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Plankton Diversity in Ballast Water of an Inter-island Passenger-Cargo Ship Calling the Philippine Ports

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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 plankton diversity in ballast water of the inter-island passenger-cargo vessel calling the ports of Iloilo-Bacolod-Manila-Cagayan de Oro, Philippines and vice-versa. Specifically, this study aimed to determine the presence of phytoplankton and zooplankton diversity and species density of this plankton measured in cells/ml using the haemacytometer technique. Composite sampling was employed having one liter of ballast water used per ballast tank. A total number of 15 genera of phytoplankton (diatom) and one genus of zooplankton were recorded. *Chroococcus*, *Nannochloris* and *Protococcus* had the highest cells/ml while *Ankistrodesmus*, *Micromonas* and *Synedra* had the lowest cells/ml. The most common phytoplankton observed in ballast tanks were *Nannochloris* and *Protococcus*. *Neocalanus* (copepod) was present in all ballast tanks except in ballast tank 1 (fore-peak). The phytoplankton and zooplankton composition was found to be non-invasive in nature showing its ubiquity in the marine environment. This study provides an initial assessment or preliminary list of phytoplankton and zooplankton diversity from the ballast water of a passenger-cargo vessel calling the Philippine ports.

Keywords - Phytoplankton, zooplankton, diatom, ballast tanks, ballast water, Iloilo-Bacolod-Manila-Cagayan de Oro, Philippine ports

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 cargo carrier. Through its continuous sailing, it requires proper stability, improved trim and maneuverability (Marrero and Rodriguez 2004). Thus, 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 are 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 (1995), states that international shipping industries serve 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 the 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 the majority of the marine species found in ballast water can not survive the long journey thus difficult for their survival in ballast tanks is difficult; 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 dinoflagellate, *Prorocentrum minimum* (Pavillard) Schiller is an invasive species causing significant impact on plankton community, habitat and ecosystem community as a result of the 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 et al. 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).

OBJECTIVES OF THE STUDY

This study was conducted to determine the phytoplankton and zooplankton diversity from the ballast water of the inter-island passenger-cargo vessel calling the ports of Iloilo-Bacolod-Manila-Cagayan de Oro, Philippines and vice-versa. In addition, it will identify the species density of the phytoplankton and zooplankton measured in cells/ml using the haemacytometer technique.

MATERIALS AND METHODS

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.

Sampling

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

Sampling was done once. 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 Iloilo-Bacolod-Manila-Cagayan de Oro, Philippines and vice-versa served as a source for ballast water samples which refilled its ballast tanks in 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 which 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 diversity. The keys used in the identification of genera were Prescott (1944) and Smith and Johnson (1996).

Haemacytometer computation

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

$$D = \frac{X}{V}$$

Where:

$$X = \frac{\text{total count}}{4}$$

$$V = \frac{X}{1.0 \times 10^4}$$

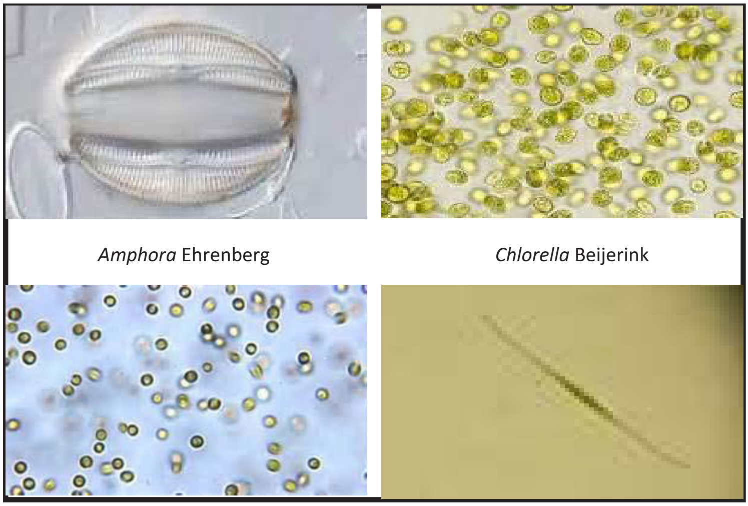
RESULTS AND DISCUSSION

Phytoplankton and Zooplankton Diversity

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

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

Plankton	Ballast tanks				
	1	2	3	4	5
A. Phytoplankton					
1. *Amphora* Ehrenberg	-	-	-	-	20, 000
2. *Ankistrodesmus* Corda	2, 500	-	-	-	-
3. *Chlorella* Beijerink	17, 500	-	-	-	-
4. *Chroococcus* Nageli	137, 500	72, 500	-	-	60, 000
5. *Closterium* Ralfs	-	7, 500	-	-	-
6. *Cyclotella* (Kuetzing) Brebisson	15, 000	-	-	-	-
7. *Gomphonema* Ehrenberg	5, 000	-	-	-	-
8. *Grammatophora* Ehrenberg	2, 500	-	10, 000	-	-
9. *Isochrysis* Parke	-	-	-	-	17, 500
10. *Loxodes* Ehrenberg	-	-	5, 000	-	2, 500
11. *Micromonas* Manton and Parke	-	-	-	-	2, 500
12. *Nannochloris* Naumann	52, 500	105, 000	30, 000	10, 000	52, 500
13. *Nitzschia* Hassall	7, 500	-	-	27, 500	-
14. *Protococcus* Cohn	5, 000	17, 500	5, 000	47, 500	10, 000
15. *Synedra* Ehrenberg	-	2, 500	-	-	-
B. Zooplankton					
16. *Neocalanus* Omura	-	2, 500	12, 500	7, 500	2, 500
Total number of cells/ml	245, 000	207, 000	62, 500	92, 500	167, 500



Amphora Ehrenberg

Chlorella Beijerink

Isochrysis Parke

Nitzschia Hassall

Plate 1. Some of the phytoplankton genera in ballast water of an inter-island passenger-cargo ship calling the Philippine ports

Phytoplankton and Zooplankton Density using Haemacytometer (cells/ml)

In the ballast tank 1 (fore-peak tank), a total number of 245, 000 cells/ml were found. The phytoplankton genera with the highest cells/ml using haemacytometer are: *Chroococcus* (137, 500), *Nannochloris* (52, 500) and *Chlorella* (17, 500) while in the ballast tank 2 (port side tank), a total number of 207, 000 cells/ml were found. The phytoplankton genera with the highest cells/ml are: *Nannochloris* (105, 000), *Chroococcus* (72, 500) and *Protococcus* (17, 500). In the ballast tank 3 (port side tank), a total number of 62, 500 cells/ml were found. The phytoplankton genera with the highest cells/ml are: *Nannochloris* (30, 000), *Neocalanus* (12, 500) and *Grammatophora* (10, 000) while in the ballast tank, 4 (starboard tank), a total of 92, 500 cells/ml were observed. The phytoplankton genera with the highest cells/ml are: *Protoccoccus* (47, 500), *Nitzschia* (27, 500) and *Nannochloris* (10, 000). Ballast tank 5 (starboard tank) had 167, 500 total cells/ml. The phytoplankton genera with the highest cells/ml are: *Chroococcus* (60, 000), *Nannochloris* (52, 500) and *Amphora* (20, 000) being recorded (Table 2).

Phytoplankton and Zooplankton Diversity

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 any ballast tanks (Table 2): *Amphora*, *Ankistrodesmus*, *Chlorella*, *Closterium*, *Cyclotella*, *Gomphonema*, *Isochrysis*, *Micromonas* and *Synedra*. *Nannochloris* and *Protococcus* occupy all of the tanks as well as the *Neocalanus* except in the ballast tank 1 (fore-peak tank) (Table 2) which imply 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*, *Nitzschia*, *Grammatophora* and *Synedra* could also be found in the study of Klein et al. (2009). *Grammatophora* 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, Canada. 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).

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, 000 and 207, 000, respectively. The tremendous increase of plankton density maybe attributed to the increase of the cells of *Chroococcus* and *Nannochloris* in these two ballast tanks. This genera might have the capacity to adapt and survive in the ballast tanks' environment (Deacutis and Ribb 2002). The planktonic diversity 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. *2*005; Laamanen 1997; Badylak and Phlips 2004); environmental conditions such as temperature (Laamanen 1997), salinity and grazing rates (Badylak and Phlips 2004).

CONCLUSIONS

In conclusion, this study serves as baseline information on the plankton composition found in ballast tanks of a passenger-cargo vessel calling in Philippine ports and thus found 15 genera of phytoplankton (diatom) 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 recommended 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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