Initial Assessment of Phytoplankton and Zooplankton Composition in Ballast Water Tanks of an Inter-Island Passenger-Cargo Vessel in the Philippines

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Abstract: Numerous studies have been conducted on ballast water species composition and diversity in other countries but not in the Philippines. Thus, this study aimed to provide baseline information on the species composition of ballast water in the inter-island passenger-cargo vessel in the Philippines. Specifically, this study aimed to determine the presence of phytoplankton and zooplankton composition in ballast water tanks water in the inter-island passenger-cargo vessel and determine the species density of the phytoplankton and zooplankton composition measured in cells/ml using the haemacytometer technique. Composite sampling was employed having one liter of ballast water was used per ballast tank. A total of 15 genera of phytoplankton and one genus of zooplankton were observed. Chroococcus sp., Nannochloris sp. and Protococcus sp. had the highest cells/ml while Ankistrodesmus sp., Micromonas sp. and Synedra sp. had the lowest cells/ml. The most common phytoplankton observed in ballast tanks were Nannochloris sp. and Protococcus sp. Neocalanus sp. (copepods) are

almost seen in all ballast tanks. The phytoplankton and zooplankton composition was found to be non-invasive in nature showing their ubiquity in the marine environment. This study provides an initial assessment or preliminary list of phytoplankton and zooplankton composition in the passenger-cargo vessel in the Philippines.
Keywords: phytoplankton, zooplankton, ballast tanks, ballast water, vessel

1. INTRODUCTION

A ship is a huge sea-going vessel [Layton, 2002] with three or more masts, square-rigged on all except for submarines [Bowditch, 2002]. It may either be passenger, oil, bulk or any dry goods. Through its continuous sailing, it requires proper stability, improved trim and maneuverability [Marrero and Rodriguez, 2004]. Thus, in order to achieve this goal, sailors or mariners use water known as ballast water. The process of taking in ballast water in the ship through pumps located in the hull, just below the waterline is called ballasting and this is located in the lower portion of the ship. This is usually done during cargo discharge when the ship is at the port. The common ballasting practice is that, during the voyage of the cargo vessel, the captain exchanges ballast at the open ocean by pumping out the existing ballast water and taking in new or fresh ballast [Deacutis and Ribb, 2002; IUCN, 1994]. The counterpart of ballasting is called deballasting. This refers to the pumping out of existing ballast water usually at the port, when cargo loading is done. Oftentimes, deballasting is done to reduce the weight of the ship, thus, raising the ship especially when entering a shallow channel area in the port [Deacutis and Ribb, 2002].

Ballast water operation is viewed as the most pressing marine environmental issue [IUCN, 1994]. Approximately, 10-12 billion tons of ballast water is transferred across the globe annually [Popa, 2009]. Due to ballasting, deballasting and ballast exchange, as well as hull attachments, marine or aquatic plants; animals, invertebrates and bacteria are transported around the world [Global Ballast Water Management Programme-IMO, 2010] which makes them exotic, alien, invasive, non-native or non-indigenous species [Carlton and Butman, 1995]. These species are considered pests in the marine environment [Global Ballast Water Management Programme-IMO, 2010]. Carlton [2005], states that international shipping industries served as primary vectors of these species accumulating to about 30, 000 species, transported and carried everyday through ballast water. These species when discharged in a new environment can out-compete the normal or indigenous species for food [U. S. EPA, 2005], evolve and develop mechanisms to spread and increase their population tremendously [Deacutis and Ribb, 2002]. Thus, these species can be considered as *r species* because they have high reproductive rates, rapid development, predominantly small body size, large number of offspring and make use of temporary habitats [Smith and Smith, 2004]. These species also disrupt ecological balance and destroy economy [Deacutis and Ribb, 2002; Global Ballast Water Management Programme-IMO, 2010]. The worst is, they can cause illness and death to humans [Global Ballast Water Management Programme-IMO, 2010], invade the native communities, and may harm the economy [Olenina *et al.,* 2010].

Meanwhile, Popa [2009] said that majority of the marine species found in ballast water can not survive the long journey thus difficult for their survival in ballast tanks while those that can adapt in the voyage inside the ballast tanks have a very small chance in surviving due to predation and competition.

The Global Ballast Water Management Programme-IMO [2010] listed ten unwanted species in ballast water. These are bacterium cholera (*Vibrio cholerae*), cladoceran water flea (*Cercopagis pengoi*), mitten crab (*Eiocheir sinensis*), various species of toxic algae, round goby (*Neogobius melanostomus*), North American comb jelly (*Mnemiopsis leidyi*), North Pacific sea star (*Asterias amurensis*), zebra mussel (*Dreissena polymorpha*), Asian kelp (*Undaria pinnatifida*) and the European green crab (*Carcinus maenus*). On the other hand, the Prince William Sound Regional Citizens' Advisory Council [2007] identified fifteen non-indigenous species (NIS) which are transported by ballast water of tanker oil, on the hulls of the vessels and in the sediment taken in the ballast tanks during the process of ballasting. These are boring sponge (*Cliona thosina*), rockweed (*Fucus cottoni*), dead man's fingers (*Codium fragile*), single horn bryozoan (*Schizoporella unicornis*), Pacific oyster (*Crassostrea gigas*), tunicate (*Botrylloides violaceus*), giant sea kelp (*Macrocystis integrifolia*), foraminiferan (*Trochammina hadai*), softshell clam (*Mya arenaria*), tube dwelling amphipod (*Jassa marmorata*), capitellid worm (*Heteromastus filiformis*), red algae NW Pacific (*Chroodactylon ramosum*) and Atlantic salmon. Olenina *et al.,* [2009] revealed that the dinoflagellates, *Prorocentrum minimum* (Pavillard) Schiller is an invasive species causing significant impact on plankton community, habitat and ecosystem community as a result of assessment period from 1980-2000 in the 11 sub-regions of the Baltic Sea. Other species found in ballast water are mussel (*Mytilopsis sallei*) found in India [Global Ballast Water Management Program, 2010], heterogeneous zooplankton [Murphy, Ritz and Hewitt, 2002; Choi *et al.,* 2005; Gollasch *et al.,* 2000; Selifinova, Shmeleva and Kideys, 2008; Williams *et al.,* 2004; Mingorance *et al.,* 2009; Kasyan, 2010; Chu *et al.,* 2006], phytoplankton species [Martin and LeGresley, 2008; IUCN, 1994; Gollasch *et al.,* 2000] and macroalgae [Flagella, 2007].

1.1 Objectives of the study

This study is conducted to determine the species composition of the inter-island passenger-cargo vessel in the Philippines. Specifically, it will identify the presence of phytoplankton and zooplankton composition in ballast water tanks and determine the species density of the phytoplankton and zooplankton composition measured in cells/ml using the haemacytometer technique. Furthermore, there is no information on the ballast phytoplankton and zooplankton composition in the Philippine setting, hence this study will serve as baseline information.

2. MATERIALS AND PROCEDURE

2.1 Materials

15 L thick plastic container, 5 sterile plastic containers with a volume of 1000 ml, ice bucket filled with ice and binocular compound microscope (Olympus BX51) was used to identify the genera of phytoplankton and zooplankton composition.

2.2 Procedure

2.2.1 Sampling

Sampling was done only once. It was in the mid of December 2010. The researchers asked permission to conduct the study from the Philippine Ports Authority (PPA), operation officer and the deck officers primarily the master and the chief officer of the ship. An inter-island passenger-cargo vessel with the route Manila to Bacolod to Iloilo, Philippines served as source for ballast water samples which refilled its ballast tanks from Cebu port. Five different ballast tanks were chosen alternately (Table 1). A manhole with a removable cover tightened with screw was removed to provide access to each tank for sampling. Composite sampling was used to collect ballast water samples, that is, it was first collected by a 15 L volume of plastic container was stirred, then, after stirring, about 1 L ballast water sample was collected at the surface of the ballast water in the container. After sampling, the ballast water samples were placed inside the ice bucket with ice and transported immediately to the Southeast Asian Fisheries Development Center-Aquaculture Department (SEAFDEC-AQD) - Fish Health Laboratory, Tigbauan, Iloilo, Philippines for the identification and counting of cells/ml (density profile) of phytoplankton and zooplankton composition. The keys used in the identification of genera were Prescott [1944] and Smith and Johnson [1996].

2.2.2 Haemacytometer computation

The analysis of phytoplankton and zooplankton density (cells/ml) was computed using the haemacytometer technique with the formula [Andersen, 2005]:

$$D = X/V \quad (1)$$

where: X = total count/4; V = X/1.0 x 10^4

3. RESULTS

3.1 Phytoplankton and zooplankton composition

A total of 15 genera of phytoplankton and one genus of zooplankton were identified in five ballast tanks. Table 2 shows the phytoplankton genera and these are: *Amphora* Ehrenberg sp., *Ankistrodesmus* Corda sp., *Chlorella* Beijerink sp., *Chroococcus* Nageli sp., *Closterium* Ralfs sp., *Cyclotella* (Kuetzing) Brebisson sp., *Gomphonema* Ehrenberg sp., *Grammatophora* Ehrenberg sp., *Isochrysis* Parke sp., *Loxodes* Ehrenberg sp., *Micromonas* Manton and Parke sp., *Nannochloris* Naumann sp., *Nitzschia* Hassall sp., *Protococcus* Cohn sp., and *Synedra* Ehrenberg sp. Only one genus of zooplankton was recorded which is *Neocalanus* Omura sp., a copepod (Table 2). For ballast tank 1 (fore-peak tank), nine genera of phytoplankton was identified and recorded and these are *Ankistrodesmus* sp., *Chlorella* sp., *Chroococcus* sp., *Cyclotella* sp., *Gomphonema* sp., *Grammatophora* sp., *Nannochloris* sp., *Nitzschia* sp. and *Protococcus* sp. In ballast tanks 2 and 3 (port side tanks), six and five genera were identified and recorded, and these are *Chroococcus* sp., *Closterium* sp., *Nannochloris* sp., *Protococcus* sp., *Synedra* sp. and *Neocalanus* sp. then *Grammatophora* sp., *Loxodes* sp., *Nannochloris* sp., *Protococcus* sp. and *Neocalanus* sp. For ballast tanks 4 and 5 (starboard tanks), four and eight genera were classified and these are: *Nannochloris* sp., *Nitzschia* sp., *Protococcus* sp. and *Neocalanus* sp. then *Amphora* sp., *Chroococcus* sp., *Isochrysis* sp., *Loxodes* sp., *Micromonas* sp., *Nannochloris* sp., *Protococcus* sp. and *Neocalanus* sp. In this study, *Neocalanus* sp. are almost seen in all ballast tanks (Table 2).

3.2 Phytoplankton and zooplankton density using haemacytometer (cells/ml)

In ballast tank 1 (fore-peak tank), a total of 245, 000 cells/ml were found. The genera with the highest cells/ml using haemacytometer are: *Chroococcus* sp. (137, 500), *Nannochloris* sp. (52, 500) and *Chlorella* sp. (17, 500) while in ballast tank 2 (port side tank), a total of 205, 000 cells/ml were found. The genera with the highest cells/ml are: *Nannochloris* sp. (105, 000), *Chroococcus* sp. (72, 500) and *Protococcus* sp. (17, 500). In ballast tank 3 (port side tank), a total of 50, 000 cells/ml were found. The genera with the highest cells/ml are: *Nannochloris* sp. (30, 000), *Neocalanus* sp. (12, 500) and *Grammatophora* sp. (10, 000) while in ballast tank 4 (starboard tank), a total of 85, 000 cells/ml were observed. The genera with the highest cells/ml are: *Protoccoccus* sp. (47, 500), *Nitzschia* sp. (27, 500) and *Nannochloris* sp. (10, 000). Ballast tank 5 (starboard tank) had 165, 000 total cells/ml. The genera with the highest cells/ml are: *Chroococcus* sp. (60, 000), *Nannochloris* sp. (52, 500) and *Amphora* sp. (20, 000) being recorded (Table 2).

Table 1 shows the type of ballast tanks and the corresponding number of ballast samples were taken for each tank.

Table 1. Ballast tank type and their corresponding number of samples.

Tank type	No. of ballast water samples (L)
Fore-peak	1
Port side	2
Starboard	2
Total	5

Table 2 shows the population density (cells/ml) of phytoplankton and zooplankton composition among ballast tanks of the passenger vessels in the Philippines.

Table 2. Plankton profile from five ballast tanks of passenger-cargo vessel in the Philippines using haemacytometer in cells/ml.

	Ballast tanks				
	1	2	3	4	5
A. Phytoplankton					
1. *Amphora* Ehrenberg sp.					20,000
2. *Ankistrodesmus* Corda sp.	2,500				
3. *Chlorella* Beijerink sp.	17,500				
4. *Chroococcus* Nageli sp.	137,500	72,500			60,000
5. *Closterium* Ralfs sp.		7,500			
6. *Cyclotella* (Kuetzing) Brebisson sp.	15,000				
7. *Gomphonema* Ehrenberg sp.	5,000				
8. *Grammatophora* Ehrenberg sp.	2,500		10,000		
9. *Isochrysis* Parke sp.					17,500
10. *Loxodes* Ehrenberg sp.			5,000		2,500
11. *Micromonas* Manton and Parke sp.					2,500
12. *Nannochloris* Naumann sp.	52,500	105,000	30,000	10,000	52,500
13. *Nitzchia* Hassall sp.	7,500			27,500	
14. *Protococcus* Cohn sp.	5,000	17,500	5,000	47,500	10,000
15. *Synedra* Ehrenberg sp.		2,500			
B. Zooplankton					
16. *Neocalanus* Omura sp.		2, 500	12, 500	7, 500	2, 500
Total number of cells/ml	245, 000	205, 000	50, 000	85, 000	165, 000

4. DISCUSSION

4.1 Phytoplankton and zooplankton composition

The phytoplankton and zooplankton genera found in this study can also be found in other studies [Klein *et al.,* 2009; Choi *et al.,* 2005; Kasyan, 2010; Chu *et al.,* 2006]. The following phytoplankton genera could only be found in one of the any ballast tanks (Table 2): *Amphora* sp., *Ankistrodesmus* sp., *Chlorella* sp., *Closterium* sp., *Cyclotella* sp., *Gomphonema* sp., *Isochrysis* sp., *Micromonas* sp. and *Synedra* sp., *Nannochloris* sp. and *Protococcus* sp. occupy all of the tanks as well as the *Neocalanus* sp. except in ballast tank 1 (fore-peak tank) (Table 2) which implies the ubiquity of this copepod in ballast water as supported by the studies of Williams *et al.,* [2004]; Mingorance *et al.,* [2009]; Chu *et al.,* [2006]; Kasyan [2010]; Selifinova *et al.,* [2008]; Murphy *et al.,* [2002]; Choi *et al.,* [2005]; Gollasch *et al.,* [2000]. In the present study, *Cyclotella* sp., *Nitzschia* sp., *Grammatophora* sp. and *Synedra* sp. could also be found in the study of Klein *et al.,* [2009]. *Grammatophora* sp., can also be gleaned in the study of Martin and LeGresley [2008] not in ballast water but in the bay of Fundy, Western isles region. Most of the phytoplankton and zooplankton genera found in the present study could be found in the marine and freshwater environments which speak of their ubiquity in nature [Prescott, 1944; Smith and Johnson, 1996].

4.2 Phytoplankton and zooplankton density using haemacytometer (cells/ml)

Ballast tanks 1 and 2 (fore-peak and port side tanks) had the highest total cells/ml that is, 245, 001 and 205, 002, respectively. The tremendous increase of plankton density maybe attributed to the increase of the cells of *Chroococcus* sp. and *Nannochloris* sp.in these two ballast tanks. These genera might have the capacity to adapt and survive in the ballast tanks' environment. The planktonic composition found in this study can be attributed to seasonal variation [Marshall, Burchardt and Lacouture, 2005], successional patterns [Marshall, Burchardt and Lacouture, 2005; Laamanen, 1997]; nutrient availability such as nitrogen and potassium ratio [Marshall *et al.,* 2005; Laamanen, 1997; Badylak and Philips, 2004]; environmental conditions such as temperature [Laamanen, 1997], salinity and grazing rates [Badylak and Philips, 2004].

5. CONCLUSIONS

In conclusion, this study serves as baseline information on the plankton composition found in ballast tanks of a passenger-cargo vessel in the Philippines and thus found 15 genera of phytoplankton and one genus of zooplankton. Since this study is a preliminary assessment of the planktonic composition of ballast water in the Philippines, it is difficult to conclude that these taxa of phytoplankton and zooplankton are indeed normal or native in the Philippine waters because there was no baseline information. Nevertheless, the plankton composition found in this study is non-invasive based on or supported by other studies and are normal plankton composition in marine and freshwater environments. Thus, it is strongly to recommend that there should be a quarterly sampling of ballast water in the inter-island and foreign-going vessels in the Philippines to determine what planktonic taxa can be considered as native or non-native, invasive or non-invasive.

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REFERENCES

[1] Andersen R. A. Algal culturing techniques. Elsevier Academic Press, (2005).

[2] Badylak S. and Philips E. J. Spatial and temporal patterns of phytoplankton composition in a subtropical coastal lagoon, the Indian river lagoon, Florida, USA. Journal of Plankton Research. Vol. 26, No. 10, (2004), pp 1229-1247.

[3] Bowditch N. The american practical navigator. Bicentennial edition, Lighthouse Press, (2002).

[4] Carlton J. T. Marine invasions and the preservation of coastal diversity. Endangered Species Update. School of Natural Resources and Environment. The University of Michigan. Vol. 12 (1995), pp 1-3.

[5] Carlton J. T. and Butman C. A. Understanding marine biodiversity. Oceanus (Woods Hole Oceanographic Institution). A Research Agenda for the Nation. Vol. 38 (1995), pp 4-8.

[6] Choi K. H., Kimmerer W., Smith G., Ruiz G. M. and Lion K. Post-exchange zooplankton in ballast water of ships entering the San Francisco estuary. Journal of Plankton Research. Vol. 27, No. 7, (2005), pp 707-714.

[7] Chu K. H., Tam P. F., Fung C. H. and Chen Q. C. A biological survey of ballast water in container ships entering Hong Kong. Hydrobiologia. Vol. 352, No. 1-3, (2006), pp 201-206.

[8] Deacutis C. F and Ribb R. C. Ballast water and introduced species: management options for Narragansett bay and Rhode island. Narragansett Bay Estuary Program. R.I. Department of Environmental Management. Available at: http://www.nbep.org/publications/other/ballast/BallWaterIntroSpeciesRpt.pdf (2002).

[9] Flagella M. M., Verlaque M., Soria A. and Buia M. C. Macroalgal survival in ballast water tanks. Marine Pollution Bulletin. Vol. 54, No. 9, (2007), pp 1395-1401.

[10] Global Ballast Water Management Programme-IMO. Ten of the most unwanted. International Maritime Organization. London, UK. Available at: http://globallast.imo.org/poster4_english.pdf. (2010).

[11] Global Ballast Water Management Program. Ballast water hazard…India awakens…Mumbai, India. Available at: http://www.globallastwaterindia.com/images/shell_brochure.pdf. (2010).

[12] Gollasch S., Lenz J., Dammer M. and Andres H-G. Survival of tropical ballast water organisms during a cruise from the Indian Ocean to the North Sea. Journal of Plankton Research. Vol. 22, No. 5, (2000), pp 923-937.

[13] International Union for the Conservation of Nature (IUCN). IUCN guidelines for the prevention of biodiversity loss caused by alien invasive species. Invasive Species Specialist Group of the IUCN Species Survival Commission. Manaaki Whenua Landcare Research. (1994). ISSN: 1173-5988.

[14] Kasyan V. V. Holoplankton of ship ballast water in the port of Vladivostok. Russian Journal of Marine Biology. Vol. 36, No. 3, (2010), pp 167-175.

[15] Klein G., MacIntosh K., Kaczmarska I. and Ehrman J. M. Diatom survivorship in ballast water during trans-pacific crossings. Biology Invasions. Springer. DOI 10.1007/s10530-009-9520-6. (2009).

[16] Laamanen M. J. Environmental factors affecting the occurrence of different morphological forms of cyanoprokaryotes in the northern Baltic sea. Journal of Plankton Research. Vol. 19, No. 10, (1997), pp 1385-1403.
[17] Layton C. W. T. Dictionary of nautical words and terms. Brown, Sons & Ferguson, Ltd., Nautical Publishers, (2002).
[18] Marrero J. P. and Rodriguez E. M. Marine pollution from ships' ballast water. Journal of Maritime Research. Vol. 1, No. 1, (2004), pp 35-42.
[19] Marshall H. G., Burchardt L and Lacouture R. A review of phytoplankton composition within Chesapeake Bay and its tidal estuaries. Journal of Plankton Research. Vol. 27, No. 11, (2005), pp 1083-1102.
[20] Martin J. L. and LeGresley M. M. New phytoplankton species in the Bay of Fundy since 1995. ICES Journal of Marine Science. Vol. 65 (2008), pp 759–764.
[21] Mingorance M. C., Gomez J. I., Lozano F., Gomez A. U., Gonzalez J.A. and Calvilla J. M. Ballast and unballast operations in oil tankers: planktonic organisms that can travel with the ballast water. Journal of Maritime Research. Vol. 6, No. 3, (2009), pp 27-40.
[22] Murphy K. R., Ritz D. and Hewitt C. L. Heterogeneous zooplankton distribution in a ship's ballast tanks. Journal of Plankton Research. Vol. 24, No. 7, (2002), pp 729-734.
[23] Olenina I., Hajdu S., Wasmund N., Jurgensone I., Gromisz S., Kownacka J., Toming K. and Olenin S. Impacts of invasive phytoplankton species on the Baltic sea ecosystem in 1980-2008. Information from the Phytoplankton Expert Group (PEG). HELCOM Indicator Fact Sheets 2009. Available at:
http://www.helcom.fi/BSAP_assessment/ifs/ifs2009/en_GB/InvasivePhytoplanktonSpecies/. (2009).
[24] Popa L. Marine bio pollution through ballast water. Marine Transportation and Navigation Journal. Vol. 1, No. 1, (2009), pp 105-109.
[25] Prescott G. W. How to know the freshwater algae. 3rd edition, University of Montana, (1944).
[26] Prince William Sound Regional Citizens' Advisory Council. Non-indigenous species. Fact Sheet. Regional Citizens' Advisory Council. Available at: www.pwsrcac.org. (2007).
[27] Selifonova J. P., Shmeleva A. A. and Kideys A. E. Study of copepod species from the western black sea in the cruise r/v 'Knorr' during May-June 2001. Acta Zoologica Bulgaria. Vol. 60, No. 3, (2008), pp 305-309.
[28] Smith D. L. and Johnson K. B. A guide to marine and coastal invertebrate larvae. USA, (1996).
[29] Smith R. L. and Smith T. M. Elements of ecology. Pearson Education, Inc., (2004).
[30] Unites States Environmental Protection Agency (U.S. EPA). Factsheet: ballast water and aquatic invasive species. Office of Water. Office of Wetlands, Oceans, and Watersheds. Washington, D.C. Available at:
http://water.epa.gov/polwaste/vwd/ballastwater/invasive_species_factsheet.cfm. (2005).
[31] Williams R. J., Griffiths F. B., Van der Wal E. J. and Kelly J. Cargo vessel ballast water as a vector for the transport of non-indigenous marine species. Estuarine, Coastal and Shelf Science. Vol. 26, No. 4, (2004), pp 409-420.