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Phytoplankton diversity and abundance in Panguil Bay, Northwestern Mindanao, Philippines in relation to some physical and chemical characteristics of the water

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Abstract. Phytoplankton composition diversity, abundance and their relation with the physico-chemical parameters of the waters in two coastal sites in Panguil Bay, Philippines were compared. A total of 93 species belonging to four major groups (diatoms, dinoflagellates, silicoflagellates and cyanobacteria) were identified, with the diatoms being the chief component of the phytoplankton. Using several diversity indices, results showed minimal differences in the phytoplankton species between the two sites. The results of NPMANOVA revealed significant differences ($p<0.05$) in phytoplankton relative abundance between sites and within sites between months. These differences were attributed to variations in the physico-chemical characteristics of the water as reflected from the results of Canonical Correspondence Analysis (CCA). Since results of the study reflect the importance of physical and chemical factors of the water on the phytoplankton community structure in Panguil Bay, it is suggested that changes in these factors, may it be due to natural or anthropogenic sources, may lead to impacts or changes in phytoplankton dynamics.
Key Words: Tropical phytoplankton, diversity and abundance, Panguil Bay, Philippines.

Introduction. Phytoplankton are microscopic single-celled plants that are too small to be seen by the naked eye. These include the dinoflagellates, diatoms, coccolithoporids, and cyanobacteria. They are very important in the marine food web because they convert the sun's energy into consumable and available food forms which nourishes the entire food web of the oceans. Although the function of these producers (such as macroalgae) in the marine ecosystem cannot be ruled out, the phytoplankton community largely contribute (up to 70%) to the oceans entire primary production. Thus, it is in the single-celled organisms that the major amount of energy from the sun is trapped, making them the main source of the food energy for the next trophic level (i.e., zooplankton) in the marine food chain. Aside from their vital role in the aquatic food webs, phytoplankton are also used as ecological indicators by providing information concerning the ecosystem condition or health. In particular, these organisms respond rapidly to the wide range of pollutants and thus can provide potentially useful early warning signals of deteriorating conditions and the possible causes (Deeley & Paling 1999). One response of the phytoplankton is the detectable changes in species composition as a result of any number of factors like eutrophication, increased use of coastal waters for recreational or commercial use and commercialization of habitat along adjacent river system (Martin 2001).

Studies of marine phytoplankton are necessary for us to estimate the resource of the coastal waters. Phytoplankton that appear accidentally from surface water up to 50 m depth can have different composition, species number and density (Satyanarayana 1990). It is suggested that the occurrences and density of different types of species of phytoplankton in the bodies of water are usually affected by water quality (Levine &

Miller 1991). The fundamental indicators of water quality are its physical (water temperature, transparency, current and total suspended solids) and chemical (pH, dissolved oxygen, salinity and nutrients) properties which are likewise affected by the inputs entering the bodies of water (Falkowski et al 1998). These inputs are the many pollutants from land-based sources that are brought about by several anthropogenic activities such as logging, livestock, agricultural practices, residential and resort development, damming, sewage, oil, hydrocarbons, sediments, nutrients, pesticides, litters and marine debris and toxic wastes that enter the sea via the river water outputs and other run offs from land. Further, the amounts and timing of freshwater inflows and sediment inputs into the coastal water influence the quality and productivity of phytoplankton (San Francisco Bay Food Web Technical Report, 2004).

Due to the important position phytoplankton occupies in the marine food chain and its substantial impact on global environmental balance, this study was carried out in order to investigate the composition, diversity and abundance of phytoplankton, to get a general view of the physico-chemical condition of the coastal water and then correlate it to the phytoplankton diversity and abundance.

Material and Method. Panguil Bay in Northwestern Mindanao is one of the richest body of water in the Philippine Archipelago with a total water area of 18,000 ha. It is shaped like a canine tooth and has an irregular coastline that measures about 112 km (Figure 1). The mouth exits into the larger Iligan Bay and is the deepest portion (57.50 m) while the shallowest area (1.50 m) is in the inner most part of the bay. About 29 rivers and 46 minor tributaries carry freshwater and enrich the bay with nutrients enabling it to support a wide variety of aquatic life. Moreover, the tidal fluxes that bring in freshwater from the larger Iligan Bay allow it to renew and stabilize its ecosystem making an ideal habitat for economically important aquatic resources of the region (Post-Resource and Ecological Assessment Monitoring and Training Project in Panguil Bay, 1996).

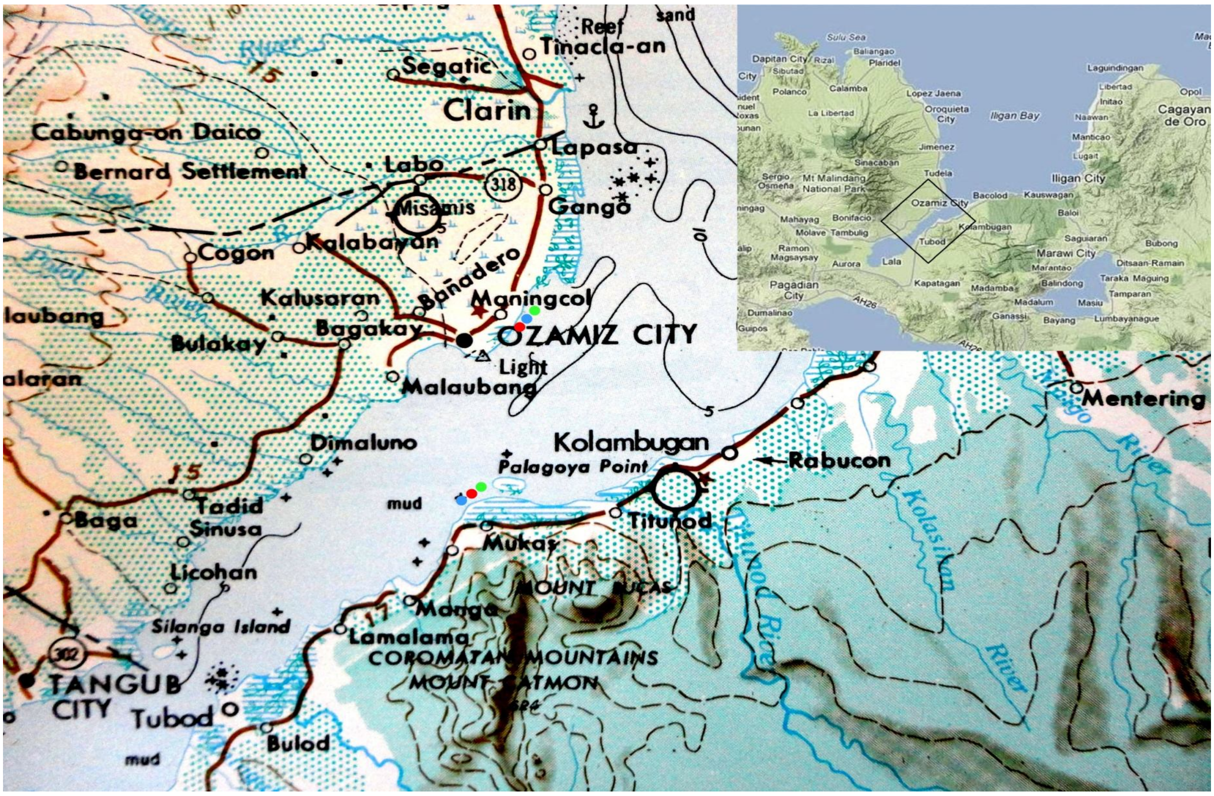

Figure 1. Geographical location of the two study sites where the three sampling stations are located. Inset is the map of Panguil Bay enclosed in a diamond. Legend: ●station 1 ●station 2 ●station 3

Within the bay, the study was carried out for a period of three months (September-November 2009) in three sampling stations established in two different coastal sites namely, Doña Consuelo, Maningcol in Ozamiz City and Mukas in Kolambugan. Doña Consuelo, Maningcol is situated 08^0 10’ 5.52” North Latitude and 123^o 52’ 10.13” East Longitude and is located northwest at the entrance of Panguil Bay whereas, Mukas is situated 08^0 6’ 24.00” North Latitude and 123^o 50’ 38.87” East Longitude. Both areas receive the population’s domestic waste and drainage via river tributaries. In addition, a commercial seaport is also present in Mukas where it provides transport ferry services in Panguil Bay with the used of ferry boats.

Monthly samplings were done in each sampling stations during morning to noon to record the physico-chemical parameters of the water and to collect phytoplankton samples. Field data like water temperature, pH, salinity, dissolved oxygen and water motion were measured “in situ”. Surface water temperatures and pH were measured using a portable pH meter. Salinity was estimated with the aid of a handheld refractometer (Atago, Japan). Dissolved oxygen was determined by the modified Winkler’s method (Grasshoff et al 1983). Water motion was estimated using the clod card deployment of Doty (1971). For total suspended solids, the gravitational filtration method was adopted. For nutrient analysis, surface water samples were collected in a pre acid-washed polyethylene bottles and stored in an ice box for transport to the laboratory. The water samples were analyzed for inorganic nitrates and phosphates following the standard methods of Strickland & Parsons (1972).

Phytoplankton samples were collected by lowering a conical plankton net (length: 0.45 meter; mouth diameter: 0.21 meter; mesh size opening: 50μm) to a depth of 5 m. Triplicate phytoplankton samples were collected at each station and preserved with Lugol’s solution. For quantitative analysis, the settling method described by Sukhanova (1978) was adopted. For numerical counting of the phytoplankton samples, a Sedgewick-Rafter counting chamber cell was used and the strip counting method was adopted. Relative abundance of phytoplankton species was based on cell density derived from the numerical counting of the phytoplankton sample. Phytoplankton were identified using the standard works of Cupp (1943), Yamaji (1982), Marshall (1986), Thomas (1997), Garcia & Odebretch (2008) and Al-Kandari et al (2009).

Diversity indices were computed using Shannon-Weaver Index, Margalef Index and Menhinick index. Cluster analysis was used to deternine the major groupings of phtyoplantkon present between the two sites. Canonical Correspondence Analysis (CCA) was employed to determined the physico-chemical parameters that influenced the relative abundance of phytoplankton. Non-Parametric Multivariate Analyses of Variance (NPMANOVA) was used to determine the differences in phytoplankton relative abundance between sites and within sites. All statistical analyses were done using the software PAST version 2.13 (http://folk.uio.no/ohammer/past/) (Hammer et al 2001).

Results and Discussion. A total of 93 phytoplankton species belonging to four major groups (diatoms, dinoflagellates, silicoflagellates and cyanobacteria) were identified in the two coastal sites in Panguil Bay (Table 1), with the diatoms constituting the chief components of the phytoplankton groups. In the marine environments, especially in nutrient-rich nearshore waters, diatoms are the dominant groups in phytoplankton communities (Valiela 1984). The coastal waters in Doña Consuelo, Maningcol recorded the highest number of phytoplankton taxa (87) when compared to those in Mukas (84).

The level of the diversity of phytoplankton in the two sampling sites, namely Mukas and Doña Consuelo, Maningcol is shown in Table 2. It can be seen from the results that difference in the number of taxa was minimal, having only a difference of three taxa between the two sites which favors that of Mukas. Results further revealed very minimal difference in the diversity of phytoplankton species between the two sites as reflected in the Shannon-Weaver (H) values. This would mean that the level of phytoplankton diversity in both sites were almost similar.

Table 1

Composition and species richness of phytoplankton species in the two coastal sites in Panguil Bay during the months of September, October and November 2009

Phytoplankton species	*Mukas*			*Doña Consuelo*		
	S	*O*	*N*	*S*	*O*	*N*
Bacillariophyceae (Diatoms)						
Achnanthes sp.	-	+	+	+	+	+
Amphora sp.	+	+	+	+	+	+
Asterionella japonica Cleve	+	-	+	+	+	+
Asterolampra marylandica Ehr	-	-	-	-	+	-
Bacillaria paxillifer G. F. Gmelin	+	+	+	+	+	+
Bacteriastrum delicatulum Cleve	+	+	+	+	+	-
Bacteriastrum elongatum Cleve	+	+	+	+	-	-
Bacteriastrum hyalinum Lauder	+	+	+	+	+	+
Bacteriastrum varians Lauder	+	+	+	+	+	+
Biddulphia longicruris Greville	+	+	+	+	+	-
Biddulphia mobiliensis Bailey	+	+	+	+	+	+
Biddulphia sinensis Greville	+	+	+	+	+	+
Campylodiscus ralfsii W. Smith	+	-	+	+	+	-
Cerataulina pelagica (Cleve) Hendey	+	+	+	+	+	+
Chaetoceros affinis Lauder	+	+	+	+	+	+
Chaetoceros compressus	+	-	-	+	+	+
Chaetoceros curvisetus Cleve	+	+	+	+	+	-
Chaetoceros decipiens Cleve	+	+	+	+	+	+
Chaetoceros diversus Cleve	-	-	+	+	+	+
Chaetoceros laciniosus	-	-	+	+	+	+
Chaetoceros laevis Leudiger-Fortmorel	-	+	-	+	+	+
Chaetoceros pendulus Karsten	+	+	+	+	+	+
Climacosphenia moniligera Ehrenberg	+	+	-	-	-	-
Cocconeis pediculus Ehrenberg	+	-	-	+	-	+
Corethron hystrix Hensen	+	-	+	+	+	+
Corethron pelagicum Brun.	+	+	-	+	+	+
Coscinodiscus sp.	+	+	+	+	+	+
Dactyliosolen antarcticus Castracane	+	+	-	+	-	+
Ditylum brightwelli (West) Grunow	+	+	+	+	+	+
Ditylum sol Grunow	+	+	+	-	-	-
Donkinia sp.	-	-	+	-	+	+
Eucampia cornuta (Cleve) Grunow	+	+	+	-	-	-
Eucampia zoodiacus Ehrenberg	+	+	+	+	+	+
Fragillaria striatula	+	+	+	-	+	+
Grammatophora marina (Lyngbye)	+	+	+	+	+	+
Guinardia flaccida (Castracane) Péragallo	+	+	+	+	+	+
Gyrosigma balticum	+	+	+	+	+	-
Hemiaulus indicus	-	+	-	-	-	-
Hemiaulus sinensis Greville	+	+	+	+	+	-

Phytoplankton species	Mukas			Doña Consuelo		
	S	O	N	S	O	N
Hyalodiscus stelliger Bailey	-	-	+	-	+	-
Lauderia borealis Gran	+	+	+	+	+	+
Leptocylindrus danicus Cleve	+	-	-	-	+	+
Licmophora abbreviata Agardh	+	-	+	+	+	+
Melosira nummuloides C. A. Agardh	+	+	+	+	+	+
Melosira sulcata (Ehrenberg) Kützing	+	+	+	+	+	+
Navicula cancellata	+	+	+	+	+	+
Navicula sp.	+	+	+	+	-	-
Nitzschia frigida Grunow	-	+	-	+	+	-
Nitzschia longissima Ralfs	+	+	+	+	+	-
Nitzschia pungens Cleve	+	+	+	+	+	+
Nitzschia sigma Kütz	+	+	+	+	+	+
Nitzschia sp.	+	+	+	+	-	+
Palmerina hardmaniana Greville	+	+	+	+	+	+
Planktoniella sol Schütt	-	-	-	-	-	+
Pleurosigma intermedium W. Smith	+	+	+	+	+	+
Pleurosigma normanni Ralfs	+	+	+	-	+	+
Pleurosigma pelagicum Péragallo	+	+	+	+	+	+
Pleurosigma rectum Donkin	+	+	+	+	+	+
Rhizosolenia alata forma gracillima (Cleve)	+	+	+	+	+	+
Rhizosolenia calcar avis M. Schultze	+	+	+	+	+	+
Rhizosolenia cylindrus Cleve	+	+	+	+	-	-
Rhizosolenia hebetata (Bailey) Gran forma	+	+	+	+	+	+
Rhizosolenia imbricata Brightwell	+	+	+	+	+	+
Rhizosolenia setigera Brightwell	+	+	+	+	-	-
Rhizosolenia stolterfothii H. Péragallo	+	+	+	+	+	+
Rhizosolenia styliformis Brightwell	-	+	-	+	+	+
Skeletonema costatum (Greville) Cleve	-	+	-	+	+	+
Stephanopyxis palmeriana	+	+	+	-	-	-
Striatella unipunctata Lyngbye	+	+	+	-	-	+
Surirella cuneata A. schmidt	+	+	+	+	+	+
Surirella gemma Ehrenberg	+	-	+	+	-	-
Synedra sp.	+	+	+	+	+	+
Thalassionema nitzschioides Grunow	+	+	+	+	+	+
Thalassiothrix frauenfeldii Grunow	+	+	+	+	+	+
Thalassiothrix sp.	+	+	+	+	+	+
Triceratium favus Ehrenberg	-	+	-	-	-	-
Cyanophyceae						
Phormidium subfuscum	-	-	-	+	+	-
Trichodesmium sp.	-	+	+	+	-	-
Chrysophyceae (Silicoflagellates)						
Dictyocha fibula Ehrenberg	+	+	+	+	+	+

Phytoplankton species	Mukas			Doña Consuelo		
	S	O	N	S	O	N
Dinophyceae (Dinoflagellates)						
Ceratium furca Ehrenberg	+	+	+	+	+	+
Ceratium fusus Jöergensen	+	+	+	+	+	+
Ceratium macroceros Cleve	+	+	+	+	-	+
Ceratium sp.	+	+	-	+	+	+
Ceratium tripos Muller	-	-	-	-	+	+
Ceratocorys horrida Stein	-	-	-	+	+	-
Dinophysis homunculus Stein	-	-	-	+	+	+
Dinophysis miles Cleve	-	-	-	+	+	-
Dinophysis rapa Stein	-	-	-	-	+	+
Ornithocercus thumii Schmidt	-	-	-	-	+	+
Perdinium grande	+	+	+	-	+	+
Peridinium depressum Bailey	+	+	+	+	+	-
Peridinium granii Ostenfeld	-	-	+	+	+	+
Podolampas bepis Stein	+	-	+	+	+	+
Total number of species	68	70	71	75	75	67
Grand total number of species	84 (Mukas)			87 (Doña Consuelo)		

S September, O October, N November, + present, - absent

Table 2

Diversity profiles of the sampling sites

Diversity index	Site	
	1	2
Taxa (S)	80	77
Individuals	88012	35072
Dominance (D)	0.09458	0.07514
Shannon (H)	0.9054	0.9249
Simpson (1-D)	0.9054	0.9249
Evenness (e^H/S)	0.2303	0.3496
Menhinick	0.2697	0.4112
Margalef (d)	6.939	7.262
Equitability (J)	0.665	0.7581
Fisher alpha	8.672	9.357
Berger-Parker	0.1886	0.1893

Relative abundance among the phytoplankton groups during the three sampling months (September, October, November) in the two coastal sites (Mukas and Doña Consuelo, Maningcol) showed the diatom group to be the most abundant (>90%) while the dinoflagellates and silicoflagellates were very low (< 12%) (Figure 2). Among these diatoms (Figure 3), the following were the top 4 diatom species in the coastal waters of Mukas during the three sampling months: *Lauderia borealis* (20.46%), *Thalassiothrix frauenfeldii* (19.45%), *Palmarina hardmaniana* (18.70%) and *Coscinodiscus sp.* (11.51%) dominated in September, while the appearance of *Coscinodiscus sp.* (17.07%), *Lauderia borealis* (9.93%), *Thalassiothrix frauenfeldii* (8.77%) and *Bacteriastrum varians* (6.70) were prevalent in October, and *Thalassiothrix frauenfeldii* (27.40%), *Coscinodiscus sp.* (13.05%), *Chaetoceros decipiens* (12.37%) and *Chaetoceros affinis* (6.93%) were common in November. For the coastal waters in Doña Consuelo, Maningcol, the month of September was observed to be dominated by the appearance of *Thalassiothrix frauenfeldii* (18.25%), *Lauderia borealis* (10.85%), *Palmerina hardmaniana* (8.10%) and *Chaetoceros decipiens* (4.94%). In October, it was observed to be dominated by *Thalassiothrix frauenfeldii* (15.84%), *Lauderia borealis* (11.97%) *Chaetoceros curvisetus* (6.61%) and *Coscinodiscus sp.* (6.31%). Fort he month of November, it was dominated by the appearance of *Coscinodiscus sp.* (53.21%), *Thalassiothrix frauenfeldii* (6.15%), *Lauderia borealis* (4.64%) and *Thalassionema nitzschioides* (2.06%).

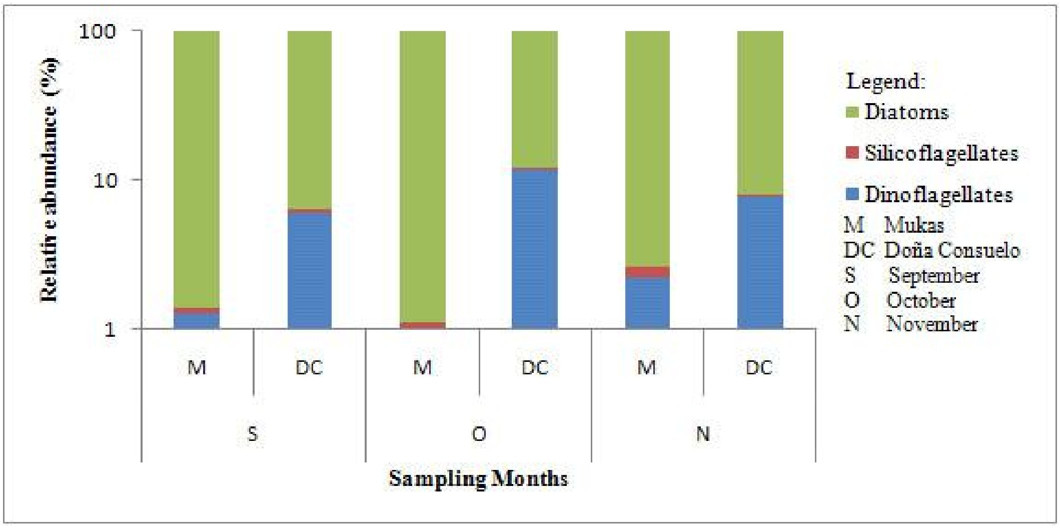

Figure 2. Relative abundance (%) of phytoplankton groups during the months of September, October, November 2009 in Mukas and Doña Consuelo, Maningcol Ozamiz City.

To compare the phytoplankton relative abundance between the two coastal sites (Doña Consuelo, Maningcol and Mukas), NPMANOVA (Non-Parametric Multivariate Analysis of Variance) showed that the sites had significant effect on the relative abundance ($p<0.05$) (Table 3). This effect or difference was manifested in the high phytoplankton abundance occurring in Mukas (Figure 3). On the other hand, the results of the comparison (NPMANOVA) of the phytoplankton relative abundance between stations within site (for Mukas and Doña Consuelo) showed no significant difference ($p>0.05$). However, significant differences ($p<0.05$) were observed in the phytoplankton abundance between sampling months within site (for Mukas and Doña Consuelo, Maningcol). In Mukas, these dramatic differences were apparent in the high phytoplankton abundances occurring in the month of September while Doña Consuelo showed high abundance in the month of November (Figure 3).

The water quality parameters assessed in the two sampling sites have shown variations (Table 4). However, such differences are well within the limits for marine waters favorable for fish growth and propagation.

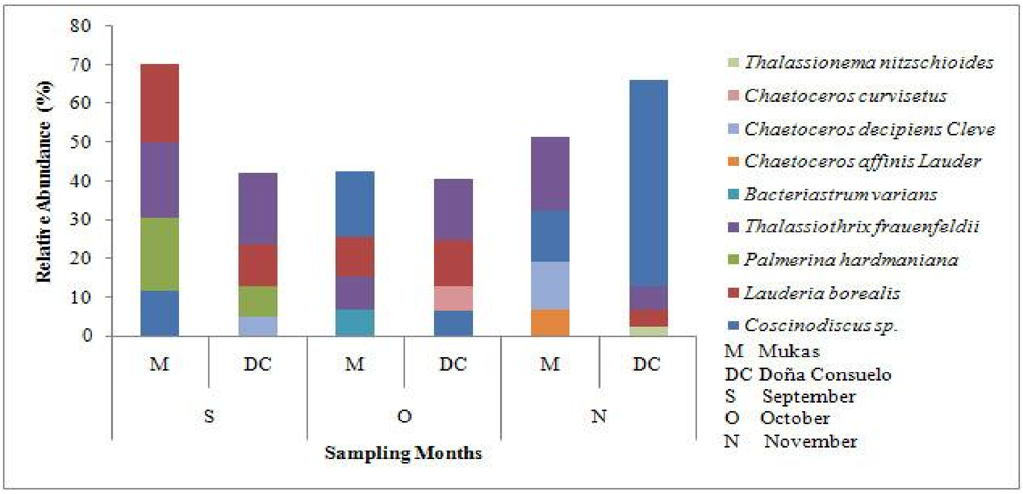

Figure 3. Relative abundance of the top 4 diatom genera during the months of September, October, November 2009 in Mukas and Doña Consuelo, Maningcol Ozamiz City.

Table 3

Results of the Non-Parametric Multivariate Analyses of Variance (NPMANOVA) showing significant differences in phytoplankton community structure between and within sites

Source	*Sum of squares*		*F*	*P (same)*
	Total	*Within group*		
Between sites	3.852×10^4	2.638×10^4	23.94	0.0009*
Within site 1 (between months)	7456	2083	30.96	0.0009*
Within site 1 (between stations)	7456	7075	0.65	0.6503
Within site 2 (between months)	1.893×10^4	3635	50.48	0.0009*
Within site 2 (between stations)	1.893×10^4	1.828×10^4	0.42	0.6933

*significant at p=0.05 level of confidence

Table 4

Range values of the physico-chemical profile of the two sampling sites during September, October and November 2009

Physico-chemical Parameters	*Mukas*			*Doña Consuelo*		
	Sep	*Oct*	*Nov*	*Sep*	*Oct*	*Nov*
Water Temp (°C)	28.50-31.40	30.00-30.70	28.40-29.50	29.50-33.50	29.00-30.50	29.60-32.00
Salinity (ppt)	29.00-35.00	29.00-30.00	14.00-27.00	30.00-34.00	27.00-31.00	25.00-31.00
TSS (g L^{-1})	53.00-76.10	46.70-67.60	22.00-35.70	60.80-92.80	86.30-99.99	42.00-85.50
Water flow (cm s^{-1})	7.49-8.62	8.92-11.93	8.91-10.95	9.03-9.97	6.31-9.94	9.19-9.65
pH	8.66-8.89	7.66-7.69	9.50-9.52	8.58-8.87	7.74-7.77	9.39-9.44
DO (mg L^{-1})	2.52-7.57	1.74-2.80	2.32-2.54	4.30-6.99	2.37-2.89	2.14-2.77
NO_3-N (mgN L^{-1})	0.50-0.57	0.57-0.71	0.40-0.66	0.60-0.70	0.40-0.60	0.55-0.75
PO_3-P (mgP L^{-1})	0.03-0.33	0.01-0.07	0.04-0.09	0.02-0.04	0.01-0.04	0.02-0.07

Standard values for marine and coastal waters: Water temperature maimum rise of 3°C; TSS not more than 30 mg L^{-1} increase; pH range from 6.0 to 8.5; DO greater than 5mg L^{-1}; Nitrate not more than 1.0 mgN L^{-1}; Phosphate not more than 1.0 mgP L^{-1} (Philippine waters standard values from DENR-DAO, 1990). Note: DO values <5mg L^{-1} reflected in Table 2 could be attributed to contamination of the chemicals used in the process of the Winkler Method.

In order to know if phytoplankton species and their abundances are similar between the two sites, cluster analysis using Ward's method was employed. Results revealed two different or distinct clusters that separate these two sites (Figure 4). This is further supported by the results of the Canonical Variate Analysis in Figure 5 where the two sites are separated along the first canonical variate axis. This would mean that phytoplankton community structure, such as the species and its abundance, in the two sites are different. The biplot in Figure 5 further shows that temperature may have strongly influenced these differences. Data on water temperature revealed variations between the two sites. The coastal waters of Doña Consuelo, Maningcol had higher temperature ranges (29.00°C-33.50°C) as compared to Mukas (28.40°C-31.40°C). It was observed that high water temperature values in Doña Consuelo, Maningcol coincided with low phytoplankton abundance while low water temperature values in Mukas coincided with high phytoplankton abundance. The temperature values recorded in Mukas appeared to be suitable for algal growth where the phytoplankton reached its maximum values. The present study is in accordance with those of Touliabah et al (2010), Perumal et al (2009) and Kebede & Ahlgren (1996) who reported that optimum temperature for phytoplankton growth is between 28.5 °C to 31 °C.

Aside from water temperature, other factors namely total suspended solids (TSS) and salinity can also explained the observed differences in phytoplankton abundance between the two sites. Higher values of TSS (42 g L^{-1}-99.99g L^{-1}) and salinity (25ppt-34ppt) were observed in the coastal waters of Doña Consuelo, Maningcol when compared to those in Mukas (TSS: 22 mg L^{-1} -76.10 mg L^{-1}; salinity: 14ppt-35 ppt). The high values of TSS and salinity in Doña Consuelo coincided with low phytoplankton abundance whereas low values of TSS and salinity coincided with high phytoplankton abundance in Mukas. It is expected that when TSS increases due to an increase in suspended particles, the light penetration is reduced which would likewise reduced the photosynthetic activity and growth of phytoplankton (Balogun & Ladigbolu 2010; Tas et al 2009). On the other hand, several studies have shown that phytoplankton growth favors low salinity that is within favorable limits (Tiwari & Nair 2002), but phytoplankton abundance tend to decrease when salinity increases (Tamminen & Kuosa 1996).

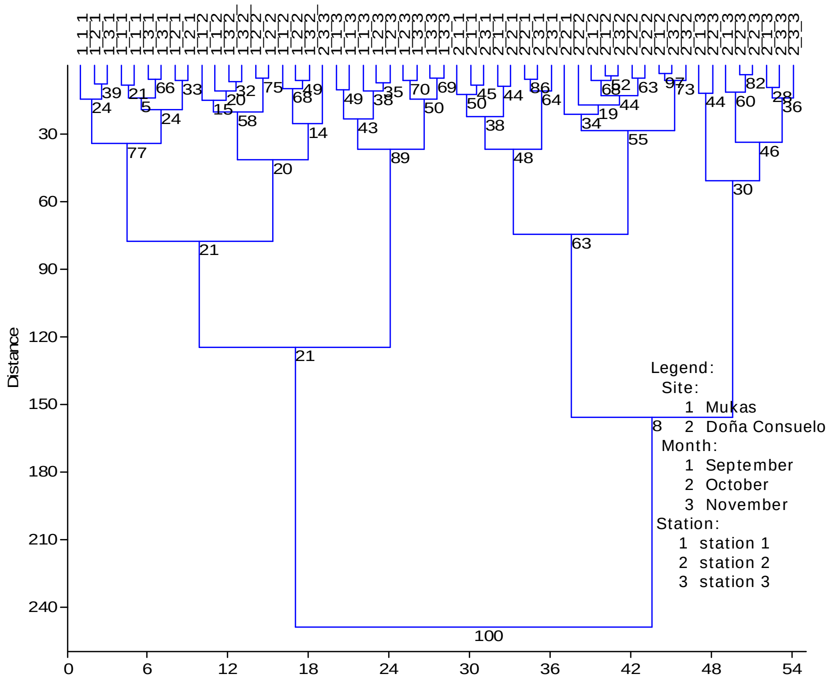

Figure 4. Cluster diagram showing diversity of phytoplankton between two sites. The diagram was computed using Ward's method analysis using Euclidean distance measure (Boot N:100)

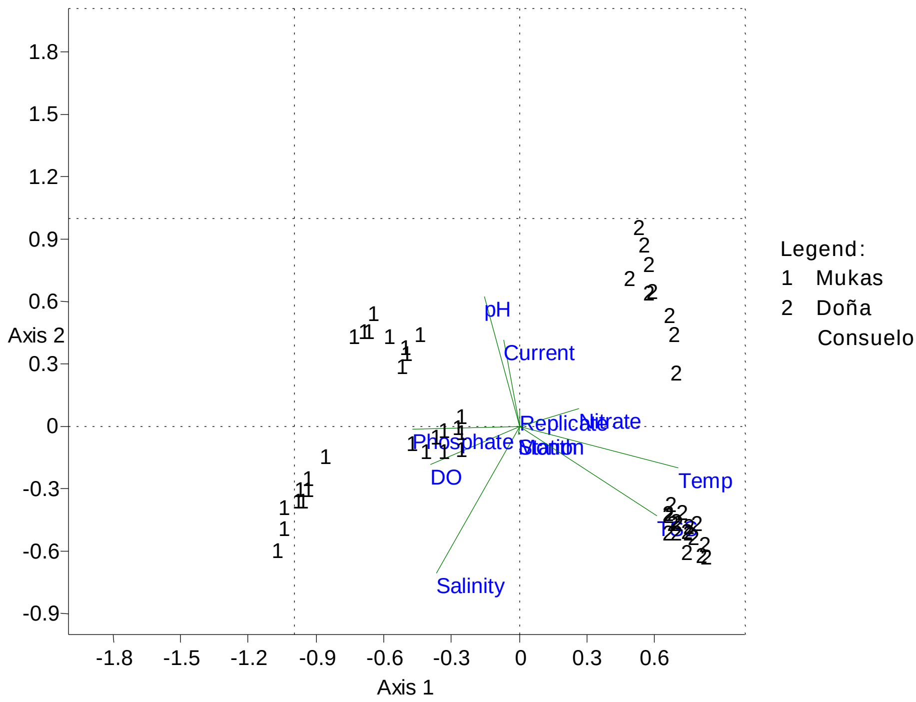

Figure 5. Ordination plot showing distribution of phytoplankton diversity between the two sampling sites in relation to the physico-chemical parameters of the water

Moreover, monthly variations in species diversity and relative abundance were apparent within the two sites, Mukas and Doña Consuelo, Maningcol (Figure 5 and Table 3). These results can be attributed to differences in water pH, salinity and flow/motion between sampling months. In Mukas, it was observed that surface water salinity values were high in the months of September and October but low in November. Low values of salinity in November may be due to heavy rainful that occurred prior to sampling which may caused dilution of the seawater with freshwater coming from land run-offs (Rajkumar et al 2008; Mitra et al 1990). On the other hand, water flow/motion values were observed to be low in the month of September but high in October but then slightly decreased again in the month of November. Moreover, high pH values were observed in the month of September, but decreased in October and then increased again in November. It was reported that pH tend to shift to alkaline range if there is maximum growth of phytoplankton (Uy et al 2006; Touliabah et al 2010). In Doña Consuelo, Maningcol, the trend in the values of water salinity and pH were similar to the trends exhibited in Mukas. However, the water flow/motion values recorded were opposite with those in Mukas. It was noted in Doña Consuelo that water flow/motion values were stronger in the month of September than the values in the months of October and Novermber. The strong water flow observed in September when compared to those values in October and November may be due to the state of the water in the Bay. Gorospe & Prado (1992) reported that during southwest monsoon season (June to October), waves with whitecaps were experienced in the northern part of the Bay (i.e. between Maigo-Clarin segment and Simbuco-Basirang segment). Since Doña Consuelo, Maningcol is located near the entrance of the mouth of the Bay where the Maigo-Clarin segment occurred, it can be deduced that strong water flow/motion observed in September may be due to the conditions observed by Gorospe & Prado (1992).

Conclusions. The water quality parameters in the two coastal sites of the bay may have shown variations in its values, but these are within the tolerable limits for marine waters that is favorable for fish growth and propagation. Variations in the phytoplankton community structure, abundance and diversity in the coastal waters of Mukas and Doña

Consuelo, Maningcol in Panguil Bay were attributed to the physical and chemical factors in the areas. It was observed that temperature, total suspended solids and salinity greatly influenced the differences in phytoplankton abundance between sites. Moreover, it was noted that water salinity and pH can be responsible to the monthly fluctuations in phytoplankton diversity and abundance. Since results of the study reflect the importance of physical and chemical factors of the water on the phytoplankton community structure in Panguil Bay, it is suggested that changes in these factors, may it be due to natural or anthropogenic sources, may lead to impacts or changes in phytoplankton dynamics. Hence, it is recommended that local government units should do constant monitoring of the sites to prevent possible eutrophication that may occur in the near future.

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