INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 13, No. 1, p. 122-135, 2018

RESEARCH PAPER OPEN ACCESS

Intertidal marine mollusks on selected coastal areas of Iligan Bay, Northern Mindanao, Philippines

Angelyn C. Magsayo, Maria Lourdes Dorothy G. Lacuna*

Department of Biological Sciences, Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines

Key words: *Nassarius*, *Cerithium coralium*, Diversity, Total organic matter.

http://dx.doi.org/10.12692/ijb/13.1.122-135 Article published on July 15, 2018

Abstract

Considering the vital role benthic mollusks occupy in the marine food web and its significance in the world economy, this study was realized so as to give valuable information on the composition, diversity and abundance of benthic mollusks on the intertidal zones of Iligan City and Kauswagan, Lanao del Norte in Mindanao, Philippines. Samplings were done along the intertidal flats during low tide between the months of June and July 2015 using the transect-quadrat methods. A total of 66 molluskan species were classified, with 56 species categorized as gastropods, while 10 species are bivalves. Diversity profiles were calculated using Shannon-Weaver Index and results revealed diverse living assemblages of molluscan community in both study sites with several *Nassarius* species and *Cerithium coralium* being abundant. Comparing the abundance of mollusks among the 4 stations showed station 3 as having the lowest total number of individuals per m^2. The result of the CANOCO indicated that total organic matter may have been responsible to such low abundance of molluskan assemblage in station 3. The current findings obtained from this study are of immense importance in understanding the reason behind the successful existence and dynamicity of intertidal communities in the coastal zones of Northern Mindanao as well as in the continuous monitoring and conservation efforts in these 2 areas considering that several industries are present along the coasts as well the existence of unregulated gleaning activities.

* **Corresponding Author:** G. Lacuna ✉ mileskung12@gmail.com

Introduction

Marine molluscs is a group of highly diverse organisms which are considered to be the most prominent and well-recognized invertebrate animals and include the snails, oysters, clams, octopus, squids and cuttlefish.

In terms of species abundance, this group make up the second largest invertebrate phylum on Earth succeeding the arthropods (Ruppert and Barnes, 2004). Over 70,000 living species have been described globally and roughly one-third (22,000 species) occurred in the Philippine Archipelago of which 2-4% (440-880 species) are endemic in the country (Ong *et al.*, 2002). Among the constituents of Phylum Mollusca, the gastropods and bivalves (pelecypods) are the most dominant where they comprised 98% of the molluscan population (Anandaraj *et al.*, 2012).

The role of gastropods and bivalves in the benthic community cannot be ignored since they form an essential link in the aquatic food web as food source of wide array of molluscivorous intertidal animals (Creswell, 1990; Castell and Sweatman, 1997; Burkepile and Hay, 2007) as well as indicators of the health condition of certain habitat or environment (Daka *et al.*, 2006; Gomez-Ariza *et al.*, 2006)and as source of protein (Schoppe *et al.*, 1998; Del Norte-Campos *et al.*, 2003).

Insight in the distribution and abundance among molluscs is essential in understanding the ecology of these species since this may demonstrate the external parameters (abiotic and biotic factors) that are responsible in influencing their distribution.

Most often, variability in the spatial structure of molluscs (*i.e.* high species richness) is related to the sediment size (Rahman and Barkati, 2012; Esqueda-Gonzalez *et al.*, 2014), organic matter and calcium carbonate contents of the sediment. Conversely, other parameters such as biotic, (i.e. predation, competition and recruitment) may also affect the abundance of molluscan population. Since no single environmental factor can solely control the distribution patterns of molluscs, it is suggested that interplay between the abiotic and biotic parameters can therefore influence these assemblages (de Arrudaand Amaral, 2003).

Despite numerous ecological studies documented around the globe, studies on molluscan diversity in the Philippines were limited to the Northern and Central regions of the country (Dolorosa and Schoppe, 2005; Batomalaque *et al.*, 2010; Dolorosa and Jontila, 2012; Dolorosa and Dangan-Galon, 2014; Picardal and Dolorosa, 2014), with relatively few works done in Southern Philippines (Tabugo *et al.*, 2013; Manzo *et al.*, 2014; Masangcay and Lacuna, 2017). In order to address this gap, this study aim to document the species diversity and abundance of gastropods and bivalves and determine the environmental factors that may have influenced their diversity and abundance.

Materials and methods

Study area and sampling stations

Iligan Bay is recognized by the Philippine Bureau of Fisheries and Aquatic Resources (BFAR) as a major fishing ground for its rich fishery resources such as fish, algae and mollusks and as an important food producer and as a living space for human and for wildlife. Four coastal areas along Iligan Bay were chosen as sampling stations, with three coastal areas located in Iligan City and the other one in Kauswagan, Lanaodel Norte (Fig. 1).

Station 1 was positioned in a seagrass bed in Dalipuga, Iligan City, while station 2 was located in Fuentes, Iligan City which is distinguished by a rocky shore often mixed with some fine sands. Station 3, situated in Buru-un, Iligan City, is categorized as a sandy shore which is mixed with boulders, whereas station 4 was established in Kauswagan, Lanao Del Norte that is adjacent to a port where seagrass beds are present.

Field collection of mollusks and "in situ" determination of environmental parameters

Three transect lines (50 m long), with a distance of 50m from each other, were laid down on the intertidal flat in each sampling stations.

Four quadrats (1.0 m^2), which were 10 m apart, were set along each transect line. All transect lines were positioned perpendicular to the coastline with each transect being placed starting from the shoreline going towards the sea. Live epifaunal mollusks encountered on the surface of the sediment in each quadrat were handpicked.

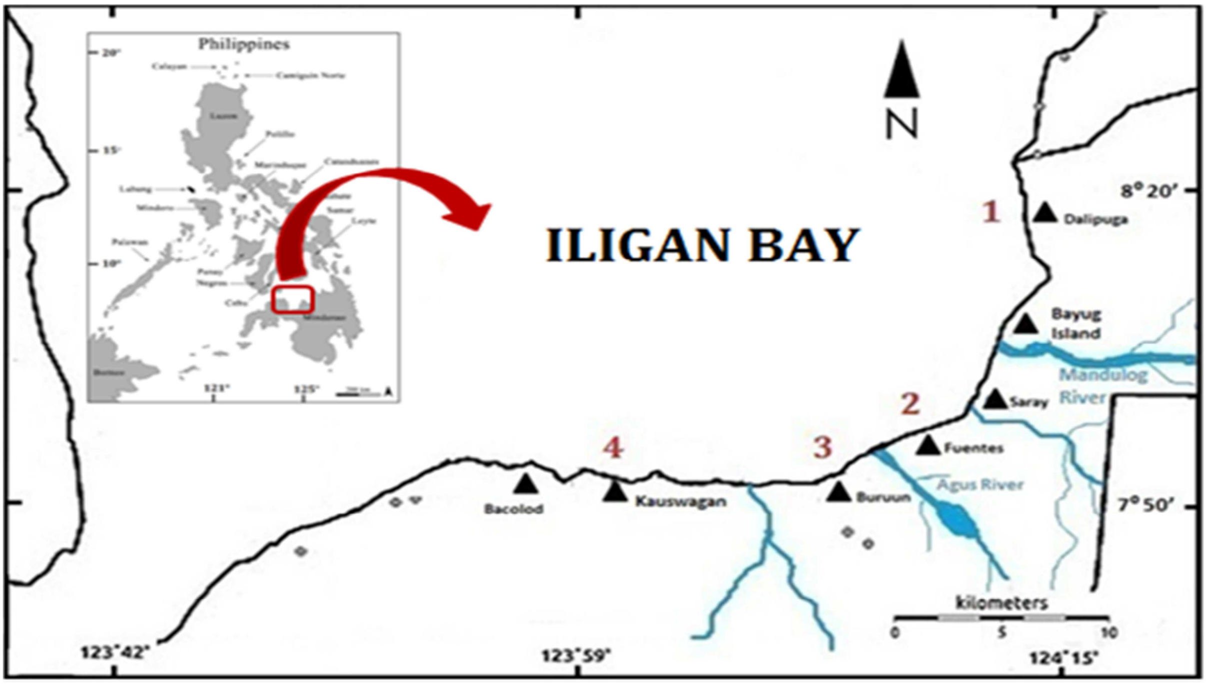

Fig. 1. Geographical locations of the four sampling stations on the intertidal zones of Iligan Bay where mollusk samples were gathered. (www.map-hill.com).

Afterwards, live infaunal mollusks in each quadrat were likewise obtained by collecting sediments which were dug to a depth of 15 cm and these sediments were then sieved using a sieve screen with a 1.0mm mesh opening. Dead mollusks and empty shells were not included in the collection.

All mollusks gathered were preserved in 10% seawater-formalin solution. Measurement of the environmental parameters such as temperature, pH and salinity of the sediments were done directly on the field using the field thermometer, pen type pH meter (PH-009) and refractometer (ATAGO), respectively.

In each transect line, all environmental factors were determined three times. On the other hand, three sediment samples for the determination of total organic matter, calcium carbonate and grain size were gathered in each transect, separately deposited in a Ziplock bag and then stored in a freezer until analysis.

Laboratory analysis of the samples collected

Epifauna and infauna samples were cleaned by washing it with seawater and by removing epiphytes that adhered on the shells and then preserved with 70% ethanol (Rueda *et al.*, 2009). Each collected mollusks were classified to species level and then counted.

The soft tissues of a voucher specimen representing each identified molluscan species were removed, then the shells were cleaned, measured to the nearest 0.1 mm using a Vernier caliper and then photographed using a digital camera (Sony Cyber-Shot, 16 MP).

Molluscan data were computed as density and relative abundance. Density was expressed as number of individuals per m^2, while relative abundance for each species was expressed as a percent of total molluscan species present. Identification of molluscs were based on books (Springsteen and Leobrera, 1986; Poppe *et* *al.*, 2006) and the illustrated guides to marine gastropods (www.gastropods.com.) and seashells (www.seashellhub.com., www.jaxshells.com.).

For calcium carbonate determination, sediment samples were dried in an oven at 70°C for about 8 hours. Afterwards, twenty-five grams were weighed (W_1), mixed with HCl (0.1 N) and stirred until no CO_2 bubbles appeared before it was stored. After 24 hours, the sample was filtered and the upper liquid phase discarded.

The residual sediments were dried at 70^0C for 8 hours and reweighed again (W_2). Calcium carbonate percentage was measured by the following formula:

$$CaCO3(\%) = \frac{100\ (W_1\text{-}W_2)}{W_1}$$

For the analysis of total organic matter (TOM), sediment samples which filled up half of the pre-weighed crucibles were placed inside an oven for drying at 70^0C for 24 hours. Following the designated time period, the sediments were weighed (A) and then put inside a furnace for 12 hours at 550^0C. Afterwards, the sediments were allowed to cool before it were being reweighed again (B) until constant weight was attained. The total organic matter was calculated as follows:

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

For the grain size analysis, a 100g oven-dried sediment were sieved using a series of screen sieves of 2.36 mm, 1.77 mm, 0.850 mm, 0.425 mm, 0.150 mm, and 0.075 and 0.053 mm mesh opening. The remaining soil particles in each sieve were carefully removed and weighed separately. The percentage of each particle fraction was calculated as shown below:

$$\text{Percentage Weight} = \frac{\text{Dry weight of sediments}}{\text{Total dry weight of sediments}} \times 100$$

Molluscan data were represented as density and relative abundance. Density was expressed as number of individuals per m^2, and was computed as follows:

$$\text{Density}(ind/m^2) = \frac{\text{Total no. of species A}}{\text{Total area examined}}$$

Relative abundance for each species was expressed as a percent of total molluscan species present and was calculated using the following formula:

$$\text{Relative abundance}(\%) = \frac{\text{Abundance of Species A}}{\text{Abundance of all Species}} \times 100$$

Statistical analyses

Diversity indices were computed using Shannon-Weaver Index in order to determine changes in the molluscan composition. The difference on the abundance of molluscan species between sampling stations was determined using Kruskal-Wallis Test. The relationship between abiotic parameters, sediment contents and the numerical abundance of molluscan assemblage was determined using the Canonical Correspondence Analysis (CCA). All analyses were done using PAST (Paleontological Statistical) software version 2.17 (http://folk.uio.no/ohammer/past/) (Hammer *et al.*, 2001).

Results and discussion

Molluscan species composition

A list of molluscs encountered in all sampling stations in the intertidal zones of Iligan City and Kauswagan is presented in Table 1.

A total of 66 species of molluscs belonging to Class Gastropoda and Bivalvia were recorded, with 56 species being gastropods under 19 families, while 10 species are bivalves belonging to 6 families. Further, 44 of these gastropods are epifauna, while 12 species are infauna.

The present study recorded more gastropods when compared to the other molluscan classes and this is in agreement with other studies done in most intertidal flats were gastropods were reported to be the most dominant group (Noseworthy and Sik, 2010; Vera *et al.*, 2013; Leopardas *et al.*, 2016).

Physico-chemical parameters, organic matter and grain size

The mean values of the physical and chemical parameters of the sediment as well as its organic contents and sediment texture are presented in Table 2.

The values for sediment temperature ranges from 28.19 °C to 34.47 °C, with station 1 showing the lowest temperature reading but highest in station 2. The differences in the temperature readings are associated with the time of sampling and determination of these abiotic parameters. Collections and measurements of temperature in stations 2 and 3 were done from noon time to mid-afternoon on the same day where the intensity of the sun is at its highest peak, and it is expected that these stations records high temperature values.

Table 1. Comparison of intertidal molluscan species in Iligan City and Kauswagan, Lanaodel Norte, Northern Mindanao, Philippines.

Class	Family	Species name	Station			
			1	2	3	4
Bivalvia	Arcidae	Barbatia foliata*	-	+	-	-
		Anadara labiosa*	-	-	+	-
	Isognomonidae	Isognomon californicum*	-	+	-	-
		Isognomon ephippium*	-	+	-	-
	Lucinidae	Anodontia cf. edentula*	+	-	+	+
		Codakia tigerina*e	-	+	-	+
	Mytilidae	Hormonia mutabilis*	-	+	-	-
	Psammobiidae	Garipallida*	+	-	-	-
		Psammotaea virescens*	-	+	-	-
	Pinnidae	Atrina lamellate*	-	+	-	+
Gastropoda	Angariidae	Angaria melanacantha*	+	+	-	+
	Buccinidae	Engina incarnate*	+	-	-	-
	Bullidae	Bulla ampulla*	+	-	-	+
		Bulla vernicosa*	+	-	-	-
	Bursidae	Bursa tuberosissima*	+	-	-	-
	Cerithiidae	Cerithium coralium*	-	+	+	+
		Cerithium punctatum*	+	-	-	-
		Cerithium rostratum*	+	-	-	-
		Cerithium zonatum*	-	+	-	-
		Clypeomorus pellucida*	-	+	+	-
	Conidae	Conus barbara*	+	-	-	-
		Conus ebraeus*	+	-	-	-
	Costellariidae	Austromitra aff. canaliculata*	+	-	-	-
		Vexillum virgo*	+	-	-	-
	Cypraeidae	Monetaria annulus*	-	-	-	+
		Monetaria moneta*	-	-	-	+
	Liotiidae	Loitinariaperonii*	-	-	+	+
	Littorinidae	Littorina undulate*	+	-	-	-
	Mitridae	Mitra pediculus*	-	-	-	+
	Muricidae	Murex negros*	-	+	-	-
		Semiricinula turbinoides*	-	+	-	-
	Nassaridae	Nassarius albescens*	+	-	-	+
		Nassarius ecstilbus*	+	-	-	-
		Nassarius globosus*	+	+	+	+
		Nassarius livescens*	+	+	-	-
		Nassarius luridus*	+	+	+	+
		Nassarius macrodon recidivus*	-	-	-	+
		Nassarius marmoreus*	-	-	-	+
		Nassarius nigra*	+	-	-	+
		Nassarius nodifer*	+	-	-	+
		Nassarius Pyrrhus*	+	-	-	-

Table 1. (Cont'n). Comparison of intertidal molluscan species in Iligan City and Kauswagan, Lanaodel Norte, Northern Mindanao, Philippines.

Class	Family	Species name	Station			
			1	2	3	4
	Nassaridae	*Nassarius reeveanus**	+	+	-	+
	Naticidae	*Mamillamelanostomoides**	+	-	+	-
		*Natica fasciata**	-	+	-	-
		*Notocochlisantoni**	-	+	-	-
		*Notocochlisvenustula**	+	-	-	-
		*Polinicesflemingianus**	+	+	+	+
	Neritidae	*Neripteron cf. neglectus**	-	-	+	-
		*Neripteron siquijoren sis**	+	-	-	+
		*Nerita albicilla**	+	-	-	-
		*Nerita nigerrima**	+	-	-	-
		*Nerita picea**	-	+	-	+
		*Nerita plicata**[e]	+	-	-	-
		*Nerita polita**	+	-	-	+
		*Nerita signata**	-	-	-	+
		*Vittina waigiensis**	+	-	-	-
	Planaxidae	*Fissilabia decollata**	+	+	-	-
	Rhizoridae	*Volvulella cf. Paupercula**	+	-	-	+
	Strombidae	*Canarium urceus urceus**[e]	+	-	+	+
		*Canarium labiatum**	+	-	+	+
		*Strombus auredianae**	-	+	+	-
		*Strombus labiatus**	-	+	+	+
	Trochidae	*Cantharidus suarezensis**	-	+	+	-
		*Herpetopomaatrata**	+	-	-	+
		*Herpetophobia Stratum **	+	-	-	+
		*Tectus fenestratus**	-	-	+	+
Total number of species			38	25	16	30

Legend: + present; - absent; *infauna *epifauna[e]ediblbe.

On the other hand, much lower temperature readings were noted in stations 1 and 4 since samplings were done late in the afternoon until evening. For sediment pH, the values ranges from 7.88 to 8.75 showing the slightly alkaline nature of seawater where it can buffer against changes in pH (Giere, 2009).

For sediment salinity, values recorded in all stations were much lower when compared with the standard values in Philippine waters set by DENR-Administrative Order No. 2016-08 (DENR-Administrative Order, 2016). These lower values were expected considering that river tributaries exit along the coastal zones in Iligan City and Kauswagan.

The input of freshwater from these rivers may have diluted the salinity content of the marine waters resulting to the lowering of the salinity values. For $CaCO_3$, the value ranges from 10% to 13% with stations 2 and 4 obtaining the lowest value while highest in station 1. For total organic matter (TOM), the values ranges from 9.3% to 18.6% with station 4 showing the lowest value while highest in stations 1 and 2. For the sedimentary structures, the type of substrate in stations 1, 2 and 3 are categorized as sandy with mixtures of gravel that is made up of granules. However, station 4 is predominantly sandy mixed with small assorted stones, a characteristic often common in most seagrass beds.

Table 2. Environmental parameters in all four sampling stations in Iligan City and Kauswagan, Lanaodel Norte, Northern Mindanao, Philippines.

Physico-chemical parameters	Stations			
	1	2	3	4
Temperature	28.19	34.47	31.68	31.04
pH	8.15	8.53	8.75	7.88
Salinity (ppt)	30.16	23.33	21.39	30.83
$CaCO_3$ (%)	13	10	11	10
TOM (%)	13	13	12	9
Gravel (%)	33.84	37.7	50.1	14.21
Sand (%)	66.07	62.29	49.83	84.79
Very Coarse Sand (%)	12.31	9.45	7.97	8.43
Coarse Sand (%)	14.09	11.27	14.72	12.89
Medium Sand (%)	17.91	14.35	13.5	18.41
Fine Sand (%)	19.64	21.43	12.18	27.99
Very Fine Sand (%)	2.13	5.79	1.46	17.07
Silt (%)	0.09	0.01	0.07	1
Sediment Texture	Sandy	Sandy	Sandy	Sandy

Species richness anddiversity

The level of diversity of molluscan species in the four sampling stations on the intertidal flat of Iligan City and Kauswagan, Lanaodel Norte are presented in Table 3.

Table 3. Diversity profile of the four sampling stations for the intertidal molluscs in Iligan City and Kauswagan, Lanaodel Norte, Northern Mindanao, Philippines.

Diversity index	Station			
	1	2	3	4
Taxa (S)	38	25	16	30
Individuals	232	261	53	233
Dominance (D)	0.05016	0.1145	0.1036	0.1062
Shannon (H)	3.227	2.524	2.478	2.727
Equitability (J)	0.8871	0.7841	0.8938	0.8017

The current results showed variations in the species diversity values with station 1 showing a much higher Shannon index value (H=3.227). Further, there is also a clear cut difference in the number of taxa among the four sampling stations with more species of molluscs noted in station 1 (38) but least in station 3 (16). Although there are differences noted in the number of taxa between these stations, species were observed to be evenly distributed as reflected in the equitability value (J values=0.7-0.8) wherein there were no species dominating as noted in the low dominance value (D<1).

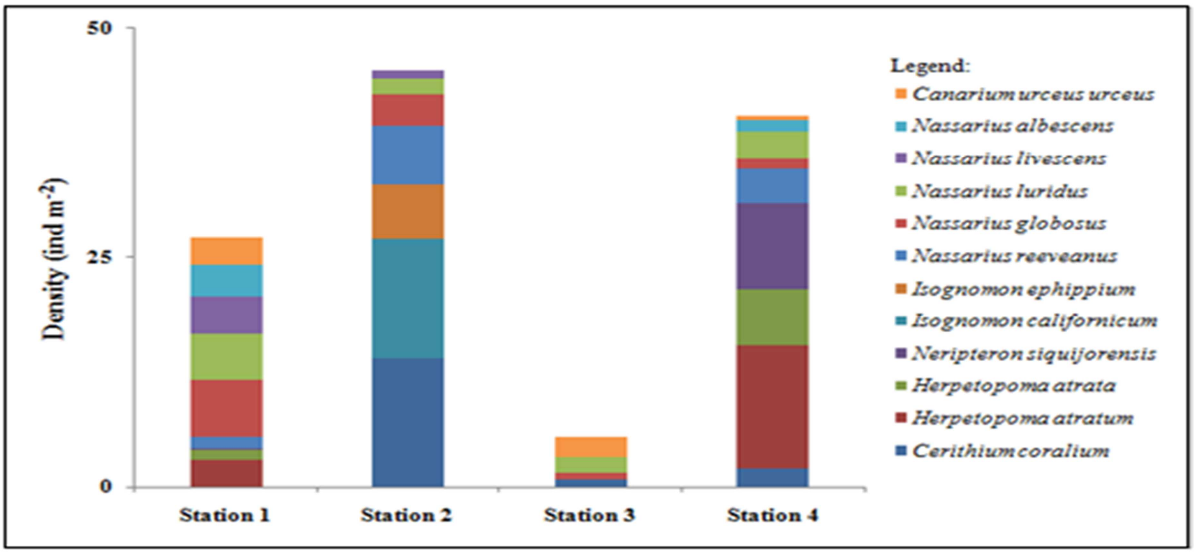

Fig. 2. Density of the top 12 benthic molluskan fauna in the 4 sampling stations on theintertidal zones of Iligan City and Kauswagan, Lanaodel Norte.

These results may therefore imply that the intertidal flats of the study areas still host rich assemblage of molluscan community.

The current results are comparable with earlier reports which showed high species diversity of molluscs on intertidal flats with seagrass beds (Quintas *et al.*, 2013), unvegetated and rocky substrata (Jaiswar and Kulkarni, 2001; Nieves *et al.*, 2010; Flores-Rodriguez *et al.*, 2012; Galenzoga, 2016).

Species abundance

Among the 66 mollusc species recorded in the present study, only the 12 most abundant molluscan fauna in each stations were considered for discussion. Fig. 2 exhibited the top 12 species that were commonly seen and most abundant in all 4 sampling stations. In station 1, the most frequently encountered species was *Nassarius globosus* representing 6.25 ind m^{-2} of the total number of organisms. Next in rank was *Nassarius luridus* which accounted to about 5 ind m^{-2} of the total number of organisms, followed by *Nassariuslivescens* at 4 ind m^{-2}, while trailing behind were *Nassarius albescens* and *Canarium urceus urceus* garnering 3.5 ind m^{-2} and 3 ind m^{-2}, respectively. In station 2, the most abundant species recorded was *Cerithium coralium* consisting to about 14 ind m^{-2}, followed in decreasing order by *Isognomon californicum* and *Isognomon ephippium* at 13ind m^{-2} and 6 ind m^{-2}, respectively. Trailing behind was *Nassarius reeveanus* which consisted to about 6.3 ind m^{-2}, while *N. globosus* was the least abundant at 3.5 ind m^{-2}. Moreover, in station 3, species with the highest density was *C. urceusurceus* at 2.25 ind m^{-2}, followed by *N. luridus* which consisted to about 1.75 ind m^{-2}, whereas *N. globosus* and *C. coralium* were the least abundant which garnered at 0.75 ind m^{-2}. In station 4, the molluscan species that obtained the highest number of individuals was *Herpetophobia Stratum* comprising to about 13.5 ind m^{-2}, whereas *Neripteron siquijoren sis* or also known as *Neritasiquijoren sis* followed in rank at 9.5 ind m^{-2}. Trailing behind were *Herpetopomaatrata, N. reeveanus*, *N. luridus*at 6 ind m^{-2}, 3.75 ind m^{-2} and 3 ind m^{-2}, respectively, while the least abundant was *C. coralium* at 2ind m^{-2}. Generally, several *Nassarius* species and *Cerithium coralium* predominate most of the 4 stations in both study areas, suggesting that these above-mentioned molluscan species occurred in a great variety of substrata in the intertidal zones. The nassariids, widely known as dog whelks (in the UK) or nassa mud snails (in the USA), are common and quite abundant in most intertidal flats with sandy (Aji and Widyastuti, 2017) to muddy substrata (Dittmann and Vargas, 2001) and even in rocky areas (Vohra, 1971).

For instance, the dog whelk *Nassarius livescens* was abundantly encountered on sandy seagrassbeds(Teh *et al.*, 2014); *Nassarius globosus* and *Nassarius luridus* predominates on muddy seagrass flats (Puturuhu, Unpublished Thesis), while *Nassarius albescens* prefers both sandy seagrass(Alfaro *et al.*, 2009) and rocky (Masangcay and Lacuna, 2017). The widespread distribution of nassariids within the intertidal zones is owed to their being carrion feeders or opportunistic scavengers where they often consumed bodies of dead animals as well as plants (Harasewych,1998), although some are either herbivores, detritivores/detritus feeders (Scheltema, 1964) or carnivores (Morton and Britton, 2002). The presence of their very long extensible proboscis enables them to be well-suited to opportunistic scavenging/predation as well as deposit feeding (Morton, 2011). Previous study reported *N. globossus* as deposit feeders which exploit the organic matter or detritus that are quite abundant on seagrass bed and leaves (Puturuhu, Unpublished Thesis), while *N. albescens* was observed as scavengers in sandy intertidal flats (Taylor and Reid, 1984), whereas *N. livescens* was shown to be carnivores (Edgar and Robertson, 1992). In the current study, *N. globossus*, *N. albescens*, *N. luridus* and *N. livescens* were dominant on sandy seagrass beds (station 1 and 4) as well as on sandy flat (station 3) and it is probable that these nassariids utilized the seagrass beds both for refuge and source of food and that of the sandy bottom as good supply of food.

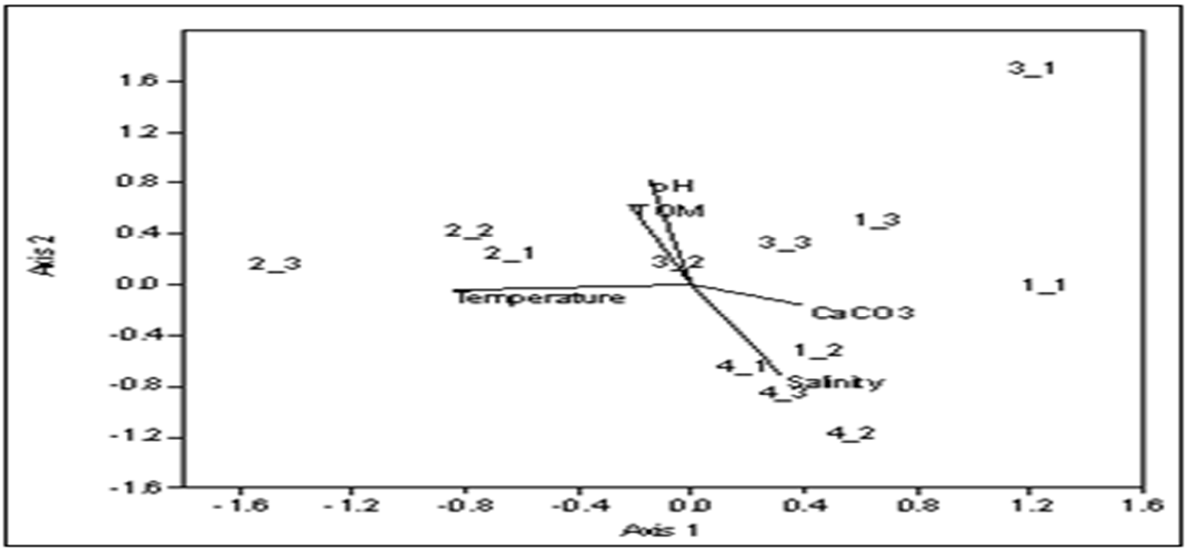

Fig. 3. Canonical Correspondence Analysis (CCA) biplot of the distanceamong the 4 sampling stations and the environmental parameters thatinfluence the distribution and abundance of intertidal benthic mollusks.

Cerithium coralium also known as coral horn was reported to occur in marine (Barnes, 2003) and estuarine (Houbrick, 1992) intertidal zones as well as on sandy substrates with the presence of the seagrass*Halophila ovalis* (Vohra, 1971) and on algal mats in sandy flats (Alfaro *et al.*, 2009). This species has been reported to be deposit feeders creeping over substrates and feeding on detritus containing high algae content (Yipp, 1980). In the present study, *C. coralium* was abundant in stations 1 and 4 where seagrass beds are found and in station 2 where algal mats were seen over the sandy bottom. These habitats provide the source of food needed by this specific gastropod since they prefer feeding on detritus containing high algae content.

Isognomiids are epifaunal filter feeding bivalves that inhabit intertidal zones and often found attached to rocks, coral boulders, sponges (Tsubaki *et al.*, 2011) and on roots of mangroves (Springsteen and Leobrera, 1986). The species *Isognomon ephippium* which is well-known and common in the Indo-Pacific region, most often clumped on intertidal rocky or hard substrate (Tsubaki *et al.*, 2011) and mangroves (Printrakoon *et al.*, 2008).

In the current study, *I. ephippium* and *I. californicum* were observed to aggregate together on boulders and rocks, suggesting that the hard substrata were used by these 2 species of isognomiids to attached themselves firmly to the ground.

The trochid *Herpetopoma* species are herbivorous gastropods that dwell on rocky intertidal bottoms where hard/rocky substrate are often covered with seaweeds. In particular, *Herpetopomaatrata* was reported to occur on bottoms consisting of coarse sand mix up rubbles and rocks (Taylor and Glover, 2004). In the present study, *H. atrata* was observed in high abundance in station 4 where seagrass are found and where the substrate is made up of coarse to fine sands often mixed with loose small-sized stones.

Abundance of mollusks among the 4 sampling stations were compared using the Kruskal-Wallis Test and results demonstrated that only station 3 was significantly different between station 1 (p=0.000288), station 2 (p=0.0371) and station 4 (p=0.005061). Further, the result of theCanonical Correspondence Analysis or CCA (Fig. 3) indicated that total organic matter (TOM) may have been responsible to the low abundance of molluscan assemblage in station 3.

It has been recorded that station 3 contained low amount of TOM contents in the sediments (See Table 2) when compared to the 3 stations. It has been reported (Snelgrove and Butman, 1994) that organic matter contents in the sediments are the chief source of food for both deposit and suspension feeding organisms. Several studies had emphasized the importance of seagrass beds as good source of food specially among deposit/detritus feeders because detritus and organic matter usually settles on seagrass leaves and on the sediments in the seagrass bed in high abundance (Kitting *et al.*, 1984; Fredriksen *et al.*, 2004; Hily *et al.*, 2004).

These sources of total organic matter are essential for many organisms for their growth, reproduction and survival. It is probable that the low amount of total organic matter in station 3 may not be enough to support the physiological needs of the molluscs assemblage in this station considering that majority of them are deposit/detritus feeders. Aside from low total organic matter content in the sediment, the physical setting in station 3 such as the absence of seagrass beds, rocks and boulders may likewise be attributed to low abundance and low species richness of molluscs population in the said station. It has been reported that seagrass beds, rocks and boulders on the intertidal zones hosts rich taxa of molluscan species (Marina *et al.*, 2012; Flores-Rodriguez *et al.*, 2014) since these habitats provide anchor (against wave action), refuge (against desiccation and predators) and appropriate supply of food among molluscs population in general.

Conclusion

High diversity and uniformity in the distribution of mollusks in the present study areas were observed indicating that the intertidal zones in Iligan City and Kauswagan, Lanaodel Norte support rich population of benthic non-edible molluscan fauna. Moreover, molluscs abundance were recorded to be significantly different among stations and it is assumed that total organic matter (TOM) contents in the sediments may have influenced these variations. Since the role of benthic molluscan fauna is very crucial in the function of the food webs of the marine ecosystems as well as their impact in the world economy, the current results are therefore of vital importance in understanding the reason behind the successful existence and dynamicity of intertidal communities in the coastal zones of Northern Mindanao.

The present findings can also be utilized in the continuous monitoring and conservation efforts in Iligan City and Kauswagan, Lanaodel Norte considering that several industries are present along the coasts as well as the existence of unregulated gleaning activities. It is recommended that monthly assessments on the areas must be done in order to obtain a record on the patterns of distribution of the intertidal molluscs as well as the effects of changes in seasons (i.e. NE and SW monsoons) to their distribution.

References

Aji LP, Widyastuti A. 2017. Molluscs Diversity in Coastal Ecosystem of South Biak,Papua Keanekaragaman Moluska di Ekosistem Pesisir Biak Selatan, Papua. Oceanologidan Limnologi di Indonesia **2(1)**, 25-37.

Alfaro AC, Zemke-white WL, Nainoca W. 2009. Faunal composition within algal mats and adjacent habitats on Likuri Island, Fiji Islands. Journal of the Marine Biological Association of the United Kingdom **89(2)**, 295-302. https://doi.org/10.1017/S0025315408002774

Anandaraj T, Balasubramanian U, Murugesan P, Muthuvelu S.2012.Biodiversity of Marine Mollusks in East Coastal Area of Thanjavur District, Ttamil Nadu, India. International Journal of Pharmaceutical and Biological Archives **3(1),** 131-133.

Batomalaque GA, Arce BGP, Hernandez MBM, Fontanilla IKC. 2010. Survey andspatial distribution of shoreline malacofauna in Grande Island, Subic Bay. Philippine Journal of Science **139(2)**, 149-159.

Barnes RSK. 2003.Interactions between benthicmolluscs in a Sulawesi mangal,Indonesia: the cerithiid mud-creeper Cerithium coralium and potamidid mud-whelks,Terebraliaspp. Journal of the Marine Biological Association of the United Kingdom **83,** 483-487. https://doi.org/10.1017/S002531540300.7380h

Burkepile DE, Hay ME. 2007. Predator release of the gastropod Cyphoma gibbosum increases predation on gorgonian corals. Oecologia**154(1)**, 167-173. http://dx.doi.org/10.1007/s00442-007-0801-4

Castell LL, Sweatman HPA. 1997. Predator-prey interactions among some intertidal gastropods on the Great Barrier Reef. Journal of Zoology**241(1)**, 145-159. https://doi.org/10.1111/j.1469-7998.1997.tb05505.x

Creswell PD. 1990. Handling times, prey size and species selection by Cancer novaezelandiae (Jacquinot, 1853) feeding onmolluscan prey. Journal of Experimental Marine Biology and Ecology **140(1-2),** 13-28. https://doi.org/10.1016/0022-0981(90)900.77-P

Daka ER, Ifidi I, Braide SA. 2006. Accumulation of heavy metals from single and mixed metal solutions by the gastropod mollusk Tympanotonus fuscatus (Linnaeus) from a Niger Delta estuary: Implications for bio monitoring. African Journal of Biotechnology **5(20)**, 1954-1962. https://doi.org/10.5897/AJB2006.000-50.91

De Arruda EP, Amaral CZ. 2003. Spatial distribution of mollusks in the intertidal zone of sheltered beaches in South-eastern of Brazil. Revista Brasileira de Zoologia**20(2),** 291-300.

Del Norte-Campos AG, Declarador MB, Beldia RA. 2003. Catch composition, harvest and effort estimates of gleaned macroinvertebrates in Malalison Island, northwestern Panay. University of the Philippines Visayas Journal of Natural Sciences **8**, 129-141.

DENR-Administrative Order No. 2016-08. Water quality guidelines and generaleffluents standards of 2016. Manila, Philippines. P6.

Dittman S, Vargas JA. 2001. Tropical tidal flat benthos compared between Australiaand Central America. Ecological studies**151,** 275-293.

Dolorosa RG, Dangan-Galon F.2014. Species Richness of bivalves and gastropods in Iwahig River-Estuary, Palawan, the Philippines. Journal of Fisheries and Aquatic Studies **2(1)**, 207-215.

Dolorosa RG, Jontila JBS. 2012. Notes on common macrobenthic reef invertebrates of Tubbataha Reefs Natural Park, Philippines. Science Diliman **24(2)**, 1-11.

Dolorosa RG, Schoppe S. 2005. Focal benthic mollusks (Mollusca: Bivalvia and Gastropoda) of selected sites in Tubbataha Reef National Marine Park, Palawan, Philippines. Science Diliman**17(2)**, 1-10.

Edgar GJ, Robertson AI. 1992. The influence of seagrass structure on the distribution and abundance of mobile avifauna: Pattern and Process in a Western Australian Amphibolis bed. Journal of Experimental Marine Biological and Ecology**160**, 13-31. https://doi.org/10.1016/0022-0981(92)90107-L

Esqueda-Gonzalez MC, Rios-Jara E, Galvan-Villa CM, Rodriguez-Zaragoza FA. 2014. Species composition, richness, and distribution of marine bivalve molluscs in Bahia de Mazatlan, Mexico. Zookeys**399,** 49-69. http://dx.doi.org/10.3897/Zookeys. 399.6256.

Flores-Rodriguez P, Flores-Garza R, Garcia-Ibanez S, Valdes-Gonzales A,Violante-Gonzalez J, Santiago-Cortes E, Galeano-Rebolledo L, Torreblanca-Ramirez C. 2012.Molluscs Species Richness on the Rocky Shores of the State of Guerrero, Mexico, as affected by rains and their geographical distribution. Natural Resources **3**, 248-260.

Flores-Rodríguez P, Flores-Garza R, García-Ibáñez S Torreblanca-Ramírez C, Galeana-Rebolledo L, Santiago-Cortes E. 2014. Mollusks of the rocky intertidalzone at three sites in Oaxaca, Mexico. Open Journal of Marine Science **4,** 326-337. http://dx.doi.org/10.4236/ojms.2014.44029

Fredriksen S, Christie H,Bostrom C. 2004. Deterioration of eelgrass (ZosteramarinaL.) by destructive grazing by the gastropod Rissoa membranacea (J.Adams).Sarsia**89,** 218–222. https://doi.org/10.1080/00364820410005593

Galenzoga DM. 2016. Community Structure of Molluscs in Northern Samar, Philippines. International Journal of Life Sciences Research **4(1),** 100-104.

Giere O. 2009. Meiobenthology: The Microscopic Motile Fauna of Aquatic Sediments. 2nd Ed., Springer-Verlag Berlin Heidelberg, 25-26.

Gomez-Ariza JL, Santos MM, Morales E, Giraldez I, Sanches-Rodas D, Vieira N, Kemp JF, Boon JP, Ten-Hallers-Tjabbes CC. 2006. Organotin Contamination in the Atlantic Ocean off the Iberian Peninsula in relation to shipping. Chemosphere **64(7),**1100-1108. http://dx.doi.org/10.1016/j.chemosphere.2005.11.068

Hammer O, Harper DAT, Ryan PD. 2001. Past: Paleontological statistics software package for education and data analysis. Paleontologia Electronica **4**, 1-9.

Harasewych MG. 1998. Family Nassariidae. In: Beesly PL, Ross GJB, Wells A, Ed.Mollusca: the southern synthesis. Fauna of Australia. CSIRO Publishing, Melbourne,829-831.

Hily C, Connan S, Raffin C, Wyllie-Echeverria S. 2004.In vitro experimental assessment of the grazing pressure of two gastropods on Zostera marina L. ephiphytic algae. Aquatic Botany **78(2)**, 183-195.

Houbrick RS. 1992. Monograph of the Genus Cerithium Bruguiere in the IndoPacific (Cerithiidae - Prosobranchia). Smithsonian Contributions to Zoology**510**, 1-211.

Jaiswar AK, Kulkarni BG. 2005. Conservation of molluskan biodiversity fromintertidal area of Mumbai coast. Journal for Nature Conservation **17,** 93-105.

Kitting CL, Fry B,Morgan MD. 1984. Detection of inconspicuous epiphytic algae supporting food webs inseagrass meadows. Oecologia**62**, 145–149. http://dx.doi.org/10.1007/BF00379006.

Leopardas V, Honda K, B, Go GA, BolisayK, PantallanoAD,UyW, Fortes M, Nakaoka M. 2016. Variation inmacrofaunal communities of seagrass beds along a pollution gradient inBolinao, northwestern Philippines. Marine Pollution Bulletin **105(1),**310-318. http://dx.doi.org/10.1016/j.marpolbul.2016.02.004.

Manzo K, Estandarte M, Dalipe RE, Ulangutam J, Lecera JM, Acob A, Diamalod, J, Salmo W, Jumawan J. 2014. Survey and diversity of intertidal mollusks in Alabeland Maasim, Sarangani Province, Philippines. Aquaculture, Aquarium, Conservation and Legislation International Journal of the Bioflux Society**7(6),** 449-457.

Marina P, Urra J, Rueda JL, Salas C. 2012. Composition and structure of the molluscan assemblage associated with a Cymodoceanodosa bed in south-eastern Spain: seasonal and dielvaration. Helgoland Marine Research **66,** 585-599. http://dx.doi.org/10.1007/S10152-012-0294-3

Masangcay SIG, Lacuna MLDG. 2017. Molluscan (Gastropoda and Bivalvia) diversity and abundance in rocky intertidal areas of Lugait, Misamis Oriental, Northern Mindanao, Philippines. Journal of Biodiversity and Environmental Sciences (JBES) **11(3),**169-179.

Morton B. 2011. Behaviour of Nassariusbi callosus (Caenogastropoda) on a northwestern Western Australian surf beach with a review of feeding in the Nassariidae. Molluscan Research **31**, 90-94.

Morton B, Britton JC. 2002. Holothurian feeding Nassarius dorsatus on a beach inWestern Australia. Journal of Molluscan Studies **68,** 187-189. http://dx.doi.org/10.1093/mollus/68.2.187

Nieves PM, de Jesus SC, Macale AMB. Pelea JMD. 2010. An Assessment of Macro-Invertebrate Gleaning in Fisheries on the Albay Side of Lagonoy Gulf.Kuroshio Science **4-1,** 27-35, 2010.

Noseworthy RG, Sik CK. 2010. The Diversity and Ecology of Mollusks at Seogundo. Southern Jeju Island, Republic of Korea. Korean Journal of Malacology **26(1),** 19-31.

Ong PS, Afuang LE, Rosell-Ambal RG. 2002. Philippine Biodiversity Conservation Priority-setting Program (PBCPP), Philippine Biodiversity Conservation Priorities: A Second Iteration of the National Biodiversity Strategy and Action Plan: Final Report Quezon City: Protected Areas and Wildlife Bureau-Department of Environment and Natural Resources, Conservation International-Philippines, Biodiversity Conservation Program-University of the Philippines Center for Integrative and Developmental Studies, 114p.

Picardal RM Dolorosa RG. 2014. The molluscan fauna (gastropods and bivalves)and notes on environmental conditions of two adjoining protected bays in Puerto Princesa City, Palawan, Philippines. Journal of Entomology and Zoology Studies **2(5),** 72-90.

Poppe GT, Tagaro SP, Dekker H. 2006. Visaya: The Seguenziidae, Chilodontidae, Trochidae, Calliostomatidae and Solariellidae of the Philippine Islands. Visaya Supplement **2**, 1-228.

Printrakoon C, Wells FE,Chitramwong Y. 2008. Distribution of mangrove molluscsin the upper Gulf of Thailand. Raffles Bulletin of Zoology **18**, 247-257.

QuintasP, Moreira J, Troncoso JS. 2013.Distribution patterns of molluscan fauna in seagrass beds in the Ensenada de O Grove (Galicia, north-western Spain). Journal of the Marine Biological Association of the United Kingdom, **93(3),** 619–630. https://doi.org/10.1017/S0025315412001555

Rahman S, Barkati S. 2012. Spatial and Temporal variations in the Species Composition and Abundance of Benthic Molluscs Along 4 Rocky Shores of Karachi. Turkish Journal of Zoology **36(3),**291-306. http://dx.doi.org/10.3906/zoo-1004-26

Ruppert EE, Fox RS, Barnes RD. 2004. Invertebrate Zoology.7[th]Ed.Thomson Brooks/Cole, 963p.

Rueda JL, Gofas S, Urra J, Salas C. 2009. A highly diverse molluscan assemblage associated with eelgrass beds (Zostera marina L.) in the Alboran Sea: micro-habitat preference, feeding guilds and biogeographical distribution. Scientia Marina **73(4)**, 679-700.
http://dx.doi.org/10.3989/scimar.2009.73n4679

Scheltema RS. 1964. Feeding habits and growth in the mudsnail Nassarius obsoletus. Chesapeake Science**5,** 161-166.

Schoppe S, Gatus J, Milan PP, Seronay RA.1998. Cleaning activities on the islands of Apid, Digyo and Mahaba, Inopacan, Leyte, Philippines. Philippine Scientist**35,**130-140.

Snelgrove PVR, Butman CA. 1994. Animal-sediment relationships revisited: Cause vs. Effect. Oceanography and Marine Biology: An Annual Review **32**, 111- 177.

Springsteen FJ, Leobrera FM. 1986. Shells of the Philippines. Malate, Metro Manila: Carfel Shell Museum, 377 p.

Tabugo SRM, Pattuinan JO, Sespene NJJ, Jamasali AJ. 2013. Some Economically Important Bivalves and Gastropods found in the Island of Hadji Panglima Tahil, in the province of Sulu, Philippines. International Research Journal of Biological Sciences **2(7),**30-36.

Taylor JD, Glover EA. 2004. Diversity and distribution of subtidal benthic molluscs from the Dampier Archipelago, Western Australia; results of the 1999 dredge survey (DA2/99). Records of the Western Australian Museum **66,**247-291.

Taylor JD, Reid DG. 1984. The abundance and trophic classification of molluscs upon coral reefs in the Sudanese Red Sea. Journal of Natural History **18(2)**, 175-209.

Teh CP, Nithiyaa N, Ng PF, Woo SP, Norhanis MR, Zulfigar Y, Tan SH. 2014. The diversity of the marine macro gastropods on the seagrass meadows in Merambong Shoal, Johore.Malyan Nature Journal **66(1-2),** 132-138.

Tsubaki R, Kameda Y, Kato M. 2011. Pattern and process of diversification in an ecologically diverse epifaunal bivalve group Pterioidea (Pteriomorphia, Bivalvia). Molecular Phylogenetics and Evolution **58,**97-104.
http://dx.doi.org/10.1016/j.ympev.2010.11.014.

Veras DRA, Martins IX, Cascon HM. 2013. Mollusks: How are they arranged in the rocky intertidal zone? Iheringia, Série Zoologia, Porto Alegre**103(2),** 97-103.

Vohra FC. 1971. Zonation on a Tropical Sandy Shore. Journal of Animal Ecology **40,**679-708.
http://dx.doi.org/10.2307/3445.

Yipp MW.1980. The Distribution of Ground-dwelling Gastropods in a Small Mangrove Stand in Hong-Kong. In B. Morton and C. Tseng, editors, Proceedings of the First International Marine Biological Workshop: The Marine Flora and Fauna of Hong Kong and Southern China, Hong Kong, Hong Kong: Hong Kong University Press, 705-720.