Species density and diversity of sea cucumber along the intertidal zone of Dilakit, Divilacan, Isabela, Philippines

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Abstract. Sea cucumbers are among the most significant marine invertebrate resources, providing livelihood and income to many coastal communities. Divilacan is among the coastal town of Isabela that support the province's need for cheap and sustainable food and livelihood. The study was conducted to assess the status of sea cucumber communities along the intertidal zone of Dilakit, Divilacan, Isabela. The study was specifically carried out in the coralline flats and seagrass beds areas with the use of belt-transect method. Results revealed seven species of sea cucumbers belonging to four families that occurred in the sampling stations. Of the seven species*, Holuthuria leucospilota, Holuthuria scabra, Holuthuria atra, Holuthuria arenicola, Stichopus horrens, Bohadschia marmorata*, and *Synapta maculata*, all were found in both corraline flats and sea grass beds. The density and diversity of the identified species were studied. The most abundant species among the two sampling stations is *S. maculata*. The identified species of sea cucumber were subjected to various indices of diversity: species richness, index of species richness, species diversity, dominance and evenness. Very low richness, diversity, and density were noted in both sampling sites.
Key Words: sea cucumber, abundance, coral reef, sea grass.

Introduction. The municipality of Divilacan is situated in North eastern Isabela which is one of the four coastal municipalities of the province. The town is bounded on the north by the town of Maconacon; on the east by the vast Philippine Sea; on the west by the towns of Tumauini and Ilagan and on the south by the town of Palanan. The municipality lies with geographical coordinates of 17° 3′ 12″ North latitude, 122° 32′ 32″ East longitude. Divilacan, as a coastal area, is blessed naturally with a high variety of sea cucumber that inhabits a wide area of sea grass beds, soft-bottom sediments and coral reefs. Statistically, there are 1,200 species of sea cucumber known worldwide of which approximately fifty species are being exploited (Ram et al 2010). In the Philippines, the presence of approximately 64 species of sea cucumber was reported (Seal 1911), with many species bearing different genus names from the more recent literature. Past studies also showed a significant increase in the number of Holothurids in Philippine waters as mentioned by Domantay (1957), with 99 species, Schoppe (2000), with 100 species, and Olavides et al (2010) with 170 species.

Sea cucumbers are highly nutritious containing a high concentration of proteins, carbohydrates, fats and minerals including some vitamins, in the absence of cholesterol; they are considered as a tonic food (Jiaxin 2003). For the last several years, the country has been a major exporter of the processed sea cucumbers known as Trepang or Beche-de-Mer (Akamine 2002). Sea cucumbers are important resources for coastal livelihood and ecosystems.

Sea cucumbers are now under review by the Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora, due to a high utilization, in order to examine their enlistment as endangered species. The recovery of depleted populations is slow and sporadic. Therefore, information on ecology of sea cucumbers is essential for an efficient and durable management of this resource throughout the world (Kinch 2002; Choo 2008).

This study aimed to assess the species diversity and density of sea cucumbers found along the intertidal zone of Dilakit, Divilacan, Isabela. Specifically, the study seeked to answer the following research problems: the species of sea cucumber; the status of sea cucumber species; physico–chemical characteristics of the coastal waters, regarding dissolved oxygen, temperature, pH, salinity, turbidity, water depth of Dilakit, Divilacan, Isabela. The coastal waters of the Philippines are home to a diverse number of aquatic fauna and flora, especially sea cucumbers. However, a major limiting factor to the progress of research on sea cucumber is the lack of information in diversity, density and importance of sea cucumber along the intertidal zone of Dilakit, Divilacan, Isabela. Thus, the results of the study will provide baseline information on the species density and diversity of sea cucumber abounding in the research area, intended to the academic and research institutions, for further exploration of the potential of locally available sea cucumber. The results may also be used by policy makers as a basis for formulating and implementing guidelines for coastal resources management. Future researchers may also benefit from the results of this study. The data gathered and the methods being used can be very useful for those who are interested to conduct similar research studies.

Material and Method

Research method and design. This study used the descriptive-survey method of research which aimed to describe the density and diversity of sea cucumber species along the intertidal zone of Dilakit, Divilacan, Isabela with field survey as the method of gathering the needed data.

Location of the study. This study was conducted in June 2019 along the intertidal zone of Dilakit, Divilacan, Isabela where the sampling stations for the collection of sea cucumber samples were located (Figure 1).

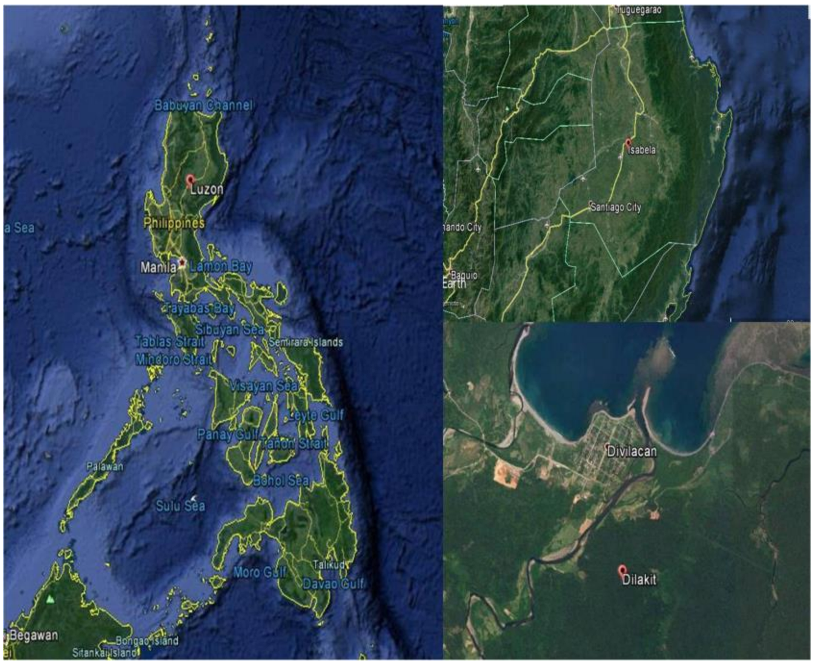

Figure 1. Location of the study at Dilakit, Divilacan, Isabela.

Data gathering procedures. Preliminary assessment was conducted to determine the area where the sampling stations were established, in two habitats, coralline flats and seagrass beds. The reef flats of the area are characterized by the presence of shape-differentiated corals dominated by massive and branching species. The state of coral covers is in poor to medium condition that might be due to intensive utilization of non-environmentally friendly techniques of fishing in the past decades. The seagrass beds are conspicuous features of the area, during the low tide. Substrates are mainly sandy with the presence of coral rubbles and rocks in some preselected sampling sites.

Establishment of stations. The belt-transect method was used in the identification, enumeration and collection of samples from intertidal regions. Two stations representing different habitats were established. At each station, three-belt transects measuring 20 m x 5 m were laid parallel to the shore, at 5 m apart. Representative sea cucumber species were collected for photo-documentation and for identification using a digital camera.

Taxonomic identification. Sea cucumber was identified based on (Purcell et al 2012). Sampled individuals were identified according to their local, English, and scientific names, and family.

Determination of species' diversity and density. The following formulas were used in the determination of species density and diversity:

Density. Density was computed using the formula (Olavides 2010):

$$D = ni/A$$

Where:
D - density of a species;
Ni - number of individuals of the i^{th} species;
A - total area sampled.

Species richness. Species richness is simply the number of species in a community. A large number of different species in a habitat represents a higher species richness, and an overall more diverse ecosystem. The following formula is used to calculate a species richness.

$$SR = TS/A$$

Where:
R - species richness;
TS - total number of species;
A - the total area.

Index of species richness*.* Margalef's index was used as a simple measure of species richness (Margalef 1958):

$$Ma = (S-1)/In(N)$$

Where:
Ma - Margalef index;
S - species richness;
In - natural logarithm.

Species diversity. The degree of uncertainty of predicting the species of a random sample is related to the diversity of a community. If a community has a low diversity (dominated by one species), the uncertainty of prediction is low; a randomly sampled species is most likely going to be dominant species. However, if diversity is high, uncertainty is high. The diversity index was calculated by using the Shannon – Wiener diversity index (1949).

$$H' = -\Sigma\ Pi \log Pi$$

Where:
H' - index of species diversity;
Pi - proportion of total sample belonging to the i^{th} species (ni/N);

ni - number of individuals of the i^{th} species;
N - total number of individuals of all species.

Dominance. Simpson's index (Simpson 1949) is a weighted arithmetic mean of proportional abundance and measures the probability that two individuals randomly selected from a sample will belong to the same species. Since the mean of the proportional abundance of the species increases with decreasing number of species and increasing abundance of the most abundant species, the value of *D* obtains small values in data sets of high diversity and large values in data sets with low diversity.

$$D = \sum pi^2$$

Where:
D - Simpson index;
pi - proportion of total sample belonging to the i^{th} species (ni/N).

Evenness. Species evenness refers to how close in numbers each species in an environment is. For calculating the evenness of species, the Pielou's Evenness Index (e) was used (Pielou 1966)

$$E = H'/\ln(S)$$

Where:
E - evenness index;
H' - diversity index;
S - species richness or the number of species.

Water quality analysis. Important physico-chemical parameters such as water pH, turbidity/transparency, salinity, temperature and dissolved oxygen (DO) were determined in situ. The temperature, dissolved oxygen, pH and salinity were measured by using the YSI 556 MPS dissolved oxygen meter and the turbidity by using Secchi disc.

Results

Species composition. The assessment revealed seven species of sea cucumber, belonging to three families occurring in the intertidal zone of Dilakit, Divilacan, Isabela. *Stichopus horrens, Holothuria scabra, Holothuria atra, Holothuria leucospilota, Bohadschia marmorata, Holothuria arenicola, Synapta maculata* species (shown in figures 2 to 8, respectively) were recorded in both sampling areas. All of the identified species of sea cucumbers were reported to be widely distributed in the Indo-Pacific region and in the country. *Holothuria* genus dominates the community of sea cucumbers in the intertidal zone of Dilakit, Divilacan, Isabela. However, a comparison of the presence of species between seagrass beds and coralline reef flats showed an interesting baseline for further researches. Based on the findings, species identified in the coral areas were also observed and taken from the seagrass beds, indicating that sea cucumbers can thrive in a wide range of habitats and substrates. However, species reported that are common only in shallow areas are found in greater numbers than those living in deeper coral areas. Coralline reef flats and seagrass beds are interconnecting areas. The result implied that sea cucumbers migrate between the two habitats for some reasons such as food availability, and spawning, despite the substrate differences. According to studies, sea cucumbers in coral reefs play an important role in recycling nutrients and in maintaining their productivity (Uthicke & Klumpp 1997). The sea grass beds' productivity, structure and ecological function could remain intact in presence of the sea cucumbers (Wolkenhauer et al 2010). The identified sea cucumber species inhabiting along the intertidal zone at Dilakit, Divilacan, Isabela is presented in Table 1.

Table 1

Taxonomic classification of identified sea cucumber species

Family	*Scientific name*	*English name*	*Local name*
Stichopodidae	*Stichopus horrens*	Warty sea cucumber	Hanginan
Holothuriidae	*Holothuria scabra*	Golden Sandfish	Kaki
Holothuriidae	*Holothuria atra*	Black sea cucumber	Black beauty
Holothuriidae	*Holothuria leucospilota*	Shy black cucumber	Utin kabayo
Holothuriidae	*Bohadschia marmorata*	Marbled sea cucumber	Lawayan
Holothuriidae	*Holothuria arenicola*	Sand sea cucumber	Patola
Synaptidae	*Synapta maculata*	Snake sea cucumber	Bar- barikis

Figure 2. *Stichopus horrens* Selenka 1867.

Kingdom: Animalia
Phylum: Echinodermata
Class: Holothuroidea
Order: Aspirochirotida
Family: Stichopodidae
Genus: *Stichopus*
Species: *horrens*
English name: Warty Sea cucumber
Local name: *Hanginan*

Diagnostic features. Coloration is highly variable, from grey to beige to dark red, dark brown or black with different colored blotches dorsally. In India, it may be greenish-brown. Dorsal surface lightly arched with long and conical, or wart-like, papillae mostly in two rows along the upper dorsal surface and a row of larger papillae along the lateral margins of the flattened ventral surface. This species is relatively small. Numerous, large podia occur on the ventral surface. The mouth is ventral, with 20 tentacles.

Figure 3. *Holothuria scabra* (Jaeger 1833).

Kingdom: Animalia
Phylum: Echinodermata
Class: Holothuroidea
Order: Aspirochirotida
Family: Holothuridae
Genus: *Holothuria*
Species: *scabra*
English name: Golden sandfish
Local name: *kaki*

Diagnostic features. In the Pacific Ocean and Southeast Asia, it can be black to grey or light brownish green, sometimes with greyish-black transverse lines. In the Indian Ocean, it is usually dark grey with white, beige or yellow transverse stripes. The ventral surface is white or light grey with fine, dark spots. The body is oval; arched dorsally and moderately flattened ventrally. The dorsal surface has deep (3 mm) wrinkles and short (1.5 mm) papillae. The body is often covered by fine muddy-sand. The mouth is ventral with 20 small, greyish, tentacles. The anus is terminal with no teeth and no Cuvierian tubules (Purcell et al 2012).

Figure 4. *Holothuria atra* (Jaeger 1833).

Kingdom: Animalia
Phylum: Echinodermata
Class: Holothuroidea
Order: Aspirochirotida
Family: Holothuridae
Genus: *Holothuria*
Species: *atra*
English name: Black Sea cucumber /lollyfish
Local name: *Black beauty*

Diagnostic features. Uniformly black and body is commonly covered with medium-grain sand, with characteristic bare circles in two rows along the dorsal surface. Tentacles are black. The anus is terminal, without teeth or papillae. Cuvierian tubules are absent. This species can also be distinguished by the reddish dye released from its body wall when rubbed (Purcell et al 2012).

Figure 5. *Holothuria leucospilota* (Brandt 1835).

Kingdom: Animalia
Phylum: Echinodermata
Class: Holothuroidea
Order: Aspirochirotida
Family: Holothuridae
Genus: *Holothuria*
Species: *leucospilota*
English name: Threadfish/Shy black sea cucumber
Local name: *Utin kabayo*

Diagnostic features. The body is black, elongated and somewhat broader in the posterior half. The body tapers moderately at both anterior and posterior ends. Long podia and papillae are randomly distributed on the dorsal surface. Ventral podia are numerous. The tegument is sometimes covered by fine sediment and mucus. The mouth is ventral with 20 large black tentacles. The anus is terminal, and this species ejects thin, long Cuvierian tubules. Juveniles have a similar appearance to adults (Purcell et al 2012).

Figure 6. *Bohadschia marmorata* (Jaeger, 1833).

Kingdom: Animalia
Phylum: Echinodermata
Class: Holothuroidea
Order: Aspirochirotida
Family: Holothuriidae
Genus: *Bohadschia*
Species: *marmorata*
English name: Marbled Sea cucumber
Local name: *Lawayan*

Diagnostic features. Normally tan with large brown blotches on the dorsal surface. Ventral surface is white to cream color. *Bohadschia marmorata* is a small to moderate-sized species with a cylindrical body, flattened ventrally and tapering at both ends. It has a very slippery texture. The ventral surface is with long slender podia, prominent on the lateral margins. The anus is large and nearly dorsal. Juveniles are light olive green with darker green blotches, which camouflage them in seagrass beds. It may or may not readily eject cuvierian tubules, depending on the region (Purcell et al 2012).

Figure 7. *Holothuria arenicola* (Semper 1868).

Kingdom: Animalia
Phylum: Echinodermata
Class: Holothuroidea
Order: Aspirochirotida
Family: Holothuriidae
Genus: *Holothuria*
Species: *arenicola*
English name: Sand Sea cucumber
Local name: *Patola*

Diagnostic features. Their coloration is cream to rusty tan. Some individuals are quite orange, becoming whitish towards either the mouth or anus. The ventral surface is yellowish-white with two rows of relatively large, dark brown, spots. *Holothuria arenicola* is a small species. The body wall is relatively thin but is very rough to the touch. It has no cuvierian tubules (Purcell et al 2012).

Figure 8. *Synapta maculate.*

Kingdom: Animalia
Phylum: Echinodermata
Class: Holothuroidea
Order: Aspirochirotida
Family: Synaptidae
Genus: *Synapta*
Species: *maculata*
English name: Snake Sea cucumber
Local name: *bar-barikis*

Diagnostic features. *S. maculata* is a long, slender sea cucumber with fifteen tentacles, growing to a length of about 2 m (7 ft) (Cannon & Silver 2017). Although not the heaviest or bulkiest sea cucumber in the world, it is probably the longest, with individuals exceptionally reaching to over 3 m (10 ft). Its coloring is variable, consisting of yellowish-brown nuances with wide longitudinal stripes and patches of darker color. The spicules (microscopic calcareous spike-like structures that support the body wall) are large and shaped like anchors and are used in locomotion; they can be as long as 2 mm. The spicules are adhesive, and the sea cucumber is very difficult to detach from a wetsuit.

Density. The result on the density of sea cucumbers in identified sampling sites is presented in Table 2. *S. maculata* was the most commonly encountered and most abundant species in the area during the assessment. This was followed by *H. eucospilota, S. horrens, H. atra, H. scabra, B. marmorata. H. arenicola* had the lowest density in the area.

Table 2

Density of sea cucumber species along the intertidal zone of Dilakit, Divilacan, Isabela

Species	*Sampling areas*			
	Coralline flats		*Seagrass beds*	
	F	*n(i)/m²*	*F*	*n(i)/m²*
Holothuria leucospilota	81	0.27	62	0.21
Holothuria scabra	11	0.04	20	0.07
Holothuria atra	43	0.14	31	0.10
Holothuria arenicola	10	0.03	13	0.04
Synapta maculata	139	0.46	198	0.66
Bohadschia marmorata	5	0.02	23	0.08
Stichopus horrens	79	0.26	65	0.27
Total	368	1.22	412	1.43
Mean	53	0.17	59	0.20

Diversity. The study investigates the diversity pattern of sea cucumber assemblages along the intertidal zone of Dilakit, Divilcan, Isabela through the simultaneous analysis of 3 major components of diversity (1) species richness, (2) Margalef index of species richness, (3) species diversity, (4) Simpson index of dominance, and (5) evenness, (Table 3).

Table 3

Diversity of sea cucumbers along the intertidal zone of Dilakit, Divilacan, Isabela

Species	*Sampling areas*						Total
	Coralline flats			*Sea grass beds*			
	1	2	3	1	2	3	
Holothuria leucospilota	30	23	28	19	19	24	143
Holothuria scabra	3	3	5	8	5	7	31
Holothuria atra	17	12	14	12	7	12	74
Holothuria arenicola	7	2	1	3	3	7	23
Synapta maculata	37	45	57	42	94	62	337
Bohadschia marmorata	4	1	0	5	7	11	28
Stichopus horrens	25	32	22	21	18	26	144
Total	123	118	127	110	153	149	780
SR		7			7		
Ma		1.01			0.99		
H’		1.543			1.54		
D		0.25			0.28		
E		0.795			0.79		

Physico-chemical parameters. The study recorded important water quality parameters such as pH, dissolved oxygen, salinity and temperature. The results show that all the recoded water quality parameters in the two sampling areas were found to be within the normal levels (Table 4).

Table 4

Physico-chemical parameters of the sampling stations

Stations		Mean DO	Mean salinity	Mean temperature	Mean pH
Seagrass beds	1	7.25	25.79	30.01	8.15
	2	6.92	26.32	30.25	9.05
	3	8.02	26.85	31.03	9.68
Coralline flats	1	7.68	27.56	32.29	8.56
	2	7.18	29.09	31.89	7.08
	3	7.32	29.02	31.75	8.15

Discussion. The richness of species in the area is very low compared to nearby areas. In intertidal zones of Aurora, a total of 15 species of sea cucumber had been reported by Cañada et al (2020). This is may be due to the various anthropogenic activities in the study area, like an improper waste disposal from the residential areas. Coastal areas are the interface between water draining from inland river basins and the oceans, and can therefore receive high concentrations of natural and anthropogenic materials, including minerals, soils, nutrients and organic matters. These wastes largely affect the species diversity, abundance and biomass, and structure of the benthic community (Müller et al 1995). Margalef index has no limit value and it shows a variation depending upon the number of species. Thus, it is used for comparison of the sites and takes only one component of diversity (species richness) into consideration, reflecting the sensitivity to sample size. The only advantage of this index is that we can compare the richness of different study sites (Kocatas 1992). In the present investigation, the values of Margalef diversity index were 1.01 and 0.99 in coralline flats and seagrass beds, respectively. A higher index in a lower number of individuals could be due to a disparity in the sampling procedure, such as in the effort and spatial variation. Regarding the Shannon-Weiner diversity, both sampling areas were noted to have a value of 1.543 and 1.54. Shannon-Weiner diversity index varied from 0 to 3.5. Rarely the values exceeded 3.5. Almost comparable values obtained may relate to the observed species richness between sampling areas.

The result may suggest that sea cucumber communities were able to thrive in both ecosystems and also indicating a regular movement of the species from one area to another. Another reason is that early life stages of sea cucumbers are planktonic in nature. Their larvae could be distributed by current in different areas until they will reach the settlement stage. The evenness of distribution among species was noted higher in coralline flats than in seagrass areas, with values 0.795 and 0.793, respectively. A higher evenness was obtained to sea coralline flats due to the higher number of *S. maculata*. However, these values are both closer to 1, implying that sea cucumber populations are uniformly distributed both habitats. Regarding the dominance, the Simpson index varied at the two sampling locations with 0.25 in coral reef flats and 0.28 in seagrass beds. Simpson index ranges from 0 to 1. However, this index assigns a more important weight to the common or dominant species. So far, no article has been published on the population of sea cucumbers in Isabela, to be compared with the results of this study.

Habitat type. Two stations, representing different habitats, were established. Station 1 was mainly covered by seagrasses *Cymodocea*, *Halodule*, *Thalassia* and *Enhalus*. The substrates ranged from sandy to silty. Station 2 is a coralline area that has 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.

Water quality parameters. Physico-chemical parameters were recorded such as pH, Dissolved Oxygen, salinity and temperature. Dissolved oxygen and temperature levels in the two sampling areas were found to be within the normal levels. Salinity levels were recorded to be within the range for marine water. According to Esteves (1998) most marine environments exhibit pH values ranging from 6 to 8, which is also true for the results in this study. The present study's observations suggest there is already a need for any management intervention on the sea cucumber resources of Divilacan, Isabela. The resource situation unveiled in this study will serve as a baseline that should be used for proper program/project preparation and implementation. Hence, the following are recommended: the local governments Divilacan, Isabela should organize venues for coastal activities such as clean-up campaigns. Further investigations should be conducted particularly on the species identification based on spicules.

Conclusions. Based on the findings of the study, there were only 7 species of sea cucumbers present in the area during the study. The species composition in both habitats was identical. Species diversity is lower than in nearby areas, showing that a limited number of species can be found in the area. The density of sea cucumbers is very low, indicating an overexploitation in both coralline flats and seagrass bed areas of Dilakit, Divilacan, Isabela.

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Conflict of interest. The authors declare no conflict of interest.

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