulis* was found on sandy substrate with patches of live corals and rubble, while *P. graeffei* was spotted feeding on dead corals covered with algae.

Sea cucumber density

To account for both the burying and nocturnal species, day and night surveys were conducted at all stations, except Station 3 where only night surveys were carried out due to logistical constraints. Most of the species displayed varying densities across the stations between day and night sampling. During the day, *Synapta maculata* at Station 1 had the highest mean density (±SD)

Figure 2. Sea cucumber species at Arreceffi Island, Honda Bay, Palawan, Philippines.

Family Holothuriidae:
a) *Actinopyga lecanora*, b) *Bohadschia marmorata* (inset: yellow variant), c) *B. vitiensis*, d) *Holothuria atra* (inset: specimen just undergone fission), e) *H. coluber* (inset: ventral side of the mounth), f) *H. edulis* (dorsal and ventral sides), g) *H. fuscocineraea*, h) *H. leucospilota*, i) *H. scabra* (grey and black variants), j) *H. gracilis*, k) *Pearsonothuria graeffei* (inset: mouth with its tentacles);

Family Stichopodidae:
l) *Stichopus noctivagus*, m) *S. rubermaculosus*, n) *S. vastus*; Synaptidae: o) *Synapta maculata*.

at 14.0±10.5 ind. 100 m^{-2}. During the night, *Bohadschia marmorata* was quite abundant with an estimated density of 19.0±2.6 ind. 100 m^{-2} (Table 2). Few individuals of *H. fuscocinerea* (3.0±2.6 ind. 100 m^{-2}) were also noted at night, sharing the habitat with *B. marmorata. Holothuria atr*a was also abundant at Station 1, and its densities remained almost the same during the day (8.7±2.1 ind. 100 m^{-2}) and night (9.3±2.5 ind. 100 m^{-2}). *Actinopyga lecanora* and *B. vitiensis* also displayed the same densities during both surveys at Station 1. *Holothuria scabra* was found at both Stations 1 and 2, its density was highest during daytime at Station 2 at 9.3±7.1 ind. 100 m^{-2}. This could be due to sandy-silty substrate in Station 2 that is more preferred by this species (Mercier et al. 2000). In contrast, *Holothuria edulis, H. gracilis* and *Pearsonothuria graeffei* were only encountered at Station 3, with densities estimated at 8.7±4.7, 0.3±0.6 and 1.0±1.2 ind. 100 m^{-2}, respectively. It is also noted that *Stichopus noctivagus*, *S. rubermaculosus* and *S. vastus* were only noted at Station 3. These species, together with *P. graeffei*, are usually found in reef areas (Purcell et.al. 2012).

Size structure

Mean and maximum sizes of sea cucumbers encountered during the survey are presented in Table 3. Sizes were generally close to or within the reported range of measurement, except for few species. For instance, the mean length (±SD) for *H. coluber (*37.6±4.6) is more than twice as long than its reported mean size in the country (18 cm), but comparable to that recorded in Indonesia (26 cm), New Caledonia (40 cm) and Papua New Guinea (40 cm) (Purcell et al. 2012). Similarly, *S. noctivagus* measured 27 cm but Kerr et al. (2006) noted that this species grows to only about 20 cm. In Pulau Besar, Johore Marine Park in Malaysia, *S. rubermaculosus size ranges from* 26.0 cm to 28.5 cm, but a larger specimen measuring 34 cm was noted in this study. *Stichopus vastus mean (*49.0± 10.6 cm) and maximum sizes (56.0 cm) were also higher than its reported measurements at 34.0 cm and 35.0 cm, respectively (Purcell et al. 2012).

Discussion

The recorded number of sea cucumber species in this study represents 34% of the total species in Palawan (Jontila et al. 2014). Many were noted to have overlapping distribution, particularly the holothuriid species, which are known to inhabit shallow, sheltered lagoons and inner reef flats with silty to sandy substrates (Conand 1998; Jaquemet et.al. 1999) and sheltered coral reef

Table 2. Mean (±SD) density (ind. 100 m^{-2}) of sea cucumbers during day and night surveys at Arreceffi Island, Honda Bay, Palawan, Philippines.

		Day		Night		
		Station 1	Station 2	Station 1	Station 2	Station 3
Family Holothuriidae						
1	*Actinopyga lecanora*	4.0±1.0	0.3±0.6	4.0±2.0		
2	*Bohadschia marmorata*	1.7±1.5	0.7±1.2	19.0±2.6	2.7±1.5	
3	*B. vitiensis*	1.0±1.0		1.0±1.0		
4	*Holothuria leucospilota*	8.7±2.1	3.0±3.0	9.3±2.5	1.7±1.5	
5	*H. atra*	2.0±2.0	0.7±1.2	0.3±0.6		
6	*H. coluber*					8.7±4.7
7	*H. edulis*			3.0±2.6		
8	*H. fuscocinerea*	3.7±1.2	0.7±0.6	1.7±1.5	1.0±1.7	
9	*H. scabra*	2.7±2.5	9.3±7.1	1.7±2.9	2.0±2.0	
10	*H. gracilis*					0.3±0.6
11	*Pearsonothuria graeffei*					1.0±1.2
Family Stichopodidae						
1	*Stichopus noctivagus*					0.3±0.6
2	*S. rubermaculosus*					0.3±0.6
3	*S. vastus*					0.7±1.2
Family Synaptidae						
1	*Synapta maculata*	14.0±10.5	3.3±1.5	4.7±1.5	3.7±3.2	

* Spotted also during the day during the free dive survey around the island.

Table 3. Comparison of mean (± SD) length (cm) and maximum length of sea cucumbers recorded in this study and that of Purcell et al. (2012).

		n	This study		Purcell et al. 2012	
			Mean (SD) length (cm)	Maximum length (cm)	Mean/range length (cm)	Maximum length (cm)
Family Holothuriidae						
1	*Actinopyga lecanora*	24	20.1±3.3	25	20	24
2	*Bohadschia marmorata*	73	17.6±5.1	23	18	26
3	*B. vitiensis*	6	25.7±3.2	31	25–35	40
4	*Holothuria leucospilota*	62	17.7±5.5	29	26*/15–30	28/45
5	*H. atra*	5	37.6±4.6	43	18–40	60
6	*H. coluber*	26	25.7±6.4	39	20	38
7	*H. edulis*	9	27.9±4.4	32	20	30
8	*H. fuscocinerea*	21	31.9±7.8	41	37*/23–50	65/50
9	*H. scabra*	47	19.0±5.5	33	19–37	40
10	*Holothuria gracilis*	1	31.0	31		
11	*Pearsonothuria graeffei*	2	37.0±5.7	41	17–35	45
Family Stichopodidae						
1	*Stichopus noctivagus*	1	27.0	27	20**	20
2	*S. rubermaculosus*	1	34	34	26.0–28.5***	28.5
3	*S. vastus*	2	49.0± 10.6	56	33–35	35
Family Synaptidae						
1	*Synapta maculata*	77				

* Romero and Cabansag (2014)
** Kerr et al. (2006)
*** Massin et al. (2002)

edges with hard substrates (Purcell et al. 2012). In this survey, as much as 60% of the holothuriid species were encountered in shallow (1–2 m) seagrass beds. Some of the most abundant species (*B. marmorata*, *Holothuria atra* and *H. scabra*) were noted in these areas but substrate preferences were apparently different. Bohadschia marmorata and *H. fuscocinerea* tend to aggregate in seagrass areas with fine to silty substrate with patches of the algae *Halimeda opuntia*. In contrast, *Actinopya lecanora, H. atra, H. leucospilota* and *H. scabra* were encountered in sandy seagrass beds and coralline flats having coarse to fine substrates. Although regarded as nocturnal species, *B. marmorata* and *B. vitiensis* (Conand 1998; Purcell et al. 2012) were also encountered early in the morning with the sun out already. In Guam, *B. vitiensis* was also spotted during the day within the sandy lagoon at depths of 5–7 m (Michonneau et al. 2013). It is possible that these species tend to respond to temperature because during the reconnaissance survey done at around 20:00, no individuals were seen in the area where their aggregation was noted earlier. It could be attributed to the warmer temperature of the water at that time. However, further investigations must be conducted to verify this observation.

The same distribution with it conspecifics in Indo-Pacific were displayed by *Stichopus* species in coralline flats and reef areas (Conand 1998; Purcell et al. 2012). During the survey though, *S. noctivagus* was noted only once, due to the nocturnal and cryptic behaviour of this species. This species has not been reported in earlier studies conducted in the Philippines (Domantay 1934, 1962; Tan-Tiu 1981; Reyes-Leonardo 1984; Jeng 1998; Lane et al. 2000; Schoppe 2000a; Akamine 2005) until 2006 when Kerr et al. (2006) documented it in Central Philippines. *Stichopus rubermaculosus* is also a nocturnal and cryptic species observed foraging on sandy substrate with dead corals and rubble. Distinguished by the red spots on its dorsum papillae with brown-black patches (Massin et al. 2002), this species was only recently reported in Palawan, Philippines (Jontila et al. 2014). In contrast, *S. vastus* was quite common in coral reefs and areas having hard substrates. It is among the commercially processed sea cucumber in the country (Schoppe 2000b; Akamine 2005; Purcell et al. 2012).

For most sea cucumbers, distribution is associated with feeding and protection (Mercier et al. 2000; Dissanayake and Stefansson 2012). As such, detritus feeders and burrowing sea cucumbers such as

Actinopyga, Bohadschia and *Holothuria* species were abundant in seagrass beds of Stations 1 and 2. Similarly, cryptic species and those feeding on sediments and benthic algae such as *Holothuria coluber, P. graeffei* and *Stichopus species* were found on coralline flats and coral reefs where their food is abundant. For *H. atra* and *S. chloronotus*, it was found that in addition to bottom coverage, current strength is also a major factor in their distribution (Uthicke 1994). Having a suitable settlement site is also another factor in the recruitment of sea cucumbers (Eriksson et al. 2012). Studies have shown that seagrass beds are important settlement areas for sea cucumbers inhabiting shallow and intertidal areas (Friedman et al. 2012; Dissanayake and Stefansson 2012). This could possibly explain the high diversity and density of species noted at Stations 1 and 2.

Studies have also shown that as re-workers of sediments, sea cucumbers are important in maintaining the productivity of an aquatic ecosystem (Lampe 2013). In coral reefs, the ammonium excreted by benthic holothurians enhance the microalgal assemblage (Uthicke and Klumpp 1997), which also contributes to the overall production of coral reefs (Sorokin 1993). Burrowing dendrochirotids also increase the benthic primary production as organic nutrients become available for benthic microalgae (Wolkenhauer et al. 2010), and the survival of other species is affected by changes in their density (Birkeland 1988). This could be correlated to higher diversity of associated species observed in the seagrass area of Station 1, wherein at least eight seagrass species were identified: *Cymodocea rotundata, Enhalus acoroides, Halodule pinifolia, H. uninervis, Halophila minor, Syringodium isoetifolium* and *Thalassia hemprichii).* Macroalgae, particularly *Halimeda* and *Padina* spp., as well as invertebrates (*Cyprea* species, crabs, sea urchins, sand dollars) and even fishes (*Plotosus lineatus*) were also common at Station 1. In contrast, far fewer numbers of associated species were sighted at Station 2, sea cucumber distribution is sparse. Only four species of seagrasses were recorded, including *C. rotundata, E. acoroides, H. uninervis* and *T. hemprichii*. Other flora and fauna were also less abundant at this station. In coral reef areas, much higher numbers of species could probably be encountered if more stations and transects were established. The occurrence of rare species presents an opportunity for further studies of these species and others that have not yet been fully investigated.

So far, no article has been published on the population of sea cucumbers in Palawan in order to compare with the results of this study. But based on Jontila et al. (in this issue), it appears that Arreceffi Island has higher density estimates of sea cucumbers than coastal municipalities in Palawan that are open to exploitation. These estimates are much higher than those recorded in the Bolinao-Anda reef system in Pangasinan (Olavides et al. 2010) and Tubbataha Reefs Natural Park (TRNP) (Dolorosa and Jontila 2012). This could probably be due to the high exploitation rate in these areas, except in TRNP. The impact on sea cucumbers from overharvesting has been well-documented. For instance, in Wadi Quny and Eel Garden in the Red Sea, *Bohadscia marmorata* and *B. vitiensis* were exploited to depletion after a decade of fishing (Hasan and Abd El-Rady 2012). Similar trends were noted in areas with open access such as Lomaiviti, Fiji and in shallow lagoons of Mauritius where sea cucumber densities were only 0.83 and 8.14 ind. 100 m^{-2}, respectively (Lalavanua et al. 2014; Lampe-Ramdoo et al. 2014). For *B. marmorata* and *H. atra,* their high densities could partly be due to their ability to reproduce sexually and asexually through transverse fission (Conand 1995; Laxminarayana 2005, 2006; Purwati 2009). It is also possible that they are aggregating in this area since the survey was conducted in February, which is the peak of their spawning season (Purcell et al. 2012). Similarly, *H. edulis* and *H. leucospilota* were also abundant in sandy reef areas outside the transects. Reichenbach and Holloway (1995) noted that these species also reproduce by fission.

Conclusion

The recorded population of sea cucumbers at Arreceffi Island in Honda Bay, Palawan, Philippines indicates that the area is a critical habitat for these species. The occurrence of aggregations of *Bohadscia marmorata* and *Holothuria scabra* indicates successful spawning in the area. Although juveniles were barely noted due to the difficulty in finding them, the presence of suitable substrates and the high population of adults and sub-adults suggests that the island could be a source of larvae, which could help revive populations of sea cucumbers in nearby depleted sites around Honda Bay, and that recruitment could be high in the area. Overall, the results of this study highlight the importance of protecting the habitat in conserving sea cucumber species. Protection could go along with tourism, as long as it is properly managed. Creating a marine protected area is often prompted with implementation issues due to financial and management problems. Having an area for tourism that generates income for its protection appears to be a good option. The Arreceffi Island and TRNP prove that tourism, protection and conservation work together.

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