Analysis of Preparedness towards Implementation of BWM Convention: Challenges and Opportunities of Croatian Ports

As being identified as global issue, identification and analysis of ballast water origins is of highlighted importance. Aim of this paper is analysis of Croatian ports preparedness for process of implementation of International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM). In accordance, quantities and origin of ballast water are observed from 2008-2018, with analysis from year 2014 to 2017. One – way repeated measures ANOVA was used to idenfication of significance of differences between observed years (2014-2017). Furthermore, available additional indicatiors conected to ballast water were observed for all Croatian ports. Non-linear dinamics of amount of ballast water quantities has been identified, while one-way repeated measures ANOVA did not revealed significant increase (p>0.05) of number of ships with ballast water and appropriate indicators. Additionaly, results indicate that Croatian ports face challenges for implementation of BMW Convention, which is primarly connected to deficit of port based facilities and inadequate monitoring via Croatian Integrated Maritime Information System - CIMIS. Results of this study contain integrated guidelines for implementation of convention and indicate necessity of additional effort investment with aim of minimizing risks conected to ballast water transportation, which contain risks regarding protection of ecosystem and human health, which reduces or prevents material damages.

Keywords: *reception facilities, convention, ballast, BWM, environment, Croatian Ports*

Introduction

According to IMO it is estimated that 10 billion tonnes of ballast water is transported per year, with 7000 species being transfered in ballast water every hour of everyday. Furthermore, single invasion happens every 9 weeks, with 2.4 billion people living within areas 100km of the coast, while approximately 80% of World trade is carried by ships [1]. Therefore, biopollution, i.e. the redistribution of the Earth's species to habitats and ecosystems that were previously isolated from each other, is globally recognized as menace to biodiversity, the economy, and human health [2]. Article 196(1) of the 1982 United Nations Convention on the Law of the Sea (UNCLOS), which provides that ―States shall take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from the use of technologies under their jurisdiction or control, or the intentional or accidental introduction of species, alien or new, to a particular part of the marine environment, which may cause significant and harmful changes thereto," [3]. *International convention for the control and management of ships ballast water and sendiments* (BWM), within Article 1 defines „Ballast water is the water with its suspended matter taken on board in order to achieve acceptable level of stability, trom, list, draught, and stresses of the ship“ [4]. Depending on size, vessels can take from few thousands to over 10^5 tones of sea water for ballast [5]. Ballast water has emerging risks which include economical effect such as damage in tourism, or human health and ecological impact as a resoult of possible transfer of non-native species such as algae, bacteria, viruses, fish larvae, or crustaceans [6,7]. In Adriatic sea, invasive species are green algae *Caulerpa taxifolia* and *Caulerpa Racemosa*, and it is particulary important to explore scientific methods which would slow down their growth, especially in the protected area [8]. Constant decline of time from loading to discharge of ballast water has impacted better survival rate of non-native species during the voyage [9]. Furthermore, economic global impact of ballast water is estimated at around 10 billion euros with increasing trend [10]. Salinity of sea water is relevant factor in biodiversity, as changes in salinity range can cause changes in organisms which are located in specific area [11]. Averege salinity of Adriatic Sea is 38.3‰, which is which is higher than the world average. Considering relevance of salinity in ballast water observation, Article 13.of Ordinance on ballast water Management and control ships which perform ballast water exchange as a method of ballast water management can discharge sea-water with salinity above 36‰ [12]. Climate change effects on marine organisms and ecosystems is expected to increase with changes in temperature, salinity, acidification, circulation, stratification and other parameters, though due to the complexity of marine ecosystemsand non-linear interactions with climatic and non-climatic stressors, the change is not predictable [13].

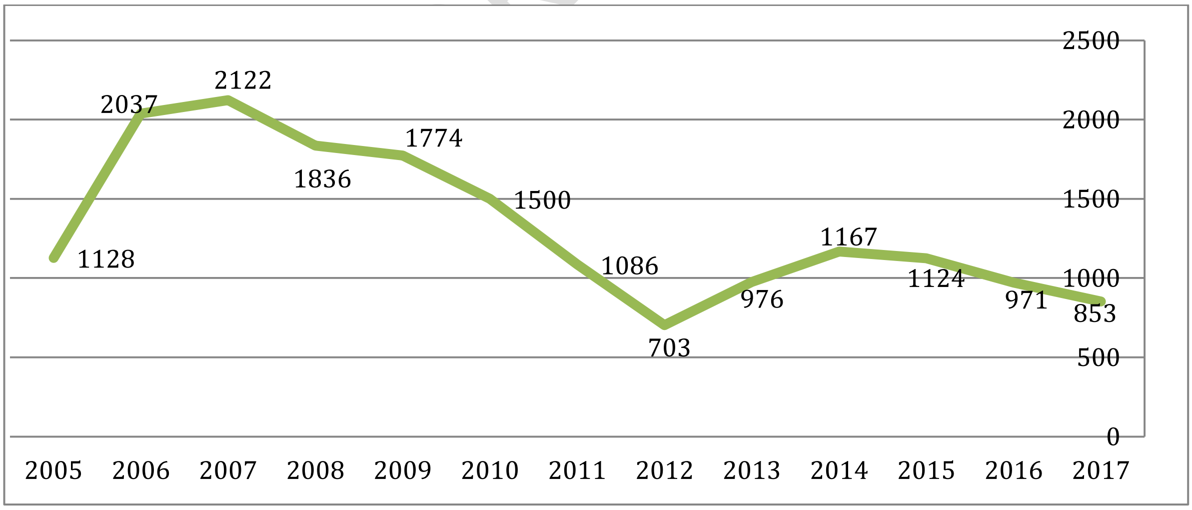
Literature review

International convention for the control and management of ships ballast water and sendiments is adopted in London 2004 **(**IMO**)** with aim to minimize and prevent risks arising from the transfer of harmful organisms and pathogens. Convention stated as obligatory to each Party to ensure that in ports and terminals where cleaning and repair of ballast tanks occurs, adequate facilities are provided for the reception of sediments, which can't couse delay to ships and are required to provide for the safe disposal of sediments that does not impair or damage their enviroment, human health, property or resources of those of other states. While convention doesn't provide exact requirements regarding facilities, parties are obligated to endeavour, individually or jointly to promote and facilitate scientific and technical research and monitor the effects in waters under their jurisdiction. Furthermore, within Article 13 it has been required that parties provide support for those which request technical assistance, to train personnel, to ensure relevant technology, to initiate research and development programmes, and to undertake other action aimed at the effective impementation of Convention. Convention is made from basic part and supplement which includes technical standards and and requirementsas written in *Regulations for the control and management of ships' ballast water and sediments* [14]. Convention entered into force in the Republic of Croatia, and it is from great importance to identify current situation regarding vessels carring ballast water in Croatia, and to point activities necessary to meet requiriments of Convention properly. Consequently, the problem is addressed globaly and it is of great scientific importance to do trend analysis, even annually, which includes data about quantity and origin of ballast water. Data collection and analysis of ballast water parameters help minimize risk connected with ballast water negative impact, which include impact on health, ecology and economy. In accordance with previously stated facts, the aim of this paper is to do analysis of Croatian sea ports Pula, Senj, Ploče, Split, Šibenik, Zadar, Rijeka and Dubrovnik ballast water parameters from year 2014 to 2017. In compliance with Convention, shipyards are to identify options for installing ballast water treatment systems in their new construction specifications – both within the construction programme or through retrofitting. This could involve providing system drawings to show how a selection of different treatment options might be fitted, ensuring that sufficient space has been allocated for retrofitting treatment systems if they are not included in the initial build. Piping connections are also to be fitted to ballast systems in preparation for retrofitting of the selected treatment equipment. Price of investment in equipment is high, and could cost as much as $2million depending on the manufacturer. As for operating costs, it depends on the type of system and starts from as little as a few dollars per 1000m^3 of treated water. Many system suppliers quote operating costs below $20 per 1000 m^3 [15]. To minimize negative impact of ballast waterr, under Regulation B-4 of Convention, all ships using ballast water exchange should: whenever possible, conduct ballast water exchange at least 200 nautical miles from the nearest land and in water at least 200 metres in depth, taking into account Guidelines developed by IMO; in cases where the ship is unable to conduct ballast water exchange as above, this should be as far from the nearest land as possible, and in all cases at least 50 nautical miles from the nearest land and in water at least 200 metres in depth. When these requirements cannot be met areas may be designated where ships can conduct ballast water exchange. All ships shall remove and dispose of sediments from spaces designated to carry ballast water in accordance with the provisions of the ships' ballast water management plan (Regulation B-4).[16]The Adriatic Sea is a mostly shallow, over 800 km long and around 150–200 km wide, with major axis in the northwest–southeast direction. It can be divided into three sections, with increasing depth from north to south, with di fferent characteristics, different widths and topographic gradients (Trincardi et al., 1996). The northern section, reaching an average bottom depth of about 35 m, gently slopes part in south-eastern direction down to around 100 m depth to a line between Pescara and Sibenik, where as lope leads to the central basin at depths of 140-150 m (Trincardi et al., 1996; van Straaten, 1970). The northern part of the basin is, by convention, bounded to the south by the transect approximately at 43.5°N. The central Adriatic is up to 50 km wide, it shows an average depth of 130-150m, but is also characterized by the presence of the Pomo Depression forming the "Meso-Adriatic Trench" (Trincardi et al., 1996; van Straaten, 1970). The depressions, known by Italians as Pomo Pit and by Croatians as Jabuka Pit (in both languages the term means "apple") is a complex transverse depression, reaching the depth of 240-270 m (van Straaten, 1970). The southern area shows a wide depression 1218-1225m deep and contains a comparatively large bathyal basin, by shelf surfaces of varying width; the continental shelf is wider in the Manfredonia Gulf (ca.70–80 km), it becomes narrower further to the south (less than 30–40 km) and it is limited by the Ionian Sea (Artegiani et al., 1997a, b; Ponti and Mescalchin, 2008; Trincardi et al., 1996; van Straaten, 1970)[17].

Case of Croatia

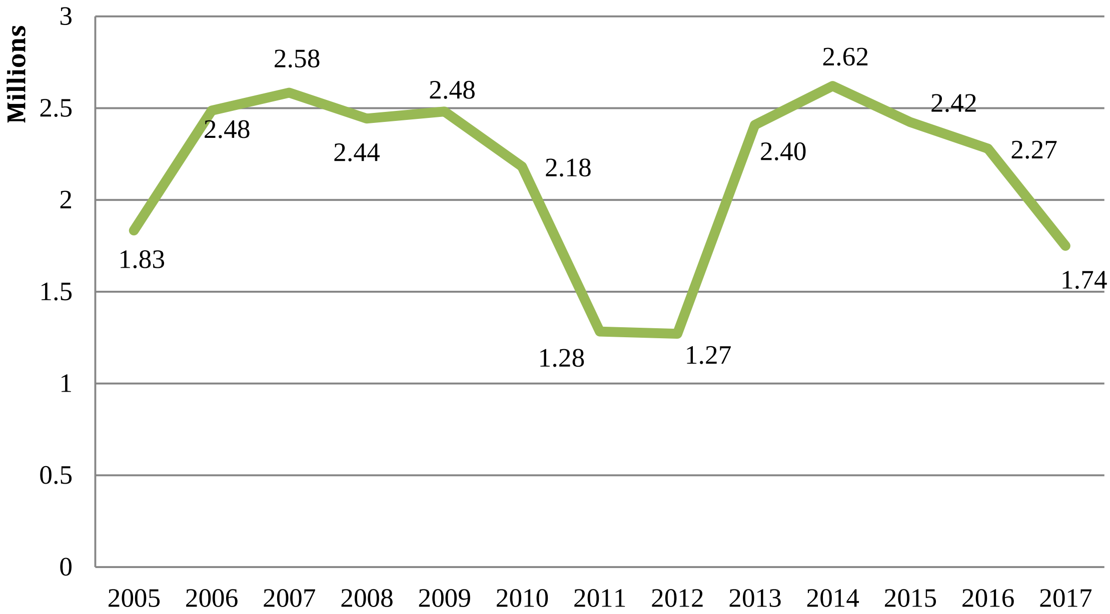
Purpose of this paper is to analyse trends of rise or fall of ballast water quantities and origin of ballast water imported to Croatia, and preparednessof seven port authorities in Croatia (Split, Zadar, Ploče, Dubrovnik, Rijeka, Šibenik i Pula) for implemetation of BWM Convention. Picture 1. shows number of vessels who discharge ballast water in Adriatic Sea from year 2005 to 2018.

Picture 1. *Number of vessels who discharged BW in Adriatic Sea from 2005 to 2018*



As it can be seen from Picture 1, there is decreasment of vessels who discharge ballast water, and decline of ballast water quantities in recent years. Again, there is rise in year 2013 when CIMIS was included in analysis, but from that year there is constant decline.

Picture 2. *Qauntity of discharged BW in Croatia for interval from year 2005 to 2017*

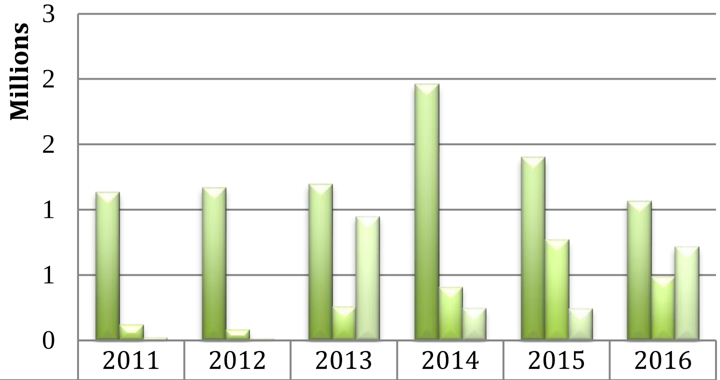


As it can be seen from Pic 2, From year 2014 to 2017 there was constant decline of quantity of ballast water discharged in Croatia, while the amounts were highest in year 2014. In year 2013, CIMIS was used to analyse data, while before 2013 data was analysed by hand. It is possible that is the reason for rise in year 2013.

Origin of Discharged Ballast Water

Origin analysis demonstrates constant **decline** of BW from Adriatis Sea in observed period. In year 2011. 89% discharged BW came from Adriatic Sea, and 2% of BW came from other sea. In year 2016. only 47% of BW origin came from Adriatic Sea. In year 2011. only 2% of BW came from other sea, while in year 2016. 31% of discharged BW origin came from other sea. In year 2008. biggest quantity of BW came from Adriatic sea which is 86%, and 11% came from Mediterranean Sea and Black Sea. New trends implicate growth of BW from Mediterranean Sea and from other sea.

Picture 3. *Shows trends of BW origin from year 2011. to 2016*



	2011	2012	2013	2014	2015	2016
From Adriatic Sea	1,138,491	1170246	1200256	1963270	1403377	1069133
From Mediterrain Sea	122,754	84831	257645	410301	773513	491703
From Other Sea	21,771	16307	950314	247781	247288	718830

In year 2013, quantities of BW from Other Seas were similar to quantities from Adriatic Sea, which indicates rapid growth of BW from te Other Seas. Data shows increasment for ballast imported from other seas, while before, ballast water was mostly from Adriatic Sea.

Data Aquisition

All data were collected through direct or e-mail communication with Croatian Ministry of Sea, Transport and Infrastructure. During communication with all officials, it was clearly stated that all data will be used only for the purpose of the scientific researches. Consequently, different indicators for 2014-2017 period were requested and gathered: number of vessels with ballast water (NVBW), ballast water transported (BWT), total volume of ballast water capacity (VCBW), number of vessels which discharged ballast water (NDBW), ballast water discharged (BWD).

Methods

All data were presented as mean±standard deviation and sum of all Croatian ports. One-way repeated measures ANOVA was used to identification of significance of differences between observed years (2014-2017). Degrees of freedom were Greenhouse-Geisser corrected if assumption of sphericity appeared to be violated. Partial eta-squared (η^2) was used for effect size assessment and Bonferroni correction was applied when main effect appeared to be significant or at the border of statistical significance. All data was processed using data analysis software system Statistica 13.2 (Dell Inc., Tulsa, USA). Type I error was set at α=5%.

Results

Table 1. shows number of vessels with ballast water (NVBW), ballast water transported (BWT), total volume of ballast water capacity (VCBW), number of vessels which discharged ballast water (NDBW), ballast water discharged (BWD) for Port Authorities observed from year 2014 to 2017.

Table 1. *Descriptive parameters: Mean ± standard deviation*

	2014	**2015**	**2016**	**2017**
	Mean±σ (Sum)	**Mean±σ (Sum)**	**Mean±σ (Sum)**	**Mean±σ (Sum)**
Number of arrivals	788.14±525.33 (5517)	771.71±534.90 (5402)	811.29±562.31 (5679)	808.14±533.27 (5657)
Prijavilo BW kapetaniji	603.00±388.93 (4221)	586.43±413.54 (4105)	590.86±384.71 (4136)	571.29±365.90 (3999)
VCVW[$10^6 m^3$]	24.24±29.80 (170)	24.62±35.15 (172.35)	26.47±36.09 (185.32)	26.58±40.35 (186.05)
NVBW	513.57±343.66 (3595)	476.71±329.82 (3337)	478.71±332.48 (3351)	455.57±331.96 (3189.00)
Doveženo BW [$10^6 m^3$]	9.28±9.68 (64.971)	10.45±18.01 (73.16)	8.17±10.94 (57.20)	7.56±12.26 (52.91)
NDBW	160.57±153.48 (1124)	138.71±125.03 ()	118.29±117.74 (828)	121.86±129.66 (853)
BWD [$10^6 m^3$]	5.00±6.58 (34.972)	4.49±5.90 (31.408)	3.26±3.89 (22.80)	4.94±7.21 (34.59)

Regarding number of arrivals, reported BW, ballast water capacity, repeated measures ANOVA did not revealed significant differences between Croatian ports ($F=0.962$, $p=0.432$, $\eta^2=0.138$; $F=0.746$, $p=0.538$, $\eta^2=0.111$; $F=0.406$, $p=0.751$, $\eta^2=0.063$) respectively. On the other side, ANOVA identified differences on the border of statistical significance in NVBW($F=2.479$, $p=0.094$, $\eta^2=0.292$) whilst Bonferroni correction revealed differences between 2014 and 2017 as almost significant ($p=0.090$). Furthermore, regarding Imported BW, NDBW, BWD ANOVA did not revealed significant differences ($F=0.485$, $p=0.697$, $\eta^2=0.075$; $F=1.527$, $p=0.242$, $\eta^2=0.203$; $F=0.322$, $p=0.809$, $\eta^2=0.051$) respectively so Bonferroni correction was not applied.

Preparedness of Port for Implementation Of Convention

Port Rijeka is the largest port in Croatia with a cargo throughput of 11.2 million tonnes (2016), mostly oil, general cargo and bulk cargo, and 214,348 Twenty-foot equivalent units (TEUs).At present one shore tank (2.000 GMT capacity) for oily/ballast water at Bakar Petrol berth of INA (Refinery Rijeka) only for tankers. Discharging through one 12" line at 200-300 CBM/h rate. M/T ECOMAR capable to collect 1.000 MT. of oil residues &

ballast/bilge water directly from ships and discharging it later on to shore tank at Bakar Petrol berth. [18]. The Port of Split is the largest passenger port in Croatia and the third largest passenger seaport in the Mediterranean, and with Ports and Port Authorities not directly engaged in collection of ballast water from ships, it is posible to provide services through private sector (registered concessionaires); - Fixed reception facilities in ports do not exist and the collection of wastes is carried out by mobile units (tank trucks and/or vessels. Concessionaire for Port of Split is Cian d.d., which collects ballast water by dedicated tank trucks (road tankers) owned by the company. Upon request the company offers collection of BW from ships at anchor in the port of Split, from where BW collected is transported to Solin, near Split, for treatment. In Solin “Cian” owns a modern and well maintained waste treatment plant (called the “Centre for collection, storage and treatment of oily materials”), the only such facility in the southern part of the Croatian coast. Company has vaccum trucks, and ADR trucks – 100m^3, which makes Port capable of handling up to 5 000kg per day. Notice of arrival must be sent 48 prior to arrival, informing Harbour Master Office about ballast water onboard. ”Cian” has a valid licence to carry out activities related to hazardous waste management” for various categories of “waste oils”, issued by the Ministry of Environmental Protection, Physical Planning and Construction, and regularly collects waste oil and oil/water mixtures from ships in ports of Zadar, Šibenik, Split, and Dubrovnik, for which it has concessions, and on a case-to-case basis from the port of Ploče where it is sub-contracted by the concessionaire. Port of Dubrovnik is passenger port, and has none of cargo, with no operations with ballast water registred in CIMIS. [19]

Conclusion

Croatia has undertaken activities to implement the International Maritime Organization’s Ballast Water Management Convention, but did not fully meet requirements. Despite positive activities such as BALMAS project wich integrated all activities to enable a long-term, environmentally efficient sustainable implementation of ballast water management measures in the Adriatic, and development of strategies, there is still problem of insuficient shore treatment technologies. Port of Rijeka has shore tank, while all others have concessions with companies specialised for waste disposal. There is system of control which tracks quantities of ballast water CIMIS, and certan program improvments are implemented after this analysis, as authors sugested measurments for upgrades to Ministry of maritime affairs transport and infrastructure. Correct data are required to track trends, which allows better solutions for ballast water management, to minimize risks of invasive species.

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