Density, Abundance, and Distribution of Sea Cucumbers in Belize

Densidad, Abundancia y Distribución de los Pepinos de Mar en Belice

Densité, L'abondance et la Distribution des Concombres de Mer au Belize

ARLENIE ROGERS
Environmental Research Institute, University of Belize, Belmopan City, Belize C.A.
In collaboration with the Belize Fisheries Department, Belize Audubon Society, and
Toledo Institute for Development and Environment

ABSTRACT

The high demand for sea cucumbers in Asian markets and the increasing need for alternative livelihoods in Belize led to the creation of a new fishery. This paper assesses the socioeconomics, population structure, distribution, and abundance of two species of sea cucumber (*Isostichopus badionotus*, and *Holothuria mexicana*). Sea cucumbers have been fished in Belizean waters for the past 20 years but legally only since 2009. It is now a popular fishery where 13% of respondents noted sea cucumber fishing as their primary fishing activity. With a Total Allowable Catch of 182,750 pounds per annum, the rush has created new markets and prices. Although fishers know very little about the sea cucumbers, they noticed a decrease in catch and the need to travel farther to fish. To assess the density, abundance and distribution, 32 randomly selected sites along the coast of Belize were surveyed in 2012. Mean length was 20.5 cm for *H. mexicana* and 22 cm for *I. badionotus*. Mean adult weight was 562 g for *H. mexicana* and 346 g for *I. badionotus* while body wall data for *H. mexicana* was 487 g. The largest number of individuals ranged from 170 - 300 cm for *H. mexicana* and 140 - 220 cm for *I. badionatus*. A total of 124 *H. mexicana* individuals and 108 *I. badionatus* were quantified, with mean densities of 12.9 and 1.8 ind./ha, respectively. We estimated a total stock or abundance of 6,840,159.76 individuals of *H. mexicana* and 1,117,978.41 individuals of *I. badionotus*; at 7,318970.9 pounds of *H. mexicana*.

KEY WORDS: Belize, density, abundance, distribution, sea cucumber

INTRODUCTION

Sea cucumbers are fished in several countries around the world. Very famous in the Asian continent for its delicacy, it is processed in North America (USA and Canada), Central America (Belize, Guatemala, Honduras, Nicaragua and others) and South America (Peru, Chile and others) and some of the Caribbean islands (Bahamas, Bermuda, Cuba, Haiti and others) for export to these markets. Species previously and or currently harvested in the Mexico, Central and South American region include *Actinopyga agassizi, Holothuria mexicana, H. impatiens, H. theelii, H.atra, H. kefersteini, H.inornata, H. arenicola, Isistochopus badionotus, I. Fuscus, Isostichopus mulitifidus, Athyonidium chilensis, Pattalus mollis, Parastichopus parvimensis and Stichopus horrens* (Guzman and Guevara 2002; Toral-Granda and Martinez 2008). Hendler and Pawson (2000) report 18 species present in the Rhomboidal Cayes of Belize, including, *Holothuria impatiens, Euapta lappa, Holothuria thomasi, Isostichopus badionatus, Actinopyga agassizi, Holothuria mexicana, Euthyonidiella destichada, Isostichopus macroparentheses, , Holothuria cubana, Holothuria floridana, Holothuria arenicola, Leptosynapta nannoplax, Synaptula hydroformis, Leptosynapta imswe, Chiridota rotifer, Ocnus suspectus, Pseudothyone belli and Thyone pseudofusus*.

Several studies have been conducted on the reproductive biology, population structure, density, abundance and distribution of sea cucumber in the region. Each species is unique and has different length and weight at maturity. The population structure, density and abundance however, are heavily dependent on the level of exploitation in each country. In Belize, the fishery was opened in 2009 with a Total Allowable Catch (TAC) of 250,205 pounds (lbs.). In 2010 and 2011 the TAC was set at 110,000 lbs. and 182,750 lbs. respectively. It remained at 182,750 lbs. in 2012 and in 2013. The fishing season is from January 1 to June 31. The fishery however is closed at any month during the open season once the TAC is met. Only 70 fishers are granted fishing licenses every year while 5 - 7 exporters are granted sea cucumber exporting licenses (James Azueta, Belize Fisheries Department, personal communication).

The first phase of this project was to conduct a socioeconomic assessment of the fishery. The second phase was to conduct an assessment of the density, abundance, distribution and population structure. The latter the first assessment attempt carried out along the entire coast of Belize. The results of this study will assist the Government of Belize in deciding the future of the sea cucumber fishery in Belize.

MATERIALS AND METHODS

A total of 124 *H. mexicana* and 108 *I. badionotus* were collected in Mango Creek in Southern Belize between the months of January-June, 2011. Sea cucumbers were placed in cold sea water and left for 10 seconds until completely relaxed in order to facilitate measurements (Laboy-Nieves and Conde 2006). Length was measured for both species as well as body wall weight from gutted individuals of *H. mexicana* (sensu Conand 1981, Chao et al. 1993, 1995; Guzman, et al, 2003). To measure body wall weight, gonads were extracted by making two incisions through the ventral body wall and removing all internal parts. To assess the population abundance and distribution, sampling sites were identified in a 1:50 000 scale map. The map was divided into 6 areas based on the Belize Fisheries Department identified fishing areas. These are labeled as areas 1-6; Turneffe, Lighthouse, Glovers, Bacalar Chico to Belize City; Belize City to Gladden Spit and Gladden Spit to Sapodillas respectively. In each area, a total of 6 sites were selected to be surveyed inside Marine Reserves and non-protected areas using stratified random sampling. These sites were selected based on habitat preference for *H. mexicana* and *I. badionotus*. In each site, four replicate belt-transects of 30 m x 5 m were run perpendicular to the coast, totaling a sample of 21,600 m^2 (2.16 ha). Transects were separated from each other as a necessary measure to ensure independence between samples as required for statistical analysis. In each transect, data were collected on species of sea cucumber encountered, depth where they are found, number of sea cucumbers encountered, the estimated total length of sea cucumber in a relaxed state, time of the day and time spent on transect. Descriptive information on habitats where each species was found was also gathered. All data were collected simultaneously by different dive teams between May and June, 2012. Specimens were collected, preserved in methanol and adequately labeled. The density distribution of all the species was mapped using Geographical Information System (GIS). Density was obtained by calculating D using the formula:

$$D = \frac{\Sigma n_i}{\Sigma a_i} = \frac{N}{A}$$

Where:
D = density
Ni= individuals found in transect i
Ai = area surveyed in transect I (in ha)
A = total area surveyed
N = total number of individuals found

All data sets were analyzed using non parametric statistics. Spearman Rank Order Correlation analysis was used to test for relationship between biometric variables (body weight and size). ANOVA tests were used to compare density differences between areas and Tukey tests to compare density differences among areas and habitats.

RESULTS

Population Structure

Size differed between the two species (*sig.* 0.043 < 0.05); *H. mexicana* had a mean length of (SE ±) 20.5 cm (range: 11-30 cm) and *I. badionotus* a mean length of (SE ±) of 22 cm (range: 17-30cm). Mean adult weight also differed between species (*sig*. 0.00 < 0.05); *H. mexicana* had a mean weight of (SE ±) 562 g (range: 173-2,387 g) and *I. badionatus* a mean weight of (SE ±) of 346 g (range: 224 g - 576 g). Body wall data was collected for *H. mexicana* only because this species is the most abundant and the only one that is commercially exploited (hence, stock biomass was calculated for *H. mexicana* only). Mean body wall weight for *H. mexicana* was 487 g. The relationship between body wall weight and size was significant (Figure 1).

Size distribution was bimodal for *H. mexicana* (median of 19 cm; Figure 2) and *unimodal for I. badionatus* (median of 20.3 cm; Figure 3). The largest number of individuals ranged from 12 - 17 cm and 27 - 32 cm for *H. mexicana* and 17 - 22 cm for *I. badionatus*. Body wall weight distribution for *H. mexicana* was bimodal, with a greater number of individuals between 250 - 350 g and 550 - 650 g; median of 458 g and mean of 487 g (Figure 4).

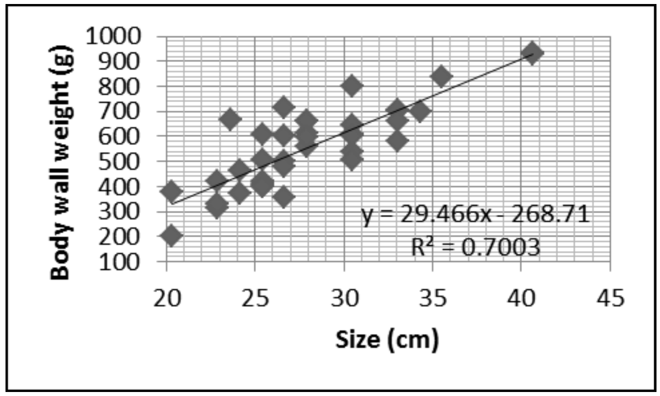

Figure 1. Relationship between body wall weight and size of *H. mexicana*.

Population Distribution and Abundance

Sampling sites were heterogeneous and contained different biological communities and habitats; 25% consisted of patch reef, 30% consisted of dense sand and seagrass beds, 25% consisted of sand and sparse seagrass beds, 15% consisted of seagrass beds along with coral rubble and 5% of sparse seagrass beds near shore. *I. badionotus* was found in sand and sparse seagrass beds (10 ind./ha);

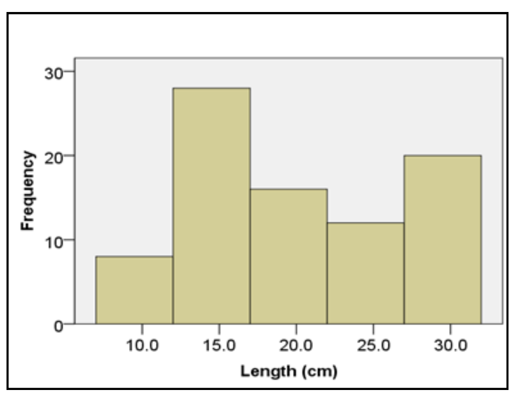

Figure 2. Size distribution for *H. Mexicana.*

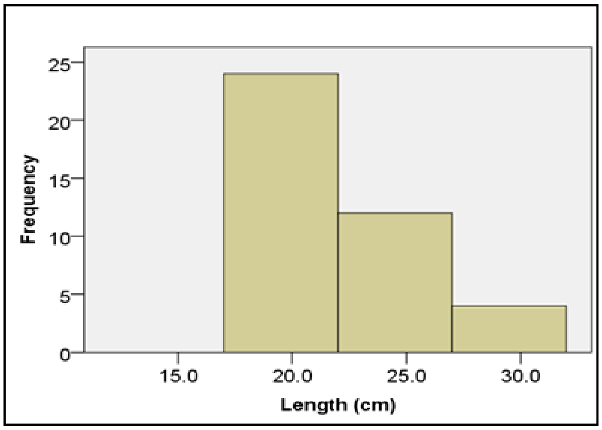

Figure 3. Size distribution for *I. badionotus*

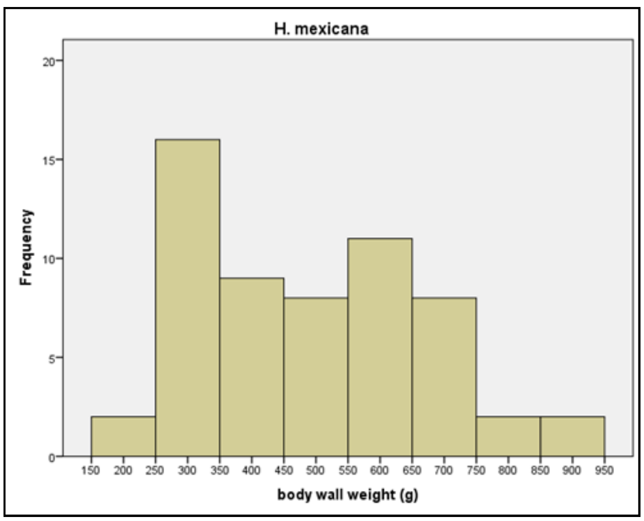

Figure 4. Body wall weight distribution for *H. mexicana.*

seagrass and coral rubble (50 ind./ha); and sparse seagrass near shore (16.7 ind./ha). There was a significant difference in density in these three habitats ($p < 0.0001$). Population density also varied significantly among habitat types for *H. mexicana* ($p < 0.0001$) including sand and sparse sea grass beds (60 ind./ha), sand and dense sea grass beds (110 ind./ha); seagrass and coral rubble (333 ind./ha); patch reef (33 ind./ha) and sparse seagrass nearshore (36.9 ind./ha). Density also varied significantly among areas for both species. *I. badionotus* was recorded in Area 1 (38.9 ind./ha); Area 2 (97.2 ind./ha) and Area 6 (27.8 ind./ha). Whereas *H. mexicana* was recorded in Area 1 (38.9 ind./ha); Area 2 (97.2 ind./ha); Area 4 (11.1 ind./ha); and Area 6 (241.7 ind./ha). *H. mexicana* was the most abundant among habitats and areas surveyed. Based on the total area of suitable habitat type, it was absent in 48% of the total habitat area surveyed. Based on area, it was absent in 59% of the total surface. On average, *I. badionotus* had lower densities than *H. mexicana* and a larger area of absence. It was absent in 64.2% of the total habitat area surveyed and in 57.4% of the total surface area. We found a total of 140 individuals of *I. badionotus* and 20 individuals of *H. mexicana* in 2.16 stratified randomly sampled hectares, with average densities of 56.9 ind./ha and 9.3 ind./ha, respectively. By extrapolating the data gathered to the total worked area with suitable shallow habitats along the coast of Belize (120,213.7 ha), we estimated a total stock or abundance of 6,840,159.76 individuals of *H. mexicana* and 1,117,978.41 individuals of *I. badionotus*.

Other Species Recorded in this Study

During this study, other species that were documented included *Isostichopus badionotus, Actinopyga agassizi, Holothuria Mexicana, Holothuria impatiens, Holothuria thomasi, Holothuria floridana, Euapta lappa*, and *Astichopus multifidus*.

DISCUSSION

Socioeconomic surveys conducted among sea cucumber fishers and non-sea cucumber fishers reveal that both *H. mexicana* and *I. badionotus* are harvested although the Belize Fisheries Department allows the harvest of *H. mexicana* only. These surveys also reveal that *I. badionotus* has higher economic value than *H. mexicana*. Although only 13% of fishers noted sea cucumber fishing as their primary fishing activity, this fact clearly demonstrates the value placed on this new fishery. Fishers noted to have fished for sea cucumbers for the past 20 years but legally only since 2009. The socioeconomic results also indicated that the need to find secure markets and quality beche-de-mer is a shortcoming for the local fishers. Fishers noted that although it is a relatively new fishery, they are not faced with lower catches and the need to travel farther to fish.

The bimodal population structure of *H. mexicana* was mainly composed of individuals of 12 - 17 cm and 27 - 32 cm. In Florida, the reported minimum length at maturity for *H. mexicana* was 57.9 and 75.7 cm for males and females respectively (Engstrom 1980). Whereas in Panama, the reported minimum length at maturity for *H. mexicana* is 30 - 50 cm (Guzman et al, 2003). The unimodal population structure of *I. badionotus* was mainly composed of individuals of 17 - 22 cm. In Venezuela, the minimum length at maturity for *I. badionotus* is reported to be 18 cm (Rodriguez-Milliet and Pauls 1998) and 45 cm in Panama (Guzman et al. 2003). In terms of body wall weight, the bimodal distribution for *H. mexicana* showed mainly individuals of 250 - 350 g and 550 - 650 g. The observed minimum weight of reproduction for both species was 50 - 100 g in Panama (Guzman et al. 2003). The reproductive cycles for any of the two species in Belize to determine the actual length and weight at maturity and spawning activity have not been studied. Therefore, the results of this study cannot determine the actual length or weight at maturity for any of the species. If compared to the data collected for Florida and Panama, it can be suggested undersized individuals are being fished. The fishing season was open in 2011 and in 2012 when this study was carried out. This may have also affected the population structure reported. The densities reported are considerably lower when compared to those reported in Panama (who banned the fishery in 1997 and is now in recovery); 161.8 ind./ha for *H. mexicana* and 117.4 ind./ha for *I. badionotus*. For *H. mexicana*, the mean weight of 487 g is equivalent to 1.07 pounds and the current stock is estimated at 6,840,159.76 individuals. The total estimated stock therefore is 7,318970.9 pounds of *H. mexicana*. The Total Allowable Catch (TAC) is 182,750 pounds per annum. If this TAC is maintained, the current stocks may support the fishery for another a few number of years; this abundance estimate discounts new recruits, reproductive success, predation, and fishing.

The most abundant species was *H. mexicana* in Area 6. Area 6 is an interesting area as sediments and nutrients from major watersheds are transported by the rivers and creeks in Southern Belize into the sea. These sediments dictate the distribution of marine habitats (CZMA/I, 2013) and their corresponding organisms. Detritus feeders like sea cucumbers depend on these sediments. The fact that four major rivers; Monkey River, Deep River, Rio Grande and Moho River and a number of streams empty into this area may be the reason for the abundance of sea cucumber in this area. Freshwater runoff from the karst hills in Southern Mexico, Eastern Guatemala and the Maya Mountains of Southern Belize, discharge into the coastal lagoons and inner channel between the shoreline and the barrier reef (Clarke et al. 2013). This facilitates exchange of sediments and other suspended materials that are needed to maintain ecosystem functions (Clarke et al. 2013, Siegel et al. 2002).

CONCLUSION AND RECOMMENDATIONS

The results of this study indicate that very few species exist in the areas studied. The results also indicate that the commercially exploited species are not abundant. Several factors may have impacted these results. For instance, this study was carried out prior to the closing of the sea cucumber season. Furthermore, the fishery was opened since 2009 and this study was conducted between 2011 and 2012. We recommend that a study on the reproductive cycle of the commercial species be conducted, including *H. Mexicana, I. badionotus, A. agassizi, H. impatiens* and *H. arenicola*. Although reproductive cycle studies have been completed in Panama, Florida, and Venezuela, in tropical waters as Belize the cycle may not be the same. We also recommend adopting the precautionary principle and learn from our neighboring countries that have banned the fishery. Belize must consider sustainable ways of harvesting sea cucumber such as sea cucumber culture.

ACKNOWLEDGEMENTS

I want to express our tremendous appreciation to the Belize Fisheries Department, the Belize Audubon Society and the Toledo Institute for Research and Development for their full support and collaboration in this research effort. I want to thank the Environmental Research Institute of the University of Belize for funding this study, in particular to Dr. Leandra Cho-Ricketts for her patience and continuous guidance. I want to thank the University of Belize for supporting this research effort. Tremendous appreciation goes to the Belize Fisheries Department for all the assistance provided, particularly to Mr. Isaias Majil, Mr. Adriel Castaneda, Mr. Lyndon Rodney, Mr. Carballo, Edward Bochub, Mr. Rudolph Williams, Mr. Clayton Gabourel, Mr. Victor Vasquez, Mr. Marvin Nunez, Mr. Henry Brown, Ms. Alicia Ek and Ms. Kirah Forman. We give special thanks to the University of Belize Faculty Mr. Santos Chicas, Ms. Sylvia Noralez, Mr. Gertrudez Velasquez and Mrs. Shirlene Savery for their help with data analysis and GIS maps. Special thanks to the fishers of the coastal fishing communities of Belize. I highly value the spirit of volunteering from the Environmental Research Institute staff and University of Belize student volunteers: Mr. Allan Romero, Ms. Jenelle Grifith, Mr. John Romero and Ms. Monique Lamb under the leadership of Marine Biologist, Ms. Jani Salazar.

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