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The Sea cucumbers (Holothuroidea) of Palawan, Philippines

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Abstract. Sea cucumbers are among the heavily exploited invertebrates in the Philippines that are not regulated due to limited scientific information needed to support the development of management measures. This study was therefore conducted to generate information on sea cucumber species in Palawan, Philippines. Sixteen sites covering different habitats (intertidal flats, seagrass beds, mangrove areas and coral reefs) were surveyed for the occurrence of sea cucumbers. The survey was done through walking, snorkeling and diving using the Self Contained Underwater Breathing Apparatus (SCUBA). Gathering of sea cucumbers together with fishers was also conducted to document other species that might have been missed during the independent survey. A sample of each species was collected and photographed after relaxation. Samples were then preserved either in 10% buffered formalin solution or 95% ethanol for archiving. The survey has recorded 44 species under family Caudinidae (1), Holothuriidae (26), Stichopodidae (16) and Synaptidae (1). Twenty-three are newly reported in the province and 36 are harvested for trading and local consumption. It was evident that Palawan harbors high diversity of sea cucumbers but collection is heavy also and unregulated.
Key Words: *trepang*, species composition, distribution, Palawan, Philippines.

Introduction. Sea cucumbers are among the heavily fished invertebrates in tropical regions (Conand 2006; Choo 2008; Hasan & Abd El-Rady 2012). They are harvested mainly for the production of *trepang* – a dried body wall of sea cucumber that is considered as a prime Chinese delicacy (Conand 1989; Schoppe 2000a; Akamine 2002; Gamboa et al 2004; Toral-Granda et al 2008; Purcell 2010). Sea cucumbers are also used in the production of various pharmaceutical products (Choo 2008; Bordbar et al 2011). They are ecologically important too for they enhance the ocean's productivity through recycling of sediments, bioturbation (Miller & Pawson 1990; Uthicke & Klumpp 1997; Uthicke 2001; Wolkenhauer et al 2010; Lampe 2013) and by serving as biofilters (Conand 2006).

Globally, there is a growing demand for *trepang* as indicated by its increasing trade value despite of the general decline in the volume of production (Gamboa et al 2004; Akamine 2005). Such demand has led to excessive harvesting and local depletion of some high-valued species of sea cucumbers (Brown et al 2010; Purcell 2010). Many islands in the Pacific like Solomon Islands, Cook Island, Papua New Guinea, Samoa, Palao, Marshall Islands, Federated States of Micronesia and Tuvalu and Tokelau have declared closure of their sea cucumber fishery for the stocks to recover (Pakoa & Bertram 2013). Australia, Indonesia and Egypt also had declining populations of sea cucumbers (Uthicke 2004; Hasan & Abd El-Rady 2012).

In the Philippines, sea cucumbers are heavily collected also. The country was in fact identified as the only sea cucumber hotspot in Asia for its high species diversity which is threatened by overfishing (Choo 2008; Toral-Granda et al 2008). The overharvesting of sea cucumbers in the country and the need to manage its fishery has long been emphasized by Trinidad-Roa (1987) but until today, no concrete regulations

specific to sea cucumbers have been made. Such has resulted to depletion of wild population as indicated by the declining export volume over time (Gamboa et al 2004). In 1992, the country shared at least 15% of the global production (Akamine 2005) but went to just around 10% recently (Brown et al 2010). The shifting of *trepang* production from low-volume/high-value to high-volume/low value also indicates that there is a shortage of supply from the wild (Akamine 2002, 2005). However, the status of wild population is difficult to ascertain due to inadequate studies and the lack of monitoring. Information on sea cucumber in the Philippines remains inadequate and there is a need to add to the studies conducted before including but not limited to the works of Domantay (1934 and 1962), Reyes-Leonardo (1984), Tan Tiu (1981), Schoppe (2000a), Kerr et al (2006) and Olavides et al (2010).

Palawan is one of the major producers of sea cucumber in the Philippines (Schoppe 2000b; Akamine 2005; Brown et al 2010) but studies on sea cucumbers are limited only to production and trade, leaving the non-commercial species unaccounted. The latter though are also prone to exploitation as the present economically important ones are becoming scarce in the wild. Thus, it is important to document them before they get depleted. Benchmark data on wild population are also important for the long-term monitoring of sea cucumbers' wild population and for managing its fishery.

As a continuing endeavor of the Philippines to manage its sea cucumber fishery, the Department of Science and Technology-Philippine Council for Agriculture, Aquatic and Natural Resources Research Development (DOST-PCAARRD), and the Commission on Higher Education (CHED) implemented a nationwide species inventory and assessment of sea cucumbers in 2011. Fourteen different Higher Education Institutions (HEIs) all over the country were tasked to conduct a study on sea cucumbers in their respective sites/regions. In Palawan, the Western Philippines University (WPU) was chosen to implement the project and the result of one of its components, the species inventory, is presented in this paper.

Material and Method

Study sites. The province of Palawan is located in the southwest part of the Philippines. Due to its high species diversity and relatively pristine marine environment, the province was dubbed as the country's "last ecological frontier". Considering the vast area of Palawan, study sites were strategically selected to have representatives of northern, southern, western and eastern part of the province. A total of 16 sites (Annex B) under the municipalities of Araceli, Bataraza, El Nido, Quezon and Roxas including Honda Bay and Sta. Lucia Cove in Puerto Princesa Bay, Puerto Princesa City (PPC) were surveyed for the presence of sea cucumbers (Figure 1). The survey which covered the intertidal areas, coralline flats, shallow seagrass beds, mangroves and coral reefs was conducted from March 2012 to February 2013.

Collection of specimen. The survey was done through wading and snorkeling in shallow intertidal areas, coralline flats, seagrass beds and mangroves. In coral reefs, SCUBA gears were used in the survey. Gathering of sea cucumbers was also done with fishers and divers to account other species that might have been missed during the independent survey. A sample of each species encountered was collected, photographed and preserved for future reference. Also, an interview with gatherers and middlemen was conducted to determine the commercially important species.

Preservation and identification of specimen. Sea cucumber samples were immersed in seawater with 5% $MgCl_2$ for about 10 minutes to relax the body and avoid evisceration during preservation (Samyn et al 2006). After which, a photograph of the dorsal and ventral sides was taken. To preserve the specimen, either a 10% buffered formalin or 95% ethanol was used, whichever is available. The specimens were then deposited at Western Philippines University (WPU) laboratory. Identification was based on the works of Conand (1998), Schoppe (2000a), Massin et al (2002), Kerr et al (2006) and Purcell et al (2012).

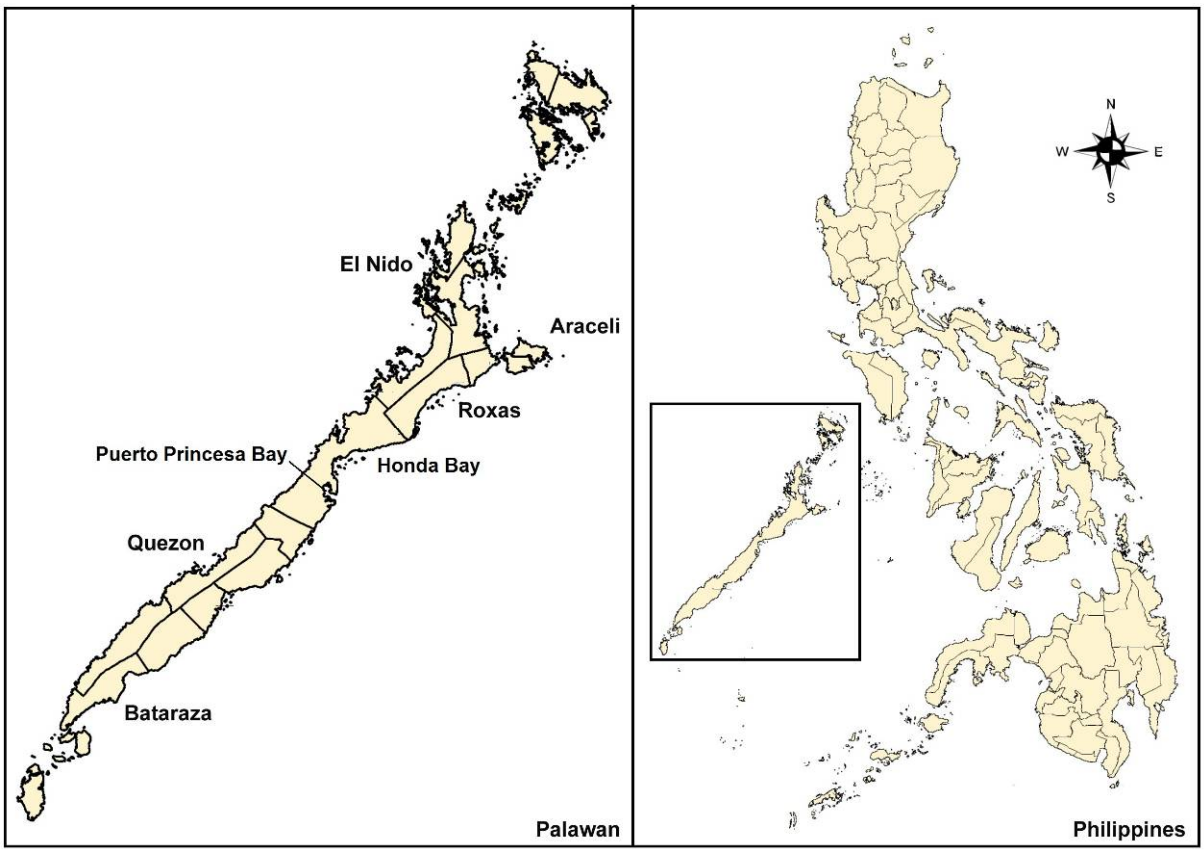

Figure 1. The map of Palawan, Philippines showing the sampling sites (source: www.mapinfo.com; accessed on July 10, 2014).

Results and Discussion

Species composition. A total of 44 species belonging to the families of Caudinidae (1), Holothuriidae (26), Stichopodidae (16) and Synaptidae (1) were recorded in this study (Table 1). However, seven species under Holothuriidae (2), Stichopodidae (4) and Caudinidae (1) need further examination to confirm their identification. Photos of the species encountered here are provided in the Annex A.

Many of the recorded species in this study are widely distributed in Indo-Pacific and have been previously reported in the country. The most common species are *Actinopyga lecanora, Bohadschia marmorata, Holothuria atra, H. coluber, H. scabra, Stichopus horrens,* and *Synapta maculata,* as they were noted in all sampling sites. Other species under family Holothuriidae like *A. echinites, B. vitiensis, H. edulis, H. fuscogilva, H. fuscopunctata, H. whitmaei* and *Pearsonothuria graeffei,* including *Stichopus chloronotus, S. herrmanni, S. vastus, Thelenota ananas* and *T. anax* of family Stichopodidae are also frequently encountered. Most of the species belonging to Holothuriidae were noted in shallow areas like seagrass beds and coralline reef flats. The same distribution was reported in Calatagan, Batangas (Reyes-Leonardo 1984), Central Philippines (Kerr et al 2006), in Bolinao-Anda, Pangasinan, Philippines (Olavides et al 2010) and in Red Sea, Egypt (Lawrence et al 2004). On the other hand, species under Stichopodidae were exclusively encountered in coral reefs, except for *S. herrmanni* and *S. ocellatus* that were found in sandy-seagrass beds. These species were noted to be closely associated in terms of habitat in Malaysia and Papua New Guinea (Massin et al 2002). An unknown species of *Acaudina* under family Caudinidae was only found in the muddy substrate of mangrove forest in Quezon, Palawan. This species was not documented in any other sites of this survey, not even in other parts of the country. However, interview with middlemen revealed that it was heavily collected in Puerto Princesa Bay, Palawan back in the 1990's.

Table 1

Sea cucumber species distribution by site

No	Species	Sites						
		Araceli	*Bataraza*	*El Nido*	*Honda Bay*	*Puerto Princesa Bay*	*Quezon*	*Roxas*
	Oder Aspidochirotida, Family Holothuriidae							
1	*Actinopyga echinites*				+		+	
2	*A. lecanora*	+	+	+	+	+	+	+
3	*Bohadschia argus***			+				
4	*B. marmorata*	+	+	+	+	+	+	+
5	*B. ocellata**		+					+
6	*B. vitiensis**	+	+	+	+			+
7	*Holothuria albiventer**							+
8	*H. arenicola**							+
9	*H. atra*	+	+	+	+	+	+	+
10	*H. cavans**							+
11	*H. coluber*	+	+	+	+	+	+	+
12	*H. edulis*		+		+			
13	*H. fuscocinerea*				+			+
14	*H. fuscogilva*			+			+	+
15	*H. fuscopunctata*	+		+			+	+
16	*H. hilla**						+	+
17	*H. impatiens**				+			
18	*H. leucospilota*	+	+	+	+	+	+	+
19	*H. lineata**							+
20	*H. notabilis**	+						+
21	*H. pervicax**							+
22	*H. scabra*	+	+	+	+	+	+	+
23	*H. whitmaei*			+			+	+
24	*Holothuria* sp.1*				+			
25	*Holothuria* sp.2*						+	
26	*Pearsonothuria graeffei*	+		+	+			+
	Oder Aspidochirotida, Family Stichopodidae							
27	*Stichopus chloronotus*	+	+	+			+	+
28	*S. herrmanni*	+	+	+			+	+
29	*S. horrens*	+	+	+	+		+	+
30	*S. monotuberculatus**							+
31	*S. noctivagus**				+			
32	*S. ocellatus**							+
33	*S. quadrifasciatus**							+
34	*S. rubermaculosus**				+			
35	*S. aff. rubermaculosus**							+
36	*Stichopus* sp.1 *							+
37	*Stichopus* sp.2 *							+
38	*Stichopus* sp.3 *							+
39	*Stichopus* sp.4 *							+
40	*S. vastus**		+	+	+		+	+
41	*Thelenota ananas*	+	+	+			+	+
42	*T. anax*	+		+			+	+
	Order Apodida, Family Synaptidae							
43	*Synapta maculata**	+	+	+	+	+	+	+
	Order Molpadida, Family Caudinidae							
44	*Acaudina* sp.*						+	
	Species richness	16	15	19	18	7	20	35

*Newly recorded species in Palawan; **Only dried sample was obtained from fisher.

Among the study sites, the municipality of Roxas had the most diverse species of sea cucumbers containing 35 of the total recorded species. Gathering of sea cucumbers is very popular in this area particularly in Green Island. Fifty percent of Stichopodidae species were encountered only in this municipality (Table 1), mainly as catch of fishers from coral reefs of 5-8 meters deep. Many of which (*S. chloronotus, S. herrmanni*, *S. horrens, S. vastus, T. anax* and *T. ananas*) have been reported in many parts of the country (Schoppe 2000a, Kerr et al 2006, Olavides et al 2010) but some like *S. noctivagus* and *S. rubermaculosus* have limited documentation. The former was only seen in Central Philippines (Kerr et al 2006) while the latter has not been reported at all, except in this study.

Comparatively, Quezon and El Nido had high number of species at 20 and 19, respectively. A little less was recorded in Honda Bay, Araceli and Bataraza with 18, 16 and 15 species, correspondingly. On the other hand, only seven species were recorded in Puerto Princesa Bay. This can be attributed to limited sites, which covered only the shallow areas dominated by sandy and muddy seagrass beds in Sta. Lucia Cove. Thus, encounter of species that prefer other habitat types such as coral reefs is very unlikely. In addition, no gatherers were interviewed in this area, unlike in Roxas and other municipalities.

There are 23 species noted in this survey that were not previously reported in Palawan (Schoppe 2000b) and therefore, new record to the province. These include 13 species under family Holothuriidae, nine species of family Stichopodidae and one under family Caudinidae (Table 1).

From the 44 recorded species, 36 have commercial value but only 32 are processed into *trepang.* The *Acaudina* sp., *H. arenicola, H. lineata* and *Holothuria* sp. 2 are sold and consumed raw by locales (Table 2). The present number of exploited species is much higher than the earlier accounts of traded species in Palawan. Schoppe (2000b) noted 25-26 species while Akamine (2005) reported only 24, of which only 18 were identified to either genus or species level. The rest were listed using their local names. Note that some species previously reported by Schoppe (2000b) and Akamine (2005) (*Actinopyga mauritiana, A. obesa, A. miliaris, H. rigida, H. inhabilis, H. pulla* and *Thelenota rubralineata)* were not encountered in this study. Conversely, there are species that are not collected before but are now traded in the market. These include *B. ocellata, B. vitiensis* and *H. arenicola* of family Holothuriidae and *S. monotuberculatus, S. ocellatus, S. quadrifasciatus, S. rubermaculosus, S. aff. rubermaculosus, S. vastus, Stichopus* sp. 1, *Stichopus* sp. 2, *Stichopus* sp. 3 and *Stichopus* sp. 4 of Stichopodidae. It is possible that the species collected before have been exploited to depletion whereas the occurrence of new traded species is due to expansion of fishing grounds.

In 2013, the Philippine National Standard (PNS) for dried sea cucumber released by the Bureau of Agriculture and Fisheries Standards of the Department of Agriculture (DA-BAFS) listed 36 commercially species of sea cucumbers. Five out of the seven high-value species they listed are also collected in Palawan (*H. fuscogilva, H. nobilis, H. scabra, H. whitmaei, S. horrens*). However, many of the regularly harvested *Stichopus* species noted in this study are not yet included in the list. It is possibly be due to the difficulty in identifying these species once processed. Buyers would sometimes classify different species that are similar in appearance under one category or name.

The changing pattern of exploited resource-species and expansion of fishing grounds are clear indicators of overfishing (Akamine 2002; Toral-Granda et al 2008; Purcell 2010). Interview revealed that gleaners and artisanal fishers who used to collect sea cucumbers in shallow seagrasses and coralline flats are now venturing to deep coral reefs for sea cucumbers are now very scarce in such areas. Also, bigger and more valuable species like *H. whitmaei* and *S. horrens* are found in coral reefs.

Currently, the number of commercial species in Palawan represents 77% of the exploited species in the country (Labe 2009) and almost 55% of that in the world (Purcell 2010).

Table 2

Sea cucumber species reported by different studies in Palawan, Philippines

No.	Species	Schoppe (2000b)	Akamine (2005)	This study
	Order Aspidochirotida, Family Holothuriidae			
1	*Actinopyga echinites**	+	+	+
2	*A. lecanora**	+	+	+
3	*A. mauritiana**	+		
4	*A. miliaris**	+		
5	*A. obesa**	+		
6	*Actinopyga* sp.*	+	+	
7	*Bohadschia argus**	+	+	+
8	*B. marmorata**	+		+
9	*B. ocellata**			+
10	*B. vitiensis**			+
11	*Bohadschia* spp.		+	
12	*Holothuria albiventer*			+
13	*H. arenicola***			+
14	*H. atra**	+	+	+
15	*H. cavans*			+
16	*H. coluber**	+		+
17	*H. edulis**	+	+	+
18	*H. fuscocinerea**	+	+	+
19	*H. fuscogilva**		+	+
20	*H. fuscopunctata**	+	+	+
21	*H. hilla*			+
22	*H. impatiens*			+
23	*H. inhabilis**	+		
24	*H. leucospilota**	+	+	+
25	*H. lineata***			+
26	*H. notabilis*			+
27	*H. pervicax*			+
28	*H. pulla**	+		
29	*H. rigida**	+		
30	*H. scabra**	+	+	+
31	*H. whitmaei**	+		+
32	*Holothuria* sp. 1			+
33	*Holothuria* sp. 2**			+
34	*Pearsonothuria graeffei**	+	+	+
	Order Aspidochirotida, Family Stichopodidae			
35	*Stichopus chloronotus**	+	+	+
36	*S. herrmanni**	+	+	+
37	*S. horrens**	+	+	+
38	*S. monotuberculatus**			+
39	*S. noctivagus*			+
40	*S. ocellatus**			+
41	*S. quadrifasciatus**			+
42	*S. rubermaculosus**			+
43	*S. aff. rubermaculosus**			+
44	*S. rubralineata**	+		
45	*S. vastus**			+
46	*Stichopus* sp. 1*			+
47	*Stichopus* sp. 2*			+
48	*Stichopus* sp. 3*			+
49	*Stichopus* sp. 4*			+
50	*Thelenota ananas**	+	+	+
51	*T. anax**	+	+	+
	Order Apodida, Family Synaptidae			
52	*Synapta maculata*			+
	Order Molpadida, Family Caudinidae			
53	*Acaudina* sp.**			+
	Subtotal	26	18	44

* Species traded as *trepang* (dried); ** Species sold fresh or consumed fresh.

Combining the results of the three studies (Table 2), Palawan now has a total of 53 species. This record is comparatively higher than other sites in the country. For instance, only 40 species were documented in the islands of Negros, Cebu, Bohol and neighboring localities (Kerr et al 2006) and 35 species in Bolinao-Anda, Pangasinan (Olavides et al 2010). Much lower number of species were noted by earlier studies in Lingayen Gulf with

25 (Domantay 1962), Central Philippines (Cebu and neighboring islands) have 27 (Tan-Tiu 1981) and Calatagan, Batangas with 28 species only (Reyes-Leonardo 1984). In Tubbataha Reefs Natural Park (TRNP), Palawan, only five species (*B. argus, H. atra, P. graeffei, S. chloronotus* and *T. ananas*) were reported (Dolorosa & Jontila 2012).

Based on the results, Palawan harbors a great diversity of sea cucumbers. However, it was also evident that harvesting is uncontrolled. More species are being traded and new fishing grounds are now exploited. If left uncontrolled, valuable species will likely be depleted, leading to exploitation of new species and probably, collapse of fishery in the long run (Labe 2009; Purcell et al 2012). Such scenario is similar to the cascading effect of upper trophic level overfishing that led to exploitation of other high-valued species at lower trophic level like sea cucumber (Essington et al 2006; Foley 2013). Once overfished, the livelihood of sea cucumber collectors and those involved in its fishery will be affected. Also, excessive harvesting of the same could cause imbalance to the marine ecosystem. According to studies, sea cucumbers in coral reefs play an important role in recycling of nutrients and maintaining its productivity (Uthicke & Klumpp 1997). Similarly, the sea grass beds' productivity, structure and ecological function could be impaired when sea cucumbers are removed from it (Wolkenhauer et al 2010). In addition, changes in sea cucumbers' density may even have serious consequences on the survival of other species that are part of the same ecosystem (Birkeland 1988). And if overfished, sea cucumbers' population is difficult to revive for as external spawners, the success of reproduction is heavily reliant on the number of aggregating individuals (Bruckner 2006).

Such vulnerability of sea cucumbers to local extinction and the loss of fishery productivity is actually a global concern (Purcell 2010). Some Pacific islands have declared closure of their fishery to allow recovery of species (Hasan & Abd El-Rady 2012). Others have implemented size limit and quota system to regulate the trade (Purcell et al 2009). The International Union for Conservation of Nature (IUCN) also listed 16 sea cucumber species as Endangered (high risk of extinction) or Vulnerable (at risk of extinction). Some highly exploited species found in Palawan like *A. echinites, H. fuscogilva, H. scabra, H. whitmaei, S. herrmanni* and *T. ananas* are included in the list (Conand et al 2014). In the Philippines, the management of sea cucumbers is very generic under Republic Act 8550 or the Philippine Fisheries Code of 1998. Protection of populations is limited to the establishment of marine protected areas (MPAs) (Choo 2008). Restocking of heavily fished species like *H. scabra was* also tested (Gamboa et al 2004) but turned out to be expensive with minimal return (Toral-Granda et al 2008). Nevertheless, the Department of Agriculture – Bureau of Fisheries and Aquatic Resources (DA-BFAR) drafted a fisheries administrative order for the size limit and quota system to regulate sea cucumber harvest and trade. However, its implementation will only proceed after the consultation with the stakeholders is finalized.

Conclusions. It was evident from the results of this study that Palawan contains high diversity of sea cucumbers. Given the vast area and the diversity of habitats that are not yet surveyed, there is a high probability of encountering more species. But sea cucumbers face numerous threats from overexploitation, which could lead to depletion of species and imbalance of ecosystem. When sea cucumbers' fishery collapsed, the economic well-being of those involved in it will be compromised. The fishers and gatherers will likely be the most affected and in such case, they will look for new resource to be exploited. Immediate action should therefore be done but as mentioned, necessary information has to be provided first to come up with any management measures. Thus, in addition to inventory of species, studies on the status, biology and ecology of the sea cucumbers especially those with high commercial value must also be conducted.

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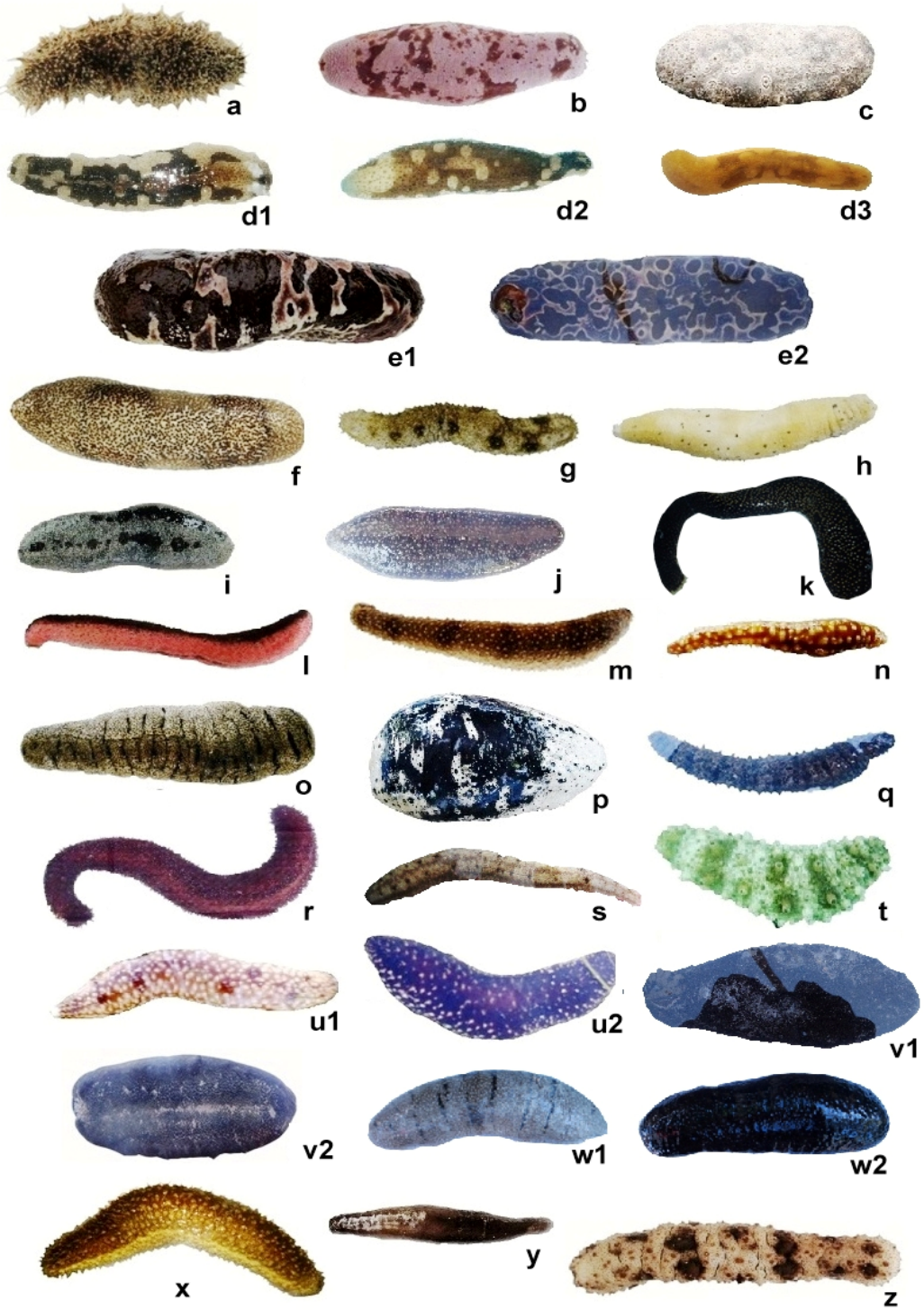
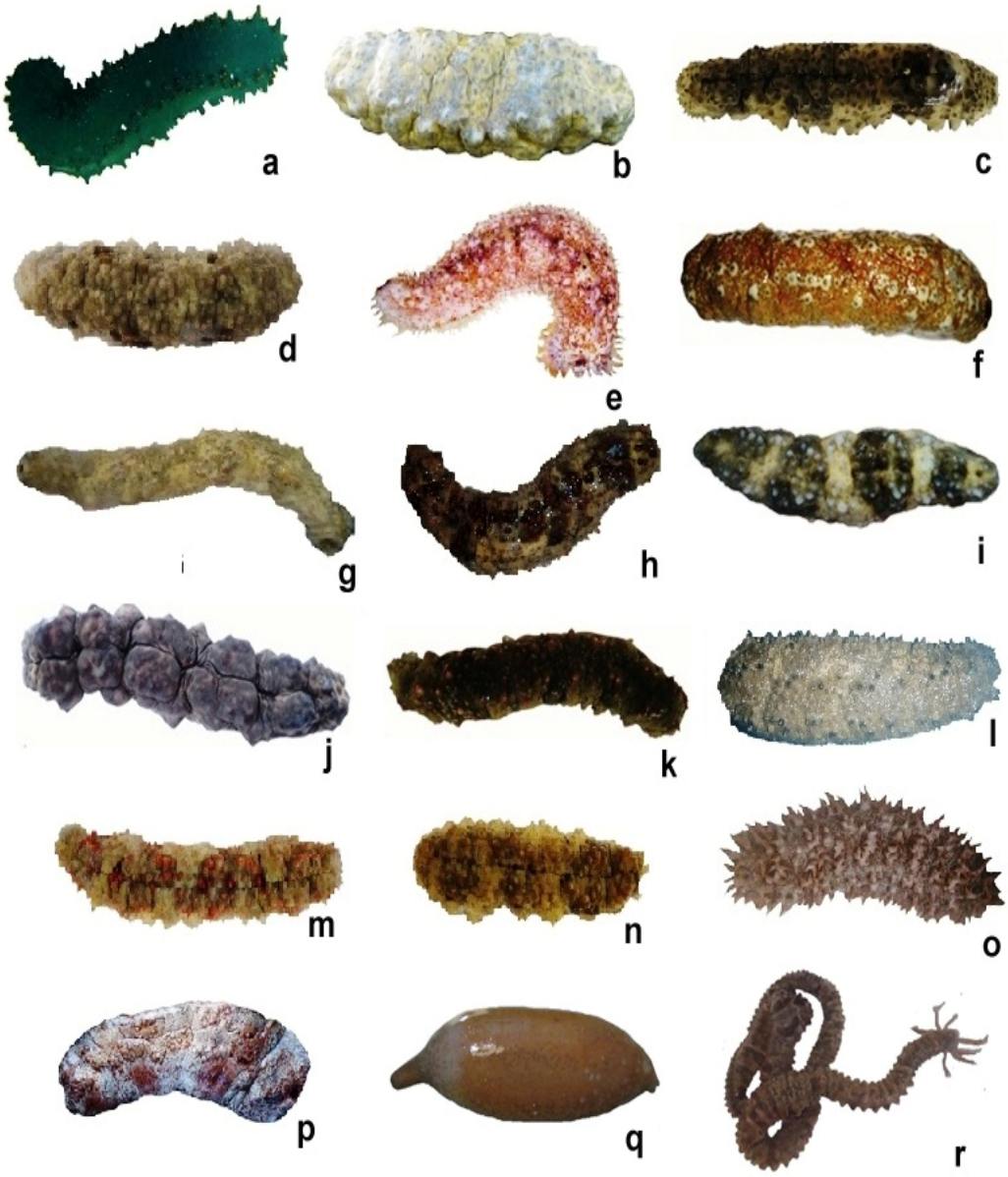
Order Aspidochirotida, Family Holothuriidae: (a) *Actinopyga echinites*; (b) *A. lecanora*; (c) *Bohadschia argus*; (d1, d2, & d3) *B. marmorata* variants; (e1 & e2) *B. ocellata*; (f) *B. vitiensis*; (g) *Holothuria albiventer*; (h) *H. arenicola*; (i) *H. atra*; (j) *H. cavans*; (k) *H. coluber*; (l) *H. edulis*; (m) *H. fuscocinerea*; (n) *H. hilla;* (o) *H. fuscopunctata;* (p) *H. fuscogilva*; (q) *H. impatiens*;(r) *H. leucospilota*; (s) *H. lineata*; (t) *H. pervicax*; (u1 & u2) *H. notabilis* variants; (v1) *H. whitmaei* (fresh); (v2) *H. whitmaei* (dried); (w1 & w2) *H. scabra* variants; (x) *Holothuria* sp.1; (y) *Holothuria* sp.2; and (z) *Pearsonothuria graeffei*.



Order Aspidochirotida, Family Stichopodidae: (a) *Stichopus chloronotus*; (b) *S. hermanni*; (c) *S. horrens*; (d) *S. monotuberculatus*; (e) *S. noctivagus*; (f) *S. ocellatus*; (g) *S. quadrifasciatus*; (h) *S. rubermaculosus*; (i) *S. aff. rubermaculosus*; (j) *S. vastus*;(k): *Stichopus* sp.1; (l) *Stichopus* sp.2; (m) *Stichopus* sp.3; (n) *Stichopus* sp.4; (o) *Thelenota ananas*; (p) *T. anax*, **Order Molpadida, Family Caudinidae**: (q) *Acaudina* sp.; and **Order Apodida, Family Synaptidae** (r): *Synapta maculata*.



Annex B

List of study sites by location

Municipality/City	*Study site*
Araceli	1. Poblacion pier
Bataraza	2. Igang-Igang
	3. Rio Tuba
El Nido	4. San Fernando
	5. Sibaltan
	6. Villapaz
Honda Bay, Puerto Princesa City	7. Dos Palmas/Arreceffi Island
	8. Tagburos
Puerto Princesa Bay, Puerto Princesa City	9. Sta. Lucia cove
Quezon	10. Aramaywan
	11. Tamlangon
	12. Tataran Is.
Roxas	13. Caramay
	14. Green Island
	15. Jolo
	16. Tinitian