

THE OCCURRENCE OF MARINE ORGANISMS - IN BALLAST WATER OF SHIP VISITING COLOMBO HARBOUR

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Abstract

Ballast water is a major source of biological invasions around the globe. More than 4500 bulk carriers, cargo vessels and oil tankers arrive to Colombo harbor annually and they discharge a large amount of ballast water in Sri Lankan marine environment. Present research was to study the occurrence of marine organisms in the ballast water of ships visiting Colombo harbour. Ballast water samples were taken from ships visited to Colombo harbor from different ports in Indian Ocean. The species densities were recorded. In addition biological oxygen demand, chlorophyll-a, conductivity, dissolved oxygen, nitrate, pH, orthophosphate, salinity, and temperature were measured in the sample. The vital status (live and dead) of the zooplankton species studied was ascertained using neutral red staining techniques. Thirty-three plankton species were recorded in ballast water samples which included fourteen copepods, eight dinoflagellates, eight diatoms, one protozoan, one rotifer, and one mollusc. Highest density was recorded for *Thalassionema* sp. and lowest density was recorded for unidentified species belong to family Tintinnidae and gastropod veliger larvae. *Ceratium furca*, *Ceratium fusus*, *Peridinium* sp., *Protoperidinium grande*, *Protoperidinium obtusum*, and *Protoperidinium robustum* were the six species of potentially harmful red tide forming dinoflagellates which were recorded during the study. Neutral red staining technique revealed that there were no live zooplankton species in the ballast water samples. According to the Pearson Correlation there were strong positive linear relationships between species density with nitrate ($r^2=0.845$) and orthophosphate ($r^2=0.800$) levels and also pH ($r^2=0.694$) had slightly positive linear relationships with species density. The temperature ($r^2=-0.758$) had negative linear relationship with species density.

Keywords: ballast water, Colombo harbor, plankton species, staining technique, physico-chemical parameters

1. INTRODUCTION

The global scale movement of ships has resulted in a massive transfer of freshwater and marine organisms to the surrounding water (National Research Council, 1996). Ships are a leading source of biological invasions in coastal ecosystems (Carlton, 1985, Ruiz et al., 2000, Endresen et al., 2003, Hayes and Sliwa, 2003). The subsequent discharge of ballast water results in many organisms being released at ports-of-call or in transit, creating numerous opportunities to establish non-native populations (McGee, 2006). The maintenance of ballast water becomes critical during loading and unloading when ballast must be pumped in/out to avoid stresses as a hold is emptied or filled (Eamen et al, 2008).

As the extent of commercial vessel traffic varies considerably among ports, risk of invasion in ports' can fluctuate depending on the frequency and volume of ballast water it receives (Smith et al., 1999). In addition, variability among vessel types, source regions, voyage season, routes and durations can alter the types, numbers and viability of organisms being transported (Verling et al., 2005).

The risk of species introductions with de-ballasting is a source of considerable concern, because many of the organisms that are passed through ballast water intakes. These ballast waters are

transported over long distance. The biota transferred through ballast water worldwide is thought to exceed 10,000 species daily (Flagella, 2007). The viability of introduced species in recipient waters can provide important information for categorizing the potential threats from foreign species found in international commercial ships entering ports (Kang et al., 2010).

Non indigenous vertebrates' larval and egg stages, invertebrates, plants' life stages, algae, bacteria and viruses can all be transported as contents of ships' ballast tanks or cargo holds. Once introduced, these species may do significant harm to marine environments, and local economies (Horm et al., 2008). Cholera (*Vibrio cholera*), Cladoceran water flea (*Cercopagis pengoi*), mitten crab (*Eiocheir sinensis*), toxic algae (red/ brown/ green tides) various species, round goby (*Neogobius melanostomus*), North American comb jelly (*Mnemiopsis leidyi*), North Pacific seastar (*Asterias amurensi*), zebra mussel (*Dreissena polymorpha*), Asian kelp (*Undaria pinnatifida*) and European green crab (*Carcinus maenu*) are the most common invasive species via ballast water (IMO, 2003).

The Colombo Harbor is the major port in Sri Lanka. It serves as an important terminal in Asia due to its strategic location in the Indian Ocean. Present study was carried out in Colombo harbor, to do a quantitative analysis of plankton sampled from ballast waters with a variety of foreign port sources. The objectives were to (1) study of the occurrence of marine organism of the ballast water visiting Colombo harbor; (2) develop a method for distinguish dead and live zooplankton in marine waters; (3) identify the variation of each ship with respective to the species density. And (4) identify the variation of each species with respect to physical, chemical and biological parameters.

2. MATERIALS AND METHODS

2.1. SHIP SELECTION AND SAMPLING

Ballast water samples were taken mainly through manholes. Sampling was restricted to four ships arrived to Colombo harbor in Sri Lanka. One was an oil tanker and others were cargo vessels. Ballast water was collected from side ballast tankers of ships. Three samples were collected in each ship.

Table 2.1: The sampled ships & their last ballasting regions

Ship	Last ballasting region
Ship 1	Chiththogon Harbor
Ship 2	Mid Indian ocean
Ship 3	South Indian coastal waters
Ship 4	Klang port in Malaysia

Sampling for physico-chemical parameters and chlorophyll-a were done using standard sampling method. Approximately 200 liter of ballast water was filtered through 55µm plankton net. Then the samples were fixed with lugol's solution.

2.2. LABORATORY ANALYSIS

Temperature (Philips Harris, thermometer), pH (340 / WTW), conductivity (330 / WTW), salinity (ATAGO/ S/Mill-E Hand refract meter), were measured by using meters. Dissolved oxygen (mg/l), and biological oxygen demand (mg/l) were measured by using Winkler method. Nitrite (mg/l), orthophosphate (mg/l) and Chlorophyll-a were measured by using standard methods (Silva et al, 1996). Plankton identification was carried out by using Microscope Image Projecting System (MIPS) and plankton guide.

	Ship 1	Ship 2	Ship 3	Ship 4
<u>Copepod</u>				
<i>Acrocalanus</i> sp. *	667	500	500	667
<i>Calanopia</i> sp.	333	333	0	333
<i>Calanus</i> sp. *	500	500	667	333
<i>Euchaeta</i> sp	333	0	333	0
<i>Isias</i> sp. *	333	833	667	500
<i>Isias tropica</i>	667	333	167	167
<i>Microsetella</i> sp.	0	333	0	333
<i>Paracalanus parvus</i>	833	333	333	0
<i>paracalanus</i> sp.	0	667	500	167
<i>Pseudodiaptomus</i> sp.	500	0	500	167
<i>Temaro</i> sp.	333	167	167	0
unidentified calanoid copepod *	167	0	0	500
unidentified nauplius larvae	833	667	833	667
unidentified crustacean larvae	500	0	500	0
<u>Dinoflagellates</u>				
<i>Ceratium furca</i> * ⁺	666	667	500	333
<i>Ceratium fusus</i> * ⁺	167	167	667	667
<i>Ceratium tripos</i>	667	500	0	0
<i>Peridinium</i> sp. ⁺	833	1000	500	0
<i>Prorocentrum</i> sp. *	167	333	167	167
<i>Protoperidinium grande</i> ⁺	667	0	0	500
<i>Protoperidinium obtusum</i> ⁺	0	333	667	167
<i>Protoperidinium robustum</i> ⁺	333	167	667	167
<u>Diatoms</u>				
<i>Biddulphia mobiliensis</i>	1000	1000	500	333
<i>Chaetoceros</i> sp.	0	167	0	167
<i>Coscinodiscus</i> sp. *	1000	500	667	167
<i>Navicula</i> sp.	0	167	0	500
<i>Odontella</i> sp.	0	167	0	167
<i>Pleurosigma</i> sp. *	667	333	333	167
<i>Thalassionema nitzschoides</i>	0	667	500	167
<i>Thalassionema</i> sp. *	1500	500	500	833
<u>Protozoa</u>				

* Species were common in all ships.

⁺ Species known to form red tides.

3.2. WATER QUALITY PARAMETERS

Table 3.2: Physico-chemical & biological parameters

Parameters	Units	Ship 1	Ship 2	Ship 3	Ship 4
Biological Oxygen Demand	mg/l	0.18 + 0.01	0.17+0.02	0.23+0.01	0.23+0.03
Chlorophyll a	mg/m ³	0.67+0.47	0.13+0.04	0.11+0.04	0.13+0.05
Conductivity	μS×10 ³	48.43+1.00	51.03+0.05	50.57+0.04	44.7+0.07
Dissolved Oxygen	mg/l	4.58+0.04	4.63+0.03	4.60+0.07	4.61+0.05
Nitrate	mg/l	0.02+0.00	0.01+0.00	0.01+0.00	0.01+0.00
Orthophosphate	mg/l	0.25+0.00	0.09+0.00	0.18+0.00	0.05+0.00
pH		7.62+0.02	7.73+0.16	7.64+0.01	6.82+0.16
Salinity	%	30.00+0.00	32.00+0.00	31.00+0.00	30.00+0.00
Temperature	°C	30.00+0.00	30.00+0.00	30.00+0.00	31.00+0.00

According to the Pearson correlation there were strong positive linear relationships between species density with nitrate ($r^2= 0.845$, $p=0.001$) and orthophosphate ($r^2= 0.800$, $p=0.002$) and pH ($r^2=0.694$, $p=0.012$) had slightly positive linear relationships with species density. The temperature ($r^2=-0.758$, $p=0.004$) had negative linear relationship with species density.

3.3. VITAL STATUS OF ZOOPLANKTON

Staining method to identified live and dead samples showed that the live zooplanktons were colored with red color and dead zooplankton did not show any color change. According to the results, zooplanktons contained in every ship ballast water sample were dead.

4. DISCUSSION

Thirty three species of marine organisms were identified. Among them, ten species were common in all the ships sampled, four of them are copepods (*Acrocalanus* sp., *Calanus* sp., *Isias* sp., unidentified copepods), another three are diatoms (*Coscinodiscus* sp., *Pleurosigma* sp., *Thalassionema* sp.), and other three are dinoflagellates (*Ceratium furca*, *Ceratium fusus*, *Prorocentrum* sp.). The highest density was recorded for *Thalassionema* sp. and lowest density was recorded for unidentified family Tintinnidae and gastropod veliger larvae. Pairwise comparison was conducted using Tukey test in order to compare species densities among ships. According to the analysis, ship 4 had lowest density and ship 1 had highest density. Species densities of ship 2 and 3 were not significantly different. These two ship's last ballasting regions were within the Indian Ocean. Water quality parameters were comparatively same in each ballast samples in ship 2 and 3 hence; it can be argued that the species densities were same in ship 2 and 3. Therefore, differences in species densities in ship 1 and 4 may be related to variations in water quality parameters.

Species composition in ballast water of present study was different from early study of Fernando, 2007. Sixteen additional species were recorded in present study (*Calanus* sp., *Isias* sp, *Isias tropica*, *Microsetella* sp., *Paracalanus parvus*, *Temaro* sp., unidentified nauplius larvae, *Ceratium furca*, *Ceratium fusus*, *Ceratium tripos*, *Peridinium* sp., *Protoperidinium grande*, *Protoperidinium obtusum*, *Protoperidinium robustum*, *Chaetoceros* sp., and gastropod veliger larvae).

There was a strong positive linear relationship between mean species density with nitrate and orthophosphate concentrations. The nutrient level of the water was suitable for the survival of the phytoplankton.

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