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Assemblages of mesozooplankton in Baler Bay, Aurora, Northern Philippines

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Abstract. Composition, diversity, abundance of mesozooplankton and their relation with the hydrological conditions of the waters in Baler Bay, Aurora, Northern Philippines were compared. A total of 122 taxa belonging to 9 major groups were categorized. Copepoda comprises the chief constituent of the mesozooplankton community with *Canthocalanus pauper*, *Oncaea venusta*, *Centropages furcatus*, *Acrocalanus gibber*, *Calanopia elliptica* and *Candacia catula* being the most abundant and widely distributed copepods in the said area. Using several diversity indices, high diversity and evenness but low dominance values in the mesozooplankton taxa was observed in the five sampling stations. Results of Kruskal-Walis Test revealed significant differences ($p<0.05$) in the mesozooplankton relative abundance between the sampling stations. Further, results of Canonical Correspondence Analysis revealed total suspended solids (TSS) in influencing the mesozooplankton abundance. In view of the role of copepods as key contributors of the marine zooplankton and their position in the marine food webs, the present findings are therefore important in understanding the dynamics of any marine ecosystems and are vital in terms of managing and conserving the marine resources.

Key Words: Diversity, abundance, pelagic copepods, hydrological conditions.

Introduction. Mesozooplankton, in particular copepods, provide a direct link between phytoplankton or primary producers and higher trophic levels such as fishes, seabirds, and some marine mammals (Poulet & Williams 1991). Zooplankton practically includes representatives of almost all animal groups (Harris et al 2000). One important feature about plankton is that their movement would largely depend on tides, currents, and winds, since they are small or weak to swim against the currents. So that wherever the current traverse, it brings along with it the tiny plankton communities (Omorii & Ikeda 1984). Ecological studies on zooplankton assemblage have documented more and more parameters (biotic and abiotic) that controls the distribution and abundance of this community. Most often the dominance of a certain species which is usually governed by several interacting factors may greatly vary from place to place (Dur et al 2007). For instance, dissolved oxygen influenced the mesozooplankton composition and abundance in San Ildefonso Cape, Aurora, Northern Philippines while dissolved oxygen, pH and water temperature seems to affect the community in Casiguran waters, Aurora, Northern Philippines. Moreover, the distribution of zooplankton depend largely on the physical and dynamic characteristics of the water masses (Sabates et al 1989) so that large water masses transported by the current carries along with it zooplankton assemblage (Gomez et al 2000; Lopes et al 1999; Gowen et al 1998; Tseng et al 2011). Due to the sensitivity of zooplankton community to changes in the environmental conditions of the sea, their function as indicators is often effective and remarkable. It is therefore of importance that their ecology be investigated specifically on a census of the diversity and abundance. The objectives of the study are to provide basic information about the mesozooplankton community, particularly copepod fauna, and to determine the hydrological features and its impacts to the zooplankton assemblage in Baler Bay, Aurora, Northern Mindanao.

Material and Method. Baler Bay is a bay in the northeastern part of Luzon Island, Philippines. It is part of the great Pacific Ocean that is important as a marine fishing ground for local fisherfolks. Common fish species in the bay are marlin, yellow fin tuna, salmon and local species like talakitok (African pompano and trevally) (http://baler.gov.ph/about-baler/socio-economic-profile/). Five sampling stations were established in the waters of Baler Bay (Figure 1) using a GPS (GPS map 76S, Garmin).

Figure 1. Geographical location of the five sampling stations in Baler Bay where zooplankton samples were collected. Inset is the map of the Philippines with Baler Bay enclosed in a red diamond.

Methods of *in situ* measurements and gathering of hydrographical data and laboratory analyses used in the present study were patterned from those of Angara et al (2013a, b). *In situ* measurements of hydrographical data, namely subsurface (50 m depth) water temperature, pH, salinity, and dissolved oxygen were obtained using the Oxical DO meter while salinity was taken with the aid of a handheld refractometer (Atago, Japan). Determination of total suspended solids (TSS) was done by following the gravitational filtration method. Mesozooplankton samples were collected in each of the 5 stations using a conical plankton net (length: 1.8 m; mouth diameter: 0.45 m; mesh size opening: 300 µm) towed vertically from 50 m depth to the surface. The quantity of the water filtered by the net was measured with a flowmeter (Rigosha and Co., Ltd No 1687) which was attached to the center of the net opening. Collected zooplankton samples were immediately transferred into a properly labeled polyethylene bottles and preserved in 5% buffered formalin-seawater solution. Triplicate samples were taken in each sampling station. The zooplankton and copepod individuals were sorted and identified to the nearest taxa possible using the standard works of Kasturirangan (1963), Owre & Foyo (1967), Yamaji (1962), Todd & Laverack (1991), Bradford-Grieve (1999), Mulyadi (2004) and Al-Yamani et al (2011). For zooplankton counting, the whole zooplankton sample (75 mL) was used since the plankton samples were not dense with zooplankton individuals. Using a Sedgewick-Rafter counting chamber cell, the zooplankton and copepods were counted until it reaches at least 300 individuals. Abundance of each zooplankton and copepod taxa was expressed as density (individuals m^{-3}) and relative abundance (%). Diversity indices were computed using Shannon-Weaner Index, Margalef Index and Menhinick index. Cluster analysis was used to determine the major groupings of zooplantkon present between the five sampling stations. Canonical Correspondence Analysis (CCA) was employed to determine the hydrological parameters that influenced the relative abundance of zooplankton in the five sampling stations. Kruskal-Walis Test was employed to determine the differences in zooplankton relative abundance between stations. All statistical analyses were done using the software PAST version 2.17 (http://folk.uio.no/ohammer/past/) (Hammer et al 2001).

Results and Discussion. A total of 122 zooplankton taxa belonging to 9 major groups (Protozoa, Cnidarian, Annelida, Chaetognatha, Protochordata, Arthropoda, Mollusca, Echinodermata and Chordata) were identified in the waters of Baler Bay (Table 1). Out of this, 72 species belong to Copepoda (39 from Calanoida, 24 from Poecilostomatoida, 7 from Cyclopoida, and 2 from Harpacticoida); 13 species to Chaetognatha; 3 species to Cnidaria (Siphonophore); 8 species to Protochordata; 2 species to Cladocera, Ostracoda and Mollusca; 1 species to Protozoa, Amphipoda and Decapoda; 1 representative from Mysidacea and Euphausiacea; 26 larval forms and 2 Ichthyoplankters. Among the sampling stations, it was noted that only station 1 (39) harbor the least number of species when compared to the rest of the stations (between 51 - 64). Of these 9 major groups, the Arthropoda, particularly crustaceans, were the chief constituents of the mesozooplankton assemblage in all sampling stations and consisted more than 70% of the total zooplankton population. However, the remaining 8 groups (Protozoa, Cnidarian, Annelida, Chaetognatha, Protochordata, Mollusca, Echinodermata and Chordata) were low in numbers (<22%) (Figure 2). Among the members of Arthropoda (Figure 3), the most dominant and abundant components were the copepods accounting to more than 90% of the total arthropoda population, while the rest of the arthropod members attained only less than 7%. As to the copepod-groups (Figure 4), the most species-rich (39) was Calanoida which represents >60% of the total copepod abundance on average in all stations in Baler Bay. This is followed in order by Poecilostomatoida (24) which represents more than 20%, Cyclopoida (7) accounted to more than 7% and Harpacticoida (2), being the least abundant, was <2%. The major contribution and important role of calanoid copepods in the zooplankton assemblage has been well documented in most Asian countries (Lacuna et al 2014; Angara et al 2013a; Tseng et al 2012, 2013; Jagadeesan et al 2013; Johan et al 2013; Chou et al 2012; Ka & Hwang 2011; Maiphae & Sa-ardrit 2011; Hsiao et al 2011; Chen et al 2010; Jitchum & Wongrat 2009; Tseng et al 2008, 2009; Hwang et al 2007; Dur et al 2007; Lee et al 2006; Rezai et al 2004; Lo et al 2004; Hsieh et al 2004; Uy et al 2006; Hsieh & Chiu 2002).

Further, calanoid groups has been reported to be abundant in the epipelagic regions of the ocean (Mauchline 1998; Schminke 2007; Lopes et al 2007; Miyashita et al 2009) and are also the most common and dominant constituents in shallow waters (<100 m depth) of the neritic and oceanic realms (Lacuna et al 2014; Angara et al 2013a; Tseng et al 2013; Yoshida et al 2006; Irigoien et al 2002). Their rapid and short life cycle and their ability to be commonly distributed around the worlds' oceans coupled with the uniqueness of their structure and function, enables them to become a successful group to thrive and dominate in the pelagic environments of the marine world (Schminke 2007). Since these minute creatures entirely control their natural domain, their vital position in the food web as source of food of most fishery resources (Mahjoub et al 2011; Dahms & Hwang 2007) cannot be ignored. Among the copepods, the following were the most widespread and chief constituent species representing >1% of the population in each sampling stations in the waters of Baler Bay: *Canthocalanus pauper* (range: 8 - 18%), *Oncaea venusta* (1.4 - 19.2%), *Centropages furcatus* (2 - 11%), *Acrocalanus gibber* (2 - 6.3%), *Calanopia elliptica* (2 - 5.4%) and *Candacia catula* (1.4 - 5%). Generally, these 6 copepod species were also present and recorded in all five sampling stations (Table 1, as noted by a black asterisk).

Table 1

Composition of zooplankton in the five sampling stations in Baler Bay, Aurora, Northern Philippines

Zooplankton Taxa	*Stations* 1	2	3	4	5
Holoplankton					
Protozoa					
Globigerina bulloides	+	+	+	+	+
Cnidaria					
Muggiaea atlantica	-	-	+	-	+
Muggiaea kochii	-	+	-	-	-
Diphyes bojani	-	+	-	+	-
Chaetognatha					
Sagitta demipenna	+	+	-	-	-
Sagitta oceania	+	-	-	-	-
Sagitta pulchra	+	-	-	-	-
Sagitta enflata	+	+	+	+	-
Sagitta minima	+	-	+	-	-
Sagitta nagae	-	+	-	-	-
Sagitta macrocephala	-	-	-	-	+
Sagitta maxima	-	-	+	+	+
Sagitta crassa	-	-	+	-	-
Sagitta setosa	-	-	-	-	+
Sagitta neglecta	-	-	-	+	-
Sagitta robusta	-	-	-	+	+
Krohnitta subtilis	-	-	-	-	+
Protochordata					
Oikopleura laboradoriensis	-	+	+	+	+
Oikopleura rufescens	-	+	-	-	-
Oikopleura cophocerca	-	+	-	+	-
Oikopleura dioca	-	-	+	-	-
Appendicularia sicula	-	-	-	+	-
Fritillaria sp	-	-	+	-	+
Doliolum sp.	-	+	-	+	-
Thalia democratica	-	+	-	-	-
Arthropoda					
Copepoda					
Calanaoida					
*Calanopia elliptica**	+	+	+	+	+
Calanopia minor	-	-	+	+	+
*Canthocalanus pauper**	+	+	+	+	+
*Acrocalanus gibber**	+	+	+	+	+
*Acrocalanus gracilis**	+	+	+	+	+
Acrocalanus longicornis	-	+	-	-	+
*Paracalanus parvus**	+	+	+	-	+
*Centropages furcatus**	+	+	+	+	+
Centropages abdominalis	-	-	+	-	-
Centropages orsinii	-	-	+	-	+
Centropages longiformis	-	-	-	-	+
*Candacia catula**	+	+	+	+	+
Candacia discaudata	+	+	+	+	-
Candacia aethiopia	+	-	-	-	-
Candacia truncata	-	+	+	-	+
Candacia pachydactyla	-	-	+	-	-
Candacia bradyi	-	-	-	+	+
Paracandacia truncata	-	+	-	-	-

Zooplankton Taxa	Stations				
	1	2	3	4	5
*Calocalanus pavo**	+	+	+	+	-
Pseudocalanus elongatus	+	-	-	-	-
Temora discaudata	+	+	+	+	+
Temora stylifera	-	+	+	+	-
Temora turbinata	-	+	-	-	-
*Eucalanus attenuatus**	+	+	+	+	-
Eucalanus subcrassus	-	+	+	+	+
Eucalanus mucronatus	-	+	+	-	-
Rhincalanus nasutus	-	-	-	-	+
Euchaeta longicornis	-	+	-	-	-
Acartia negligens	+	+	+	+	+
Acartia tsuensis	-	+	-	-	-
Acartia erythrea	-	-	-	+	-
Acartia danae	-	-	-	-	+
Clausocalanus arcuicornis	-	+	-	-	-
Clausocalanus pergens	-	+	-	-	-
Undinula vulgaris	-	+	-	-	-
Scolecithrix danae	-	+	-	-	-
Labidocera acuta	-	+	-	-	-
Labidocera euchaeta	-	-	-	+	-
Metridia lucens	-	-	+	-	-
Poecilostomatoida					
*Oncaea venusta**	+	+	+	+	+
Oncaea mediterránea	+	-	-	-	-
Oncaea clevei	+	-	-	-	-
Oncaea conifer	-	-	+	-	-
Oncaea media	-	-	+	-	+
Corycaeus speciosus	+	+	+	+	-
Corycaeus affinis	+	-	-	-	+
Corycaeus agilis	+	+	+	+	-
Corycaeus carinatus	+	-	-	-	-
Corycaeus dahli	+	-	-	+	+
Corycaeus gibbulus	+	-	+	-	+
Corycaeus catus	-	+	+	-	+
Corycaeus erythraeus	-	+	-	+	-
Corycaeus robustus	-	+	-	-	-
Corycaeus andrewsi	-	+	-	+	-
Corycaeus flaccus	-	-	+	-	-
Corycaeus vitreus	-	-	+	-	-
Corycaeus danae	-	-	-	-	+
Corycaeus lautus	-	-	-	-	+
Corycaeus crassiculus	-	-	-	-	+
Copilia mirabilis	+	+	+	+	+
Copilia quadrata	-	-	+	-	-
Sapphirina stellata	-	+	-	+	+
Sapphirina ovatolanceolata	-	-	-	+	-
CYCLOPOIDA					
*Oithona similis**	+	+	+	+	-
Oithona plumífera	-	+	+	-	+
Oithona robusta	-	+	+	+	+
Oithona spinirostris	-	+	-	+	-
Oithona rostralis	-	-	+	+	-
Oithona setigera	-	-	-	+	-
Oithona atlantica	-	-	-	+	-

Zooplankton Taxa	Stations				
	1	2	3	4	5
Oithona spinirostris	-	+	-	+	-
Oithona rostralis	-	-	+	+	-
Oithona setigera	-	-	-	+	-
Oithona atlantica	-	-	-	+	-
HARPACTICOIDA					
Macrosetella gracilis	-	+	-	-	-
Microsetella rosea	-	-	+	-	-
Euphausiacea (Euphausiid)	-	-	-	-	+
Mysidacea (Mysid)	+	+	+	+	+
Cladocera					
Evadne tergestina	-	+	+	+	+
Evadne nordmani	+	-	-	-	-
Ostracoda					
Conchoecia oblonga	+	+	+	+	+
Euconchoecia chierchiae	-	+	-	-	-
Amphipoda					
Hyperia sp.	-	-	+	-	-
Decapoda					
Lucifer hanseni	-	-	-	-	+
Mollusca					
Creseis sp.	-	+	+	+	+
Janthina sp.	-	-	-	+	-
Meroplankton/Larval Forms					
Echinodermata					
Ophiopluteus	-	-	+	+	-
Cnidaria					
Leptomedusa	+	+	+	-	-
Hydromedusa	-	-	+	+	+
Annelida					
Polychaete larva	-	+	+	+	-
Mollusca					
Gastropod juvenile	+	-	+	-	-
Bryozoa					
Cyphonaute larva	+	-	-	-	-
Arthropoda					
Copepoda eggs	-	-	+	-	-
Barnacle nauplius	-	+	+	+	-
Decapoda					
Crab zoea	+	+	+	+	+
Megalopa	-	-	-	+	-
Shrimp zoea	-	-	-	+	-
Mysis	-	+	+	+	+
Stomatopoda					
Squilla larva	-	+	-	-	-
Ichthyoplankters					
Chordata					
Fish eggs	+	+	+	+	+
Fish larva	-	+	+	+	+
Total number of individuals	**39**	**64**	**62**	**57**	**51**

+ presence; – absence; *****copepod species present in all sampling stations in 3 replicate samples; * copepod species present in all sampling stations in at least 2 replicate samples.

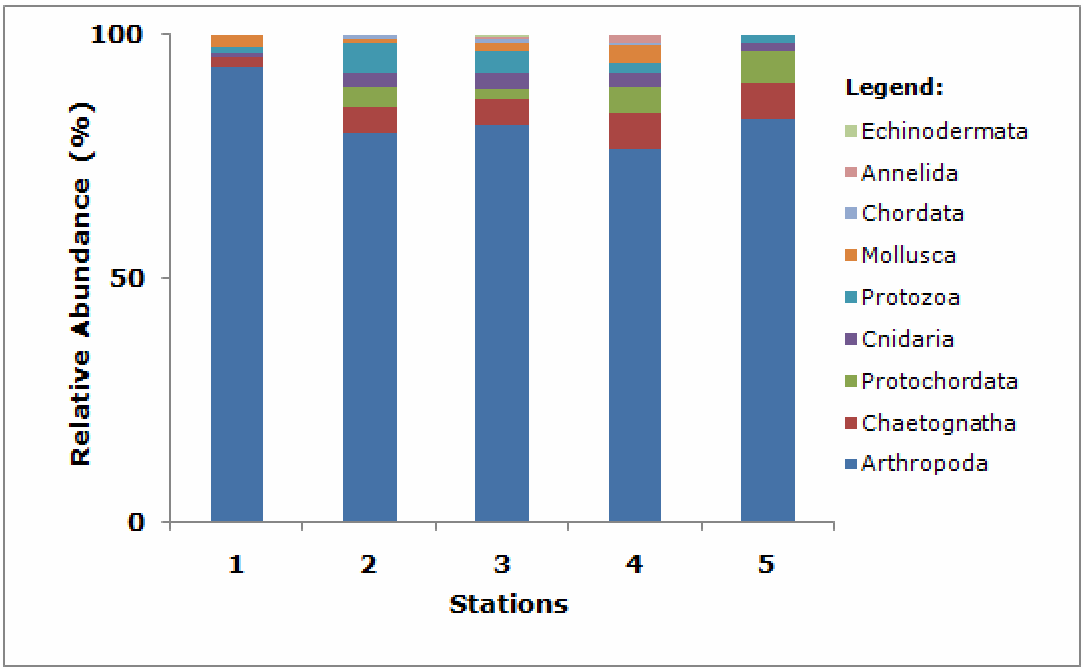

Figure 2. Relative abundance (%) of the 9 major phyla in each sampling stations in Baler Bay, Aurora, Northern Philippines.

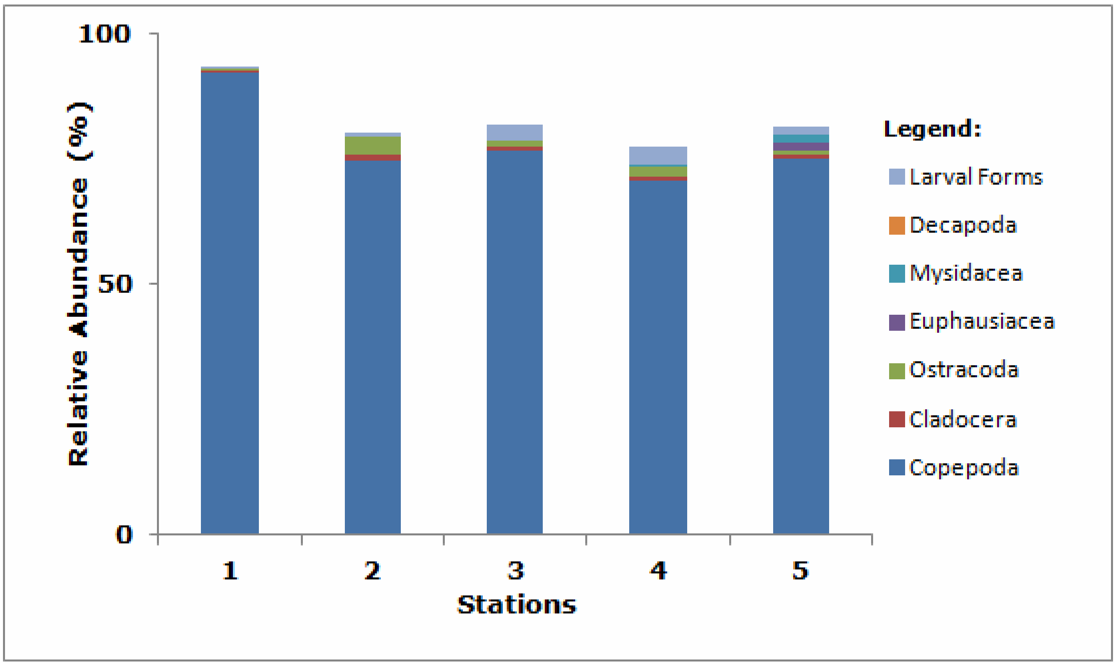

Figure 3. Relative abundance (%) of the members of arthropoda in each sampling stations in Baler Bay, Aurora, Northern Philippines.

It has been reported that the frequent appearance and dominance of these 6 copepod species is attributed to their ability to be cosmopolitan in nature since they are widely distributed in tropical and subtropical oceans, can prevail wide ranges in salinity variations and even have different modes of feeding behavior. For instance, *C. pauper* was documented to be abundant in Casiguran waters Northern Philippines (Lacuna et al 2014), along the coasts of Taiwan (Ka & Hwang 2011), in the inner Gulf of Thailand (Suvavepun & Suwanrumpha 1968) and even in oceanic zone (Noda et al 1998). *C. furcatus* was commonly observed in shallow warm waters (Hwang et al 2007), the coasts, epipelagic zones (Lacuna et al 2014; Davies & Slotwinski 2012; Achuthankutty et al 1995) and even in estuaries where they were able to flourished in salinity between 27 - 35 ppt (Achuthankutty et al 1995). *C. catula*, which was included in the list of abundant copepod species in the present study, was likewise reported to be widely distributed in the coastal, neritic and oceanic waters (Angara et al 2013a; Hsieh et al 2004; Noda et al 1998; Maiphae & Sa-ardrit 2011; Vukanic 2010; Dur et al 2007; Lo et al 2004; Chihara & Murano 1997; Campaner 1985). Further, *A. gibber* was recognized to be a warm water (Lan et al 2009; Dur et al 2007) and oceanic species (Noda et al 1998). On the other hand, the poecilostomatoid *O. venusta* which predominated in all sampling stations was observed to be commonly encountered in coastal, neritic and oceanic waters especially in Asian waters near the Pacific Ocean (Lacuna et al 2014; Hsieh et al 2004; Noda et al 1998; Chen et al 1974; Chen et al 1965), Caribbean waters (Webber et al 2005), and Southern Brazil (Campaner 1985). The abundance of *O. venusta* was attributed to the species' wide choices of food such from toxic dinoflagellates (Turner & Tester 1997; Wu et al 2004) to marine snow (Alldredge 1972). Such attribute therefore allows the organism to swing from omnivory (Turner 1986) to detritivory (Yamaguchi et al 2002). Moreover, the species can decrease respiratory losses by changing their mode of existence from pelagic to a pseudopelagic mode (Nishibe & Ikeda 2008). Hence, the wide occurrence, diverse feeding habits as well as respiratory adaptation of *O. venusta* over a wide latitudinal range and hydrographical regime seems to contribute to their successful colonization and dominance in Baler Bay as suggested by Fernandes & Ramaiah (2009). Other dominant copepods which also represent >1% of the population in at least 2 replicate samples include *Paracalanus parvus* (5.3 - 11%), *Acrocalanus gracilis* (3 - 7.4%), *Calocalanus pavo* (2.1 - 4.4%), *Temora discaudata* (1.4 - 4%), *Oithona similis* (1.5 - 6.3%) and *Eucalanus attenuatus* (1.9 - 8.1%).

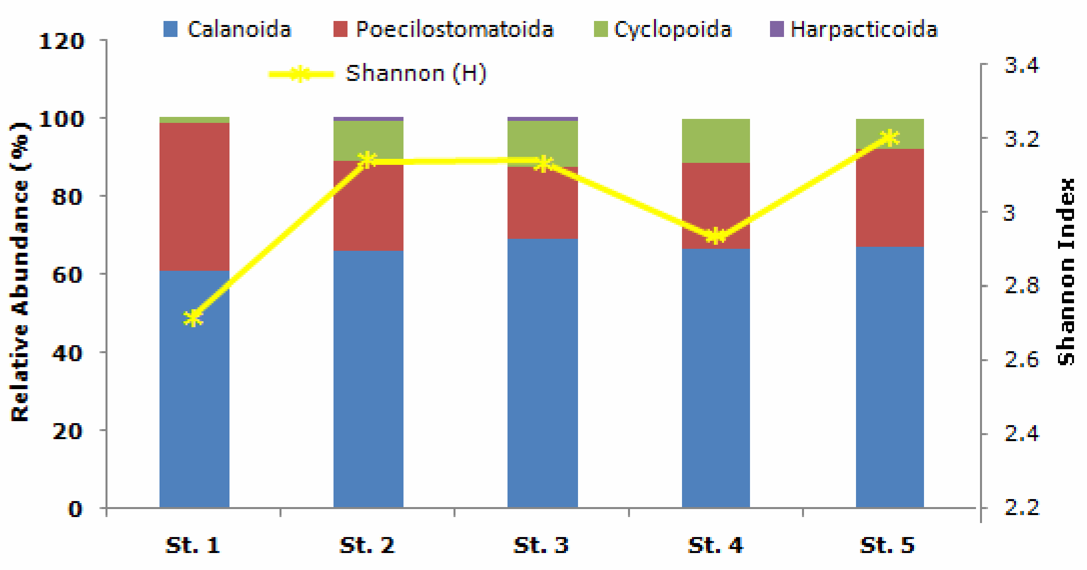

Figure 4. Relative abundance and diversity profile of copepod-groups in each sampling station in Baler Bay, Aurora, Northern Philippines.

The values for all subsurface (50 m depth) water quality parameters (*i.e.* temperature, pH, salinity, TSS and DO) in all five sampling stations are within the range for any marine faunistic assemblage to thrive and be fairly abundant (DENR 1990; Bradshaw 1957) (Figure 5). However, the mean values reflected variations between the five sampling stations. For instance, high TSS values (Figure 5a) were recorded in station 1 (22.30 - 23.10 mg L^{-1}) when compared to the rest of the stations. Slight variations in the subsurface water temperatures (29.20 - 30.40°C) among the stations were likewise observed and such differences can be attributed to light intensity changes since temperatures were measured at different times of the day. High alkaline pH range values

(9.23 - 9.56) have been recorded in all stations (Figure 5b), much higher than the slightly alkaline seawater (pH 7.5 - 8.5). This may imply the influence of the intrusion of the waters of the neighboring Pacific Ocean which may contain high concentrations of calcium carbonate.

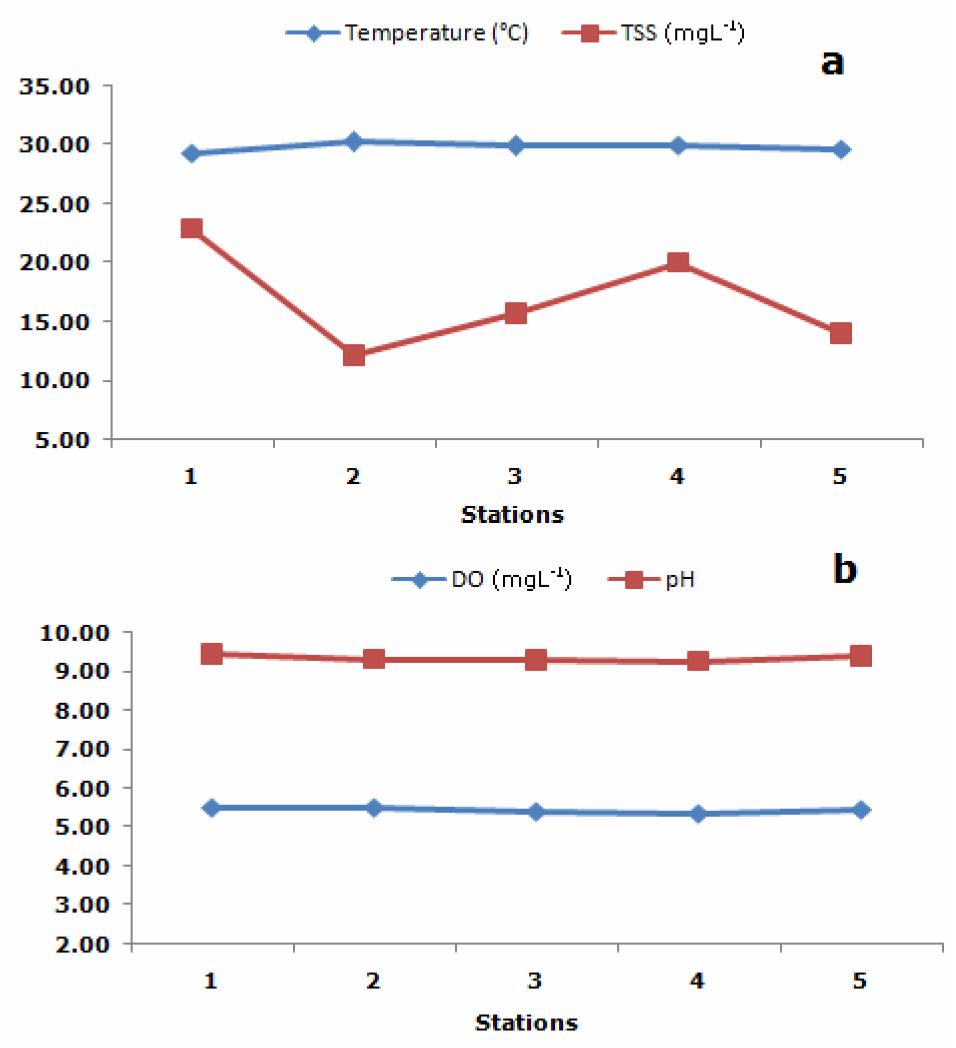

Figure 5. Mean values of (a) water temperature (°C) and TSS (mg/L), (b) DO (mg/L) and pH in the five sampling stations in Baler Bay, Aurora, Northern Philippines.

It has been reported that the alkaline pH values are almost always determined by the buffering effect of dissolved salts or seawater (Schmieglow 2004; Costa et al 2009) and from a high concentration of free CO_2, carbon-based mineral molecules suspended in the water, specifically calcium carbonate that comes from rocks like limestone or can be leached from calcite in the soil (George et al 2012). Slight changes in DO values were observed in all five sampling stations with an increased noted in station 1 (5.83 mg L^{-1}) and a minimal decreased recorded in station 4 (5.21 mg L^{-1}). For salinity values, all the five sampling stations have the same salinity values of 35 ppt. This is anticipated because of the influence and mixing of the more saline waters of the Pacific Ocean with the waters in Baler Bay.

The level of the diversity of zooplankton taxa in the five sampling stations is presented in Table 2. It can be seen from the results that there were differences in the number of taxa between the five sampling stations, with station 2 and 3 showing the highest number of zooplankton taxa (63) followed in decreasing order by Station 4 (58), Station 5 (50) and with station 1 having the lowest number of taxa (38). However, looking at the diversity of zooplankton taxa, results revealed a generally high Shannon

Weiner diversity index in all five sampling stations (range: 2.981 - 3.613), high evenness (range: 0.5055 - 0.7061) but low dominance (0.03311 - 0.08047) values. Since copepods were the chief constituents of the total zooplankton population, the levels of copepod diversity were also calculated. Data showed high levels of copepod diversity values (H' ranges from 2.739 - 3.215) in each sampling stations established in Baler Bay (Figure 4) with the highest value noted in station 5 (3.215) and lowest in station 1 (2.739).

Table 2

Diversity profiles of zooplankton taxa in the five sampling stations in Baler Bay

Diversity indices	*Stations*				
	1	*2*	*3*	*4*	*5*
Taxa (S)	39	63	63	58	50
Individuals	437	1134	1112	1185	1179
Dominance (D)	0.08047	0.04448	0.03931	0.0436	0.03311
Shannon (H)	2.981	3.553	3.613	3.477	3.564
Simpson (1-D)	0.9195	0.9555	0.9607	0.9564	0.9669
Evenness (e^H/S)	0.5055	0.554	0.5884	0.5578	0.7061
Menhinick	1.866	1.871	1.889	1.685	1.456
Margalef	6.25	8.815	8.84	8.054	6.928
Equitability (J)	0.8138	0.8575	0.872	0.8562	0.911
Fisher alpha	10.36	14.38	14.47	12.77	10.59
Berger-Parker	0.1808	0.1146	0.116	0.1004	0.06192

Similarly, high evenness values (ranges from 0.5579 - 0.8298) but low dominance values (ranges between 0.04459 - 0.09373) were recorded in the five sampling stations. Basically, very high diversity and evenness values of zooplankton taxa and copepod species but low dominance values were prominent in the present study indicating that these organisms were evenly distributed in terms of abundance in the five sampling stations and that no certain species tend to dominate in these areas. It has been shown that the levels of diversity for mesozooplankton, particularly those of the copepods, are typically enhance in oceanic waters (H' values ranged:2.50 - 5.16) than those in the neritic and coastal zones (H' values <2.50) (Angara et al 2013a; Tseng et al 2013; Marin & Delgado 2009; Fernandes & Ramaiah 2009; Tseng et al 2008; Lee et al 2006; Hsieh et al 2004; Yang et al 1999; Lopes et al 1999; Noda et al 1998; Shih & Chiu 1998; Champalbert 1996; Kang & Hong 1995). In the case of Baler Bay, the values recorded (H' ranges from 2.739 to 3.215) are within the ranges reported for oceanic waters, however, the presence of neritic and coastal species also dominated in the bay (Table 1) suggesting that wide selection of copepod species may occur hence forming an intermediate copepod assemblage in the said area. Several studies had documented that high diversity with low dominance values are common in oligotrophic, stress-free environment and low levels of ecological stress for marine microfauna and flora communities (Kouwenhoven 2000; Drinia et al 2004; Lacuna et al 2013). In general, the criterions for water quality are those reflected in the diversity indices (Balloch et al 1976; Gharib & Dorgham 2006) such that changes in its values are often related to the health status of the environment. Since the overall diversity can more or less evaluate the stability of an ecosystem, the results of the present study can therefore suggest that the waters in Baler Bay is indeed a stable marine environment that can still provide highly diverse assemblages of marine fauna and flora.

The results of the comparison (Kruskal-Walis Test) of the abundance of zooplankton species between the five sampling stations showed significant difference ($p<0.05$) where this effect or difference was manifested in the high abundance of zooplankton occurring in station 1 but low in station 4 (Figure 6). This is further supported by the results of the Canonical Correspondence Analysis reflected in Figure 7, where it showed a plot of the sampling stations across the first two canonical axes. The plot includes a vector plot that could be used to pinpoint important variables that can explain the differences in the assemblages of mesozooplankton from the different stations.

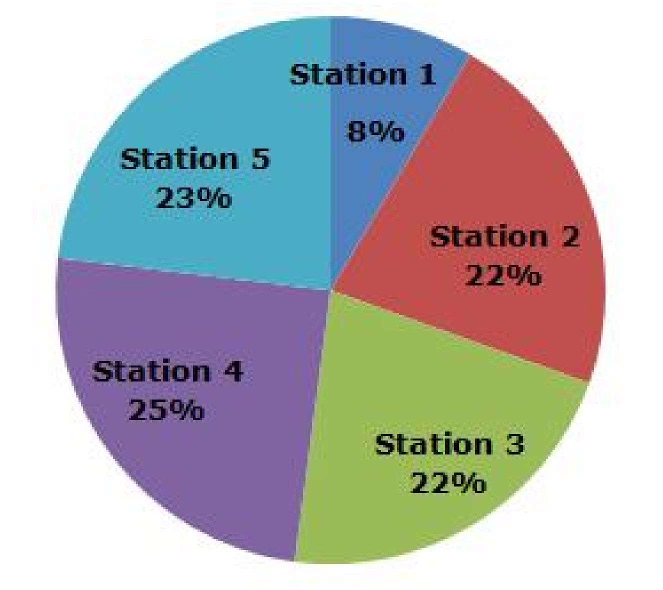

Figure 6. Relative abundance (%) of mesozooplankton in the five sampling stations in Baler Bay, Aurora, Northern Philippines.

Results in Figure 8 showed that low abundance of mesozooplankton observed in station 1 might be influenced by the presence of total suspended solids (TSS) in the water. It is noticeable that TSS value in station 1 was highest when compared with the rest of the stations (Figure 5a). It has been reported that the presence of suspended particulate matter in the water is turbidity, where light penetration in the water column is attenuated or reduced (Dawes 1981). One of the direct effects of high levels of turbidity in the water column is a decrease in phytoplankton biomass because high amounts of suspended particulate matter causes reduction of available light which is needed for phytoplankton growth and reproduction (Parr et al 1998). Since zooplankton rely on plant plankton as one of their major source of food, any alterations in the supply of their food resource may indirectly affect them (zooplankton assemblage). It is probable that the presence of elevated amount of particulate matter in suspension may have rendered the water condition in station 1 as unfavorable for phytoplankton to flourish such that zooplankton abundance was low in the said station. Although, the present data suggests the influence of total suspended solids to the low abundance of mesozooplankton assemblage in Baler Bay, Aurora, other factors like transport of water masses by currents (Gomez et al 2000; Lopes et al 1999; Gowen et al 1998), characteristics of water masses (Tseng et al 2011), seasonal monsoon effects (Yoshida et al 2006), diverse feeding habits (Turner 2004), vertical migration (Lo et al 2004), sampling time (Hwang et al 2009) and mesh-size effects (Tseng et al 2011) may have played an important role in shaping the mesozooplankton community in the area.

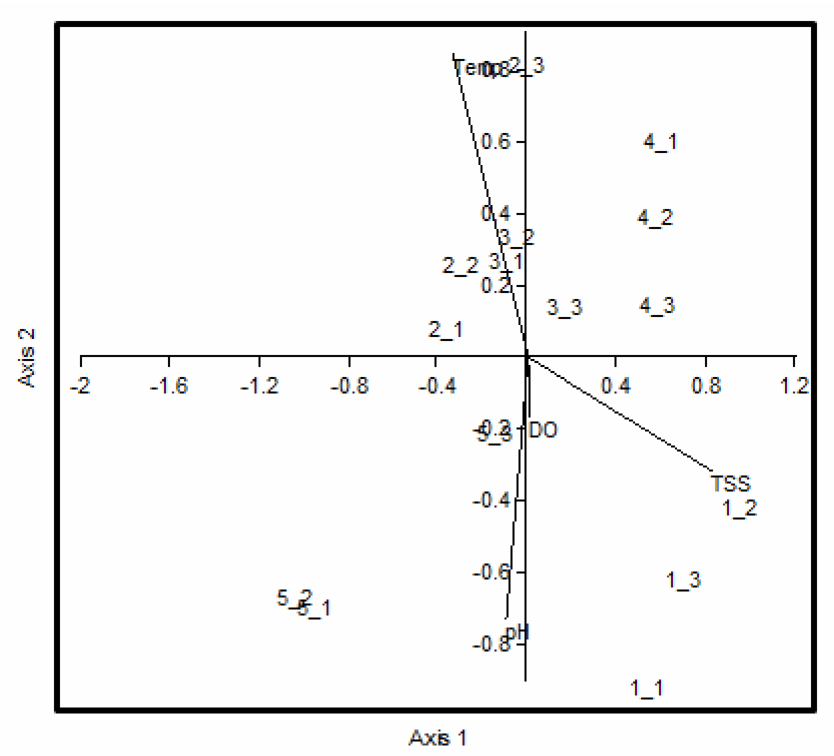

Figure 7. Results of the Canonical Correspondence Analysis - biplot showing the distance among the sampling stations and the hydrological parameters that influence the abundance of zooplankton in Baler Bay, Aurora, Northern Philippines.

Conclusions. A mixture of highly diverse coastal, neritic, and oceanic warm-water to subtropical copepod species inhabits the waters of Baler Bay, Aurora, Northern Philippines. The highly diverse mesozooplankton assemblage observed in the area can therefore suggest that the waters in Baler Bay is indeed a stable marine environment that can still provide highly diverse assemblages of marine fauna and flora. Although, hydrological condition, *i.e.*, total suspended solids (TSS), may indirectly influence the zooplankton abundance, other issues such as the water masses transported by currents, seasonal effects, diel vertical migration of the organisms and effects of mesh-size of the plankton net could also affect the mesozooplankton assemblage of the said area. The role of copepods as the chief constituents of the marine zooplankton assemblage is already well established in the marine world, they therefore occupy a very valuable place in the marine food webs such that the information produced by the present study are vital in comprehending the major activities that are happening in this ecosystem and can also be a basis for management and conservation of the marine resources. It is recommended that the circulation patterns of the ocean current must be included in any future biological and hydrological studies in order to obtain a greater picture on the factors that are responsible in shaping the mesozooplankton assemblage in Baler Bay, Aurora, Northern Mindanao.

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