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Assessment and Valuation of Commercially Important Bivalves and Gastropods within the Seagrass Beds of Laguindingan, Misamis Oriental and Rizal, Zamboanga del Norte, Philippines

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ABSTRACT

A study was conducted to assess the abundance and value of commercially important bivalves and gastropods within the seagrass beds of Laguindingan, Misamis Oriental and Rizal, Zamboanga del Norte, Mindanao, Philippines. The line transect method was used to assess the diversity of the bivalves and gastropods within the seagrass beds and coring was used in collecting sediment samples. Laguindingan was categorized as undisturbed site, while Rizal as disturbed site. The results identified three families of gastropods in undisturbed and thirteen families in disturbed, comprising a total of seven bivalves and six gastropods. *Cyprea* sp. Dominated in undisturbed area, while *Anadara inequivalves* dominated in disturbed area. The diversity index in disturbed (1.57) was greater than in undisturbed (0.88) probably due to high organic matter (2.56ppm) compared to the undisturbed area (1.92ppm). Ironically, the total volume of bivalves and gastropods production in disturbed area was higher at19.84 kg compared with2.23 kg in undisturbed. In terms of total monetary value, the undisturbed production could yield PHP 22,672.32 (USD 466.48) in an approximated area of 165 ha, while PHP 422,130.50 (USD 8,685.37) in 326 ha in the disturbed area. The study revealed that higher diversity resulted in higher production with greater monetary value derived from bivalves and gastropods in disturbed area contributed by higher organic load. Protection and management of the seagrass beds is likely most needed in both disturbed and undisturbed are as to support not only a robust but also a healthy production of shellfish fit for human consumption.

INTRODUCTION

Marine fisheries are important sources of income and livelihood (Barut et al., 2004) particularly of more than a million Filipinos living in coastal areas (Luna et al., 2004; Molluscs have been part of the lives of most people in coastal areas. Studies pertaining to molluscs come with a long history since the fourth century BC where, luxury and high-status products were made from molluscs. There were shells that were commercially valued not for its meat but for its exoskeleton, and were believed to be exported for commercial purposes, including *Crassotrea tigres, Strombus. canarium, C. queranus*, *C. leopardus* and *C. litteratus*. As food, molluscs area good source of calcium (Tabugo et al., 2013).

Seagrasses provide conditions for the growth and abundance of invertebrate sand fish that many local coastal communities collect and catch for their livelihood. Seagrass ecosystems are sources of food and yet they are continually threatened by human activities, causing their degradation and possible habitat loss (Bujang et al., 2007). Bivalves and gastropods are some of the most abundant species in the coastal ecosystem, especially the sea-grass community. They perform a significant role in the cycle of nutrients in the coastal waters. These animals are generally filter feeders which feed on organic particles and microorganisms suspended in the water. Their waste materials are deposited in the substrate which will then be absorbed by marine plants like sea-grasses. Bivalves are also prey for food fishes like flounder and cod (Ward and Shumway, 2004).

Bivalves and gastropods are widely distributed throughout the tropical waters. In many countries of Asia and the Pacific, it is a tradition to collect naturally occurring molluscs as a cheap source of food (Davy and Graham, 1982). In 1977, high production of oysters, mussels, cockles and clams were reported from many countries including the Philippines where the export earnings from shell production are PHP 850 million (Young and Serna, 1982). Despite their potential as a source of livelihood in Laguindingan, Misamis Oriental and Rizal, Zamboanga del Norte, there is limited information regarding their conservation and protection in these areas. So, the objective of the study is to assess the abundance and value of commercially important bivalves and gastropods in terms of actual costing of production within the seagrass beds of Laguindingan, Misamis Oriental and Rizal, Zamboanga del Norte, Mindanao. This can serve as a basis for strengthening the management and regulation policies for restoration and conservation of seagrass beds in the selected sites of Mindanao.

MATERIALS AND METHODS

Sampling area

The study was conducted in the southern part of the Philippines, Mindanao. There were two sites selected for the assessment and valuation study of commercially important bivalves and gastropods within the selected seagrass beds. The reference sites were considered as major gathering grounds for both traditional and commercial bivalve and gastropod gatherers based on local information. Furthermore, the disturbance of the area was determined on the basis of population and anthropogenic activities.

The first site encompassing the seagrass beds of Tubajon, Languindingan, Misamis Oriental (08°38'N, 124°27'6"E), has an estimated area of 165ha of seagrass beds. It is a fourth-class municipality in the province of Misamis Oriental. It has a population of 24,405 according to the 2015 census. This site was designated as an undisturbed area because the site is a marine protected area (MPA). It is characterized by its clear–water non-estuarine with relatively pristine condition, grown with mixed seagrass species in continuous distribution (Arriesgado et al., 2016). The area has a mangrove reforestation project and has established a Marine Protected Area with a strict no-take-zone policy (Uy, 2001). This area is one of the few extensive mixed seagrass meadows in this part of the country.

Another site was Rizal, Zamboanga del Norte (8°35'N, 123°32'E). It is subdivided into 22 barangays with an approximate total population of 14,021. This site is considered as disturbed area with an estimated seagrass bed of 326 ha (Fig. 1). The area is being anthropogenic with the existing operations of mines. Aquaculture establishments and related activities are observed in neighbouring towns specially Sibutad, Zamboanga del Norte. Tributaries and effluent sled to pressure and disturbances on the seagrass habitat characterized by white sandy area to rocky substrate. The area can be totally exposed to sunlight during lowest low tide (FAO, 2011).

Establishment of sampling station

Human impact in the seagrass beds includes harvesting of bivalves by digging. This has been done extensively in Rizal, which is characterized as a disturbed area. On the other hand, the site in Laguindingan is undisturbed and is categorized as a marine protected area (MPA). Three sampling stations were established in the disturbed area (Rizal) and undisturbed area (Laguindingan). Line transect method was used in the study following (English et al., 1997) (Fig. 2). The sites were chosen based on the presence of high diversity of seagrass species.

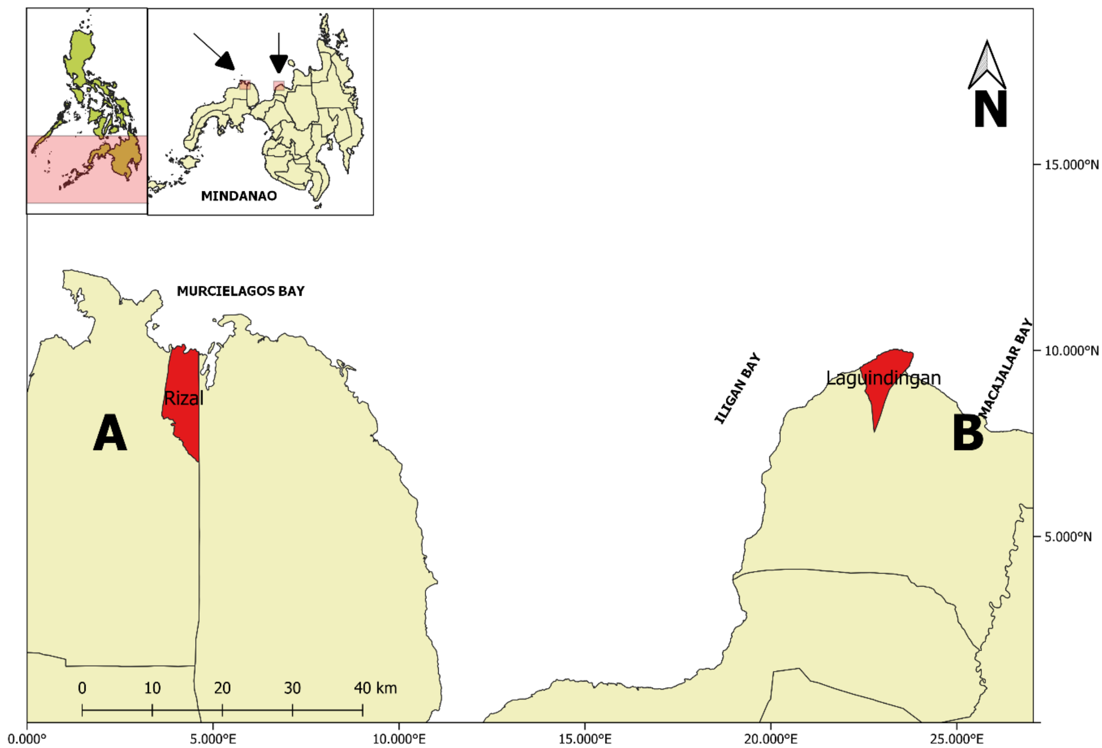

Figure 1. Location of the study sites. (A) Laguindingan, Misamis oriental (undisturbed area) and (B) Rizal, Zamboanga del Norte (disturbed area).

Collection of samples

Collection of samples was done through one shot sampling during low tide in the established station spanning the disturbed and undisturbed sites. All commercially considered bivalves and gastropods found within the transect line were counted. Percent covers of seagrasses were also determined. Samples of gastropods and bivalves were placed in the clear white bond paper for identification and documentation.

Physico-chemical parameters measurement

Water temperatures were measured using the thermometer and water salinity using a refractometer. Sediment samples were collected for organic matter using corer and placed into the plastic bags and were transported to MSU-Naawan laboratory for analysis.

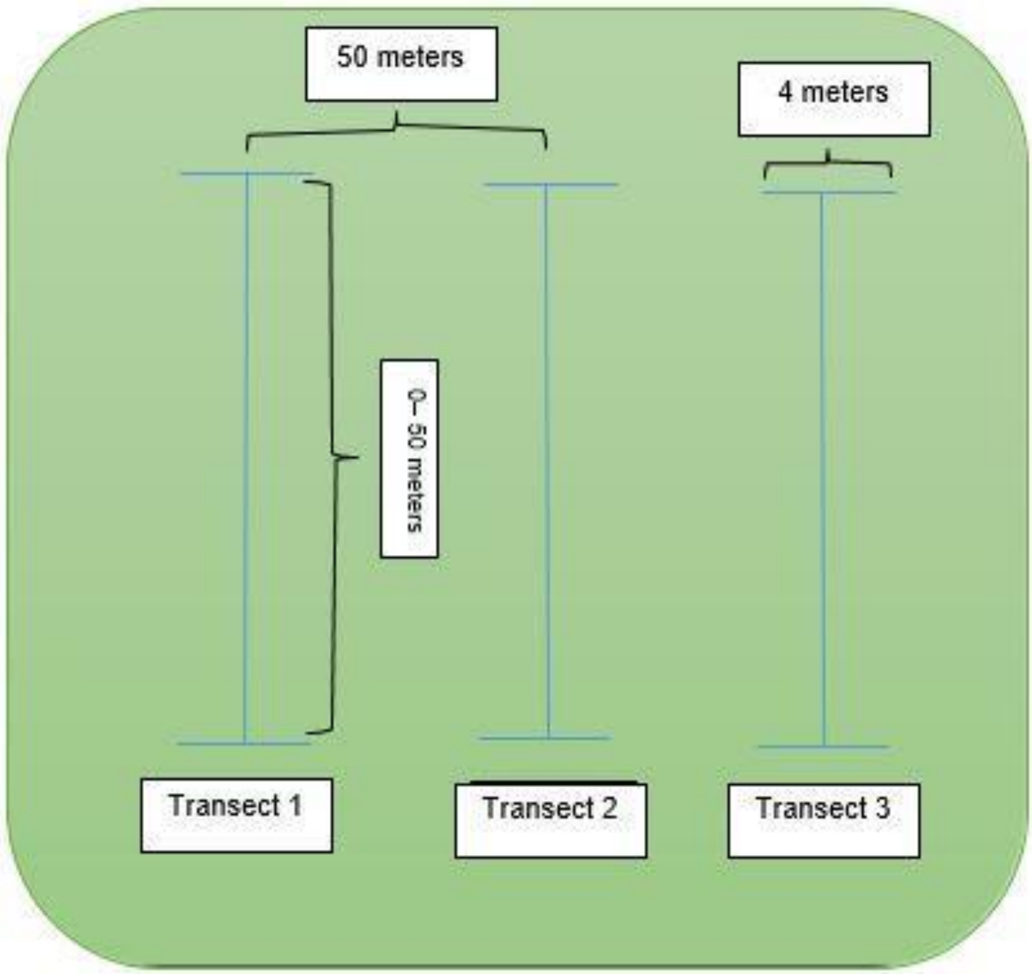

Figure 2. Establishment of sampling station.

Sand particle size analysis

Every ten (10) meters along the transect, the core was used to collect sand, until it reached 50meters. The grain size characteristics of the sediments were determined based on the system used by the United States Department of Agriculture (USDA), wherein the mesh size of 250μm will be categorized as silt and <2μm will be categorized as clay. In determining the percentage values of grains size, 100g of air-dried sediment were sieved by using a series of sieves (850, 710, 180, 150, 75, and 45 μm) shaken for five (5) minutes by a sieve shaker. The amount of sediment type in each sieve was weighed by using a weighing scale to determine the substrate composition and substrate type (Table 1). The percentage value calculated by using the formula:

$$G.S. = \frac{Ws}{W} \times 100\%$$

Where: G.S. (%) is grain size by percentage

W is the weight of the sampled sediment

Ws is the weight of the sediment in each sieve size

Table 1. Udden-Wentworth scale used to categorize grain size fractions.

Sieve Number	Size	Category
10	2mm	Very coarse sand
20	850µm	Coarse sand
25	710µm	Coarse sand
80	180µm	Fine sand
100	150µm	Fine sand
325	45nm	Clay
Pan	<45	Silt

Statistical Analysis

Abundance and relative abundance

The bivalves and gastropod abundance were estimated based on the number of individuals of every species found. These were determined by counting and recording the number of individuals per species in every sample.

Relative abundance of bivalves and gastropods were measured using the formula (Shanon-Wiener Index).

$$Relative\ Abundance = (Number\ of\ individual/species/Total\ number\ ) \times 100$$

The following useful indices of species diversity in a community were used (Odum, 1971).

a. Shanon-Wiener Index of general diversity (H)

$$H' = -\sum_{i=1}^{S} (Pi * LNPi)$$

Where:

H' = the Shannon diversity index

Σ = sum from species 1 to species S
Pi = fraction of the entire population made up of species i
S = number of species encountered

b. Pielou Evenness index (e)

$$e = \frac{H}{ln ln\, S}$$

Where *H* is the Shannon-wiener index and *S* is the number of species.

c. Dominance index (C)

$$C = \sum \left(\frac{ni}{n}\right)$$

Where *ni* is the importance value of each species. *n* is the total importance value of all species.

These formulas were connected to each other. The Shannon-Wiener index used to assess the diversity. Then, the Pielou evenness index used to assess the even distribution of the bivalves and gastropods. Lastly, the dominance index was used to identify if there were really bivalves or gastropods dominated in an area.

Valuation of bivalves and gastropods species in seagrass bed

Valuation was done based on the actual price of the bivalves and gastropods within the seagrass beds to know the total production in both areas. In addition, the price of the bivalves and gastropods were based on the market price of the certain area. Valuation was measured per square meter, per two hundred square meters and a total area of a certain site. Thus, the production and the value of the samples were based on the actual sampling data in the area.

RESULTS AND DISCUSSION

Percent cover of seagrass beds

The percent cover of seagrasses in the disturbed (Rizal) and undisturbed (Laguindingan) sites are presented in (Fig. 3). Seagrass percent cover in the undisturbed area was greater than the disturbed area. The diversity of gastropods increases as the composition of the seagrasses increases (Tan et al., 2007). Edgar and Roberston (1992) reported that the removal of epiphytes from seagrass leaves would reduce seagrass density, thus decreasing the abundance and diversity of the gastropods dependent on them. Local improvements in water clarity induced by filter-feeding bivalves can promote the spread of eelgrass, especially to depths where light would otherwise be limiting (Dennison et al., 1993). Secondary data revealed that seagrass bed in Laguindingan is dominated by *Thalassia hemprichii* (63.6% cover) with 4.3% *Enhalus acoroides* (Honda et al., 2013). Berkman International (2011) identified four seagrass species in Rizal, namely: *Thalassia hemprichii, Enhalus acoriodes, Cymodocea serrulata,* and *Syringodium isoetifolium,* with highest percent cover attributed by *T. hemprichii* (60.3%).

The Seagrass ecosystem is one of the productive ecosystems in the coastal area playing important roles in various marine life. It physically acts as abrasion barrier and ecologically as shelter for various biota, provides various types of food and becomes nursery ground for marine biota, such as crustaceans, polychaetes, echinoderms, molluscs (bivalves and gastropod) and fish, both juveniles and adults (Coles et al., 1993; Belgacem et al., 2013).

Bivalves and gastropods species composition

During sampling, no bivalve was found in the undisturbed area, probably due to very scattered distribution of bivalves. Moreover, the existence of bivalves depends on the kind of substrate. Sometimes shell gatherers use a “bolo” or spade to dig shells out of the substrate, others use pieces of wire for drawing the shells out of the holes in the sediment (Schoppe et al., 1998). They used bolo just to gather bivalves. In this study only ocular survey was done.

While seven species were identified in the disturbed area (Table 2), four species of gastropods were found in the undisturbed area while eight species were identified in disturbed area. Three families were identified in the undisturbed area and thirteen families were found in the disturbed area. *Cyprea* sp. in the undisturbed has the highest count of individuals. On the other hand, *Anadara inequivalves* has the highest count in the disturbed area.

Sediment type is one of the parameters that indicate the presence of the bivalves and gastropods. The disturbed area is characterized by sandy clay loam. The undisturbed seagrass bed is characterized by sandy-muddy. The sediment type of undisturbed area was also identified by (Balili et al, 2010) as sandy-rubble and sandy-rocky.

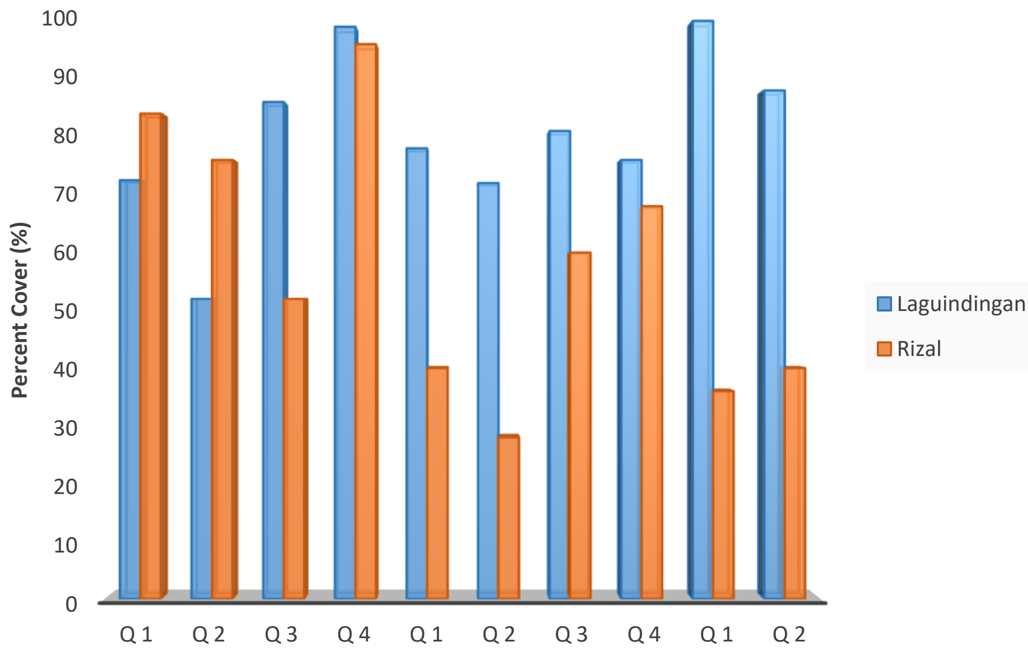

Figure 3. Percent cover of seagrasses in Laguindingan, Misamis Oriental and Rizal, Zamboanga del Norte.

Bivalves may have seemed living in a stationary life, of which they move sedentary in an erratic environment. Due to their dominance and abundance in the seagrass bed, contributing large biomasses in an area, and active filtration of large volumes of water, the net impact of their bioturbation and bio-irrigation activities on the system are considerable (Jackson et al, 2001; Vaughn and Hakenkamp, 2001; Jaramillo et al., 2007; Petersen et al., 2008).

Moreover, the juveniles of most soft-sediment bivalves live at or close to the sediment surface and move successively deeper into the sediment as they grow. Burrowing depth depends on siphon length (Zwarts and Wanink, 1989) and bivalves with short siphons live just underneath the sediment surfaces e.g. hard clams (*Mercenaria mercenaria*), while species with longer siphons maybe buried up to 40 cm down in the sediment (e.g. soft-shelled clams, *Mya arenaria*) or even 80 cm (Geoducks, *Panopea abrupta*); however, shallow-burying bivalves (such as clams) tend to move more, thereby bioturbating the uppermost sediment layers more than the deep burrowers.

Table 2. List of bivalves and gastropods species found in the seagrass beds of Laguindingan, Misamis Oriental (undisturbed) and Rizal, Zamboanga del Norte (disturbed).

Family	Scientific Name	Local Name	Laguindingan	Rizal
Bivalves				
Cardiidae	*Corculum* sp.	litob	-	/
Arcidae	*Anadara granosa*	solud2	-	/
Arcidae	*Anadara inequivalves*	Litob	-	/
Lucinidae	*Codakia* sp.	Tagnipis	-	/
Ostreidae	*Crasostrea iredalei*	Talaba	-	/
Pectinidae	*Decatopecten* sp.	Tipay	-	/
Placunidae	*Placuna placenta*	Kapiz-Capiz/s	-	/
Isognomonidae	*Isognomon alatus*	Wasay-wasay	-	/
Gastropods				
Muricidae	*Chicoreus* sp.	Baboy-baboy	-	/
Strombidae	*Strombus canarium*	Bongkawil	-	/
Cypraeidae	*Cyprea* sp.	Cowry/sigay	/	/
Strombidae	*Strombus* sp.	Conch	/	-
Pinnidae	*Atrina inflate*	Katupngan	-	/
Naticidae	*Nerita* sp.	Sihi	/	/
Strombidae	*Canarium labiatum*	Sikad	/	/
Trochidae	(unidentified)	Topshell	-	/

Relative species abundance

The most abundant species found in the undisturbed area was *Cyprea* sp. (Cowry) with 63.5 % relative abundance to other species. Only one species, *Canarium* sp. (Sikad-sikad) in the undisturbed area was found to be commercially important. While *Anadara inequivalves* (Litob), was the most abundant species in disturbed area that happened to be of commercial importance. Other species of commercial importance are *Corculum* sp. (Cockle), *Codakia* sp. (Tagnipis), *Magallana* sp.(Talaba), *Decatopecten* sp. (Scallop), *Placuna* sp. (Capis), *Isognomon* sp. (Wasay-wasay), *cichoreus* (Murex), *Strombus* sp. (Bongkawil), *Cyprea* sp. (Cowry), *Atrina* sp.

(Katupngan), *Nerita* sp. (Sihi), *Canarium* sp. (Sikad), *Anadara* sp. (Solud solud) and Top shell.

Anadara inequivalves probably dominated the area because this species prefers to live in a sandy clay loam type of soil. If the substrate is too coarse then it cannot easily burrow and may damage its shell (Cohen, 2005). The reason why this species is rare in Laguindingan is probably on the substrate type which is sandy-clay loam to sandy rubbles. It is remarkable that *Cyprea* sp. is dominating in the undisturbed seagrass bed in Laguindingan indicating pristine and less polluted environment. This area was given the Malinis at Masaganang Karagatan (MMK) Award, an annual search for outstanding coastal communities in the Philippines initiated by the Bureau of Fisheries and Aquatic Resources (BFAR) to promote fisheries protection and conservation in the country (PIA, 2018).

Species diversity

The results of Pielou-Evenness and Shanon indices were greater than the dominance index in both disturbed and undisturbed. It can be noted that both Shannon-Wiener and Evenness indices in this study were inversely proportional to the index of dominance (Table 3). (Odum, 1971), the high value of diversity indicated a low dominance. In terms of diversity, Pielou-Evenness and Dominance indices showed that the disturbed has higher values compared to the undisturbed. For the dominance index, the undisturbed got the higher value compared with disturbed site. One of the plausible factors that contribute to high diversity of disturbed compared to the undisturbed is the organic matter. The organic matter of the disturbed site was 2.56ppm, while for the undisturbed was 1.92ppm (Table 4).

One of the possible reasons why the organic matter in disturbed sites is greater than undisturbed is maybe due to anthropogenic and aquaculture activities. In the disturbed area, a 20-ha fishpond was operating in Balubohan, Rizal with milkfish and prawns as its main cultured species (Campiseño et al., 2011). The waste from aquaculture effluent will most likely meander to the Murcielagos Bay of which seagrass bed in Rizal, Zamboanga del Norte is encompassed without any filtrations. In Laguindingan, no aquaculture establishment and related major aquaculture activity are present in the area. This undisturbed area has been conferred the MMK Award in 2017 (PIA, 2018). The polluted effluents most likely released to the sea will be converted into organic matter, thus less pollution in undisturbed than in disturbed. The greater the organic matter the greater is the diversity, because the organic matter serves as the nutrients for the phytoplankton, most organic matter is respired back to dissolved inorganic forms within the surface ocean and thus recycled for use by phytoplankton (Eppley and Peterson, 1979).

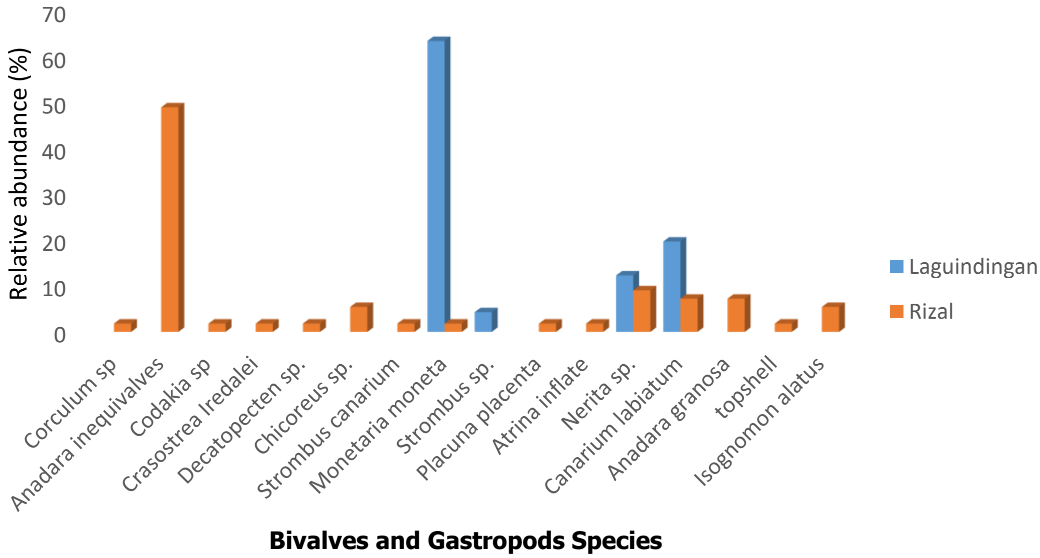

Figure 4. Relative abundance of bivalves and gastropods in the seagrass bed of Rizal, Zamboanga del Norte and Laguindingan, Misamis Oriental.

Table 3. Calculated values of species diversity indices of bivalves and gastropods for every site.

Site/Location	Shannon-Wiener Index	Pielou Evenness index	Dominance Index
Undisturbed	0.88	0.73	0.49
Disturbed	1.57	0.87	0.27

With the presence of phytoplankton, the population of zooplankton will also increase. It was observed that some of the zooplankton attach to the leaves of the seagrass and some will just float to the water. Since most of the bivalves are filter feeders and most of the gastropods are attached to the seagrass searching for food, chances are plankton can easily be filtered in both bivalves and gastropods because of their abundance. According to Macintosh et al. (2002), it is not just grazers but other agents such as predators or any disturbances that prevent competitive dominant species from monopolizing their sources that may possibly affect species diversity in the area. Additionally, algae are found to be evenly distributed, when not one species dominates.

Moreover, Pielou (1966) stressed that the diversity of an area is at a maximum for a given number of species when individuals are distributed evenly among the species. Low diversity results when only a few species occur at greater density. Hence, the greater the productivity, the greater the diversity.

Physico-chemical parameters

The average water temperature in undisturbed area is 31°C while in disturbed is 32°C. The narrow range of temperature between the two sites was perhaps due to sampling time because sampling was done in the noon time in both places. The water pH in undisturbed is 8.3 and 8.5 in the disturbed. Water salinity in undisturbed is 33ppt while 34ppt in disturbed.

Table 4. Physico-chemical parameters in disturbed and undisturbed areas.

Location	Temperature	Salinity	pH	OM
Laguindingan	31	33	8.3	1.92
Rizal	32	34	8.5	2.56

Valuation

Valuing the samples was classified into: 1). Commercial in terms of human consumption and 2). Commercial in terms of cultural and ecological significance. The meat of molluscs forms an essential part of the diet among the coastal people around the country, and for those families who can't afford to buy fish. During certain seasons of the year, weather conditions limit fishing and so gleaning molluscs or ''panginhas" is the only means of livelihood. For example, a great proportion of income of the fishermen is obtained from gathering of molluscs (Alcala and Alcazar, 1984). These are the shells that are exploited for their whole decorative value, used as souvenir items and decorations. Many pacific islanders were using shells as personal ornaments, a form of money, and for ceremonial gatherings. For example, the shell necklaces and bracelets worn by the Solomon and Trobriand Islanders indicate a high rank status among the villagers (Stacey, 1973). The intricacy on a person's ornaments is also a demonstration of his wealth and kind of fertility symbol. Sacred objects such as canoes and fine bowls were also inlaid with Mother-of-Pearl (MOP) and Nautilus shells (Stacey, 1973).

For the volume of production in terms of ecological important species (Table 5), *Atrina* sp. (Katupngan) got the highest volume of production with a total of 6,603.13

(g), while *Nerita* sp. (Sihi) obtained the lowest volume of production. The number of species is directly proportional in relation to the total volume of production. The higher the number, the higher its volume.

Table 5. Production of selected gastropod and bivalve species with ecological importance in Laguindingan, Misamis Oriental and Rizal, Zamboanga del Norte.

Site	Total area (ha)	Species	Volume of production (g)
			Total
Laguindingan	165	*Nerita* sp.	82.50
		Strombus sp.	74.25
		Cyprea sp.	1,514.70
Rizal	326	*Cyprea* sp.	88.02
		Atrina inflata	6,603.13
		Nerita sp.	32.60
		Placuna placenta	2,065.21
		Isognomon alatus	1,013.86

Table 6. Volume of production of the seagrass beds assessed for bivalves and gastropods species in Laguindingan and Rizal seagrass beds.

Site	Total area(ha)	Volume of production(g)			Value (PhP)		
	Sq.m		200 sq.m	Total area	Sq.m	200sq.m	Total area
Laguindingan (Undisturbed)	165	1.36	271.3	2,238.26	0.014	2.75	22,672.32
Rizal (Disturbed)	326	6.09	1,217.46	19,844.61	0.13	25.9	422,130.50

Implications

The ecosystem services provided by the seagrasses greatly help many animals especially bivalves and gastropods that are usually gathered by the gleaners. The Seagrass ecosystem is one of the productive ecosystems in the coastal area playing an important role in various marine life. It physically acts as abrasion barrier and ecologically as shelter for various biotas, provides various types of food and becomes nursery ground for marine biota, such as crustaceans, polychaetes, echinoderms, molluscs (bivalves and gastropod) and fish, both juveniles and adults (Coles et al,.

1993; Belgacem et al., 2013). The decayed vegetative materials and waste from the aquaculture constituted a major source of nutrients for photosynthetic activities of plants such as seagrasses and phytoplankton. Thus, this coastal ecosystem supports and helps their coastal ecosystem together with the organisms that live and depend on it. The greater production and value in Rizal (disturbed) seagrass bed compared to Laguindingan (undisturbed), does not directly imply a productive environment but is indicative that seagrass beds provide income for people living in coastal areas.

CONCLUSION AND RECOMMENDATION

Result on the assessment on the abundance and value of commercially important bivalves and gastropods within the seagrass beds is indicative that species diversity had a significant relationship to the grain sizes in both areas. As for the relationship of organic matter to species diversity, the organic matter in disturbed is greater than in undisturbed, so is the diversity. Based on the results of the study and ocular observations in the area, it is imperative that the higher the organic matter the higher the diversity of bivalve and gastropod species. However, studies should be undertaken in relation to the level of organic load that can support healthy and safe gastropods and bivalves' production. Thus, it has a tantamount measure that the higher the diversity, the higher the production and valuation of a certain area.

We recommend that the seagrass beds be included as an integral part in the coastal management plan of the municipalities of Laguindingan and Rizal and there must be strong implementation of the management of the resources. For instance, proper waste management must be enforced to lessen the waste in the disturbed site to have safe and healthy bivalves and gastropods. Protection and management of the seagrass beds are likely most needed in disturbed areas to support not only a robust but also a healthy production. Similarly, the abundance of bivalves and gastropods in disturbed areas may suggest their important role in regulating organic load and possibly pollution, because one of the studies on bivalves in the disturbed area of Rizal, Zamboanga del Norte had shown a higher bacteria load as compared to Laguindingan, Misamis Oriental. Moreover, providing alternative livelihood to the coastal community is deemed necessary to avoid the exploitation of resources in the seagrass beds in order to maintain the ecological diversity of an area. We also recommend: 1.) Follow up study after six months or one year, 2.) Filtration rate studies of bivalves for areas that are polluted, 3.) Use core method to include bivalve samples at a certain depth of the sediments.

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