

# Species Distribution, Diversity, and Abundance of Sea Cucumbers in Tropical Intertidal Zones of Aurora, Philippines

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## Abstract

The distribution, diversity, and abundance of sea cucumbers in intertidal zones of Aurora were studied from February to June 2013 to obtain baseline data. A one-hour timed-search survey covering an approximate one kilometer over a ten-meter wide area was conducted in six coastal municipalities to obtain a comprehensive list of sea cucumber species found in the zones. Only four sampling stations (Baler, Dipaculao, Dilasag, and Dingalan) were selected for belt transect survey, 50 × 50 m, based on the availability of coral-line, sandy, muddy sand, and rocky habitats which were laid perpendicular and parallel to each intertidal zone. Timed-search survey revealed a total of 15 species of sea cucumbers distributed among two Orders (Order Aspidochirotida and Order Apodida) and four Families (Family Holothuriidae, Family Stichopodidae, Family Synaptidae, and Family Chirotidae) were recorded. *Synapta maculata* is most common and has widespread distribution. Belt-transect surveys showed *Holothuria leucospilota* is among the most frequently occurring species both during day time (58%) and night time (75%). The Dilasag sampling station had the most diverse species (0.71) while the Dipaculao sampling station had the densest species of *Holothuria leucospilota* (10,014 in-ha<sup>-1</sup>) and abundant (95.91%) species.

## Keywords

Sea Cucumber, Distribution, Diversity, Abundance, Intertidal Zone

## 1. Introduction

Sea cucumbers are marine animals that live from nearshore habitats to the greatest depths. These are known as *beche de mer* or trepang when dried or

processed and are valued for their different economic uses (e.g. delicacy, traditional medicine, source of protein and fatty acids, antiviral, antitumoral and anticancerous, etc.) [1] [2]. The expanding international markets for these species ranked the Philippines as the 2<sup>nd</sup> major producer and exporter in the world, 2<sup>nd</sup> to Indonesia, with catches of around 20,000 tonnes (live) per year [3].

In the Philippines, sea cucumber collection forms part as source of livelihood for coastal communities. Collections were usually done in shallow waters but the increase in demand for these species resulted in the collection of smaller size conducted in deeper waters [4] [5]. These obvious signs of stock depletion due to fishing pressures have led to the issue of species extinction before a particular sea cucumber will be recorded.

In Aurora, anecdotal records revealed that sea cucumber trade already exists in the province in the late 60's and yet there is no inventory of species ever been conducted nor data on its distribution, diversity and abundance been recorded. Therefore, there is the need to create a baseline database for sea cucumber resources in the province before a particular sea cucumber will become extinct. This serves bases for the formulation and implementation of sustainable management strategies.

This study was conducted to provide baseline data on the species distribution, diversity and abundance of sea cucumber in the intertidal zones of Aurora, Philippines. This provided a list of sea cucumber species and their distribution through timed-search survey; determined the diversity and abundance of sea cucumber species through transect survey; and evaluated the population structure of the intertidal sea cucumber resource.

## 2. Materials and Methods

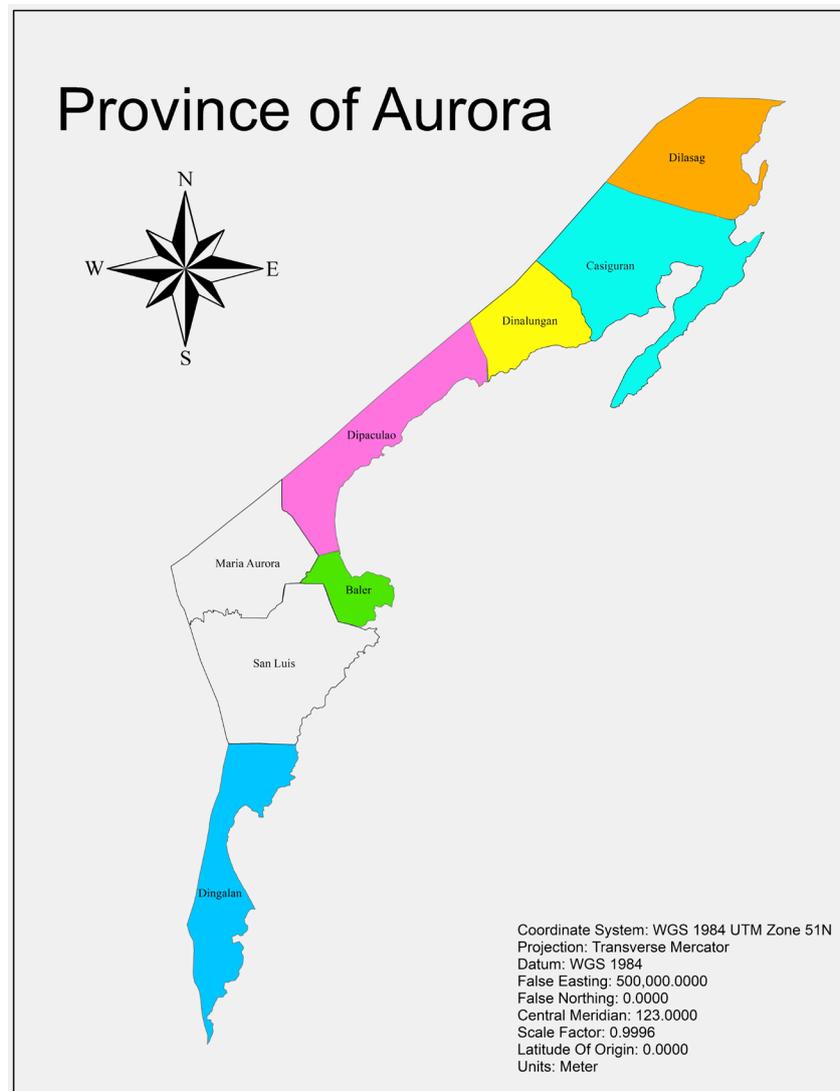
### 2.1. Timed-Search Survey

A preliminary survey was conducted in six intertidal zones (Baler, Dipaculao, Dinalungan, Casiguran, Dilasag, Dingalan) (**Figure 1**). A one-hour timed search method covering a distance of approximately 1 km over a 10-m wide area was employed to obtain a complete list of intertidal species.

All species encountered during a one hour walk were photographed (ventral and dorsal sides) *in situ* using Canon PowerShot D20; weighed up to the nearest gram using a digital weighing scale; measured for the total body length (from mouth to anus) and maximum width up to the nearest cm; identified based on external morphology (body shape, types and number of tentacles and arrangement of papillae and podia), and identification keys [5]; counted and listed on a field notebook.

### 2.2. Belt Transect Survey

Four sampling stations were selected out of the six intertidal zones surveyed based on the presence of seagrass beds, varied substrates (coralline, sandy, muddy sand and rocky) within a station and availability of wide intertidal zone



**Figure 1.** Location of the study sites in colored parts.

for the establishment of belt transects. One sampling station each in the towns of Baler, Dipaculao, Dingalan and Dilasag was established.

Three replicates of 500 m<sup>2</sup> belt transects were laid perpendicular and parallel to the intertidal zone, 10 meters apart, covering a total of 1500 m<sup>2</sup> per sampling station. Each belt transect was surveyed by four observers going along in one direction parallel to its length. All sea cucumber species found inside were photographed, measured, identified, counted and listed on the field notebook. Representative samples for each species were collected and preserved.

All surveys were conducted during the months of February to June 2013 once on day time and once on night time during the lowest tide. The GPS coordinates of each intertidal zone were taken for mapping purposes using Garmin Etrex-10.

### 2.3. Data Analysis

The following formulae were used in the analysis of data:

The species frequency was obtained from the index ( $C$ ):

$$C = \frac{P}{N} \times 100 \quad (1)$$

where:

$P$  = number of quadrats containing the species.

$N$  = total number of quadrats.

The species diversity was computed using Simpson's Diversity Index ( $D_s$ ):

$$D_s = \frac{\sum n_i (n_i - 1)}{N(N - 1)} \quad (2)$$

where:

$n_i$  = number of individuals of the species.

$N$  = total number of individuals in the sample.

The population density per species was calculated based on the index ( $D$ ):

$$D = \frac{n_i}{A} \quad (3)$$

where:

$n_i$  = total number of individuals per species.

$A$  = total area covered in hectares.

The relative abundance per species was based on the index (%  $Ab$ ):

$$\% Ab = \frac{D}{\sum D} \quad (4)$$

where:

$D$  = population density per species.

$\sum D$  = the sum total of all population densities of all species.

### 3. Results and Discussion

#### Species Distribution, Diversity, and Abundance

A one-hour timed-search survey conducted in six intertidal zones of Aurora recorded a total of 15 species of sea cucumbers distributed among two Orders (Order Aspidochirotida and Order Apodida) and four Families (Family Holothuriidae, Family Stichopodidae, Family Synaptidae and Family Chirotidae). The scientific name, English name, local name and economic value of these species are included in **Table 1**.

Most of the species were found in Dilasag (12 species) and Dipaculao (9 species) where both habitats are rich in seagrass beds, muddy sand, rock crevices, corals and coral rubbles which are preferred habitat for sea cucumbers. This is similar with the results obtained in other intertidal zones in the Philippines where most species can be found in seagrass rich habitat [4] [6].

There was only one species found in newly established marine protected area (MPA) in Dingalan with habitat composed of dead corals, coral rubbles, rocks, and very few scattered surviving patches of seagrasses. The number of species in

**Table 1.** Sea cucumber species found in intertidal zones of Aurora.

Scientific Name	Local Name	Distribution	Habitat	Economic Value
<b>Order Aspidochirotida</b>				
<b>Family Holothuriidae</b>				
<i>Holothurialeucospilota</i> Brandt	Balatuwak	Baler, Dipaculao, Dinalungan, Casiguran, Dilasag, Dingalan	Crevice, muddy sand with seagrasses	L-M
<i>Holothuriacoluber</i> Semper	Patola	Dinalungan	Tidal pool	M
<i>Holothuriahilla</i> Lesson	Rotong	Casiguran, Dilasag	Crevice and seagrass beds	VL
<i>Holothuria impatiens</i> Forskal	Sunlot	Dilasag	Seagrass beds	NC
<i>Holothuriafuscocinerea</i> Jaeger	Labuyo	Dilasag	Seagrass beds	L
<i>Holothuria sp.</i>	Rotong	Dipaculao, Dilasag	Seagrass beds	L
<i>Holothuriascabra</i> Jaeger	Putian	Dipaculao, Dilasag, Dingalan	Seagrass beds	H
<i>Holothuriaatra</i> Jaeger	Itiman	Baler, Dipaculao	Sand and coral rubbles	L-M
<i>Actinopygaechinites</i> Jaeger	Khaki	Dipaculao, Dilasag	Sand and coral rubbles	H
<i>Bohadschiakoellikeri</i> Semper	Lawayan	Dipaculao, Dilasag	Seagrass beds	M-H
<i>Bohadschia sp.</i>	Lawayan	Dipaculao, Dilasag	Seagrass beds	M-H
<b>Family Stichopodidae</b>				
<i>Stichopushorrens</i> Selenka	Hanginan	Dipaculao, Dilasag	Coral rubbles, sand and seagrass beds	H
<i>Stichophus sp.</i>	Hanginan	Casiguran, Dilasag	Coral rubbles, sand and seagrass beds	H
<b>Order Apodida</b>				
<b>Family Synaptidae</b>				
<i>Synaptamaculata</i> Chamisso and Eysenhardt	Uod	Dipaculao, Dinalungan, Casiguran, Dilasag, Dingalan	Seagrass beds, muddy sand, coral rubbles	VL
<b>Family Chiridotidae</b>				
<i>Chiridotid sp.</i>	Uod	Dilasag	Seagrass beds	NC

Based on Olavides 2010: H (high) = P1000 - 4000/kg, M (medium) = P500 - 1000/kg, L (low) = P100 - 500/kg, VL (very low) ≤ P100/kg; NC (non-commercial).

this MPA was less than the species found in open access areas such as in Dinalungan (3 species), Baler (2 species) and Casiguran (3 species) which have combinations of habitat e.g. tidal pools, coral rubbles, sand, boulders, rock crevices

and patches of seagrasses.

The number of species found in intertidal zone of Aurora comprises 15% of the 100 species found in the Philippines [5]. This is fewer than those found in taxonomic studies conducted in other parts of the country [4] [7] [8]. However, this present study does not include species that could be found in deeper waters. It would also be worthy to emphasize that two species (*Holothuria scabra* and *Stichopus* sp.), which are listed during the 2002 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) as threatened species, are still present in Aurora.

The frequency data of the species obtained from transect surveys revealed that *Holothurialeucospilotawas* present in all sampling stations. This species was most frequently occur-ring both during the day (58%) and night (%) (Table 2). Most sea cucumber species especially the Holothuriidae family are nocturnal thus it can be noted that only few were found during the day.

The presence of most number of species in Dilasagis attributed to the varied habitat in the area since different species prefer specific habitat [9]. In addition, the presence of few species in Dingalan could be due to the coral rubble substrate with very few to almost none surviving patches of seagrasses.

The species diversity was computed based only on the data obtained during the night time transect survey. Table 3 showed that the station with the most diverse species was Dilasag (0.71) while Dipaculao (0.01) had the least. Although there were three species found in Dipaculao compared with Baler (2 species) and Dingalan (2 species), the enormous population of *Holothurialeucospilota* as compared to *Bohadschia koellekeri* and *Bohadschia* sp. lowers the species diversity

**Table 2.** Sea cucumber species found per sampling station during transect surveys.

Species Name	Baler (rock crevices and seagrass beds)		Dipaculao (rock crevices, seagrass beds, muddy sand)		Dilasag (rock crevices, seagrass beds, muddy sand, coral rubbles)		Dingalan (rock crevices, very few patches of seagrasses, muddy sand, coral rubbles)		Species Frequency (%)	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
	<i>Holothuria leucospilota</i>	+++	++	+	+++	+	+	++	+++	58
<i>Holothuria hilla</i>						+			0	8
<i>Holothuria fuscocinerea</i>						+			0	8
<i>Holothuria scabra</i>		++		++				+	0	41
<i>Bohadschia koellekeri</i>							+++		0	25
<i>Bohadschia</i> sp.				+					0	8
<i>Stichopus horrens</i>							+++		0	25
<i>Synapta maculata</i>			++	++	+	+++			25	41
<i>Chiridotid</i> sp.							+		0	8

+++ = three transects 500 m<sup>2</sup> each.

**Table 3.** Species diversity ( $D_s$ ) of sea cucumbers per sampling station.

Species Name	Baler (rock crevices and seagrass beds)		Dipaculao (rock crevices, seagrass beds, muddy sand)		Dilasag (rock crevices, seagrass beds, muddy sand, coral rubbles)		Dingalan (rock crevices, very few seagrasses, muddy sand, coral rubbles)	
	N	n (n - 1)	N	n (n - 1)	N	n (n - 1)	N	n (n - 1)
<i>Holothuria leucospilota</i>	9	72	1506	2,266,530	2	2	17	272
<i>Holothuria hilla</i>	0	0	0	0	3	6	0	0
<i>Holothuria fuscocinerea</i>	0	0	0	0	3	6	0	0
<i>Holothuria scabra</i>	2	2	0	0	0	0	1	0
<i>Bohadschia koellekeri</i>	0	0	8	56	23	506	0	0
<i>Bohadschia sp.</i>	0	0	1	0	0	0	0	0
<i>Stichopus horrens</i>	0	0	0	0	4	12	0	0
<i>Synapta maculata</i>	0	0	0	0	9	72	0	0
<i>Chiridotid sp.</i>	0	0	0	0	2	2	0	0
<b><math>\Sigma n(n - 1)</math></b>		<b>74</b>		<b>2,266,586</b>		<b>606</b>		<b>272</b>
<b>Total (N)</b>		11		1515		46		18
<b>Species Diversity (<math>D_s</math>)</b>		<b>0.33</b>		<b>0.01</b>		<b>0.71</b>		<b>0.11</b>

value. The large population of *Holothuria leucospilota* has increased the probability that two species randomly gathered in Dipaculao sampling station will belong to this same species.

The Dilasag sampling station revealed five species with low to high economic values and two species of non-commercial to low economic values. This is because of the presence of seagrass beds, coral rubbles, rock crevices and muddy sand habitats. These habitats served as shelter and source of food for several species. In addition, these species which were small were spared from gathering since most of the sea cucumber gatherers in this area prefer larger size species collected from open waters through skin diving and compressor diving.

The density and percent abundance for each species per sampling station showed that *Holothuria leucospilota* both in Dipaculao (10,014 ind·ha<sup>-1</sup>, 99.09%) and Dingalan (113 ind·ha<sup>-1</sup>, 94.96%) and *Bohadschia koellekeri* in Dilasag (153 ind·ha<sup>-1</sup>, 50.1%) is high (Figure 2). Low densities and % abundance of *H. leucospilota* was observed in Baler (60 ind·ha<sup>-1</sup>, 82.19%), *B. koellekeri* in Dipaculao (53 ind·ha<sup>-1</sup>, 0.52%) and *Synapta maculata* both in Dilasag (113 ind·ha<sup>-1</sup>, 19.6%) and Dipaculao (33 ind·ha<sup>-1</sup>, 0.33%).

The density of all other species in all sampling stations ranges from 0 to 26 ind·ha<sup>-1</sup> (Figure 2). Although the density of some species is low (less than 100 ind·ha<sup>-1</sup>) it is still alarming that most of the sea cucumber species were within the critical level (less than 30 ind·ha<sup>-1</sup>) for the population to reproduce [10] and

may imply fishing pressures within the sampling stations. It would be worthwhile to note that sea cucumbers have late maturity, density-dependent reproduction and low rates of recruitment such that even without fishing pressure it would take 50 years to rebuild an overexploited fishing grounds [3].

The high density of *Holothuria leucospilota* in Dipaculao (10,014 ind·ha<sup>-1</sup>) as compared to recorded data in Madagascar (5000 ind·ha<sup>-1</sup>) [9] can be attributed to the rich seagrass beds, muddy sand substrate with coral rubble and rock crevices with algae which are preferred habitat for this species (Figure 2). Aside from this, the low economic value may have spared this species from fishing pressures allowing them to reproduce in the area.

Pooled results for all sampling stations revealed that *H. leucospilota* had a high level of density and % abundance (2556 ind·ha<sup>-1</sup>, 95.91%) while *B. koellekeri* falls within the category of low level density (51 ind·ha<sup>-1</sup>, 1.91%) (Figure 3). The rest of the species were within the critical level. In the absence of fishing pressures, sea cucumbers may occur on Indo-Pacific reef flats at densities

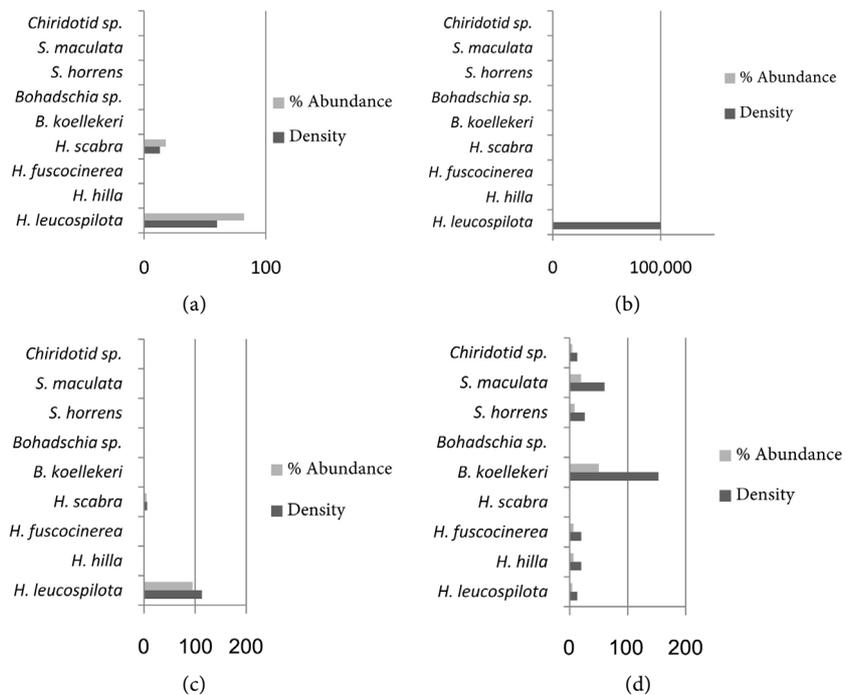


Figure 2. Density (*D*) and relative abundance (%) of sea cucumber per species in (a) Baler; (b) Dipaculao; (c) Dilasag; (d) Dingalan.

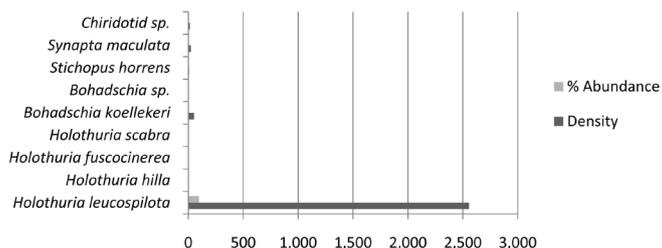


Figure 3. Pooled density and relative abundance (%) per species in all sampling stations.

over 35 per square meter or 350,000 ind·ha<sup>-1</sup> [3]. The data obtained in this study, therefore, show an obvious overexploitation of sea cucumber resources in the province.

#### 4. Conclusion

Based on these results, the following conclusions are drawn: The intertidal zones of Aurora contain a variety of sea cucumber species with economic value, most of the sea cucumber species found in Aurora belong to Family Holothuriidae which are nocturnal species and are of high to medium economic value; Dilasag sampling station has the most diverse species because of its wide habitat rich in seagrass beds, coral rubbles and rock crevices; threatened species, *Holothuria scabra* and *Stichopus* sp. are present in Aurora but their density is in the critical level to repopulate, the Dipaculao sampling station showed *Holothuria leucospilota* as the densest and most abundant species because of rich seagrass beds, algae, coral rubbles and rock crevices which are preferred habitat for this species, and the low density and abundance of species with high to medium economic value (*Holothuria atra* and *Stichopus horrens*) imply a low rate of recruitment of these species.

#### 5. Recommendation

For a more comprehensive inventory of sea cucumber species found in Aurora waters, the following are recommended: The inventory must include species found in deeper waters, and sampling for 12 months must be conducted to cover all species that were juvenile during the conduct of this study and were obscured from view within sediments, crevices and corals.

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#### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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