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Ballast operations at ports: Nemrut Bay analysis

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ABSTRACT

Ballast water operations are one of the most essential activities of commercial ships whose purpose of existence is to carry cargo between ports. With their growing ballast capacities, ships become an important vector that carries the origin species of the sea waters they took into their ballast tanks. Foreign species were transported between ports with ballast water in these operations, which have been going on since the mid-1800s. Although various guidelines were published by the International Maritime Organization (IMO) regarding ballast water, whose adverse effects on the marine environment began to be noticed in the international arena in the late 1980s, the desired positive effect could not be achieved. As a result of technological developments and R&D studies, ballast water treatment systems (D-2 Standard), which have completed the type approval process, have started to be applied on ships. The deadline for applying treatment systems, which have various types in terms of method and capacity, on ships is September 8, 2024. In this study, an application was made on ships calling Aliağa Port Nemrut Bay to investigate compliance with the International Ballast Water Management Convention and ship ballast operations' by port state control measures. This study showed that most ballast water at Aliağa Port (73%) was treated and discharged. Mechanical filter + UV treatment systems are also the preferred type (63%) among other systems. Also, according to this study's data set, the Adriatic Sea is the majority (44%) among other origins for Aliağa Port.

Keywords: Ballast water, Ship ballast water operations, Ballast water treatment, International ballast water management convention

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Introduction

To ensure positive stability, increase the draft, adjust the trim and keep the stresses on the ship within appropriate limits, ships often fill solid objects such as sand, gravel and stones in the port where they discharge their cargo, and this concept is called ballast. In the mid-1850s, seawater began to serve as ballast on ships, especially in England, when bulk cargo ships were built that used seawater instead of useless dry ballast in the coal trade (Carlton, 1985; NRC, 1996).

Different microorganisms in various numbers and species are transferred with ballast water in international maritime trade and can change the ecosystem of the place by clinging to the places they are transported to (Medcof, 1975; Hayes ve Sliwa, 2003). Ballast water systems are fundamental for commercial ships today and are critical in their functionality. Regardless of the ship's type, purpose and size, ballast tanks are considered an integral part of the ship design (David et al., 2018).

Intake or discharge times are very important in ballast water operations. The most critical factor determining this period is the hourly capacity rate of the ballast pumps installed on the ship. Smooth and timely ballast operations are extremely important for ships taking full cargo. One of the most important factors that negatively affects biodiversity is the introduction of alien species. When we look at the adverse effects of alien species, we can list the changes in food webs, the spread of new diseases and the struggle for food with native species. Foreign invasive species can interact with native species and cause the gene pool to change (Elton, 1958; Occhipinti Ambrogi, 2001).

The global impact of alien species transported through ships' ballast water is a significant concern (Carlton, 1985; Davidson & Simkanin, 2012). This method of transfer has led to notable changes in marine environments worldwide. Numerous negative effects exist, including the Japanese single-celled flagellated animal in Australia, the European zebra mussel in Canada, and the American carnivorous jellyfish in the Black Sea (NRC, 1996).

Turkish coasts have also been affected by invasive species. In a study conducted in the Marmara Sea, samples taken from the ballast water of 21 different ships were examined, and 38 different bacterial species foreign to the Marmara Sea marine fauna were detected (Altug et al., 2012). In 2014, high numbers of pathogenic bacteria were detected as a result of experiments conducted on samples taken from 5 different regions of the Marmara Sea (Tuzla, Tuzla shipyards region, Kartal, Derince, Zeytinburnu) (Elçiçek, 2014). In another scientific study, it was determined that ballast waters carried 122 different alien species detected on the coasts of Türkiye. It has been revealed that the spinoid polychaetes polydora cornuta, streblospio gynobranchiata and pseudopolydora paucibranchiata, which are among the invasive species, were carried to the Izmir Bay by ballast waters (Çınar et al., 2005). Another study determined that the number of alien species detected on Türkiye's Aegean Sea coast was 165. Compared to the scientific study conducted in 2005, an increase of 69% was recorded. This increase was shown to be due to the increase in detections due to the increasing number of scientific studies (Çınar et al., 2011).

David et al. (2018) analysed and compared the ballast water discharged in the Ports of Hamburg and Tallinn. In this study, where ship data from 2012 was used, the discharge estimation method obtained the amount of discharged ballast water data. Ballast water source port data is also considered the ship's previous port.

Chen et al. (2022) conducted a ballast water risk analysis study in Latvia's Riga and Taiwan's Kaohsiung Ports. In this study, ballast water risk analysis was made with factors determined using the characteristic data of incoming ships, and the aim was to determine priorities for port state control inspections. Data such as ship name, IMO number, ship flag, ship type, ballast source port, last port of the ship, next port of destination and gross tonnage were obtained from the ships arriving at Riga and Kaohsiung Ports between 2013 and 2015. The identified risk factors are specific to the ship: ship type, ship flag performance and number of voyages. This study ignored the ships' ballast notations (D-1 or D-2 compliance).

In the ballast water risk analysis conducted by Hasanspahic et al. (2022) in the Ploce Port of Croatia, previous risk analysis studies in the literature were examined based on the G7 Guideline of the International Ballast Water Management Convention, and factors were determined for the analysis of possible risks posed by ballast water. Accordingly, ship age, voyage duration, ship type, voyage frequency, flag of the ship discharging ballast, salinity rate and water temperature of the source and presence of invasive species in the source port were determined. Data on ships arriving at the Port of Ploce between July 2013 and January 2022 were obtained and analysed through the port management information system of the Croatian Maritime Administration. This study ignored the ships' ballast notations (D-1 or D-2 compliance).

International Ballast Water Management Convention

The aim of the Convention, which entered into force 13 years ago, is to minimise the spread of invasive/alien species through ballast water. The Convention has many technical requirements for both the control and management of ballast water and sediment, which requires the application of different methods to achieve this. The Convention includes 5 Sections, 23 Rules, and 14 Guidelines.

For all ships over 500 gross tons embarking on international voyages, possessing a 'Ballast Water Management Certificate ' and a 'Ballast Water Record Book ' is not just a recommendation but a legal requirement (IMO, 2004). In practical terms, ships must treat their ballast water to the standards set by the Convention. These standards, categorised as D-1 (Ballast water replacement) and D-2 (Ballast water treatment), are not mere suggestions but stringent guidelines that must be followed.

In outline, Standard D-1 requires ships to replace existing ballast water in an area at least 200 nautical miles offshore and with a water depth of at least 200 meters. D-2 Standard means reducing the number of organisms in the existing ballast water with various equipment and systems on the ship (IMO, 2004).

Ballast Water Treatment Standard (D-2 Notation)

The D-2 Standard plays a crucial role in safeguarding marine ecosystems by limiting the number of harmful microorganisms that a ship can discharge into the sea in ballast water. It sets the minimum requirements for systems likely to be installed on ships, emphasising the importance of compliance with these restrictions to preserve our oceans.

According to the Convention,

- Less than 10 microorganisms greater than or equal to 50 micrometres per cubic meter,
- Less than 10 microorganisms between 10 micrometres and 50 micrometres per millimetre,
- Less than 1 colony forming unit (Cfu) per 100 millilitres of Toxicogenic Vibrio cholerae,
- Less than 250 cfu per 100 mililitres of Escherichia coli,
- Determined as less than 100 cfu per 100 millilitres of intestinal Enterococci (IMO, 2019).

Systems used in ballast water treatment must be tested by G8 and G9 guidelines and have received a "Type Approval Certificate" from the administrations or authorised classification societies. The requirements for a ballast water treatment system to have a type approval certificate are included in the G8 (Guide for Approval of Ballast Water Management Systems) and G9 (Guide for Approval of Ballast Water Management Systems Using Active Substances) guidelines. To confirm compliance with the D-2 standard, the specified tests must be carried out at the land facility and ship (Prabovo, 2018; Top, 2019). All ships constructed after the date on which the Convention came into force must comply with the D-2 Standard. A transition plan has been determined for existing ships, as many detailed processes are required, such as the physical installation of ballast water treatment systems on ships, as required by the standard. This transition plan has been determined according to the International Oil Pollution Prevention Certificate (IOPPC) renewal inspection dates of existing ships. According to this plan, the mandatory deadline for compliance with the D-2 Standard is 08.09.2024 (Bilgin Güney, 2022; IRClass, 2017).

Ballast Water Treatment Methods

It is determined that three main methods are used among existing type-approved ballast water treatment systems. Ballast water treatment systems are developed by creating mixed systems using these 3 methods: Mechanical, Physical and Chemical. The systems seen on ships have two stages. The first stage is the Mechanical Filter. The second stage is mostly physical or chemical. Seawater passing through a mechanical filter is treated by a preferred physical or chemical method (Bilgin Güney, 2018). Treatment of ballast water means the elimination of aquatic organisms. Ballast treatment methods can be explained in four main ways: mechanical methods, physical methods, chemical methods, and alternative methods. This section will share alternative methods, such as scientific studies and concept designs. Table 1 shows four main ballast treatment methods and their details.

Upon reviewing the current list of type-approved systems announced by IMO and USCG, it becomes evident that most ballast water treatment systems for ships are intricate models, often necessitating the combined use of at least two different systems. A closer look at the USCG's current list of type-approved ballast water treatment systems reveals that 46 out of the 52 systems are ballast water treatment systems used in conjunction with mixed systems (IMO, 2023; USCG, 2023a). This data underscores the preference for ballast water treatment systems that employ multiple methods, further emphasising the complexity.

Let us delve into the mechanical Filter + UV System. Regarding its functioning, the seawater, drawn from the sea chest valve during ballast intake, is meticulously guided through a pump and a mechanical filter of the treatment system. It then passes through the UV chamber, ensuring thorough treatment, before being directed to the ballast tank. Similarly, during ballast discharge, the water from the tank is precisely pumped through the UV chamber and discharged into the sea, maintaining the system's efficiency and control (AlfaLaval, 2023).

Table 1. Ballast water treatment methods

BALLAST WATER TREATMENT METHODS	
Mechanical Methods	Filtration, Hydrocyclone, Electro Mechanical Separation
Physical Methods	Heat, Ultraviolet, Deoxygenation, Ultrasound and Cavitation, Magnetic
Chemical Methods	Disinfecting Biocides, Non-Disinfecting Biocides
Alternative Methods	Port-Based System, Ballastless/Zero Discharge (Continuous Ballastless Concept, Bad (Heavy) Air Ballast Method, Fixed Internal Ballast Methods, Potable Ballast Water Concept), Continuous Flow Concepts (Longitudinal Main Bodies Concept, Buoyancy Control Compartments Concept, Advanced Ballast Water Exchange concepts)

Mechanical Filter + Electrochemical System: During the ballast intake to the ship, the seawater from the sea chest valve passes through the pump filter and reaches the mechanical filter of the treatment system. After the seawater passes through the mechanical filter through the flow meter on the line, the chemical used is added to the seawater via the chemical dosage pump. Afterwards, ballast water, whose chemical content is measured in the ballast water control unit, is taken into the tank. In ballast discharge, after the water taken from the ballast tank passes through the flow meter via the pump, the neutralising agent required according to the type of chemical substance previously introduced into the system for purification is added to the water to ensure that the active substance is at the allowed limit values. After chemical measurements of the water passed through the control unit are made, it is pumped into the sea (AlfaLaval, 2023; Jang & Cha, 2020).

In the Mechanical Filter + Electrolysis system, seawater passed through the pump filter during ballast water intake to the ship is taken into the electrolysis chamber. While microorganisms are eliminated by the electric current given to the water in this chamber, sodium hypochlorite is also formed due to the electrolysis process. Ballast water passed through the electrolysis chamber is taken into the ballast tank, and the purification process continues until it is in the tank. During ballast discharge from the ship, the water waiting with the active substance in the tank is taken with a pump and passed through the control unit. According to the measurement result in the control unit, the neutralising agent is added to the water with the dosage pump to ensure the active substance is within the allowed limit values (Bilgin Güney, 2017).

The Ozone/Inert Gas method offers several advantages. This system introduces ozone or oxygen-free inert gas into the ballast water as it passes through the pump filter. This method also included in the USCG-type approval list, is particularly effective as the presence of solids has a negligible impact on the purification process. The oxygen cylinders are filled via the air compressor and then transferred to the ozone generator chamber. The ozone gas produced in the ozone generator is then added to the ballast water line (Yang & Tong, 2021).

Control and Management Project of Harmful Aquatic Organisms Carried by Ballast Water in Türkiye

Türkiye's national project was launched in 2002 under the responsibility of the Undersecretariat of Maritime Affairs of the Republic of Türkiye under the name "Control and Management Project of Harmful Aquatic Organisms Carried by Ballast Water". In this project, where Tübitak Marmara Research Center is the implementing agency, data such as the amount of ballast water carried by ships arriving at Turkish ports between 2002 and 2006 and ballast water resources were collected. In the light of this data collected in the developed ballast water risk analysis software, the adverse effects of invasive species on Turkish coasts were evaluated. In addition, a geographical information system has been created on the Turkish coasts within the scope of the current legislation, and sensitive coastal areas have been determined. In the project's first phase, there are Ballast Water Reporting Forms from all ships calling at Turkish ports in the 5-year data pool. A web-based Ballast Water Risk Assessment System has been created by TÜBİTAK to be used in the risk assessments envisaged to be carried out within the scope of the GloBallast Project. In this system, environmental risk analysis methods have been applied to the requirements of the Convention, taking into account the G7 Guideline of the Convention (Olgun, 2011).

In the project's second stage, a case analysis study was conducted as a pilot application in the Botaş Port between 2011 and 2012. This study, a significant part of the project, explained port state control inspections of 206 ships and analysed their ballast water management plans. The alarming findings were that alarming-37 of the ships were evaluated as high risk, and ballast water samples were taken from these ships and analysed (GEF-UNDP-IMO, 2017). Two different risk assessment methodologies were applied for Turkish ports in the project. When examined with the applied Globallast Risk Assessment Method and the Advanced HELCOM Method, the results revealed that an average of 23 million tons of ballast water was discharged to the Turkish coasts annually. The report further stated that 66 species were transported to Turkish coasts, and 19 were described as harmful organisms. Of these, three in particular (Mnemiopsis leidyii, Rapana Venosa, Beroe ovata) were found to cause a decrease in fish stocks and economic losses in the Black Sea (Republic of Türkiye Prime Ministry Undersecretariat of Maritime Affairs, 2010).

Risk analysis and evaluation of ballast water was carried out at Botaş Ceyhan Terminal using the ballast water risk assessment method and software developed within the scope of the GloBallast Project, in which Türkiye is also a stakeholder. When the results of the study, whose data were collected between June 2006 and June 2010, are examined, it is seen that 45,551,876 tons of ballast water were discharged in a total of 1126 ship operations, and the Mediterranean Sea comes first in terms of source, with 69%. When source ports were examined in detail, it was stated that 17 of all 133 source ports were Mediterranean ports and included in the highest risk group (Olgun, 2011, Republic of Türkiye Prime Ministry Undersecretariat of Maritime Affairs, 2010).

2010, an economic evaluation was conducted for Türkiye's ballast water management. The report used market price and travel cost analysis methods for quantitative estimates. It revealed that the total value of sectors such as fishing, aquaculture, and coastal tourism was 1 billion dollars, 323 million dollars, and 18 billion dollars, respectively (at the exchange rate dated 30.06.2010). The report also highlighted a significant finding: In the worst-case scenario, the total potential cost of invasive, harmful species to these sectors could reach 8.16 billion dollars. This underscores the critical need for effective ballast water management. The ballast water management convention's national implementation cost was 822 million dollars (Interwies & Knuchua, 2017). The 2010 report also analysed the source ports of ballast water discharged in Turkish ports and their regions, with the results presented in Table 2 below.

Table 2. Analysis of ballast water discharged on Türkiye Coasts (GEF-UNDP-IMO, 2017)

Source Region	Ballast Water (ton)	Percent
Mediterranean Sea	12.794.422	54%
Black Sea	6.271.615	27%
Northeast Atlantic	1.332.463	6%
Northwest Atlantic	755.201	3%
Indian Ocean	582.168	3%
South Atlantic Ocean	493.292	2%
Northwest Pacific Ocean	465.468	2%
Eastern Pacific Ocean	261.882	1%
Red Sea	250.398	1%
Persian Gulf	223.239	1%
Other	160.771	0%
Total	**23.590.920**	**%100**

Deficiencies Detected in Ballast Water Under Port State Control

The Ballast Water Management Convention Guidelines, a pivotal document published by the Marine Environment Protection Committee on 17 October 2014, play a crucial role in determining the scope and implementation method of inspections. The guide's second part outlines a comprehensive four-stage inspection format for ballast water management systems and components on ships (IMO, 2014). During port state control inspections, it is important to note that there could be 16 deficiencies across 3 distinct areas related to ballast operations (Med MoU, 2022).

Port State Control Inspection Procedures (Resoultion A.1155 (32)) by IMO aims to ensure uniformity in practice worldwide. The International Ballast Water Management Convention and inspection methods of its applications onboard ships are methodised. Annual reports of various MoU are analysed in this section. US Coast Guard 2022 Annual PSC Report stated that a concentrated inspection campaign was implemented on ballast water-related issues in 2022 and that the deficiencies detected in ships within the scope of ballast increased by 25% compared to 2021. When we look at the statistical analysis of ballast water deficiencies detected on ships during the year, "Ballast Water Management Systems" comes first with 118 deficiencies. In second place, there is "Reporting of Defective Systems" with 44 deficiencies, and in third place is "National Ballast Information Office Reporting" with 30 deficiencies (USCG, 2023b). When the Paris MoU 2022 Annual Report is examined, it is seen that the number of "Ballast Water Management" deficiencies detected on ships is recorded as 528 in 2020, 706 in 2021 and 892 in 2022. "Ballast Water Management" deficiencies, which are observed to increase in number every year, are examined under the title "Main Deficiency Categories" in the report (Paris MoU, 2023b).

Materials and Methods

This study was applied to ships arriving at Aliağa Port in 2023 under port or flag state control. This study aims to investigate current practices and determine Convention compliance progress on ships within the scope of the International

Ballast Water Management Convention requirements, to which Türkiye is also a party, without distinguishing between ships whose transition phase is ongoing or completed within the scope of the Convention. Quantitative research techniques were used. Primary and secondary data were collected to ensure that the study progressed by its purpose. The data contained in the Ballast Water Reporting Forms and International Ballast Management Certificate were obtained on ships during PSC inspections and as pre-arrival information declarations from the ships. These were considered primary data, and the port state control data regarding the ships obtained from the open-source EQUASIS website were considered secondary data. The data was analysed using descriptive statistics and Microsoft Office Excel program graphs.

Table 3 shows details of the data set used in this research. Primary data contains five topics deriving from ballast water reporting forms and international ballast water management certificates. Secondary data contains seven topics regarding ship characteristics.

Table 3. Primary and Secondary Data Used in the Study.

Data Type	Data Name
Primary Data (Data obtained from Ballast Water Reporting Form and International Ballast Water Management Certificate.)	• Type of ballast operation (receiving or discharging) carried out by the ship in the port • Amount of ballast discharged by the ship • Ship's ballast notation (compliance with D-1 or D-2 Standard) • Type of ballast water treatment system on board • Source port of the ballast discharged by the ship
Secondary Data (Open-source data from EQUASIS website.)	• Ship type • Ship's flag • Gross tonnage of the ship • Age of the ship • Deficiency in ballast detected on the ship as of the date of entry into force of the contract • High, medium or low status in the Paris MoU performance list of the organisation Authorised on behalf of the flag for certification of the ship (Paris MoU, 2022a).

Results and Discussion

Data was collected from 50 ships called Aliağa Port (Nemrut Bay) between March and June 2023, which were subject to port state control or flag state control inspection within the scope of the Convention. These data were transferred to the Microsoft Excel program, and frequency and percentage information were calculated using descriptive statistics.

Analysis was made according to the ships' ballast operations in the port, and ships discharging ballast were examined according to their ballast notations. At the same time, the amounts of discharged ballast water were analysed according to their treatment status. It is understood that 76% of the ballast discharged at Aliağa Port is treated and discharged into the sea. It is seen that 74% of these are passed through the Mechanical Filter and UV Purification System.

Figure 1 shows ballast notations of all ships' in a data set of this research.

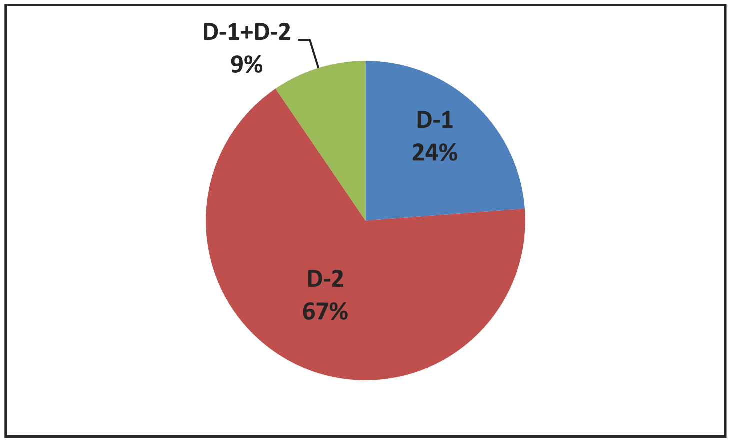

Figure 1. Ships' Ballast Notations Analysis

The amounts of ballast water discharged in the port were examined according to ship types. Crude Oil/Product Tankers were in first place.

Figure 2 explains the types of ships which constitute this research's data set.

In Figure 3, the ballast notations of the ships arriving at Aliağa Port were examined according to whether they were D-1, D-1+D-2, or D-2. According to the notation, the systems on ships with ballast treatment systems were analysed in terms of type, and mechanical filters and UV treatment systems were used first.

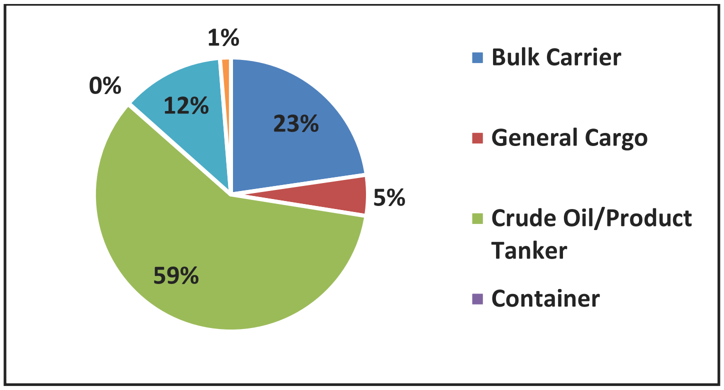

Figure 2. Ship Type Analysis of Ballast Discharged Ships

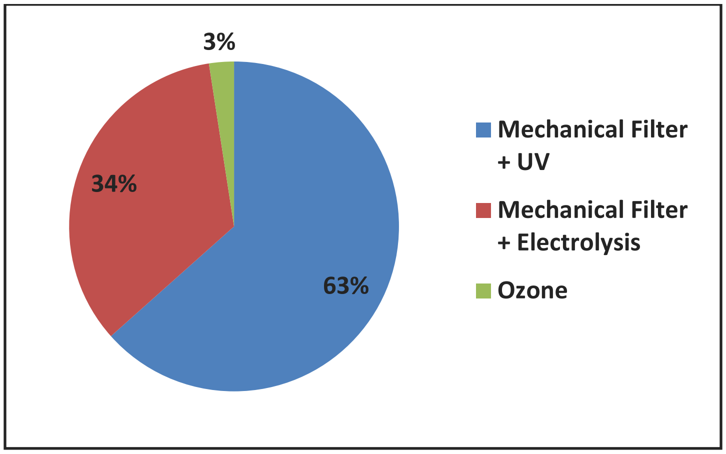

Figure 3. Treatment Equipment Analysis

The amount of discharged ballast water was first examined according to the regions where the source ports are located in Figure 4. Subsequently, a local analysis was made of the Mediterranean, which had the highest ballast water discharge amount, 66%. According to this analysis, the Adriatic Sea has the highest rate as a resource in the Mediterranean, 44%.

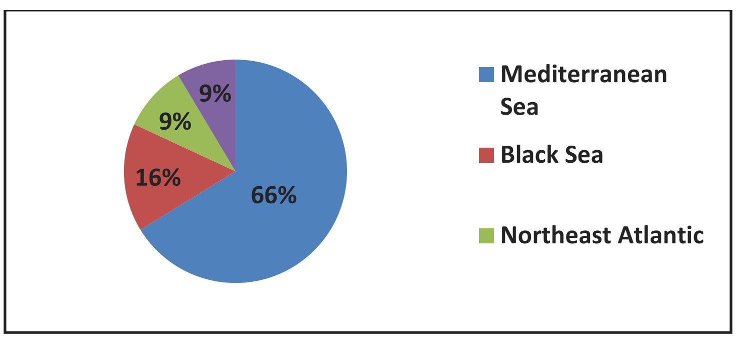

Figure 4. Discharged Ballast Origins

Figure 5 shows Mediterranean ballast water origins discharged at Nemrut Bay. Adriatic Sea (44%) is the major donor for Nemrut Bay regarding ballast waters. Alboran Sea (20%) and Ionian Sea (14%) are other important donor ports.

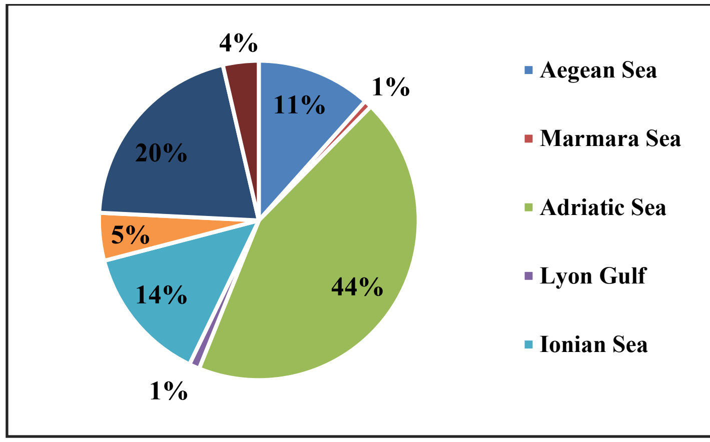

Figure 5. Discharged Ballast Origins in the Mediterranean Sea

Bulk carriers are the most frequent ship type with 36%, and general cargo ships are the second most frequent with 22% of this study. It has been observed that Mechanical Filter + UV Treatment Systems are the most preferred ballast water treatment systems in bulk cargo ships and general cargo ships according to ship types in the research data set. Figure 6 shows the treatment equipment types of bulk carriers and general cargo ships.

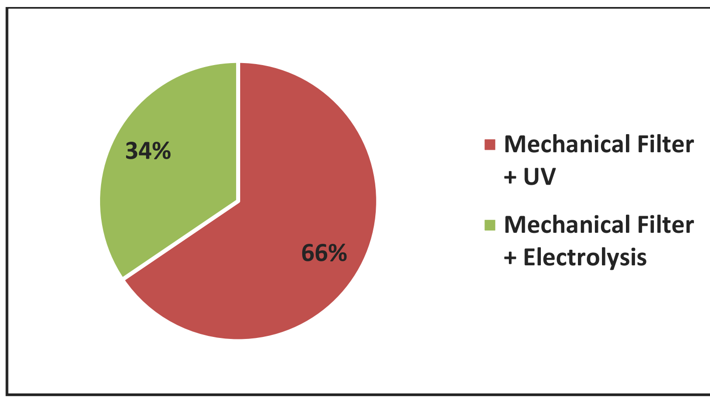

Figure 6. Treatment Equipment of Solid Bulk Carriers

Crude oil/product tankers are the third most frequent ship type, accounting for 20% of this study. Figure 7 shows the ballast treatment equipment of these tankers in this research data set. The mechanical filter + Electrolysis method is the most preferred treatment system (50%) for these tankers.

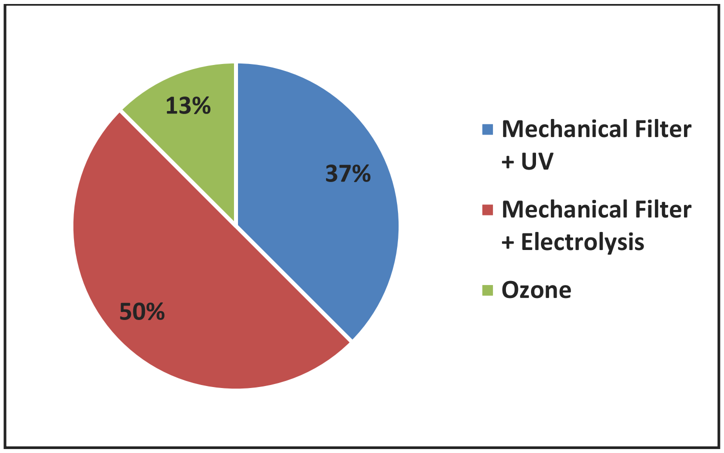

Figure 7. Ballast Treatment Equipment of Crude Oil/Product Tankers

In this context, ballast-related deficiencies detected during port state control inspections carried out on ships as of the date of entry into force of the Convention were also analysed and detailed in Figure 8. It was observed that no PSC deficiency regarding ballast was detected in 74% of the ships in the data set. An analysis of the average age of ships with ballast-related PSC deficiencies compared to ships without any deficiencies was also conducted. Accordingly, it was revealed that the average age (18,07) of the ships whose ballast deficiencies were detected during the PSC inspection was higher than the others (10,62) without deficiencies.

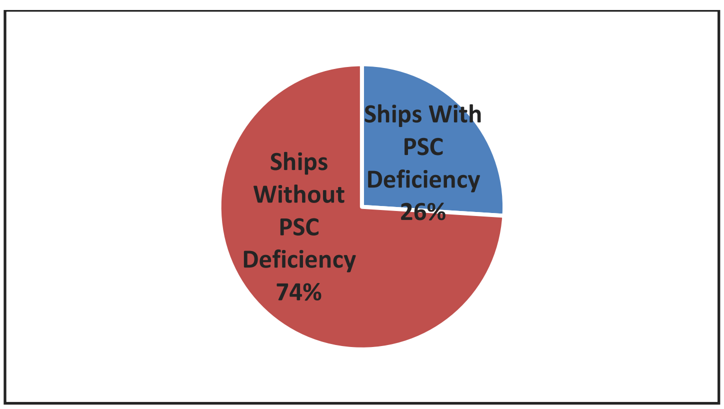

Figure 8. Ballast-Related PSC Deficiency Analysis

Figure 9 shows ship types and ballast-related PSC deficiency correlations. Based on this research data set, ships with ballast-related PSC deficiencies are analysed according to their ship types. General cargo (31%) and bulk carrier (31%) ships are the most frequent ship types with ballast-related PSC deficiencies.

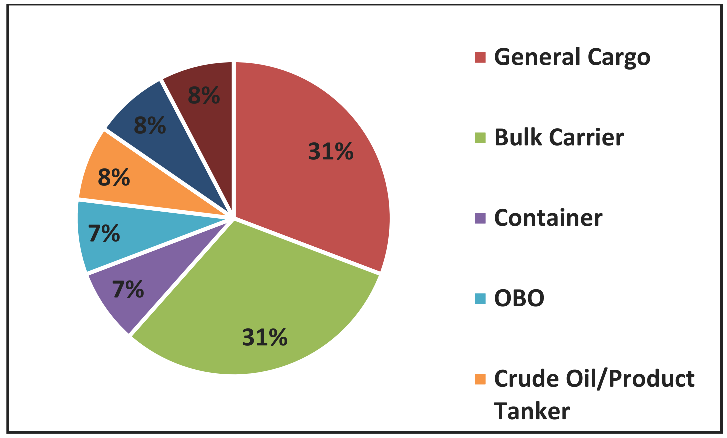

Figure 9. Ship Type Analysis with Ballast-Related PSC Deficiency

In her study, Kara (2022) revealed that the port state inspection results of the flags on the Paris MoU White List are compatible with each other regarding their performance. In this research, the fact that the ships on the Paris MoU White List (92%) are more than the others in terms of flags in which ballast deficiencies were not detected during port state inspections supports this. Figure 10 shows the flag performance of ships without ballast-related PSC deficiency.

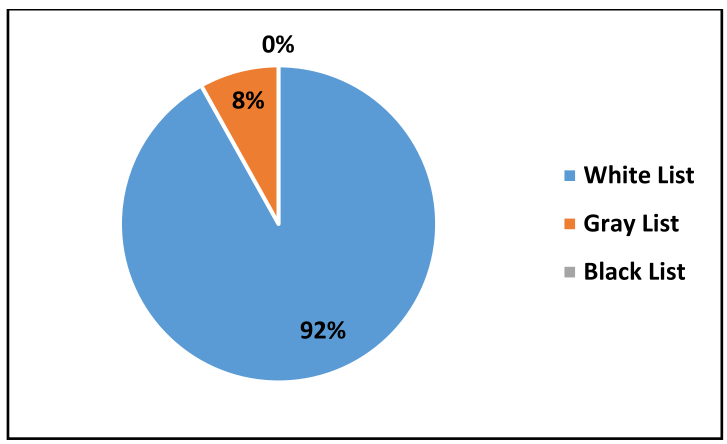

Figure 10. Flag Performance Analysis of Ships Without Ballast-Related PSC Deficiency

Chuah et al. (2023) revealed in their study that classification society performance is an essential factor in the ship's port state control inspections. Few deficiencies were detected in port state inspections of ships authorised by high-performance classification societies. This research supports this, as ships with no deficiencies in ballast during port state inspections are found to be high performers in the Paris MoU Performance List regarding classification societies (95%). Details are shown in Figure 11.

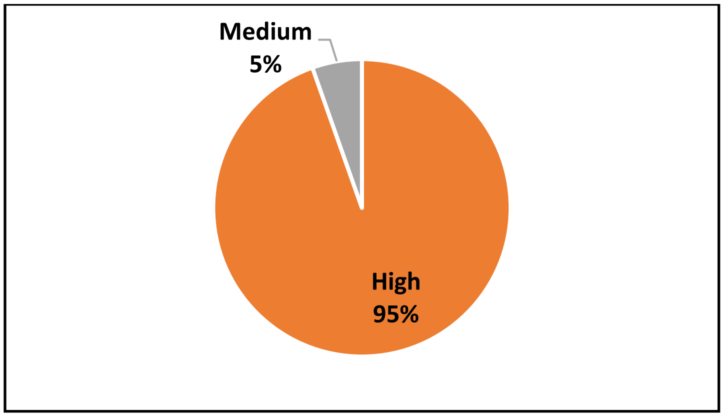

Figure 11. Recognised Organization Performance Analysis of Ships Without Ballast Related PSC Deficiency

In their study, Fu et al. (2020) revealed that the deficiencies detected in port state inspections increase as ships' service periods increase. The average age of the ships in this research's data set, where ballast deficiencies were detected during port state inspections (18.07), is higher than the average age for no deficiencies (10.62). This confirms that the risk of detecting deficiencies increases in older ships.

Limitations of the Research

- The research was geographically conducted only in Aliağa Port (Nemrut Bay).
- In the research, data could only be collected in 3 months between March and June 2023.
- In the research, data could only be collected from ships subject to port and flag state control instead of all ships calling Aliağa Port.

Suggestions for Future Studies

- Considering that there is no need to inspect every ship for the data to be collected specifically, the scope of the research can be expanded, and the implementation period can be extended with the information in the ships' ballast water reporting forms and international ballast water management certificates through the Port Management Information System,
- Continuity in practice can be ensured by integrating the ballast risk analysis format previously developed within the scope of Türkiye's national project with the updates that can be made to the Port Management Information System,
- If there is an updated port-specific ballast water risk analysis, ships with higher risk factors can also be included in the port state control targeting system. For all that, ballast water samples can be taken from high-risk ships, and detailed laboratory analysis can be carried out,
- Invasive alien species in ballast water source ports can be compared with invasive alien species detected in the local port where the research is carried out,
- Ballast operation analyses to be carried out on a port basis can be carried out by taking into account international and regional agreements,
- Ballast-related PSC deficiencies of the ships calling Aliağa Port can be analysed entirely, and a concentrated inspection campaign can be implemented in flag state inspections,
- Comparative analysis of countries' national ballast risk analysis can be made,
- Analyzing ballast water operations in all ports with heavy ship traffic in Türkiye can ensure the protection of the marine environment.

Conclusion

It has been observed that three different systems (Mechanical et al. System, Mechanical Filter and Electrolysis Treatment System and Ozone Treatment System) are preferred in terms of ballast water treatment systems on ships. It has been revealed that almost all (97%) of the treatment systems used are systems that include more than one method. Mechanical Filter and UV Treatment Systems (63%) were preferred. When we look at the current type approval lists of USCG and IMO, it is significant that most systems include more than one method. Among all systems, the majority use Mechanical Filters and UV Treatment methods.

Considering the source ports of the ballast water discharged by ships, Mediterranean Ports come first, Black Sea Ports come second, and Northeast Atlantic ports come third. When compared with the data of the Ballast Water Assessment Report for Türkiye prepared by the Prime Ministry Undersecretariat of Maritime Affairs of the Republic of Türkiye in 2010, it is seen that the results are compatible with each other, and the ranking is the same. When we look at the details on a regional basis within the Mediterranean, it turns out that the highest amount of ballast originates from the Adriatic Sea (44%). This situation reveals the need to examine ports' ballast water risk analysis, especially in the Adriatic Sea, to conduct water and ballast water risk analyses in Aliağa Port.

When the flags of the ships subject to this research were examined in terms of performance, it was understood that those in the Paris MoU White List were more than those in the Gray and Black Lists (75%). This situation provides suitable conditions for ships to meet the requirements regarding compliance with the Convention. Again, in this study, the high compliance with the D-2 Standard (82%) confirms the existence of high-performance flags.

When the performance of the ships' classification societies is examined, the majority (94%) are high-performance. This demonstrates that ships certified by high-performance classification societies are important for complying with the Convention requirements.

The International Ballast Water Management Convention is one of the international maritime agreements that took the longest time to adopt and come into force. After the Convention had entered into force, too many decisions were made by the Marine Environmental Protection Committee, and the guidelines were published and updated continuously. A severe amount of rules and regulations confirmed the literature, which can be described as the convention itself, its annexes and manuals. Although ballast water is a fundamental operational issue for ships, it also serves as a vector for transporting many living creatures that negatively affect the marine environment. Over the years, scientific studies have observed and revealed the negative effects of creatures carried by this vector on the regions where ballast water is discharged.

The most important project carried out by IMO regarding ballast is the GloBallast Program. This project lasted until the date of acceptance of the Convention on 8 September 2017, and it aimed to provide global readiness until then. Priority was given to field studies in different regions of the world, and expert groups formed with national support carried out risk analyses of ports. Türkiye also became one of the major stakeholders in this important project, and a national risk analysis was conducted.

Port state control is an essential tool in the maritime field where international conventions and national regulations are inspected on ships. All decisions taken and guidelines published by the governing body regarding international Conventions, including the transition periods between the adoption and entry into force of each international convention, must be considered at each inspection. It is one of the most effective ways to track the current implementation of any international convention on ships in maritime.

This study investigated the current practices of the International Ballast Water Management Convention on ships arriving at Aliağa Port. A data set was created based on international literature and the Convention's requirements.

When the research results are evaluated, it is revealed that the vast majority of ships are at a reasonable level of compliance with the Convention. However, it should always be taken into consideration that the maritime sector is one of the most dynamic fields of expertise by its nature. It is thought that it would be beneficial to carry out port state control inspections in the form of a concentrated inspection campaign and to examine only the Convention requirements within a specified period. In addition, it is thought that the concentrated inspection campaign, which will be implemented in flag state inspections carried out on Turkish Flagships, will ensure that the port state inspection performances of the ships in question remain high and, thus, the Turkish Flag`s White List performance remains.

As stated in the Ballast Water Assessment Report for Türkiye (2010), Aliağa Port (also known as Nemrut Bay) is the second port with the most ballast discharge. According to TÜRKLİM's 2022 data, Aliağa Port is the second largest port in Türkiye in terms of cargo handling (TÜRKLİM, 2024). This situation reveals the intensity of ship traffic and, therefore, ballast operations in Aliağa Port. It is thought that it would be beneficial to develop the specific risk analysis format for Aliağa Port within the scope of previous research in the Control and Management of Harmful Aquatic Organisms Carried by Ballast Water Project in Türkiye.

Compliance with Ethical Standards

Conflict of interest: The author(s) declare no actual, potential, or perceived conflict of interest for this article.

Ethics committee approval: This study does not require ethics committee permission or any special permission.

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