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Ballast water: A threat to the Amazon Basin

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ABSTRACT

Ballast water exchange (BWE) is the most efficient measure to control the invasion of exotic species from ships. This procedure is being used for merchant ships in national and international voyages. The ballast water (BW) salinity is the main parameter to evaluate the efficacy of the mid-ocean ballast water exchange. The vessels must report to the Port State Control (PSC), via ballast water report (BWR), where and how the mid-ocean BWE was performed. This measure allows the PSC to analyze this information before the ship arrives at the port, and to decide whether or not it should berth.

Ship BW reporting forms were collected from the Captaincy of Santana and some ships were visited near the Port of Santana, located in Macapá (Amazon River), to evaluate the BW quality onboard. We evaluated data submitted in these BWR forms and concluded that the BWE efficacy might be compromised, because data contained in these BWR indicate that some ships did not change their BW. We found mistakes in filling the BWR forms and lack of information. Moreover, these ships had discharged BW with high level of salinity, *Escherichia coli* and total coliforms into the Amazon River. We concluded that the authorities of the Amazon Region need to develop more efficient proceedings to evaluate the ballast water reporting forms and BW quality, as there is potential risk of future invasion of exotic species in Brazilian ports.

1. Introduction

The introduction of exotic species in port environments was first reported by the International Maritime Organization – IMO – in 1973 during the creation of the *International Convention for the Prevention of Pollution from Ships,* MARPOL 73/78 (Cohen and Foster, 2000). In the course of the convention, Resolution 18 for Research into the Effects of Discharge of Ballast Water containing Bacteria of Epidemic Diseases was approved, which charged IMO with the responsibility of elaborating measures of ballast water (BW) control (Cohen, 1998). Several exotic species were identified in many parts of the world (Carlton and Geller, 1993; Hallegraeff, 1992; Gollasch, 2006). Studies identified ballast water as the vector of exotic species transfer (Ruiz et al., 1997; Miller et al., 2007). The impacts caused by the organisms found in the ballast water affect the environment, the economy and human health by transferring pathogens, such as the *Vibrio cholerae* (Dobroski et al., 2009; Pereira and Brinati, 2012). In addition, these species can be found in the sediments inside BW tanks (Prange and Pereira, 2013).

Faced with this problem, the first IMO initiative was to establish Resolution A.774 (18) in 1993, following of A.868 (20), in 1997, in which it recommends ships to perform the ballast water exchange (BWE) in open ocean. In 2004, the International Convention for the Control and Management of Ships Ballast Water and Sediments (BWM Convention) took place, with the purpose of establishing guidelines for ballast water control (IMO, 2004). In 2005, Brazil established the Marine Authority Regulation for Ships Ballast Water Management of the Directorate of Ports and Coastlines, Brazilian Navy – NORMAM-20 (DPC, 2005) (De Castro et al., 2010). DPC, 2005 created the Brazilian procedures for BW management, and Brazil ratified the BW Convention in 2010.

NORMAM-20 basically considers the same procedures established by the BW Convention, adapting them to the Brazilian reality. Both consider the open mid-ocean BWE to be the most efficient model of ballast water management. However, special procedures are applied to ports of the Amazon Basin, where an additional exchange is required to reduce ballast water salinity. This should take place between the isobathic of 20 m and Macapá. In this case, the tank volume only needs to be pumped once. The same procedure

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has to be applied to the Pará River (DPC, 2005). In sum, in the Amazon River, ships need to discharge only water with low salinity <5 ppt (Santos et al., 2008).

The salinity varies between 32 and 35 ppt (parts per thousand) in port regions, but it could be higher (Doblin et al., 2010) or lower (Cohen and Foster, 2000). In open ocean, the salinity varies from 35 ppt to 37 ppt, on average (Murphy et al., 2008; Falkner et al., 2007). Thus, BWE suggests that freshwater organisms cannot survive in salt water and vice versa (Smith et al., 1999). BWE typically eliminates between 70% and 99% of the organisms originally taken into a tank while the vessel is in or near a port (Cohen, 1998).

In order to have a proof of the effectiveness of mid-ocean exchange, the ballast water salinity must be examined. This test consists in collecting a sample of the ballast water in the tank, dripping it in a refractometer and analyzing the salinity and specific weight of the sample. The result will confirm if the water collected originates from estuary, coastal or mid-ocean waters.

To guarantee this efficacy, ships need to carry out the procedures established by the BW Convention and NORMAM-20. For this, it is necessary to evaluate the BW Reporting (BWR) form filled. Basically, this verification means to use the coordinates submitted in the ballast water reporting forms. From these reports, it is possible to identify if the region of the BWE was at least 200 nautical miles from the coast and in 200 m deep waters. Since ships need to send the BWR 24 h before arriving at the port, it is possible to identify if they have exchanged BW in mid-ocean before mooring.

There are diagnostics about BWR filling problems identified in several ports in Brazil and in foreign ones. Leal Neto (2007) indicated filling problems in 919 ballast water reporting forms handed to CDRJ from May 1998 to 2002. Approximately 808 reports handed to the Port of Itajaí presented errors. Only 33.42% of the report presented data about ballast water mid-ocean exchange (Caron, 2007). This reflects the reality of ships berthing in the Brazilian ports.

However, the problem of BWR compliance is not exclusive of Brazil. The analysis of 53,503 ballast water reporting forms handed to the USA Coast Guard from 2004 to 2005 to identify the ballast water collection and discharge points showed that approximately 18,250 vessels discharge ballast water within 200 nautical miles (Ruiz et al., 1997). Miller et al. (2007) shows that BWR compliance for overseas arrivals during 2006 to 2007 was 83.5% and for coastwise arrivals was 77.8%.

From the 20.9 million of cubic meter (Mm^3) of ballast water discharged in California from July 2008 and June 2010, 88% were properly managed through the legal methods of ballast water exchange abiding by the laws of California. Approximately 2.5 Mm^3 of irregular ballast water were discharged in Californian waters in this period (Dobroski et al., 2011, 2013).

Brown (2012) compared the BWR delivered by ships at the ports of California and found a reduction in noncompliant between 2012 and 2011. The main errors identified were change in the wrong location, no change, change location unknown, incorrect geography and not intentional non-management. BWR filling, there could be a potential confusion between BWE near 50 nm from shore and 50 nm from any land mass.

Thus, the only way to identify these BWR problems is an evaluation of filling. For this, in Brazil, the first barrier to break is the free access to ballast water reporting forms handed by all ships to the ports. Secondly, a reliable analysis system is needed in order to identify ships that did not carry out the ballast water mid-ocean change. Considering the 33 ports on the Brazilian coast, the analysis of the BWR forms is vital to guarantee the execution of BW mid-ocean change.

In order to evaluate the execution of these principles in Brazil, ships BW reports were collected from the Santana Port Authority and those ships were visited near the Port of Santana, located in Macapá (Amazon River), to evaluate the BW quality onboard. The BW discharge in the Amazon region needs to meet the Resolution of the National Environment Council – CONAMA number 357 of 2005 that established criteria about the water classification and standard regarding effluent discharge in the Brazilian water. Considering these aspects, we analyzed the reports between July, 2012 and January, 2013 and noticed that some BWR indicate errors in filling, exchange location unknown, exchange in wrong location, blank spaces and others mistakes. Two ships had informed that BW change was on land.

The BW quality was evaluated, for which nine quality variables of ballast water were used (temperature, salinity, pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), total coliform (TC), *Escherichia coli* (EC)). These waters contained live microorganisms, as well as high salinity, and could not thus be discharged in the Amazon ports of destination, since they did not comply with National and International Laws. It was found that when performing the second change of ballast water, some ships are loaded with waters from the Amazon River port area of Santana/ AP upriver to other regions of the Amazon Basin. We concluded that the authorities of the Amazon Region need to develop more efficient proceedings to evaluate the ballast water reporting forms, as there is potential risk of future invasion of exotic species in Brazilian ports.

2. Material and methods

2.1. Port of Santana

The Port of Santana is located on the Amazon River, Santana channel, 18 km away from Macapá, capital of the State of Amapá, Brazil. The geographical coordinates of the location of the port are: Latitude: 0° 4′N – Longitude: 51°10′W.

The Port of Santana organized jurisdiction is a polygon composed of the following points: A: 0°03′00″ S e 51°12′30″W; B: 0°04′06″ S e 51°12′30″ W; C: 0°04′06″ S e 51°06′46″ W; D: 0°03′00″ S e 51° 06′46″ W. The public port is composed of two piers being – Pier A: 200 m long, 12 m deep and a berth for Panamax ships. Pier B: 150 m long, 11 m deep, and a berth, serves oversea and cabotage navigation. There are two private terminals: Tocantins: 270 m long and 12 m-deep berth, operates in the exportation of ore; Texaco: with 120 m quay and 10 m deep, operating petrol byproducts. The main cargo handling are chromite, manganese, wood, eucalyptus and pine chips, biomass, iron ore and cellulose.

2.2. Evaluation of ballast water reporting forms

We collected reports handed by the ships to the Santana Port Authority in Amapá (Amazon Region) in the period between July 2012 and January 2013. We identified ships last port of call and compared the coordinates indicated as the place of change versus the route from the last port of call to the port of Santana.

We identified ships characteristic such as full load capacity of Deadweight Tonnage – DWT and their ballast water tanks capacity. The tanks that changed ballast water before berthing in the Port of Santana were identified. We checked the information about physicochemical parameters of the ballast water, such as specific weight, temperature and salinity. After that, the values of specific weight were converted into salinity, considering the temperature informed in the reports. The model proposed by (Reid, 2006) was used in this conversion. The ballast water exchange method was identified for all ships that declared it.

Then, we identified ships that did not conduct the ballast water change procedures according to DPC (2005) rules. It provides that every vessel entering the Amazon River has to make a second

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