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Community Structure of Sea Cucumber in the Intertidal Zone and Extent of Its Use in Poblacion, Cortes, Surigao del Sur

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ABSTRACT

Abundance, species composition, distribution, and rapid survey on the fishery status of sea cucumbers in the intertidal areas of Poblacion, Cortes was conducted for two index seasons (dry and wet) in August and December 2017, respectively. A total of eight sea cucumber species from two families were identified during the two-monsoon seasons of collection with a higher species diversity for the dry season. *Holothuria atra* and *Synapta maculata* dominantly occurred in both seasons. These species were found mostly in seagrass and sandy areas. Canonical Correspondence Analysis showed that the total organic matter and grain size in the sediments might influence the abundance of sea cucumber in two seasons. Gleaning and fishing might have affected the abundance of sea cucumber since they serve as the primary source of food and livelihood by the residents. Sustainable sea cucumber fishery resource and conservation should be implemented in the area

Keywords: *Assessment, Community structure, Fishery, Sea cucumbers, Seasonality*

1 Introduction

Sea cucumbers are worm-like echinoderms belonging to the class Holothuroidea. They are found abundant in the seafloor, and they usually thrive in tidal flats, seagrass beds, and coral reefs (Orwa et al. 2004). Some factors that influence their distribution and abundance include habitat, substrate types, competition, fishing pressure, and predation (Conand and Muthiga 2007, and Schoppe 2000). This group of species plays a key role in regenerating nutrients in coastal communities (Hanafy 2011). These invertebrates are also recognized as food items and a basis of income for coastal fishing communities worldwide (Sanidad and Sanidad 2013).

The Philippines is home to approximately 100 species of sea cucumbers, of which 31 are commercially important (Jontila et al. 2017). Because of the standard demand for sea cucumbers and poor implementation of laws, many species are widely exploited, causing their number to decline (Schoppe 2000, Dissanayake and Steffansson 2010, Sanidad and Sanidad 2013, and Dolorosa 2015). Currently, sea cucumbers can be harvested through commercial fishing, artisanal fishing as bycatch, and handpicking in intertidal reef flats during low tide and diving using air compressor up to 20 meters deep (Subaldo 2011). Severe overfishing of sea cucumbers resulted in its decline, affecting this resource in coastal communities (Kalaeb et al. 2008).

This study aims to assess the biodiversity status and the populations' growth to provide foundation for management of the fishery resource in Cortes, Surigao del Sur. The density, species composition, and distribution of sea cucumbers in the shallow coastal area between two seasonal monsoons were also determined. Specific parameters are also correlated with sea cucumber species diversity.

2 **Materials and Methods**

Study Area

The survey of the abundance and distribution of sea cucumbers was carried out in the coastal areas of Poblacion, Cortes, Surigao del Sur, Philippines (Figure 1). Poblacion is one of the Marine Protected Areas (MPAs) in Cortes, Surigao del Sur. It is also known for its rich source of seafood. Established transects were situated inside the MPA of Poblacion and are far from the community. The locations of the three transects were determined by Geographic Positioning System (GPS). The substrates that dominated transect 1 (126° 12.230' East and 09° 16.034' North), were mostly composed of rocks and sands. Sponges and seaweeds were present in the area. In transect 2 (126° 12.228' East and 09° 16.061' North), the substrate mostly comprises of coral reefs and sand. Seagrasses, sponges, and seaweeds were also present in the area. Seagrass beds and sandy substrates dominated transect 3 (126° 12.229' East and 09° 16.090' North). Molluscs, fishes, and some echinoderms were also present in the sampling area

Data Collection

Prior to actual data collection, entry protocol within the barangay and municipality were done to request assistance in locating the fishing grounds. Three 200 m2 belt transects were established in the intertidal areas for two index seasons (dry and wet) in August and December 2017, respectively. Handpicking was used in collecting while searching for sea cucumbers in crevices, seagrass, and sandymuddy areas (Sanidad and Sanidad 2013). The methods allow for calculating density, diversity, distribution, abundance, and species richness (Orwa et al. 2004).

The body length and width of each specimen was measured with a ruler while in its relaxed state. The specimen were blot-dried and measured with a digital weighing scale as fast as possible to avoid evisceration. The specimen were then identified and classified up to species level using the available taxonomic keys, photographic guides, the publication of the Pacific Island Sea Cucumber, and Bechedemer Identification Cards (Conand 1998), and Commercially Important Sea Cucumbers of the World (Purcell et al. 2012).

Sediment samples for grain size and organic matter content were collected in each transect using a digging tool. About 200 g sediments were collected at the start and the end of each transect. Samples were placed in Ziploc bags and stored in a freezer until analysis (Moghaddasi et al. 2009). The grain size was analyzed by sieving 100 g oven-dried sediment from each sampling station using a series of sieves with mesh openings of 2000 mm, 850 mm, 600 mm, 425 mm, 300 mm, 212 mm, 150 mm, and <150 mm. The remaining sediment particles per sieve size were removed and weighed separately.

Survey of sea cucumber utilization

A survey questionnaire adopted from UP-MSI Sea Cucumber Research Program (2011) was used

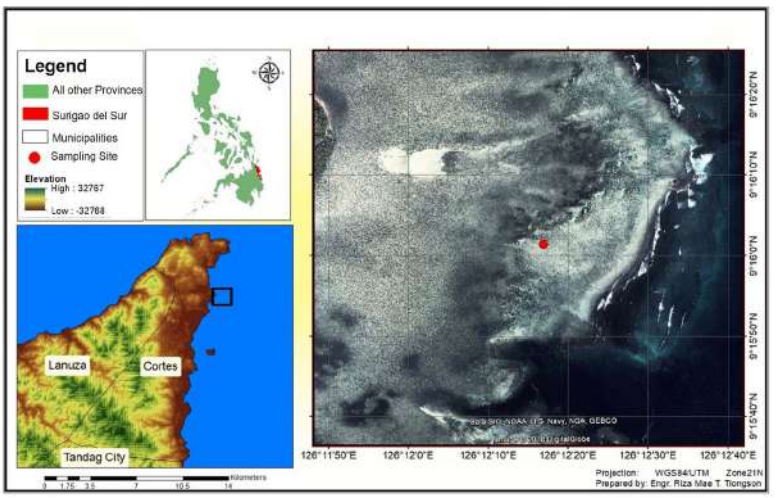

Figure 1. Map of the study site in Poblacion, Cortes, Surigao del Sur, Philippines

for the extent of sea cucumber utilization. A total of 20 respondents were interviewed regarding information such as the local name of the collected species, location of fishing grounds, kilos of catch, method of collection, number of hours, and fishery status of sea cucumber in the area.

Data Analysis

The relative abundance of sea cucumbers was calculated by dividing the species' abundance with the total abundance of all species combined. Its formula is RA = n^1/N x 100% (where n^1 is the number of individuals in species and N is the total number of individuals in all species).

Total organic matter was measured using a preweighed crucible (C), sediment was added until half-filled and then oven-dried at 70°C for 24 hours. After drying, the crucible was reweighed (A) and placed in a furnace at 550°C for about 12 hours. It was then removed and left to cool before it was reweighed (B) (Moghaddasi et al. 2009).

$$\text{TOM (\%)} = \frac{\text{(A-B) X 100}}{\text{(A-C)}}$$

For sediment grain size analysis, the percentage of each particle fraction was calculated as shown below and was classified based on the Wentworth grade classification of particle size:

$$\text{Grain size (\%)} = \frac{\text{Dry weight of weighed sediments per sieve}}{\text{Total dry weight of sediments}}$$

Diversity indices like Taxa, Dominance, Shannon, and Evenness were determined using Paleontological Statistics (PAST) software. Canonical Correspondence Analysis (CCA) was used to determine the correlation between the grain size, organic matter contents, and the sea cucumber species during two monsoons.

3 Results and Discussion

Species diversity of sea cucumbers

A total of eight sea cucumber species from two families were identified and classified during the two-index season (Table 1). Seven species were identified from the family Holothuriidae while only one species was determined for the family Synaptidae (Figure 2).

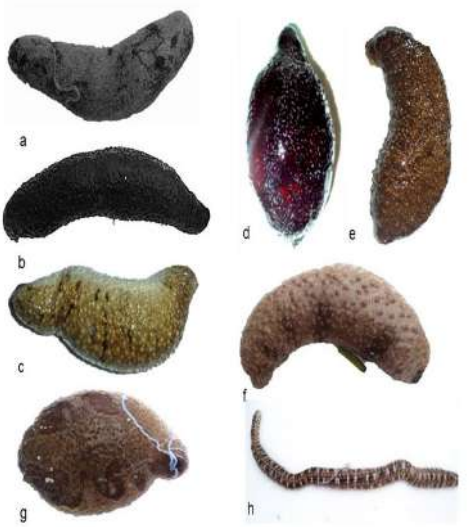

Figure 2. Sea cucumber species in the intertidal zone in Poblacion, Cortes, Surigao del Sur, Philippines. (a) *Holothuria atra*, (b) *Holothuria leucospilota,* (c) *Holothuria scabra,* (d) *Holothuria fuscopunctata,* (e) *Actinopyga echinetes*, (f) *Bohadschia vitiensis,* (g) *Bohadschia marmorata*, (h) *Synapta maculata*

Table 1. List of sea cucumber species between two seasons in Poblacion, Cortes, Surigao del Sur, Philippines.

Family	Species	Common Name	Local Name	Mean Length	Mean Weight	N
Holothuriidae	**Actinopyga echinites*	Deepwater Redfish	Bat sapatos	12.53	105.84	5
	**Bohadschia marmorata*	Brown Sandfish	Tagukan	14.66	81.72	24
	**Bohadschia vitiensis*	Brownspotted Sandfish	Sunlutan	8.47	111.36	12
	**Holothuria atra*	Lollyfish	Bat uwak	14.22	99.95	60
	**Holothuria fuscopunctata*	Elephant Trunkfish	Kagisan	17.29	288.67	8
	**Holothuria leucospilota*	White Threadfish	Bat lambi	21.61	261.28	22
	**Holothuria scabra*	Sandfish	Tood	9.57	108.29	7
Synaptidae	**Synapta maculata*	Snakefish	Bahag-bahag	55.35	63.68	56

*commercially important species

Species richness in this study is low compared to others. Quevedo, et al. (2013) identified 16 species, including common sea cucumbers like *Holothuria* sp., *Bohadschia* sp., *Actinopyga* sp., *S. maculata*, and *Synapta* sp. In Ilocos Sur, 21 species were identified (Sanidad and Sanidad 2016). In Tubbataha Reefs Natural Park, Philippines, 18 sea cucumber species were recorded, of which 12 are IUCN listed (Conand and Muthiga 2007). Although few species were noted in the sampling area, most of them are commercially important. According to local fishers, *S. maculata* and *H. atra* were the only non-commercial species in the area. All species, except *H. scabra*, were present during both seasons (Table 2). *Holothuria scabra*, a high-value species (Sanidad and Sanidad 2013), was absent during the wet season. Possible factors for its absence include mobility (Lee et al. 2018), gleaning, feeding and protection (Jontila et al. 2017), movement of water (Zhou and Shirley 1996), and productivity of detritus and nutrients in the area (Dissanayake and Steffanson 2010).

The sampling area contain seagrass beds, rocky and sandy substrates. *Holothuria atra* and *B. vitiensis* were common in seagrass and sandy areas (Table 2). *Synapta maculata* was common in seagrass beds. *Holothuria scabra, B. marmorata,* and *H. fuscopunctata* were found in sandy areas. *Actinopyga echinites* and *H. leucospilota* were found in sandy-rocky substrates. Habitat composition of the species is comparable to the results of Jontila et al. (2017), where *H. atra* is usually found day and night in shallow water, reef flats, bare sediments, and in seagrass substrates, while *S. maculata* were found in regions with presence of seagrasses beds (Romero and Cabansag 2014, Jontila et al. 2017).

Synapta maculata and *H. atra* have higher densities during the dry season (0.34 ind./m^2 and 0.33 ind./m^2 , respectively) than the wet season (0.22 ind./m^2 and 0.27 ind./m^2 , respectively). Their high densities could be due to their ability to reproduce sexually and asexually through transverse fission (Jontila et al. 2017). *Holothuria leucospilota* was quite abundant between the two monsoon seasons, with an estimated density of 0.12 ind./m^2 in dry and 0.1 ind./m^2 in the wet season. *Bohadschia vitiensis* had the highest density during the dry season with an estimated density of 0.16 ind./m^2 and only 0.08 ind./m^2 in the wet season. *Holothuria scabra* was encountered only during the dry season with an estimated density of 0.07 ind./m^2. In contrast to the study of Asha et al. (2015), maximum numerical density was observed during September, which is subsequent to heavy rains, while lowest in March might be due to the construction of embankment, habitat disturbance, and disruption of tidal flow.

Synapta maculata had the highest abundance (30%), comprising almost half of the population of sea cucumber in all sampling stations (Figure 3). This species is considered a non- target species (Quevedo et al. 2013). It is followed by *H. atra,* also known in the area as "bat uwak" with an estimated 29% abundance in all three sampling stations. This species is also a non-target and low-value as the gleaners believe that it is not safe for human consumption. This species is commonly found in coral reefs and sandy substrates (Kalaeb et al. 2008). *Actinopyga echinites* and *H. fuscopunctata* displayed the same relative abundance during the surveys of the dry season with an estimate

Table 2. Sea cucumber species habitat composition in Poblacion, Cortes, Surigao del Sur.

Species Name	Dry Season			Wet Season		
	T1	T2	T3	T1	T2	T3
Actinopyga echinites	-	Rocky	Sandy	-	-	Rocky, Sandy
Bohadschia marmorata	Sandy	Sandy	Sandy	Sandy	-	Sandy
Bohadschia vitiensis	Seagrass	Seagrass	-	-	Sandy	Seagrass, Rocky
Holothuria atra	Seagrass	Sandy	Sandy	Seagrass	Sandy, Seagrass	Sandy, Seagrass
Holothuria fuscupunctata	-	-	Sandy	-	Sandy	Sandy
Holothuria leucospilota	-	Rocky	Rocky	-	Rocky	Sandy, Rocky
Holothuria scabra	-	Sandy	Sandy	-	-	-
Synapta maculata	Seagrass	Seagrass	Seagrass	Seagrass	Seagrass	Seagrass

Legend: (-) Absent

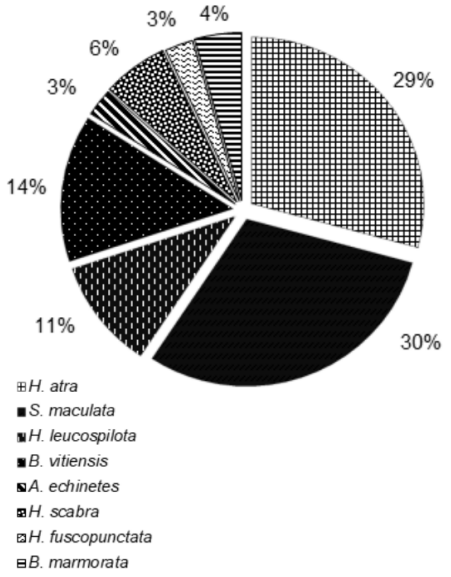

Figure 3. The relative abundance of sea cucumber in all sampling station during the dry season in Poblacion, Cortes, Surigao del Sur.

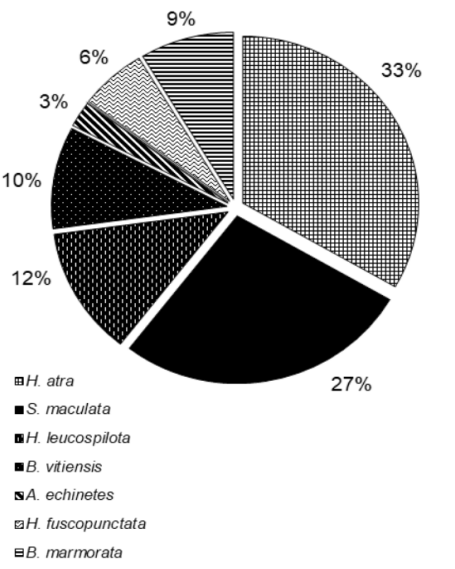

Figure 4. The relative abundance of sea cucumber in all sampling station during the wet season in Poblacion, Cortes, Surigao del Sur.

of 3%. During the wet season, *H. atra* had the highest relative abundance, with 33% in all three sampling transects (Figure 4). This species was the most common and abundant sea cucumber species in some parts of the Indo-Pacific Region, Reunion Island, and Solomon Island (Dissanayake and Steffanson 2010). *Synapta maculata* is the second most abundant species during the wet season (Figure 4). In terms of species diversity, sea cucumbers in Barangay Poblacion had very low diversity values during dry and wet seasons (Table 3). Although diversity was low, sea cucumbers are evenly distributed throughout the sampling site. High species richness is usually shaped by varied types of habitat, such as mangrove forests, seagrass meadows, reef flat and slope, and sandy habitats suited for the young and mature sea cucumbers (Dolorosa et al. 2017). In this study, the site has less varied habitats, and as expected, species richness is low. The low diversity and moderate to high evenness value may due to the population of the species that grow very slowly and are very easy to catch because they are highly visible and slowly moving in nature (Villanueva 2005).

Grain Size Analysis of the Sampling Area

The substrate of the study station is mainly composed of granule and sand (Figure 5). Sediment grain size is an essential factor in determining habitat and distribution preferences of sea cucumbers (Asha et al. 2015). The amount of sand that passes through the gut of sea cucumber are affected by any profound alteration of the ecology in areas where sea cucumber is abundant.

The variation of holothurian densities was correlated to the sediment characteristics as there is a close relationship between grain size and the

Table 3. Sea cucumber diversity indices in Poblacion, Cortes, Surigao del Sur, Philippines

Season	Shannon Wiener Diversity Index	Species Richness	Evenness
Dry	1.48	5.7	0.89
Wet	1.45	5	0.94

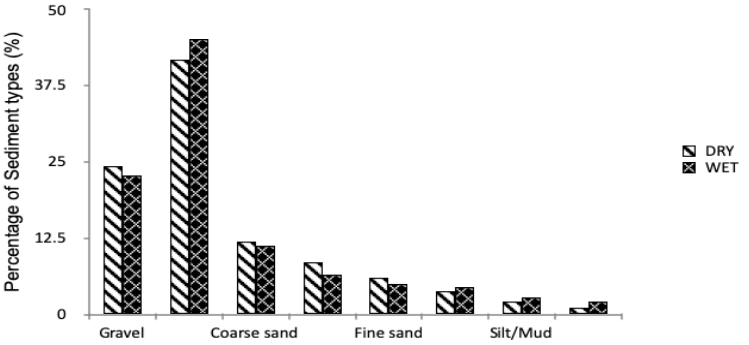

Figure 5. Sediment Composition in the intertidal flats of Poblacion, Cortes, Surigao del Sur for the two index seasons of 2017.

level of organic matter (Asha et al. 2015). The differences between these two seasons are assumed to be influenced by some critical environmental values, as revealed by CCA (Figure 6). Coarse sand, very fine sand, and Total Organic Matter (TOM) have the most extended vector among the physical attributes. The TOM was high with 5.1% and 6.84% in the dry and wet season, respectively. High TOM content means plenty of food sources for macroinvertebrates.

Additionally, TOM enhances the soil's capacity to hold nutrients and water (Malay et al. 2000). It is significant as sea urchin requires nutrients since TOM is needed for their growth and development. This implies that the associations of the species were higher within these variables. By some means, those species that were away from the vectors of the variables do not correlate. However, those species that fall along the center of the axis were classified as generalists. Species recognized within this category are considered stable. *Holothuria fuscopunctata* and *H. leucospilota* are strongly correlated to clay, silt/mud, and very fine sand. On the other hand, *B. vitiensis* and *H. scabra* respond to very little to low content of medium sand and granule and negatively correlated to fine sand, coarse sand, clay, silt/mud, very fine sand, total organic matter, and gravel. *Holothuria scabra* is usually attributed to muddy

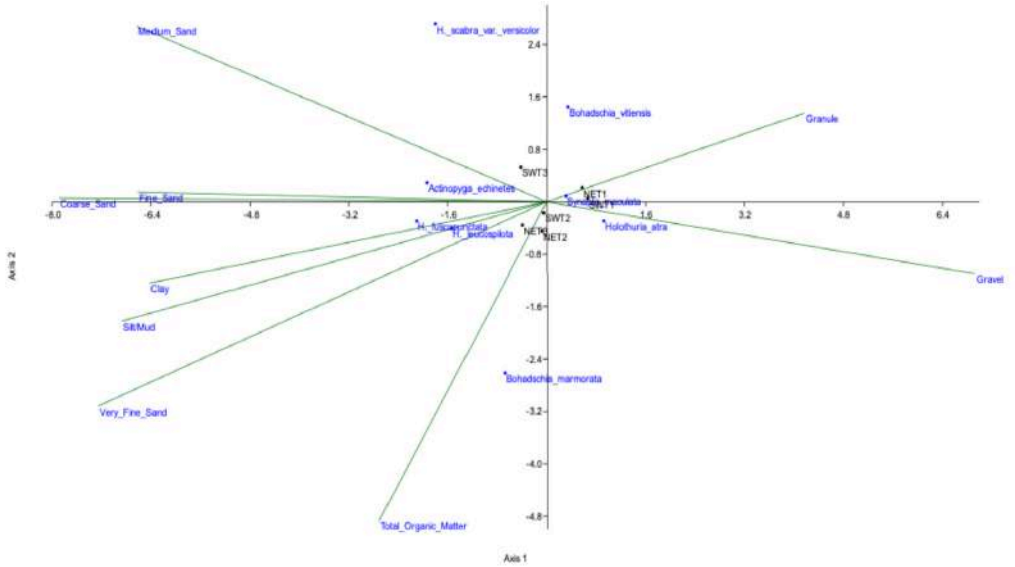

Figure 6. Canonical Correspondence Analysis (CCA) of densities of respective sea cucumber species with sediment properties and organic matter.

and seagrass substratum (Kalaeb et al. 2008).

The level of physical and chemical activity on the sediment surface is important (Hanafy 2011). Sea cucumber species are correlated with more heterogeneous habitats, including some proportion of sand, coral, and algal cover. Abundance and species diversity of echinoderms are highly influenced by the shelter from predators provided by the habitat, as well as the food resources available (Entrambasaguas et al. 2020). *Holothuria atra* has a crucial 'close cycling' mechanism where phosphorus and nitrogen are limiting for primary production (Lee et al. 2008).

Extent of utilization of sea cucumbers

Local gleaners identified common sea cucumbers, their habitat, and uses (Table 4). According to the survey, most species can be consumed and are commonly collected. Gatherers do not have size preference and harvest all consumable sea cucumbers regardless of size and species. *Holothuria scabra* and *B. marmorata,* in particular, were more valuable and are sold in markets where they can earn 20 – 50 pesos per cellophane. *Holothuria scabra* generally has higher prices than any other tropical sea cucumbers (Rahman 2014). Aside from consumption, sea cucumber species are also used as traditional Chinese medicine, which is said to treat weakness, impotence, debility of the aged, constipation due to intestinal dryness, and frequent urination (Chen 2004). Sea cucumber fisheries have been widly exploited. Insatiable demand and unsustainable fishery practices are rising, leading to a rapid decline in high-value sea cucumber resources in the Philippines (Quevedo et al. 2013).

Table 4. Socio-economic profile of 20 respondents in Barangay Poblacion, Cortes, Surigao del Sur.

Variables	N	%
Age		
Young (<25 y/o)	1	5
Middle (26-50 y/o)	9	45
Old (>51 y/o)	10	50
Gender		
Male	4	20
Female	16	80
Status		
Married	19	95
Single	1	5
Education level		
Elementary	13	65
High School	7	35
College	0	0
Organization		
None	8	40
PMA	12	60
Occupation		
Fisherman/Gleaner	16	80
Others	4	20
No. of years gleaning		
<5 years	1	5
6-10 years	8	40

Most of the gleaners in this study were elderly females who have only reached elementary level education (Table 4). They consider gleaning as one of their primary sources of living. This coincides with the study in Davao del Sur that most of the gleaners in the place have only attained elementary education; most of them are into gleaning activity for almost ten years, and it serves as their primary source of livelihood (Subaldo 2011). Sea cucumbers were usually handpicked in the intertidal flats during low tide and are best collected during a full moon when number species are plenty. Approximately 1 - 2 kilogram of assorted sea cucumbers can be gathered per harvest. Barangay Poblacion has an organization called Poblacion Mananagat Association (PMA) which manages and preserve their marine ecosystem. According to the gleaners, the organization helps to protect the marine ecosystem from illegal gleaners.

4 Conclusion

Holothuria atra and *S. maculata* were the most abundant species thriving in sandy areas and seagrass beds. They are considered non-commercial value, and gleaners did not find interest in getting them. Sea cucumbers were randomly dispersed in the area and observed in specific habitat composition. Species diversity was low since the area was disturbed by gleaners and fishers, which usually influenced the composition and abundance of sea cucumbers. Sea cucumbers are in demand in the area as it serves as a primary source of food. Although the study area was inside a Marine Protected Area, the presence of illegal gleaners is still rampant, resulting in low

species diversity of sea cucumber. If exploitation continues, sea cucumber species could disappear; productivity of the coastal ecosystems could be affected. Thus, it is recommended that the threatened species be protected and preserved to prevent these species from becoming extinct. An in-depth fishery dependent survey of sea cucumber in the area must be conducted to clarify the status and extent of its fishery. The municipality should create ordinances that will protect the sea cucumber resources in the area for the recovery of this critical commodity.

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