The implementation of ballast water management in Port of Tanjung Emas Semarang: strategy and model

[1]Agus Tjahjono, [2]Wisnu Handoko

[1] Technical Department, PIP Semarang (Semarang Merchant Marine Polytechnic), Singosari 2 a Semarang, 50242, Central Java, Indonesia; [2] Sub directorate Domestic Sea Transportation, Directorate of Sea Traffic, The Ministry of Transportation, Merdeka Barat no. 8, Central Jakarta, 10110, Indonesia. Corresponding author: A. Tjahjono, a_agus_tjahjono70@yahoo.co.id

Abstract. The discharge of ballast water by commercial vessels had affected the appearence of Non-Indigenous Species (NIS). Heavy metals Pb, Cd, and Zn were found within the ballast water discharged by the commercial vessels berthed in Port of Tanjung Emas Semarang (PTES). The research was aimed to formulate the model and strategy applied in the implementation of Ballast Water Management (BWM) in both domestic and foreign commercial vessels in PTES waters. The new model was supposed to replace the existed model. Random sampling method was used to determine the research sample. Questionnaire and interviews were employed as the data collection method. In order to identify the strategy, the data were then analyzed by using SWOT (Strength, Weakness, Opportunity, and Threat) analysis. Ballast Water Treatment (BWT) Technology had been analyzed and applied to determine an appropriate model for BWT in PTES, too. In this case, the Harbour Master and Port Authority Office (HMPAO) of Tanjung Emas can possibly apply a defensive strategy. This strategy emphasizes on the improvement of Port State Control (PSC) and penalties. In order to maintain the vessel stability, container vessels, passanger vessels, and Roll On/Roll Off (Ro-Ro) vessels are recommended to apply freshwater within their ballast tanks. Moreover, a BWT facility has also been provided by the port administrator, Pelindo III company, for bulk carrier and tanker vessels to discharge their ballast water.
Key Words: ballast water, commercial vessels, SWOT analysis, BWM implementation, model and strategy.

Introduction. The discharge of ballast water by commercial vessels had affected the appearence of Non-Indigenous Species (NIS) such as *Undaria pinnatifida,* a algae native to north west Pacific, which was spread out to Port of Phillip Bay in Australia (Primo et al 2010); oriental shrimp *Palaemon macrodactylus* in Orwell estuary, England; and snow crab *Chionoecetes opilio* in the eastern of Barents Sea (Ashelby et al 2004; Alvsvag et al 2009). The total annual loss caused by NIS to agriculture, human health, and environment in Southeast Asia is estimated to be US$ 33.5 billion (5th and 95th percentile US$ 25.8-39.8 billion) (Nghiem et al 2013).

Heavy metals Pb, Cd, and Zn were found within the ballast water discharged by the commercial vessels berthed in Port of Tanjung Emas Semarang (PTES). The content of the heavy metal Pb reached 0.37192 mg L^{-1}, the content of Cd was 0.001-0.46 mg L^{-1} whereas the content of Zn reached 0.001-2.464 mg L^{-1}. These numbers, which had surprisingly surpassed the water quality standard, jeopardized the aquatic environment of the port. In this case, the content of heavy metal within the ballast water was highly correlated to the condition of port's waters. The dischange of ballast water also affected the water quality physically, chemically, and biologically. For example, phytoplankton *Skeletonema* survived in both low and high tide (Tjahjono et al 2017a; Tjahjono et al 2017b; Tjahjono et al 2017c; Tjahjono et al 2018).

PTES is located in the north coast of Central Java, Indonesia. The port has several docks including Pusri company, Sriboga company, passanger, dock no. 25 for cargo, container, and LPG tanker dock. The port is situated in Kali Baru estuary bordered by

Banjir Kanal Timur (BKT), Banjir Kanal Barat (BKB), and Siangker estuaries. PTES provides both domestic and international docks. Pelindo III company, headquartered in Surabaya, is a state-own enterprise who runs the port service business as the port operator. On the other hand, the Harbour Master and Port Authority Office (HMPAO) of Tanjung Emas Semarang performs as the port regulator.

This research was aimed to formulate the model and strategy applied in the implementation of Ballast Water Management (BWM) in both domestic and foreign commercial vessels. The new model was supposed to replace the existed model. In this research, the technology of BWM was also explained in order to determine an appropriate model for ballast water treatment. The strategy was then proposed to the HMPAO of Tanjung Emas Semarang as the port regulator and Pelindo III company as the port operator.

Material and Method. In this research, descriptive methodology was used as the researchers attempted to describe the activities of this research clearly and systematically. Random sampling method was used to determine the research sample, theoretically, each member of the population has an equal chance of being selected as sample (Sukardi 2003). PTES was chosen based on these following reasons: a) from 1970 to 1983, the increase in the flow of goods on average each year was 10% more; b) PTES is a stopover on international cruise vessels; c) PTES connects Java Island to Karimunjawa Island, one of tourist destinations in Indonesia; d) PTES supports the supply of fertilizer and Liquified Petroleum Gas (LPG); and e) PTES is also one of domestic passenger ports in Indonesia (Pelindo III branch office Tanjung Emas 2012).

The questionnaire was distributed in the HMPAO of Tanjung Emas Semarang. The research population consisted of 105 respondents from which 82 respondents were randomly chosen as the research sample (Isaac & Michael 1983 in Somantri & Muhidin 2006) with confidence interval of 0.95. The research was held in December 2015 to April 2016. The interview, on the other hand, was done in July 2015. The numbers of commercial vessels in 2009 to 2014 were taken from the Report of Arrival and Departure Vessels (RADS) provided by HMPAO of Tanjung Emas Semarang.

The data were collected through both questionnaire and interview. The questionnaire was distributed to the employees of the HMPAO whereas the interview was done to a numbers of the office employees. The respondents were interviewed on some issues related to the implementation of BWM. An interview was also carried out to vessels's crews. The strength, weakness, oppurtunity, and threat of BWM in PTES were discussed and afterward the analysis was done by using SWOT analysis (Rangkuti 2015). Personal SWOT analysis was created by determining the indicators of strength, weakness, oppurtunity, and threat. The indicators of SWOT were then constructed. SWOT consisted of internal and external factors. Internal factor included strength and weaknesses whereas external factor includes opportunity and threat. The indicators was set based on the future goals. Last, evaluation was conducted for both internal and external factors.

Results and Discussion

The characteristics of research respondents. The respondents were the employees in the HMPAO aged 30-50 years old, with undergraduate and postgraduate degree, mostly male, and have been working for 4-34 years. The respondents were the crews of commercial vessels berthed in PTES.

Harbour Master Office of Tanjung Emas Semarang. As stated in the Decision Letter of Minister of Transportation no. 64/2010 on November 5th, 2010 about harbour master office's organization and working procedure, there are 99 harbour master offices including 4 main harbour master offices, 9 harbour masters class I, 14 harbour masters class II, 16 harbour masters class III, 16 harbour masters class IV, and 40 harbour masters class V.

The main harbour master offices are located in Medan, Jakarta, Surabaya, and Makassar whereas the harbour master class I are situated in Dumai, Panjang, Banten, Semarang, Banjarmasin, Balikpapan, Bitung, Ambon, and Sorong.

Harbour master office class I Semarang is a Technical Implementation Unit (TIU) under the control of the Minister of Transportation through the Director General of Sea Transportation. Harbour master office serves these following functions: a) examining, testing, and issuing the certificate of seaworthiness of vessel; b) supervising the loading and unloading of dangerous goods and hazardous and toxic waste, and refueling; c) supervising the seamanship, safety on dredging, reclamation, and port facility construction according to the authority and the port clearance; d) coordinating and implementing countermeasure against pollution and contamination and fire fighting, and supervising maritime environmental protection; e) implementing Search and Rescue (SAR) in port's work authority area and interest authority area; f) implementing order and patrol, investigating crimes in both port's work authority area and interest authority area, and supervising underwater work, salvage, and vessel's tug and piloting; and g) managing administrative affairs, personnel, finance, law, and public relations (Figure 1).

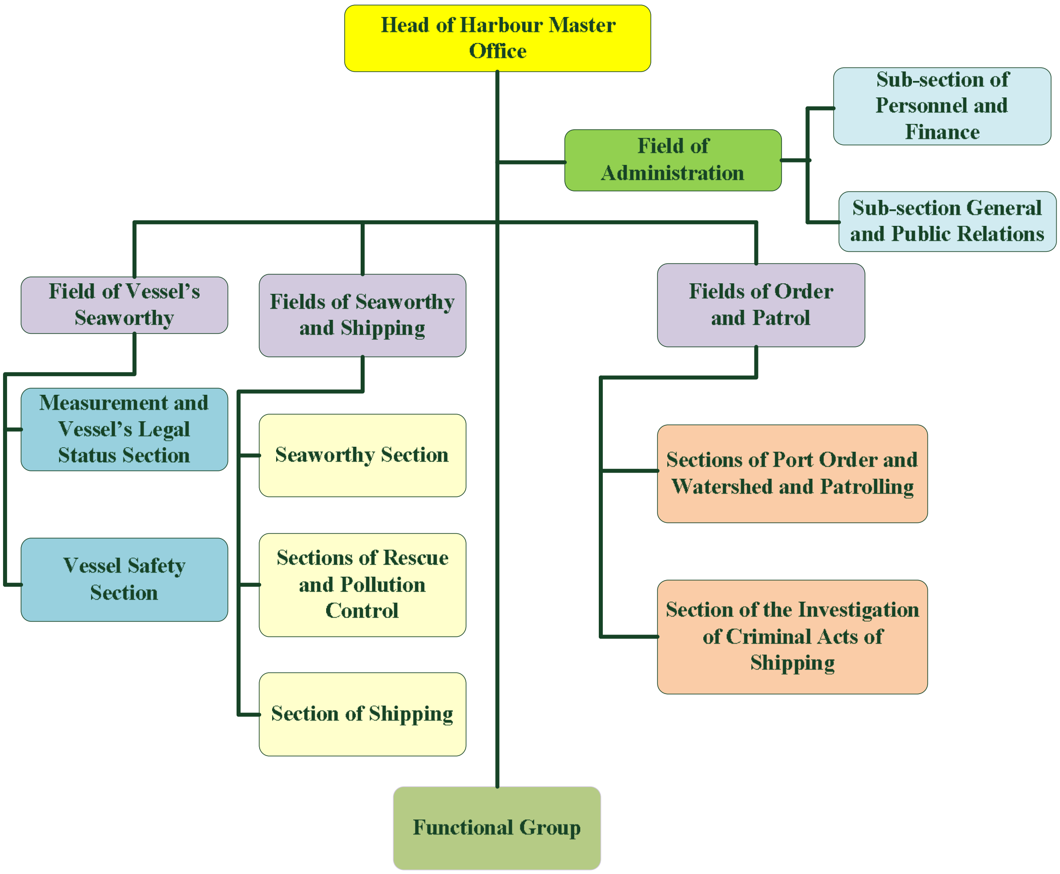

Figure 1. Organizational structure of harbour master office class I Semarang.

Vessel Seaworthiness department is in charge to check, test, and certify the seaworthiness and supervise the loading and unloading of dangerous goods and hazardous and toxic waste, and refueling. This department consists of three sections: a) seaworthiness, b) rescue and pollution control, and c) seamanship.

Seaworthiness section is responsible to supervise the order port and voyage, marine traffic, foreign vessels, vessel movements, guidance, delays, port activities, compliance of seaworthiness requirements, and the preparation of the Port Clearance Issuance (PCI).

The Pollution and Rescue Section is expected to prepare a coordination and provision of SAR, countermeasure and prevention against pollution, and fire prevention and control in port waters. This section is also expected to handle vessels frame as well as salvage, underwater activities, and preliminary investigation of vessel accidents and sea disaster. The Seamanship Section is responsible to prepare the issuance of seafarer identity documents, seafarer employment agreements.

The supervision of foreign vessels in a port was conducted by Port State Control (PSC). The supervision was under the regulation of ISM (International Safety Management) Code and Indonesia's regulation (IMO 2002; PM 119/2017). According to the supervision, three categorizations were resulted seaworthy, substandard, and unsafe. If a vessel is considered as seaworthy, a clearence out is possible issued. However, if it is categorized as substandard, the vessel operator must provide a clarification. On the other hand, if it is categorized as unsafe, there shall be corrective action and the vessel can be possibly withheld by the authorities (Lasse 2014).

A vessel is categorized as substandard when the hull, engine, equipment, safety, or vessel's crews are substantially below the standards required by a qualified convention or regulation. The categorization is considered based on these following conditions: (a) by the absence of equipment and basic facilities, (b) the equipment specifications or basic facilities do not meet the requirements, (c) vessel's deteriorating conditions or untreated equipments, (d) insufficient skills of the crews, and (e) inadequacy of vessel certificate (Lasse 2014).

SWOT analysis

Valuation of internal srategy. Based on the strategy of BWM implementation, the internal factors were elaborated 7 indicators of strengths and 7 indicators of weaknesses on the other hand, external factors were explained in 4 indicators of opportunity and 6 indicators of threat (Rangkuti 2011; Hidayat 2017) (Table 1).

Table 1

Internal and external factors in the implementation of BWM at PTES

	Strengths		*Weaknesses*
S1	Rules of prohibition of the vessels to discharge ballast water into port waters (Article 229, Law number 17/2008 on Shipping and Government Regulation number 21/2010 on the Protection of Marine Environment)	W1	It lacked of technical guidance of ballast water sampling procedures on board
S2	Port authority's obligation of the prevention of pollution and the provision of waste containment facilities (articles 236 & 237, Law no. 17/2008 on Shipping)	W2	It increased the vessel operating cost as it was required to the mid-ocean ballast water exchange
S3	Rules on the obligation for each vessel to have a water pollution prevention equipment (article 113, Government Regulation no. 51/2002 on Shipping)	W3	The installation of the equipment of ballast water management on board required extra cost (about IDR 7 billions)
S5	There had been a prohibition of any activity which led to marine pollution (article 9, Government Regulation no. 19/1999 on Management of Marine Contamination and/or Damage)	W5	There was a tendency to place the vessel safety as number one priority more than the environmental protection
S7	Communities are allowed to report any contamination and/or environmental destruction in coastal areas (article 60, Law no. 1/2014 on the Management of Coastal Areas and Small Islands)	W7	There had been no regulations on the minimal distance of water area to perform mid-ocean ballast exchange and waste cotainment facility (regulation of the Indonesian Minister of Transportation no. 58/2013 regarding Response to pollution in waters and ports)

	Opportunities		Threats
O1	The income can possiby increase by providing a ballast water storage facility	T1	The number of foreign vessels arriving to the port can possible increase
O2	There is Port State Control Officer (PSCO)	T2	The absence of sanctions for disposing of ballast water at port waters
O3	There is a collaboration of water ballast sampling and the Port Quarantine Agency in the the determination of the quality standards	T3	Some foreign species can possibly be brought through the the ballast water which cause the decrease of native species abundance
O4	The Provincial Government has announced its cooperation in the countermeasure against coastal pollution (Law no. 23/2014 on regional government)	T4	The pathogenic bacteria (such as *Vibrio cholerae*) appear through ballast water and contaminate the local waters in which it decreases its water health status
		T5	A decrease in competitiveness of domestic vessels in providing the overseas transport services occurs (as it does not provide the equipments of BWM)
		T6	There is an increase of heavy metal through the vessel's ballast water

Source: primary data being processed.

Valuation of internal and external factors. As the indicators of strategic factor were arranged, the framework of strength and weakness of the organization were able to be constructed (Rangkuti 1997). By using the analysis of internal factors, the calculation of score and rating determination could be proceeded. Based on the calculation, it was obtained that the score multiplied by rating of -1.325 on the x axis (Table 2).

The external factors influenced the establishment of opportunities and threats. The factors concerned on the conditions that occured outside the organization which affected the decision-making within the organization (Fahmi 2013). Using the analysis of the external factors, the score was calculated and the rating was determined. The result showed that the score multiplied by rating was -3.3 on the y-axis (Table 3).

Table 2

Analysis of internal factors in the implementation of BWM at PTES

No	*Variables*	*Score*	*Rating*	*Score x rating*
	Strengths			
1	Regulation on vessel's ballast water discharge at port	2.9	2.75	7.975
2	The obligation of Port Authority in the countermeasure and prevention against marine contamination and the provision of waste containment facility	2.7	2	5.4
3	Regulation on the obligation for each vessel to provide pollution prevention equipments	2.8	1.5	4.2
4	The obligation of bussines entity to ensure the conservation of environmental functions and penalties	2.9	1.25	3.625
5	The prohibition of any activities which lead to marine pollution and contamination	2.9	1	2.9
6	Domestic vessels's dominant compared to foreign vessels	2.9	0.75	2.175
7	Communities are suggested to report any pollution and/or environmental damage in coastal areas	2.9	0.75	2.175
	Sub total	20	10	28.45
	Weaknesses			
1	The lack of technical guidance of ballast water sampling procedures on board	3.2	-2.75	-8.8
2	The increasing of the vessel operating cost due to the obligation to proceed the mid-ocean ballast water exchange	3.1	-2	-6.2
3	It took extra cost to install the ballast water treatment equipment on board (around IDR 7 billions)	2.5	-1.5	-3.75
4	There has been no determination of territorial waters to perform mid-ocean ballast water exchange	2.7	-1.25	-3.375
5	There was tendency to place the vessel safety as number one priority more than the environmental protection	3	-1	-3
6	The weak of supervisory function	3.1	-0.75	-2.325
7	There is no regulation on minimal distance to safely proceed ballast water discharge and waste containment facility is not available yet	3.1	-0.75	-2.325
	Sub total	20.7	-10	-29.775
	Total			-1.325

Source: primary data being processed.

Table 3

Analysis of external factors in the implementation of BWM at PTES

No.	*Variables*	*Score*	*Rating*	*Score x rating*
	Opportunities			
1	The increasing of income by providing ballast water storage facility	2.7	4	10.8
2	The presence of PSCO	2.8	3	8.4
3	A collaboration with the Port Quarantine Agency on the collection of ballast water sampling and the determination of the quality standards	2.7	2	5.4
4	A cooperation with Provincial Goverment to overcome the coastal pollution	2.9	1	2.9
	Sub total	11.1	10	27.5
	Threats			
1	The increasing numbers of foreign vessels arrival	3.1	-2.75	-8.525
2	The absence of legal penalties for ballast water discharge in port waters	3	-2	-6
3	The introduction of non-native species within ballast water into local waters which leads to the decrease of native species abundance	2.9	-1.75	-5.075
4	The contamination of pathogenic bacteria (such *Vibrio cholerae*) through ballast water within port waters which leads to decrease of water health status	3.4	-1.25	-4.25
5	The decrease of competitiveness of domestic vessels in providing the overseas transport services (as it does not provide ballast water treatment equipment)	3	-1.25	-3.75
6	The addition of heavy metal material through dirty ballast water to PTES waters	3.2	-1	-3.2
	Sub total	18.6	-10	-30.8
	Total			-3.3

Source: primary data being processed.

Alternate strategy. Internal and external factor analysis was taken in order to perform SWOT analysis. This analysis was aimed to identify the strategy used in the implementation of BWM (Hidayat 2017). Based on the approach, various strategies such as Strengths Opportunities (SO), Strenghts Threats (ST), Weaknesses Opportunities (WO) and Weaknesses Threats (WT) can be arranged as follows.

SO strategies can be performed through these following activities: a) the provision of ballast water storage and treatment facilities by Pelindo III company, b) socialization aimed to increase the role of Port State Control Officer (PSCO) for foreign vessels and Marine Inspector (MI) for domestic vessels in supervising the role of commercial vessels in the environment protection, c) the role expansion of Quarantine Center in supervising the commercial vessel's ballast water.

WO strategies can be formulated into four activities: a) the socialization of technical guidance of sampling procedure to MI and PSCO, b) the determination of minimum distance of ballast water discharge, c) the provision of ballast water storage and treatment facilities by Pelindo III company, d) the strengthening of both MI and PSCO roles in supervising the environmental pollution in port areas.

ST strategies included: a) the determination of ballast water's drainage area before the commercial vessels entered the port waters, b) the determination of strict sanctions or penalties for those which violated the rules of BWM.

WT strategies include: a) the provision of ballast water storage and treatment facilities by PT Pelindo III company, b) the determination of sanctions and penalties for commercial vessels which violated the rules of BWM.

The analysis of strategy in the implementation of BWM. This strategy showed that the implementation of BWM in the quadrant III (x, y) indicated that the external threat was greater than the internal weakness. The quadrant III (-1.3; 3.375) showed the position which supported the defensive strategy. This strategy reduced the internal weaknesses and overcame the external threats. In this condition, the organization was unfortunatelly disadvantageous that various internal threats and weaknesses were found (Rangkuti 1997). In this position, there were some strategies which could be applied by the HMPAO of Tanjung Emas Semarang including: a) providing ballast water storage and treatment facilities by Pelindo III company, b) establishing some firmer sanctions or penalties for the violators of BWM rules (Figure 2).

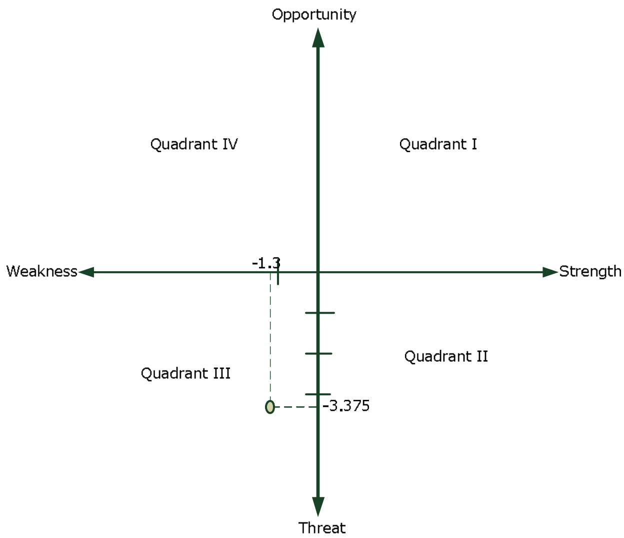

Figure 2. The diagram of SWOT in the implementation BWM at PTES.

The success of BWM implementation strategy depended on the regulators: (a) HMPAO of PTES and (b) the cooperation between the HMPAO and Pelindo III company as the port management. Strategies undertaken in Taiwan included 5 aspects: (a) planning of ballast water exchange, (b) implementation of ballast water exchange, (c) reporting ballast water exchange, (d) priority for for high risk arriving vessels, and (e) inspection to arriving target vessels by PSC (Liu et al 2014).

Another strategy to be employed at the port of Kaohsiung, as one of the busiest ports in the world, was to pay attention to the pattern of commercial vessel arrivals. It could be done by considering vessels of flag of convenience, vessel's origin and its contamination of toxic algae, regional-route vessels with higher level of risk against the resilience of alien species, and vessels with rare or no visit records (Liu & Tsai 2011).

The port of Yantian in China was experiencing the impact of a commercial vessels's ballast water as Australian *Xenostrobus securis* had been found in the region. This species was allegedly from Australia, Korea and Japan (Morton & Leung 2015). Another impact, 40 alien phytoplankton species and 17 species which had caused red-tide in China were also found. It was due to the ballast water which had been discharged in China. The total volume of ballast water exhibited a trend of slow increase from 2007 to 2014, and reached 311 million tons in 2014 (Wu et al 2017; Zhang et al 2017). China's failure to implement the BWM strategy was caused by the institutional constraints in developing BWM scheme comprehensively (Wan et al 2018).

Singapore as a major commercial vessel port has set two key factors to overcome the entry of non-indigenous species into its territory. The strategies include recording the pattern of vessel movements by calculating the duration of the vessel being berthed and the transit vessel's origin of biogeography, and implementing the regulation and test obligations for high-risk vessels prior to ballast water disposal (Lim et al 2017; Ng et al 2018).

The strategy undertaken by the European community in response to harmful aquatic organisms was by implementing D2 standards, ratifying BWM Convention, conducting routine operations of Ballast Water Management System (BWMS), reducing the burden of commercial vessels operating in Europe by implementing Risk Assessment (RA) and Decision Support System (DSS). On the other hand, non-member of European Union countries were encouraged to fullfill the European BWM requirements (David & Gollasch 2016).

The visits of commercial vessels to PTES. The visits of commercial vessels to PTES were dominated by those from Southeast Asia including Singapore, Malaysia, Thailand and Vietnam followed by those from Asia Pacific countries such as Australia, Taiwan and China. Numbers of visits within the year's average per month were 24 commercial vessels from Singapore followed by 6 commercial vessels from Malaysia and 23 commercial vessels from Thailand (Figure 3).

Domestic commercial vessels arriving at PTES were dominated by vessels from Kalimantan, Sumatera and Papua. The average number of commercial vessels from Kalimantan in a month were 12 commercial vessels followed by 13 commercial vessels from Sumatra and 35 commercial vessels from Papua (Figure 4).

The visits of the commercial vessels to PTES also showed that the vessels took less than 7 days of sailing. It means that the installation of ballast water equipments on board was not able to apply and neither was the mid-ocean ballast water exchange. BWM by the port was the possible model to apply in order to prevent the spread of plankton and heavy metals to the PTES waters.

Figure 5 demonstrated the number of domestic and foreign commercial vessels arriving at PTES in 2009 to 2014. This figure also showed that the numbers of domestic commercial vessels ranged from 1,043 to 1,408 with the annual average of 1,236 vessels. The numbers of foreign vessels arriving at PTES were smaller, ranging from 676 to 1,045 with the annual average of 768 vessels. The arrival of domestic and foreign vessels to PTES in 5 years had increased, the increase reached 35% while the foreign vessels was 54.6%.

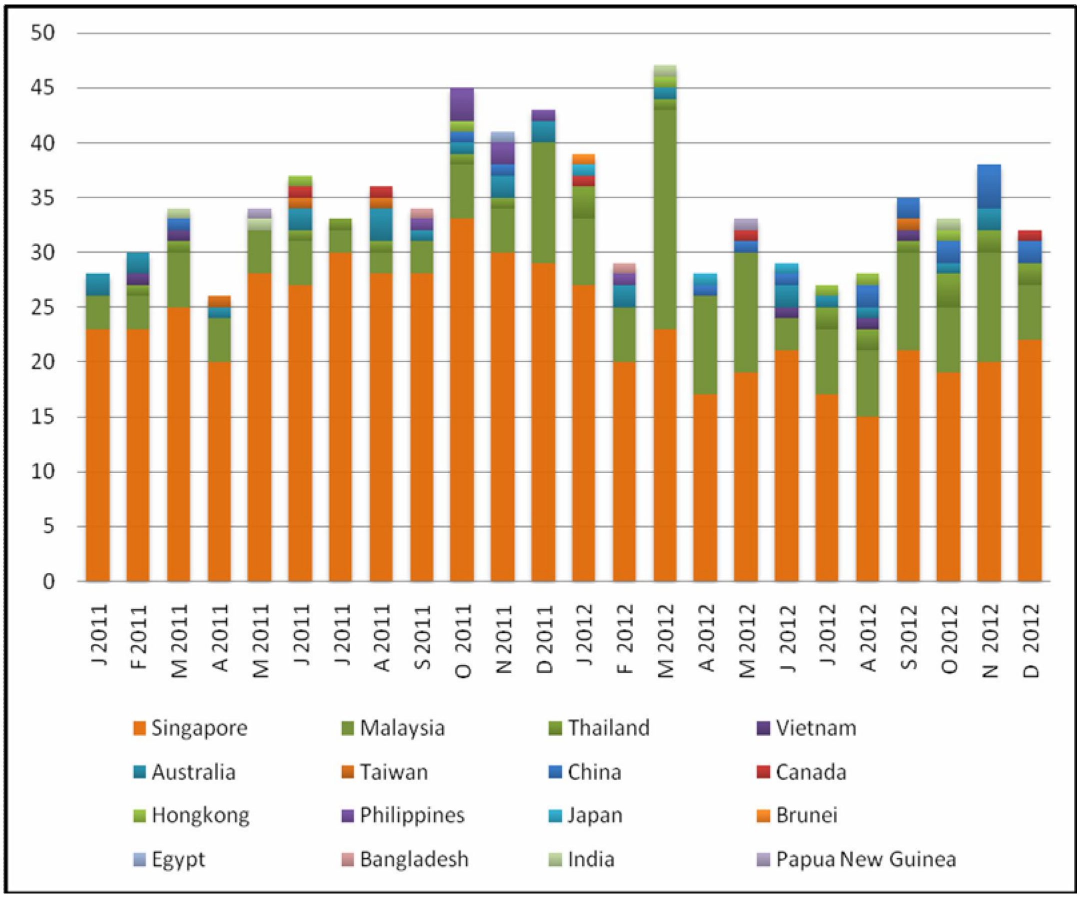

Figure 3. Numbers of foreign commercial vessels visits to PTES in 2011 to 2012 (Source: KAPTES 2009-2014).

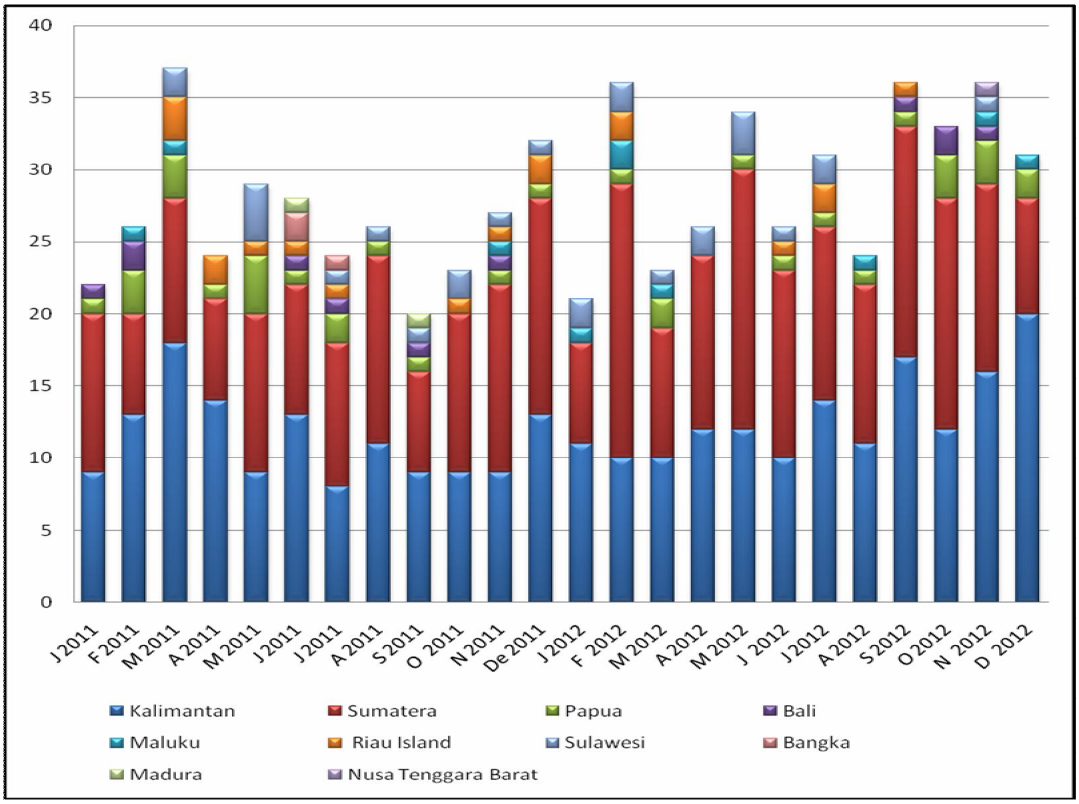

Figure 4. The number of domestic commercial vessels at PTES in 2011 to 2012 (Source: KAPTES 2009-2014).

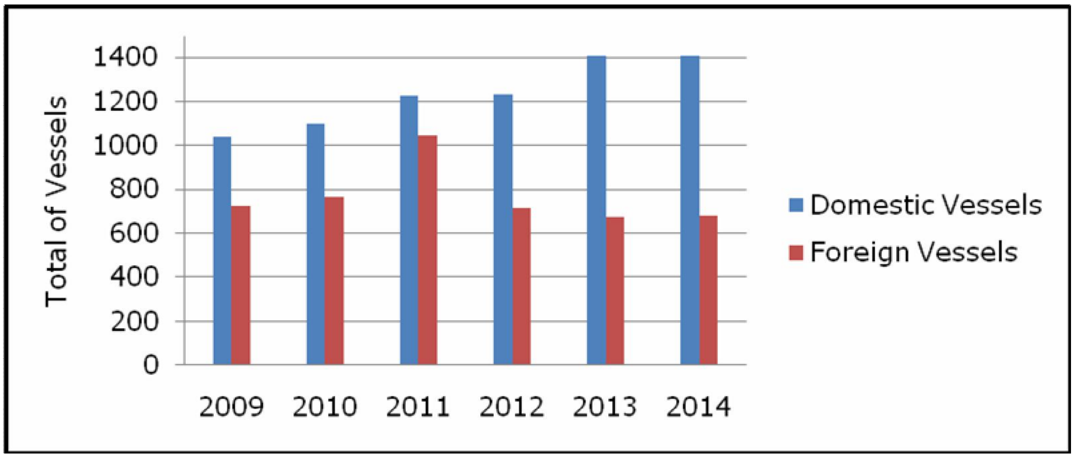

Figure 5. The recapitulation of both domestic and foreign commercial vessel's visits in PTES (Source: KAPTES 2009-2014).

Management model. Figure 6 shows the model of BWM which was currently used. Based on the model, both domestic and foreign commercial vessels arriving at PTES proceeded the ballast water exchange while loading the cargo. This model unfortunatelly caused the port waters's contamination since the ballast water contained heavy metals and plankton whose numbers had surpassed the quality standard.

Other commercial vessels which had unloaded their cargo would load the seawater of PTES into their ballast water tanks in order to maintain the vessel's stability. When they finally reached the destination port and loaded the cargoes, the ballast water would be disposed.

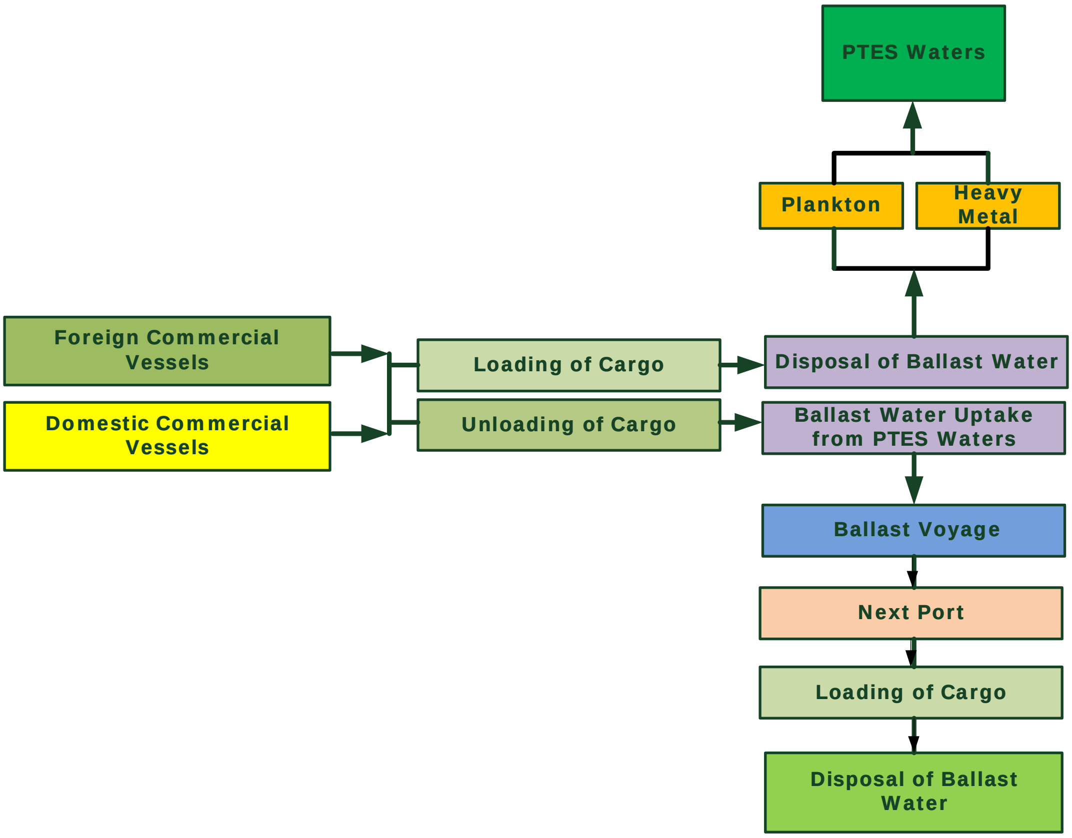

Figure 6. Existing model of ballast water management at PTES.

Figure 7 showed the BWM of the commercial vessels based on the concept cleaner production: recycle and reduce. Being carried out by Pelindo III company, the principle of the concept was providing waste containment. The ballast water was then proceeded by Pelindo III company by using effective principles.

The vessel owners did not need to install the equipments of Ballast Water Treatment (BWT) so that they were not burdened by the installation cost, inspection, and approval. Moreover, Pelindo III was able to create a new business of BWM. This business would also increase the port's revenue. Commercial vessels were suggested to use fresh water to fill their ballast tank.

Other types of commercial vessels such as passenger vessels were recommended to use freshwater provided and sold by Pelindo III company. It was more profitable for both vessels and Pelindo III company. The passanger vessels were able to use the fresh water for domestic purposes while Pelindo III could increase the company's revenue.

Pelindo III company's revenue would be increased as it sought to use freshwater and perform BWT. The concept of BWT was also proposed by two ports in Brazil. There, based on the simulation on bulk carriers, it was found that BWT at ports did not affect the vessel's capacity at ports. Simultaneously, the vessels disposed their ballast water and loaded. Moreover, it took less time to proceed ballast water disposal than to load it (Pereira & Brinati 2012).

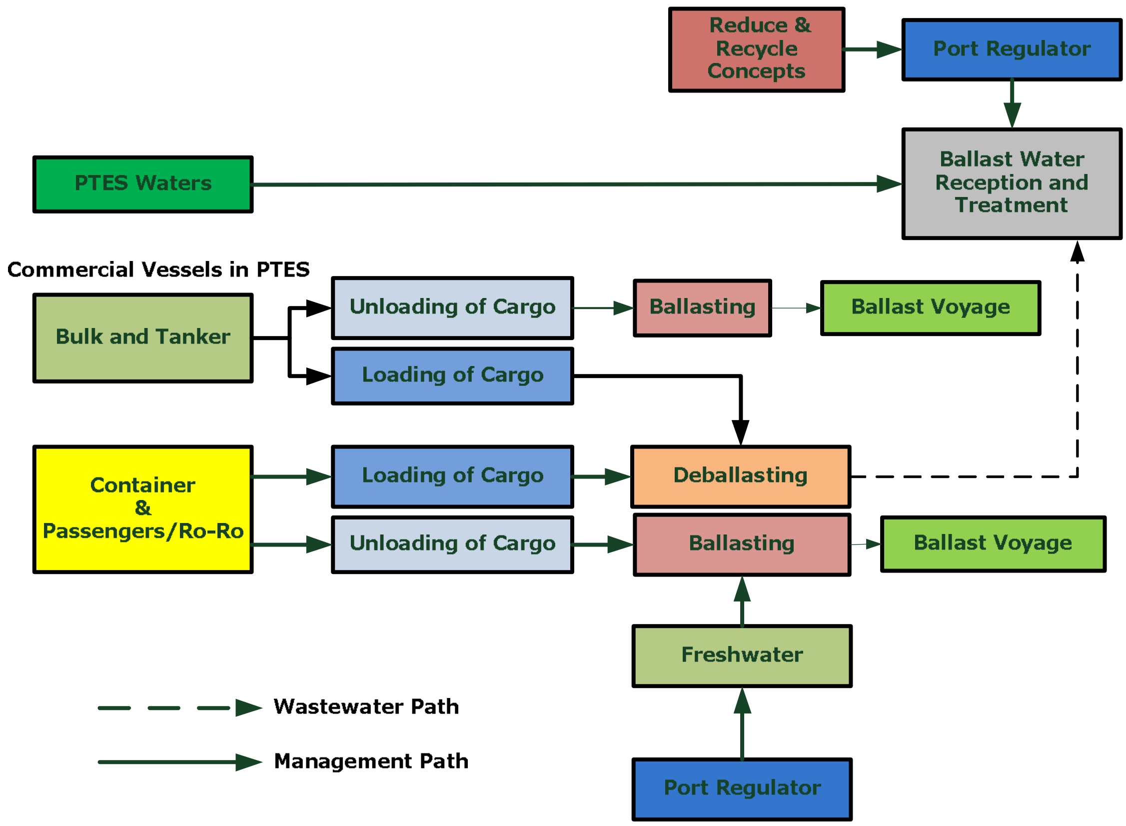

Figure 7. Model of BWM in PTES.

The cost of applying freshwater on commercial vessels. When freshwater was used, assuming the price of freshwater from Pelindo III company per February 2017, the expense was be around IDR 35,000 ton^{-1} for domestic commercial vessels and US $ 7 ton^{-1} for the foreign commercial vessels (IDR 93,275 ton^{-1}, rate per March 2017 for 1 US $ = Rp 13,325) (Pelindo III Tanjung Emas 2014). This assumption was applied for commercial vessels with less than 7 days of sailing since most commercial vessels in PTES took less than 7 days of sailing (Table 4).

Table 4

Cost estimation of using freshwater for one-way voyage

No	*Vessel's name*	*Port of origin*	*DWT (ton)*	*Capacities of ballast tank (ton)*	*Freshwater price ton^{-1} (IDR)*	*Cost (IDR)*
1	TS XXII	Dumai	10,727	3,754.45	35,000	131,405,750
2	H R	Cilacap	2,916	1,064.34	35,000	37,251,900
3	H S	Tuban	20,322	7,112.7	35,000	248,944,500
4	P A	New Orleans	22,596	7,908.6	93,275	737,674,665
5	F S	Ambon	22,596	8,247.54	35,000	288,663,900
6	A	Jakarta	11,161.5	3,906.53	35,000	136,728,550
7	R B	Bangkok	38,968	11,690.4	35,000	409,164,000
8	C F	Jakarta	57,500	20,125	35,000	704,375,000
9	I Z	Palembang	9,237.2	3,233.02	35,000	113,155,700
10	C 8	Palembang	2,110	770.15	35,000	26,955,250
11	L	Kumai	1,400	462	35,000	16,170,000
12	N G	Merak	5,909.58	2,068.35	35,000	72,392,250
13	P P	Papua	1,583.95	578.14	35,000	20,234,900
14	S	Palembang	4,999	1,824.64	35,000	63,862,400
15	Ce 8	Dumai	668	243.82	35,000	8,533,700
16	M P M	Palembang	1,185.4	414.89	35,000	14,521,150
17	B M 79	Sorong	662.27	241.73	35,000	8,460,550
18	M	Jakarta	1,500	547.5	35,000	19,162,500
19	M B 2	Jakarta	7,761	2,328.3	35,000	81,490,500
20	D F 2	Kumai	2,673	882.09	35,000	30,873,150
21	G D	Sorong	2,418.96	882.92	35,000	30,902,200
22	O K	Palembang	9,199	3,219.65	35,000	112,687,750
23	G N A	Jakarta	5,589.79	1,956.43	35,000	68,475,050
24	BC S	Singapore	9,957	2,987.1	93,275	278,621,753

Source: Primary data being processed; DWT = Dead Weight Ton.

Based on the interview to A, a former cadet of a container vessel with Dead Weight Ton (DWT) 7,760 MT route of Jakarta to Belawan with 3 days of sailing and 30 crews, it was found that the freshwater consumption was about 10 tons per day. By using the formula proposed by David et al (2012), the capacity of the container vessel's ballast tank was 2,328 tons (from 0.3 x 7,760 tons). The freshwater cost reached IDR 81,480,000 (from 2,328 ton x Rp 35,000) and in 3 days the water consumption would be 30 ton. Upon its arrival at the port of Belawan, there was 2,298 tons of freshwater left. Even if the vessel was loaded up with containers, the fresh water could still be used for the next port.

Freshwater consumption of a passenger vessel was about 100 ton per day (based on the interview with HB, Chief Officer on Pelni Shipping Company). If it was applied to Leuser Vessel (DWT 1,400 MT), the ballast tank capacity was 462 tons. Sailing from Semarang to Kumai in three days, the vessel required 300 tons of freshwater. The freshwater in the ballast tank of the passenger vessel was definitely feasible.

However, this freshwater was not able to be applied to both solid and liquid bulk cargo vessels. It was due to the fact that those kinds of vessels used their cargo as the ballast. Thus, when the vessel was loaded up in the next port, the water within its ballast tank must be disposed. The freshwater within ballast tanks on both solid and dry bulk cargo vessels could not be applied since the freshwater would be disposed entirely at the next port.

In order to follow the BWM rules, the vessel owners were obliged to invest up to US $ 5 millions (IDR 66.615 billions, USD to IDR rates in March 2017 IDR 13,325). This investment would definitely burden the vessel operating cost (BWM 2016). For example, the expenses included chloride seawater treatment US $ 0.08 m^{-3} (IDR 1,066 m^{-3}), with chloride US $ 0.08 m^{-3} per 6 months (IDR 1,066 m^{-3} per 6 months), maintenance expenses US $ 2,000 year^{-1} (IDR 26.646 millions year^{-1}) and filter US $ 3,600 screen^{-1}

per 5 years (IDR 47.962 millions screen^{-1} per 5 years). Thus, the first year investment must be paid for 1 m^3 of ballast water reached IDR 66.791 billions or more. On the other hand, Special Survey needed to be performed to the commercial vessel which obtained a new equipment. The survey was done by the Classification Bureau and for the next five years, the vessel needed to be re-surveyed.

The price of the processed ballast water was set by Pelindo III company, as the PTES operator. The price was supposed to be a half less than the freshwater price (IDR 10,000 ton^{-1}). The price was expected to attract the commercial vessels.

The technology of BWM*.* The selection of BWT model was done by the analysis of fuzzy set. The technology included: (a) filtration, (b) cyclonic system, (c) ultraviolet radiation, (d) ultrasound, (e) electroporation, and (f) radiolysis. Based on this analysis, the filtration technology was considered as the feasible combination of technology whereas ultraviolet and ultrasound were the second choices (Mamlook et al 2008).

The impact of toxins as the result of using ballast water treatment PERACLEAN® Ocean which apply peracetic acid was investigated by using both freshwater and seawater as the experiment media. Based on the result, it was found that the greater toxin response was found in freshwater than in seawater. Moreover, it was also found that toxin affected on both freshwater and cold water (de Lafontaine et al 2008).

Ballast water treatment with temporary high temperatures ranging from 55 to 80°C applied steam. However, the experiment has not been performed on ballast water with high phytoplankton content and tolerance at a high temperature (Quilez-Badia et al 2008).

Ballast water treatment on commercial vessels had also been carried out by Bradie et al (2010) by using sodium chloride brine as an emergency treatment. The study recommended the usage of brine with a concentration of 115 ‰ for 1 hour within the tank to obtain an equal salinity. However, studies on brine disposal at sea had not been held yet.

A study on the effectiveness to detect the successful performance of NaClO (sodium hypochlorite solution) to *Dunaliella salina* had been performed. This study applied Light-Induced Chlorophyl Fluorescence to detect the viability of microalgae cells. The research found that the viability of microalgae could be detected appropriately. Thus, this detector could be used as an evaluation to the BWT methods (Maw et al 2015).

The high investment cost in installing the equipment of ballast water treatment could be reduced by developing new vessel designs: zero ballast water concepts, minimal discharge, float control, and the increase of ballast water exchange. However the concept could only be done to new vessels; the old vessels were not included (Elkady et al 2014).

The model of BWT on commercial vessels was investigated by considering the cost, legality and operational conditions, and Generic-Fuzzy Analytic Hierarchy Process. Based on the methods, the most appropriate method to use was filtration: physical (deoxygenation) and chemical (chlorination) filtration (Satir 2014).

Conclusions. Based on SWOT analysis, the HMPAO of Tanjung Emas as regulator was supposed to apply a defensive strategy including providing containment facility and ballast water treatment by Pelindo III company and determining a firm sanction and penalties for the violators of BWM rules.

By considering the growing numbers of foreign commercial vessels arriving at the port, it is necessary to strengthen the role of the PSC in supervising the foreign commercial vessels.

Container vessels, passenger vessels, and Ro-Ro vessels are suggested to use freshwater to be fulfilled into their ballast tanks in order to maintain the vessel's stability. Bulk carriers and tankers could not apply this method but are suggested to dispose their ballast water into the containment tanks provided by Pelindo III company. This method would be adventageous for both bulk carriers and tankers that they do not need to provide the equipments of BWT. It was also beneficial for Pelindo III company that it was able to provide the service of dirty ballast water.

Port operator, Pelindo III company, can possibly provide ballast water containment tanks. The ballast water obtained from the commercial vessels is then processed by using both physical and chemical filtration. In addition, Pelindo III company benefits by providing and selling freshwater to passenger vessels.

Acknowledgments. We would like to express our gratitude to the HMPAO of Tanjung Emas Semarang for the aid and assistance in conducting this research, especially Mrs. Erry, who had willingly provided the research data and distributed the questionnaires. Our gratitude also goes to the interview respondents. This research is part of a dissertation on BWM.

References

Alvsvag J., Agnalt A. L., Jorstad K. E., 2009 Evidence for a permanent establishment of the snow crab (*Chionoecetes opilio*) in the Barents Sea. Biological Invasions 11:587-595.

Ashelby C., Worsfold T. M., Fransen C. H. J. M., 2004 First records of the oriental prawn *Palaemon macrodactylus* (Decapoda: Caridea), an alien species in European waters, with a revised key to British Palaemonide. Journal of the Marine Biological Association of the United Kingdom 84:1041-1050.

Bradie J. N., Bailey S. A., van der Velde G., MacIsaac H. J., 2010 Brine-induced mortality of non-indigenous invertebrates in residual ballast water. Marine Environmental Research 70:395-401.

BWM (Ballast Water Management), 2016 Counting the cost of ballast treatment. Available at: http://www. ballastwatermanagement.co.uk/news. Accessed: March, 2017.

David M., Gollasch S., 2016 How to approach ballast water management in European seas. Estuarine, Coastal and Shelf Science 201:248-255.

David M., Perkovic M., Suban V., Gollasch S., 2012 A generic ballast water discharge assessment model as a decision supporting tool in ballast water management. Decision Support System 53:175-185.

de Lafontaine Y., Despatie S. P., Wiley C., 2008 Effectiveness and potential toxicological impact of the PERACLEAN®Ocean ballast water treatment technology. Ecotoxicology and Environmental Safety 71:355-369.

Elkady H., Duanfeng H., Lianggao G., 2014 The alternatives of ballast water system. Applied Mechanics and Materials 627:347-352.

Fahmi I., 2013 [Strategic management, theory and application]. Alfabeta, Bandung, 367 pp. [in Indonesian]

Hidayat A. S., 2017 Problem analysis and development strategy of shrimp culture in Tanah Laut Regency, South Kalimantan Province, Indonesia. AACL Bioflux 10(4):850-860.

Interview of informant HB and A [(Officer on Pelni passenger vessel and cadet on container vessel) July 2015 at PIP Semarang]. [in Indonesian]

IMO (International Marime Organization), 2002 International Safety Management Code ISM and Revised Guidelines on Implementation of the ISM Code by Administrations, 2002nd edition. International Maritime Organization, London.

KAPTES (Kantor Administrasi Pelabuhan Tanjung Emas Semarang), 2009-2014 [Data of sea transport activities for domestic and foreign route in the port of Tanjung Emas Semarang in 2011-2012]. Bidang Lala dan Kepelabuhanan, Kantor Administrasi Pelabuhan Tanjung Emas Semarang. [in Indonesian]

Lasse D. A., 2014 [Port management]. PT Raja Grafindo Persada, Jakarta, 414 pp. [in Indonesian]

Lim C. S., Leong Y. L., Tan K. S., 2017 Managing the risk of non-indigenous marine species transfer in Singapore using a study of vessel movement. Marine Pollution Bulletin 115(1-2):332-344.

Liu T. K., Tsai T. K., 2011 Vessel trafic patterns in the port of Kaohsiung and the management implications for preventing the introduction of non-indigenous aquatic species. Marine Pollution Bulletin 62:602-608.

Liu T. K., Chang C. H., Chou M. L., 2014 Management strategies to prevent the introduction of non-indigenous aquatic species in response to the Ballast Water Convention in Taiwan. Marine Policy 44:187-195.
Mamlook R., Badran O., Abu-Khader M. M., Holdo A., Dales J., 2008 Fuzzy sets analysis for ballast water treatment sytems: best avalaible control technology. Clean Technologies and Environmental Policy 10(4):397-407.
Maw M. M., Wang J., Li F., Jiang J., Song Y., Pan X., 2015 Novel electrokinetic microfluidic detector for evaluating effectiveness of microalgae disinfection in ship ballast water. International Journal of Molecular Sciences 16:25560-25575.
Morton B., Leung K. F., 2015 Introduction of the alien *Xenostrobus securis* (Bivalvia: Mytilidae) into Hong Kong, China: interactions with and impacts upon native species and the earlier introduced *Mytilopsis sallei* (Bivalvia: Dreissenidae). Marine Pollution Bulletin 92:134-142.
Ng C., Goh S. G., Saeidi N., Gerhard W. A., Gunsch C. K., Gin K. Y. H., 2018 Occurence of *Vibrio* species, beta-lactam resistant *Vibrio* species, and indicator bacteria in ballast and port waters of tropical harbor. The Science of the Total Environment 610-611:651-656.
Nghiem L. T. P., Soliman T., Yeo D. C. J., Tan H. T. W., Evans T. A., Mumford J. D., Keller R. P., Baker R. H. A., Corlett R. T., Carrasco L. R., 2013 Economic and environmental impacts of harmful non-indigenous species in Southeast Asia. PLoS ONE 8(8):e71255.
Pelindo III (Pelabuhan Indonesia) Cabang Tanjung Emas, 2012 [Tanjung Emas Port Directory]. Dwitama Wukirindo, Semarang, 324 pp. [in Indonesian]
Pelindo III (PT. Pelabuhan Indonesia III) Cabang Tanjung Emas, 2014 [Circular Letter SE.11/PU.03/TMS-2014 concerning the tariff adjustment of ship and goods services within PT Pelabuhan Indonesia III (Persero) Tanjung Emas Branch], 95 pp. [in Indonesian]
Pereira N. N., Brinati H. L., 2012 Onshore ballast water treatment: a viable option for major ports. Marine Pollution Bulletin 64:2296-2304.
Primo C., Hewitt C. L., Campbell M. L., 2010 Reproductive phenology of the introduced kelp *Undaria pinnatifida* (Phaeophyceae, Laminariales) in port Phillip Bay (Victoria, Australia). Biological Invasions 12:3081-3092.
Quilez-Badia G., McCollin T., Josefsen K. D., Vourdachas A., Gill M. E., Mesbahi E., Frid C. L., 2008 On board short-time high temperature heat treatment of ballast water: a field trial under operational conditions. Marine Pollution Bulletin 56:127-135.
Rangkuti F., 1997 [Techniques to dissect business cases: SWOT analysis, weighting, rating, and OCAI methods]. Gramedia Utama, Jakarta, 240 pp. [in Indonesian]
Rangkuti F., 2011 [SWOT balanced scorecard, techniques for formulating effective corporate strategy plus how to manage performance and risk]. Gramedia Pustaka Utama, Jakarta, 274 pp. [in Indonesian]
Rangkuti F., 2015 [Personal SWOT analysis, opportunities behind every difficulty]. Gramedia Pustaka Utama, Jakarta, 211 pp. [in Indonesian]
Republik Indonesia, 1999 [Government regulation of the Republic of Indonesia no. 19/1999 regarding pollution control and/or sea destruction]. [in Indonesian]
Republik Indonesia, 2002 [Government regulation of the Republic of Indonesia no. 51/2002 regarding shipping]. Jakarta, Indonesia Legal Center Publishing. [in Indonesian]
Republik Indonesia, 2008 [Law of the Republic of Indonesia no. 17/2008 on Shipping]. Jakarta, Indonesia Legal Center Publishing. [in Indonesian]
Republik Indonesia, 2010 [Government Regulation number 21/2010 on Maritime Environment Protection]. Kementerian Hukum dan Hak Asasi Manusia Republik Indonesia. [in Indonesian]
Republik Indonesia, 2010 [Decision Letter of Minister of Transportation no. 64/2010 on November 5th about harbour master office's organization and working procedure]. [in Indonesian]

Republik Indonesia, 2013 [Regulation of the Minister of Transportation no. 58/2013 on Pollution Prevention in Waters and Ports]. Ministry of Transportation Republic of Indonesia. [in Indonesian]
Republik Indonesia, 2014 [Law no.1/2014 on Amendment to Law Number 27/2007 concerning the management of coastal areas and small islands]. Ministry of Law and Human Rights. [in Indonesian]
Republik Indonesia, 2014 [Law no. 23/2014 concerning regional government]. Ministry of Law and Human Rights. [in Indonesian]
Republik Indonesia, 2017 [Regulation of the minister of transportation of Republik Indonesia PM 119/2017 on examination of securities and security of foreign vessels]. Ministry of Transportation. [in Indonesian]
Satir T., 2014 Ballast water treatment systems: design, regulations, and selection under the choice varying priorities. Environmental Science and Pollution Research International 21:10686-10695.
Somantri A., Muhidin S. A., 2006 [Application of statistics in research]. Pustaka Setia, Bandung, 385 pp. [in Indonesian]
Sukardi, 2003 [Methodology of educational research, competence and practice]. Bumi Aksara, Jakarta, 219 pp. [in Indonesian]
Tjahjono A., Bambang A. N., Anggoro S., 2017a Analysis of heavy metal content of Pb in ballast water tank of commercial vessels in port of Tanjung Emas Semarang, Central Java Province. Journal of Ecological Engineering 18(2):7-11.
Tjahjono A., Bambang A. N., Anggoro S., 2017b The impact of ballast water disposal of commercial vessels, diversity of species and tide time in the west monsoon in port of Tanjung Emas Semarang. Journal of Biodiversity and Environmental Sciences 10(1):80-89.
Tjahjono A., Bambang A. N., Anggoro S., 2017c Analysis of heavy metal content of Cd and Zn in ballast water tank of commercial vessels in port of Tanjung Emas Semarang, Central Java Province. IOP Publishing, IOP Conf. Series: Earth and Environmental Science 55:012024, doi: 10.1088/1755-1315/55/1/012024.
Tjahjono A., Bambang A. N., Anggoro S., 2018 Plankton and heavy metal correlation from commercial vessels in port of Tanjueng Emas Semarang. E3S Web of Conference 31(06004):1-8.
Wan Z., Chen J., Sperling D., 2018 Institutional barriers to the development of a comprehensive ballast-water management scheme in China: perspective from a multi-stream policy model. Marine Policy 91:142-149.
Wu H., Chen C., Wang Q., Lin J., Xue J., 2017 The biological content of ballast water in China: a review. Aquaculture and Fisheries 2:241-246.
Zhang X., Bai M., Tian Y., Du H., Zhang Z., 2017 The estimation for ballast water discharged to China from 2007 to 2014. Marine Pollution Bulletin 124(1):89-93.

Received: 30 May 2018. Accepted: 25 July 2018. Published online: 11 August 2018.
Authors:
Agus Tjahjono, Technical Department, PIP Semarang (Semarang Merchant Marine Polytechnic), Singosari 2 a Semarang, 50242, Central Java, Indonesia, e-mail: a_agus_tjahjono70@yahoo.co.id
Wisnu Handoko, Sub directorate Domestic Sea Transportation, Directorate of Sea Traffic, The Ministry of Transportation, Merdeka Barat no. 8, Central Jakarta, 10110, Indonesia, e-mail: wisnubp2ip@gmail.com

How to cite this article:
Tjahjono A., Handoko W., 2018 The implementation of ballast water management in Port of Tanjung Emas Semarang: strategy and model. AACL Bioflux 11(4):1231-1247.