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Phytoplankton Diversity in Offshore, Port and Ballast Water of a Foreign Vessel in Negros Occidental, Philippines

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Abstract - Introduction of harmful aquatic organisms and pathogens in our ocean is one of the greatest threats according to the IMO (International Maritime Organization). Alien or invasive species travel from one ocean to the other through ballast water from the international shipping industry which is very inevitable. In the Philippines, few existing studies were established on phytoplankton composition in ballast tanks of a foreign vessel; thus this study is conducted. This study aimed to identify the phytoplankton diversity of offshore, port and ballast water from a foreign vessel docking in Negros Occidental, Philippines. Furthermore, this study aimed to determine the cell density, generic diversity and evenness and physicochemical characteristics such as pH, temperature and salinity. A total of 39 liters were taken from the middle column of the offshore, port and ballast tanks through sounding pipe and siphon technique. Temperature, pH and salinity were measured, *in situ*. All water samples were preserved with Lugol's solution and transported in the Phycology laboratory at Southeast Asian Fisheries Development Center-AQD. This study provides baseline information on phytoplankton diversity present in offshore, port and ballast water from a foreign-going vessel in the Philippines.

Keywords - ecology and conservation, ballast water, phytoplankton, generic diversity, ballast water sampling, generic evenness, Negros Occidental, Philippines

INTRODUCTION

Shipping industry transports 80% to 90% of commodities around the world (Popa, 2009; Marrero and Rodriguez, 2004). Nowadays, thousands of ships navigate the Philippine waters both inter-island and international route. Ship that is actively part of shipping industry is called merchant vessel. These breakthroughs of man can pose several hazards and threats to mankind as well as in the marine environment.

Ships use ballast water since 1850 (Hallegraeff and Bolch, 1992). This contains suspended particles which are primarily used by ships to provide trim, list, draught, stability, or even stresses created by the ship (IMO, 2005). Approximately 150, 000 metric tons of ballast water and sediment are carried by an individual vessel. This could be a mixture of waters from many ports (Deacutis and Ribb, 2002). It was noted that one of the contributory factors to marine pollution is the process of ballasting and deballasting (Popa, 2009).

Ballast water is taken on board usually at the source port if there is less cargo, a process called ballasting. On the other hand, if seawater is pumped out in the ocean after loading of cargo at the destination port, this process is called deballasting (Deacutis and Ribb, 2002). It is estimated that about 12 million tones of ballast water are transferred around the globe annually (Marrero and Rodriguez, 2004). While Popa (2009) said that every year, shipping transfers 21 billion gallons of ballast water in the ocean yearly. Consequently, about 3, 000 to 4, 500 marine species are being carried by the ships through ballasting and deballasting processes around the globe. This led to the transfer of non-indigenous, alien, non-native, exotic, invasive marine species across the globe making it as the one of the four greatest threats in the world's ocean (IMO, 2005) and the most pressing environmental issue for biodiversity loss (Manaaki Whenua Landcare Research, 1994). It was further believed that the ships ballast water and sediment served as the major vector of transferring non-indigenous, alien, non-native, exotic, invasive marine species across the globe (Chu, Tam, Fung and Chen, 2006; Hallegraeff, 1998; MacDonald, 1995; Williams, Griffiths, Van der Wal and Kelly, 1988). Meanwhile, the ships ballast tanks serve as incubators during the voyage for certain species such as diatom and dinoflagellate (Hallegraeff and Bolch, 1992).

Now that we have more equipped and high speed ships, the survival of these non-indigenous, alien, non-native, exotic, invasive marine species survive in new habitats with no natural predators and compete for native species (Popa, 2009). However, for slower speed of ships, species richness, species abundance and diversity decrease or do not survive during the voyage which may be attributed to hostility of ballast tanks (Popa, 2009; Klein, MacIntosh, Kaczmarska and Ehrman, 2009; Chu et al., 2006; Gollasch, Lenz, Dammer and Andres, 2000; Williams et al., 1988). Marrero and Rodriguez (2004) said that there is no present method that can completely eradicate alien species from the ocean. However, mid-ocean ballast water exchange can mitigate the process of transferring these unwanted stowaways (Klein et al., 2009a; Popa, 2009; Hallegraeff and Bolch, 1992; Williams et al., 1988).

Phytoplankton serves as the major food of zooplankton and other marine animals. They are microscopic plants floating in the ocean with size ranging from 2 μm to more than 20 mm (Zaiko, Olenina and Olenin, 2010). Other species are harmful such as they produce toxins affecting fish, shellfish and humans. These toxic phytoplankton form dense color of red, green and brown in the ocean (Carver and Mallet, 2003). The origins of phytoplankton are difficult to determine and in most cases are impossible to determine (Zaiko et al., 2010). Minchin and Gollasch (2002) and Hallegraeff and Bolch (1992) said that the factors affecting phytoplankton biogeography is the ocean currents. Other environmental conditions that regulate phytoplankton composition are temperature (Badylak and Phlips, 2004; Laamanen, 1997), salinity (Badylak and Phlips, 2004), nutrient concentrations or nutrient availability (Badylak and Phlips, 2004; Marshall, Burchardt and Lacouture, 2005), weight ratio of inorganic nitrogen to inorganic phosphorus (Laamanen, 1997), depends on grazing rates (Badylak and Phlips, 2004), successional patterns and seasonal variations (Marshall et al., 2005), hydrography, winds, hull fouling, movement of live shellfish and lastly, by shipping (Minchin and Gollasch, 2002).

Numerous papers were conducted on phytoplankton composition of ships' ballast water across the globe. In the Philippines, due to the absence of baseline data, Sarinas et al., (2010) conducted an initial survey on the plankton composition of the ballast tanks of the inter-island passenger-cargo vessel with the route Iloilo to Manila, Philippines and vice-versa. The species composition of phytoplankton found was noninvasive but difficult to conclude whether the phytoplankton was native or nonnative. Nevertheless, the study serves as the baseline information.

Marshall et al. (2005) found out 1, 454 phytoplankton taxa. Meanwhile, Klein et al. (2009a) studied the diatom survivors in ballast water during trans-Pacific crossings and found out 41 diatom taxa having 29 species. They also found out 86, 429 live diatom cells per liter that were contained in the ballast tanks. These authors pointed out that the invasive biology was poorly understood. Martin and LeGresley (2008) examined the phytoplankton species in the Bay of Fundy since 1995 and found eight new dinoflagellate species, 14 new diatom species and additional of five species of flagellates, small zooplankton, cyanonobacteria and haptophytes. The new species were speculated to be transported by ballast water. Meanwhile, the Manaaki Whenua Landcare Research (1994) and Hallegraeff and Bolch (1992) pointed out that dinoflagellates were a threat to the marine ecosystem because they could survive in a long journey due to their ability to form cysts in the ballast water tanks.

On the other hand, Gollasch et al. (2000) studied the survival of tropical ballast water organisms during a cruise from the Indian Ocean to the North Sea and found out that the ballast water coming from Singapore contained 30 species of diatoms and 24 taxa of juvenile and adult copepod. While in the ballast water of Colombo, they found out 16 species of phytoplankton and 21 taxa of zooplankton were dominated by 11 copepod species and three calanoids. Hallegraeff and Bolch (1992) and Hallegraeff (1998) studied comprehensively the resting spores and cysts of diatom and dinoflagellates in a ship's ballast water and concluded that there were certain species were resistant resting spores present in ballast water. They had found the following toxic dinoflagellates in their laboratory: *Alexandrium catenella, A. tamarense, and Gymnodinium catinatum* wherein these species could contaminate shellfish causing paralytic shellfish poisoning. They further added that, during dinoflagellate blooms, seafarers should not take in ballast water to avoid contamination to other ports.

Impacts of invasive stowaway species are irreversible (Popa, 2009). Deacutis and Ribb (2002) pointed out impacts of invasive stowaway species such as ecological, human health and economic impacts. Ecological changes or disruption of these invasive unwanted stowaways maybe due to lack of natural predators, abundance of food sources, tolerance to pollution, diseases and other stressors and out competing less aggressive species (Deacutis and Ribb, 2002). They also pointed out that 400 aquatic nonnative species had been found since 1990.

Europe, Australia, New Zealand, Russia (Black Sea) and United States were being affected by toxic algal blooms and pathogenic organisms. On the other hand, for human health, the *Vibrio cholera* and the toxic phytoplankton caused diseases and paralytic shellfish poisoning (PSP). In terms of economic impacts, one important invasive species were the zebra mussel that clogged the cooling tanks of power plants and drinking water reservoir species.

In Great Lakes, the economic impact of zebra mussel cost up to tens of millions of dollars just to control this invasive species. The sea lampreys, ruffle and round gobby harmed the native fish community and considered as a threat to ports and fishing industry. On the other hand, Zaiko et al. (2010) enumerated the impacts of invasive plankton and these were eutrophication, bloom of harmful algae, change in native phytoplankton community and water quality (hydrochemistry, transparency, nutrients). Olenina et al. (2010) cited *Prorocentrum minimum* as invasive species and caused impacts.

On the other hand, Zaiko et al. (2010) revealed that the impacts of invasive zooplankton species were: they compete with the native species for food and space, transfer parasites and diseases, they changed the normal zooplankton community and invasive species acting as predators to the native species.

Various studies had been conducted in different countries on species composition in the ship's ballast water, but only few studies existed in the Philippines. It is recommended that there should also be an assessment of ballast water in the foreign-going vessels docking in Negros Occidental, Philippines hence this study was conducted. In addition, since a lot of vessels are docking in Negros Occidental, an assessment should be made to find out if there was the presence of alien or invasive species in Negros Occidental. Lastly, this study will establish a baseline data on the phytoplankton diversity in offshore, port and ballast tanks from a foreign-going vessel docking in Negros Occidental, Philippines.

FRAMEWORK

The effects of unwanted species in the ship's ballast water were first reported to IMO in 1988. This was when Canada informed the Marine Environment Protection Committee (MEPC) of the IMO about invasive aquatic species in Great Lakes (IMO, 2005). In 1997, the 20th session of the IMO Assembly adopted the resolution A.868 (20) which was about the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens. In 2004, the IMO held the International Conference on Ballast Water Management for Ships at IMO Headquarters, London. Eventually, the Conference adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments or the Ballast Water Management Convention (IMO, 2005).

OBJECTIVES OF THE STUDY

This study aims to determine the phytoplankton diversity of the offshore, port and ballast tanks of a foreign-going vessel docking at Negros Occidental, Philippines. Moreover, this study sought to determine the phytoplankton density profile (cells/ml) using the Sedgwick Rafter counter cell, diversity, evenness and physicochemical characteristics such as pH, temperature and salinity.

MATERIALS AND METHODS

Materials

Thirty-nine sterile plastic bottles (20 ml and 1000 ml), 20 μm mesh size sieve, Lugol's solution, wash bottles, 1 inch-wide hose, sounding tape and paste, digital thermometer, pH meter, salinometer, Sedgwick-Rafter colony counter cell and binocular compound microscope (Olympus CH2) was used in this study.

A

B

Fig. 1. A. Sounding paste and tape. B. *In situ* measurement of water depth using sounding paste and tape

Procedure

Fig. 2. Sampling area

Sampling was done in May 2012. The sampling points were: offshore, port and ballast tanks of a foreign vessel. Three areas from the port were sampled (left, middle and right sides) with a total length of 250 m and 10 m away from the port. While a 1-inch wide hose was used to collect seawater through a siphon technique in the middle portion of the water column. A sounding tape was used to determine the depth of the water column. Then, three liters of seawater were collected for each area of the port. The same procedure was applied in offshore with 111.29 m parallel to the ship's length over-all (LOA).

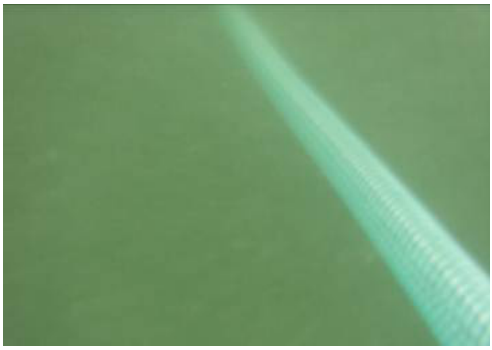


Fig. 3. Siphon technique (water collected at the middle layer of the water column)

In ballast water tank sampling, the researchers asked permission to conduct the study from the Philippine Ports Authority (PPA), Bureau of Customs, ship agent and the master of the ship. One foreign-going vessel docking in Negros Occidental, Philippines was selected as the source for ballast water samples that came from the waters of China. Seven different ballast tanks were chosen purposely: (1) forepeak tank (FPT), (2) double bottom tank (DBT) 2P, (3) DBT 3C, (4) DBT 2S, (5) DBT 1, (6) DBT 4P and (7) DBT 4S. The siphon technique was also applied in collecting ballast water among the seven ballast tanks that was at the middle layer of the ballast tanks.

Fig. 4. Sampling in ballast water tanks

Each liter was preserved with 10 ml Lugol's solution and was screened in a 20 μm mesh size screen. All remaining particles were collected in aliquot bottles (20 ml) through a wash bottle containing filtered (20 μm filter) sea water. Water physicochemical characteristics such as pH, temperature and salinity were also measured, *in situ*.

Fig. 5. *In situ* measurement of pH, temperature and salinity of ballast water

All samples were transported at the Phycology laboratory-Southeast Asian Fisheries Development Center-AQD for the intensive identification and counting of cells/ml (density profile) of phytoplankton diversity using the Sedgwick- Rafter counter cell.

The keys used in the identification of genera were Matsuoka and Fukuyo (2000), Botes (2003) and other keys and monographs available in the literature.

Data Analyses

The following environmental indexes (Atlas and Bartha, 1998) were used in this study:

Shannon Weaver-Index ($\bar{H}$) where,

$$(\bar{H}) = \frac{C}{N}(N \log N - \Sigma\, ni \log ni)$$

Where:

C = 2.3
N = number of individuals
ni= number of individuals in the *i*th species (*i*1, *i*2, *i*3, i4,…*i*x)

Shannon Evenness (e) where,

$$e = \frac{\bar{H}}{\log S}$$

Where:

$\bar{H}$ = Shannon-Weaver diversity index
S = number of species

Generic Richness on the other hand, could be measured by counting the number of genus present in offshore, port and in every ballast tank.

Kruskal-Wallis test set at .05 level of significance was employed to see if there was a significant difference in the cells/ml of plankton diversity in offshore, port and ballast water tanks.

RESULTS AND DISCUSSION

Plankton diversity, density (cells/ml), generic richness and evenness in offshore, port and ballast water tanks

Table 1 shows the phytoplankton diversity and density in offshore, port and ballast tanks, generic richness, generic diversity and generic evenness. Most of the phytoplankton found in this study were diatoms similar to the study of Gollasch et al. (2000), Klein et al. (2009a) and

Klein, Kaczmarska and Ehrman (2009b). For plankton diversity in offshore sample, the most dominant genus was the *Melosira* (88 cells/ml). It was followed by *Coscinodiscus* (16 cells/ml) and *Ditylum* (14 cells/ml). *Melosira* had a great range of taxa and a common genus in freshwater and marine epibenthic habitats (Guiry and Guiry, 2012). A total of 10 genera of plankton were found in offshore with 4.9 as its generic diversity and generic evenness, respectively (Table 1). *Coscinodiscus* are found to be a free-living marine and often abundant phytoplankton (Guiry and Guiry, 2012) and were also found in the study of Klein et al. (2009a). On the other hand, the genus *Ditylum* was a cosmopolitan genus excluding the polar waters (CIMT, 2012a).

For the port area sample, the highest number of cells was still *Melosira* (43 cells/ml), followed by *Ditylum* and *Thalassionema* (24 cells/ml), then *Asterionella, Lauderia* and *Synedra* (23 cells/ml), respectively. A total of 12 genera of plankton was found in the port area with the generic diversity and generic evenness of five, respectively. *Synedra* could be found throughout the world-in freshwater and saltwater environments (Ashley, 2012). *Synedra* was also present in the study conducted by Sarinas et al. (2010) in an inter-island vessel in Iloilo port with route Manila to Iloilo to Bacolod, Philippines.

For ballast tank 1 (FPT), a total of nine genera of plankton were recorded with *Coscinodiscus* (24 cells/ml) as the dominant plankton, followed by *Eucampia* (22 cells/ml) and *Isthmia* (18 cells/ml). Both generic diversity and generic evenness had a value of five. On the other hand, *Eucampia* was common marine planktonic genus while *Isthmia* spp. are epiphytic on seaweed (Guiry and Guiry, 2012). *Eucampia* was also found in the study of Klein et al. (2009a) from the ballast water during the trans-Pacific crossings in Canada.

For ballast tank 2 (DBT 2P), eight genera of plankton were recorded with 4.9 and 5 as generic diversity and generic evenness, respectively. The most dominant plankton was *Pseudo-nitzschia* (26 cells/ml), followed by *Isthmia* (24 cells/ml) and *Synedra* (23 cells/ml). *Pseudo-nitzschia* is an alarming diatom because it produces the neurotoxin domoic acid that can cause amnesic shellfish poisoning and domoic acid poisoning (Thessen, 2010). It was evident that toxic or harmful diatoms and dinoflagellates were indeed transported through ballast water similar to the study of Klein et al. (2009a), Doblin et al. (2004), Hallegraeff (1998) and Hallegraeff and Bolch (1992).

For ballast tank 3 (DBT 3C), six genera of plankton were identified with 4 and 5.5 generic diversity and generic evenness were recorded. This was dominated by *Synedra* (17 cells/ml), followed by *Ditylum* (15 cells/ml) and *Coscinodiscus* (14 cells/ml).

For ballast tank 4 (DBT 2S), the plankton genera went down to five genera with four and five generic diversity and generic evenness, respectively. It was dominated by *Synedra* (15 cells/ml), followed by *Coscinodiscus* (14 cells/ml) and *Isthmia* (13 cells/ml).

While in ballast tank 5 (DBT 1), a total of six genera of plankton were identified with four and 5.5 as generic diversity and generic richness, respectively. The most dominant genera of plankton was *Rhizosolenia* (24 cells/ml), *Chaetoceros* (23 cells/ml) and *Thalassionema* (22 cells/ml). The distribution of *Rhizosolenia* and *Chaetoceros* was widespread throughout the world's ocean (CIMT, 2012 b, c) while *Thalassionema* was cosmopolitan genus in temperate to tropical waters (CIMT, 2012d). *Rhizosolenia* sp. was also found in the study of Gollasch et al. (2000) from the ballast water of ships from the Indian Ocean to the North Sea. Meanwhile, the *Chaetoceros* spp. was also found in the study of Klein et al. (2009b) found in the ballast water of ships arriving at Canadian ports on the West Coast, East Coast and Great Lakes and in trans-Pacific crossings, Canada.

In ballast tank 6 (DBT 4P), nine genera of plankton were recorded as the highest genera of plankton with five as generic diversity and generic evenness, respectively. The most dominant genera were *Lauderia* and *Melosira* (26 cells/ml), followed by *Eucampia* and *Odontella* (25 cells/ml) and *Ditylum* (24 cells/ml). *Lauderia* is common and widespread in the ocean (Guiry and Guiry, 2012). *Odontella* on the other hand, was very abundant throughout the oceans (Guiry and Guiry, 2012).

Finally, for ballast tank 7 (DBT 4S), nine genera of plankton were identified with 4.2 and five as the generic diversity and generic evenness were recorded. The most dominant was the *Odontella* (15 cells/ml), followed by *Lauderia* (14 cells/ml), then *Ditylum, Isthmia, Synedra* and *Thalassionema* (13 cells/ml).

It was noted that genus *Grammatophora* in offshore, *Leptocylindricus* in the FPT, *Rhizosolenia* in DBT 2P and DBT 1 of this study were also shown in the study of Klein et al. (2009a) from the ballast water of ships during the trans-Pacific crossings in Canada.

Statistical analysis from this study showed that the cells/ml of plankton genera, showed no significant difference, $H = 14.224$, $p = .076$ in offshore, port and ballast water tanks.

Physicochemical characteristics of offshore, port and ballast water tanks

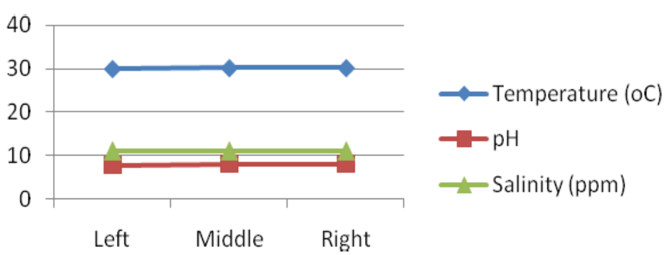
Determination of physicochemical characteristics such as temperature, pH and salinity were recorded, *in situ* with three replications for each area and tank. Temperature was measured through a digital thermometer, pH was recorded through a pH meter and salinity was measured through a salinometer. In the offshore area, the highest temperature was 30.2 ^{o}C at the middle and at the right side facing the ocean where the ship was situated during anchorage. The pH was highest at the right side at 8.1 while salinity was also the same with port area which was 11 ppm at three areas of the offshore (Fig. 6).

Table 1. Phytoplankton diversity showing the genera and density (cells/ml) in offshore, port and ballast tanks of a foreign vessel (in mean values) and generic richness and evenness

Genus	Off-shore	Port	FPT	DBT 2P	DBT 3C	DBT 2S	DBT 1	DBT 4P	DBT 4S
Arachnoidiscus H. Deane ex G.Shadbolt	-	18	-	-	-	-	-	23	-
Asterionella Hassall	-	23	-	-	-	-	-	-	11
Chaetoceros Ehrenberg	12	16	-	14	13	-	23	12	11
Coscinodiscus Ehrenberg	16	18	24	22	14	14	-	21	-
Ditylum J. W. Bailey	14	24	16	-	15	-	-	24	13
Eucampia Cleve	11	21	22	-	-	-	-	25	12
Grammatophora Ehren-berg	12	-	-	-	-	-	-	-	-
Isthmia C. Agardh	11	22	18	24	-	13	19	17	13
Lauderia Cleve	13	23	-	-	-	-	-	26	14
Leptocylindricus Cleve	-	-	7	-	-	-	-	-	-
Licmophora C. Agardh	-	-	12	-	-	-	-	-	-
Melosira C. Agardh	88	43	-	-	-	11	-	26	-
Odontella C. Agardh	-	21	-	17	11	11	-	25	15

Pseudo-nitzschia Peragallo	-	-	-	26	-	-	-	-	-
Rhabdonema Kutzing	-	-	13	-	-	-	-	-	-
Rhizosolenia Brightwell	-	-	-	13	-	-	24	-	-
Skeletonema Greville	-	-	-	18	-	-	-	-	-
Striatella C. Agardh	-	-	-	-	-	-	19	-	-
Synedra Ehrenberg	12	23	15	23	17	15	15	-	13
Thalassionema Grunow ex Mereschkowsky	12	24	13	-	11	-	22	-	13
Summary									
Generic Richness	10	12	9	8	6	5	6	9	9
Generic Diversity (H)	4.9	5	5	4.9	4	4	4	5	4.2
Generic Evenness (e)	4.9	5	5	5	5.5	5	5.5	5	5

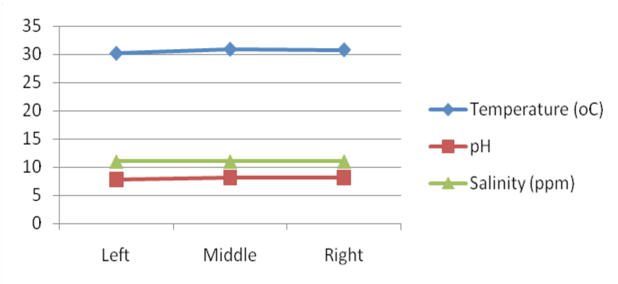
All sides of the offshore favored the growth of *Coscinodiscus, Ditylum, Lauderia, Melosira, Synedra* and *Thalassionema*. *Chaetoceros* and *Grammatophora* were only found in the left and right sides (facing the open sea) of the offshore. While *Isthmia* was only found in the left side of the offshore or maybe collected by chance during sampling. Same was true with *Eucampia* that was only found in the middle portion of the offshore.



Water parameters	Left	Middle	Right
Temperature (^oC)	30	30.2	30.2
pH	7.81	8.03	8.1
Salinity (ppm)	11	11	11

Fig. 6. Temperature, pH and salinity in offshore area (left, middle and right sides)

In the port area, the highest temperature and pH recorded was 30.9 °C and 8.08 at the middle of the port facing the ocean, respectively. While salinity was consistent at three areas (left, middle and right sides) of the port at 11 ppm (Fig. 7). All sides of the port (left, middle and right) favored the growth of *Arachnoidiscus, Asterionella, Chaetoceros, Coscinodiscus, Ditylum, Eucampia, Isthmia, Lauderia, Melosira, Odontella, Synedra* and *Thalassionema* from the given temperature, pH and salinity.

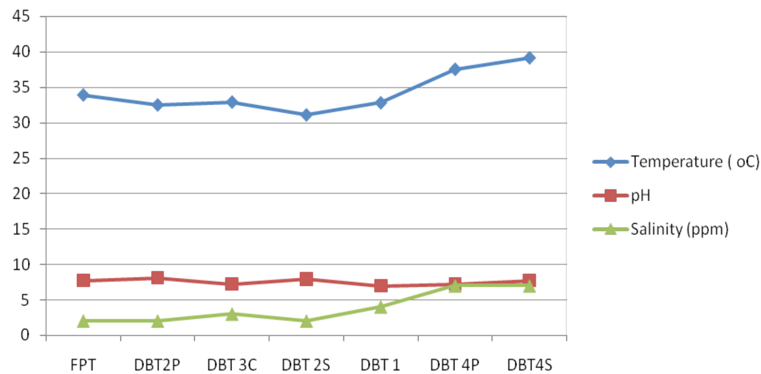


Water parameters	Left	Middle	Right
Temperature (°C)	30.2	30.9	30.8
pH	7.82	8.08	8.07
Salinity (ppm)	11	11	11

Fig. 7. Temperature, pH and salinity in port area (left, middle and right sides)

In ballast water tanks, the highest temperature recorded was 39.1 °C in DBT 4S while lowest at DBT 2S (31.1 °C). The highest pH recorded was 8.05 at DBT 2P and lowest in DBT 1 (6.97). On the other hand, salinity varies from a range of 2-7 ppm (Fig. 8).

For FPT, genera such as *Coscinodiscus, Ditylum, Eucampia, Isthmia, Leptocylindricus, Licmophora, Rhabdonema, Synedra* and *Thalassionema* favored their growth. In DBT 2P, *Chaetoceros, Coscinodiscus, Isthmia, Odontella, Pseudo-nitzschia, Rhizosolenia, Skeletonema* and *Synedra* proliferated. While in DBT 3C, *Chaetoceros, Coscinodiscus, Ditylum, Odontella, Synedra* and *Thalassionema,* were found. In DBT 2S, *Coscinodiscus, Isthmia, Melosira, Odontella* and *Synedra* proliferated. Meanwhile, in DBT 1, *Chaetoceros, Isthmia, Rhizosolenia, Striatella,* *Synedra* and *Thalassionema* were identified. On the other hand, in DBT 4P, *Arachnoidiscus, Chaetoceros, Coscinodiscus, Ditylum, Eucampia, Isthmia, Lauderia, Melosira* and *Odontella* were also identified. Finally in DBT 4S, *Asterionella, Chaetoceros, Ditylum, Eucampia, Isthmia, Lauderia, Odontella, Synedra* and *Thalassionema* favored their growth due to favorable conditions.



Water parameters	FPT	DBT2P	DBT 3C	DBT 2S	DBT 1	DBT 4P	DBT4S
Temperature (°C)	33.9	32.5	32.9	31.1	32.8	37.5	39.1
pH	7.68	8.05	7.21	7.91	6.97	7.21	7.68
Salinity (ppm)	2	2	3	2	4	7	7

Fig. 8. Temperature, pH and salinity in ballast water tanks

CONCLUSIONS

A total of 20 genera of diatoms was identified in this study. Some of the diatoms could be found in offshore and port samples, but not in ballast water and vice versa. Generic richness is highest at port area with 12 genera present. This might be due to the favorable environment which allowed the growth of the diatoms most especially in the port area. Moreover, most of the plankton found in this study could be found throughout the world's ocean. However, one genus of diatom, *Pseudo-nitzschia* found in this study was toxic or known as harmful algae. Indeed, this study presents that harmful or toxic algae can be carried through international shipping through ballast water and thus provides the baseline information of plankton composition in the offshore, port and in the ballast tanks from a foreign-going vessel. It is recommended that foreign ships entering the ports of the Philippines should follow the rules implemented by the IMO to conduct ballast water exchange in the open ocean to minimize the transfer of alien and harmful organisms. A yearly sampling should also be conducted in the ballast water in foreign-going vessels and analysis of cysts should also be given attention so as to determine the toxic or nontoxic plankton.

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