The Analysis of the Deficiencies Resulting from Paris MoU PSC Inspections

Analiza nedostataka prema pariškom memorandumu o nadzoru država Luka

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Abstract

Substandard ships pose a significant threat to human life and the environment. Therefore, detecting deficiencies and removing such vessels from service is necessary, which is one of the port state control (PSC) inspection tasks. In addition, the role of PSC inspection is to improve safety at sea and in ports. To be up to the task, the States jointly created several memoranda to fight against substandard ships. The most frequent deficiencies detected on ships during Paris Memorandum of Understanding (MoU) PSC inspections are analyzed in this paper. The analysis was made according to factors such as type of vessel, flag and the category to which deficiency belongs. Results revealed that most frequent deficiencies detected on ships, regardless of type or flag, come from International Safety Management (ISM) and fire protection. Furthermore, it is found that among the ten most frequent deficiencies, three are from the navigation safety category. Therefore, corrective actions to improve safety at sea are needed and presented.

KEY WORDS

Port State Control
maritime safety
substandard ship
deficiency
ISM

Sažetak

Brodovi koji ne zadovoljavaju standarde predstavljaju ozbiljnu prijetnju ljudskim životima i okolišu. Stoga je nužno otkrivanje nedostataka i povlačenje takvih plovila iz prometa, što je jedan od zadataka nadzora države luke (PSC). Osim toga, uloga je PSC inspekcije poboljšati sigurnost na moru i u lukama. Države su zajednički izradile nekoliko memoranduma za borbu protiv brodova koji ne zadovoljavaju standarde. U ovom se radu analiziraju najčešći nedostaci otkriveni na brodovima tijekom PSC inspekcija u skladu s Pariškim memorandumom (MoU). Analiza je napravljena prema faktorima kao što su tip plovila, zastava i kategorija kojoj nedostatak pripada. Rezultati su pokazali da su otkriveni nedostaci na brodovima, bez obzira na tip ili zastavu, najčešće vezani uz Međunarodni kodeks upravljanja sigurnošću (ISM) i zaštitu od požara. Također je utvrđeno da su među deset najčešćih nedostataka tri iz kategorije sigurnosti plovidbe. Stoga su potrebne i prezentirane korektivne mjere za poboljšanje sigurnosti na moru.

KLJUČNE RIJEČI

nadzor države luke
pomorska sigurnost
brodovi ispod standarda
nedostatak
ISM

1. INTRODUCTION / *Uvod*

The biggest concern of all maritime transport stakeholders is the safety of ships, their crews and the cargo they transport. Insufficient safety can lead to maritime accidents, which in turn can cause loss of human life, great material damage and pollution of the marine environment. In order to reduce the number of maritime accidents as much as possible and increase safety at sea, the International Maritime Organization (IMO) adopted a number of conventions, regulations and recommendations to increase maritime safety. However, the trigger to adopt new conventions and regulations were mainly catastrophic maritime accidents, like the sinking of RMS Titanic (1912), the huge oil pollution of MT Amoco Cadiz (1978), the fatal collision of ferry Dona Paz and MT Vector (1987) and sinking of the ferry Estonia (1994). Those were the turning points in making important decisions regarding increased safety at sea and, thus, maritime transport itself. Many international conventions were adopted to minimize the loss of human life at sea and ensure the safest possible transport of goods by sea. The most important conventions are (1) The International Convention for the Safety of Life at Sea - SOLAS, (2) the International Convention for the Prevention of Pollution from Ships - MARPOL, (3) the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers - STCW and (4) Maritime Labor

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Convention - MLC. These four conventions represent the four pillars of safety that the maritime industry relies on. In addition to these four main conventions, other essential conventions can be singled out, like:

- International Convention on Load Lines from 1966, amended by 1988 Protocol on load lines art. 21 [1],
- International Convention on Tonnage Measurement of Ships from 1969, art. 12 [2],
- International Convention for the Control and Management of Ships' Ballast Water and Sediments from 2004, art. 9 [3],
- International Convention on the Control of Harmful Anti-fouling Systems on Ships from 2001, art.11 [4].

In some literature, for example, in a study by Özçayir [5], the term *safety net* can be found which consists of six main elements: (1) International Maritime Organization – IMO, (2) International Labour Organization – ILO, (3) Flag State Control – FSC, (4) Classification society, (5) Marine insurance industry and (6) Port State Control – PSC. All of these maritime stakeholders' primary interest is maritime safety, and as such, they deal with setting standards for ships and ensuring that standards set are being complied with. Therefore, it aims to prevent the sailing of vessels that do not meet the set standards (substandard ships). Accordingly, in ideal conditions, the last link in the safety net, i.e. PSC, would not be necessary and was initially intended to support the application of the ship's flag state regulations [6], which bear the primary responsibility for verifying the ship's standards [5]. However, although inspections of ships are becoming more stringent and many substandard ships are detained and cannot continue with their operations, the number of maritime accidents is still significant [7]. This reflects the importance of the last link of the safety net, that is, the PSC inspections.

Since maritime accidents continue to occur despite the set standards and various inspections, it is necessary to investigate their causes and find measures to reduce or eliminate them. One of the possible ways to find the causes of maritime accidents and identify the weak links in maritime safety is the analysis of the deficiencies found by the PSC inspections.

Therefore, this paper aims to investigate the most common deficiencies detected during the PSC inspections in the Paris MoU ports for the period of the last three years (2019-2021). The Paris MoU was chosen because it covers a relatively large area, has the most member states compared to other regional MoUs, and has an average of over fifteen thousand individual ship inspections annually [8]. Furthermore, the paper analyzes and presents the ten most frequent deficiencies according to the type of ship and flag. Based on the results, proposals are presented in order to improve the overall crew performance and ship maintenance, which could reduce the number of ship deficiencies and improve the overall safety of ships. Section 2 of this paper deals with the literature review, while Section 3 deals with PSC inspection results. Section 4 is the methodology, where the research workflow is depicted, and the results are presented in Section 5. Discussion and conclusions are given in Section 6.

2. LITERATURE REVIEW / *Pregled literature*

The fact is that inspections have an increasingly important role in maritime safety, so it is not surprising that there are more and more scientific works dealing with various analyses of these inspections. Payoyo [9] evaluated the performance of the PSC by analyzing and statistically processing inspection data he recorded for the Paris MoU from 1982 to 1992. He concluded that although substandard ships are still a threat to maritime safety, inspections have several significant achievements, such as collecting data on substandard ships in the region, increased efficiency in enforcing international standards, and much better regional cooperation [9]. His conclusion coincides with the research conducted by Mejia [10] as one of the first contributions to the evaluation of PSC. Hare [11] showed that the spread of regional memorandum significantly reduced the potential for substandard ships in international navigation. Cariou, Mejia, and Wolff [12] investigated vessel characteristics influencing the period length between two inspections and found that the ship's age, type and flag of the registry are significant factors. In addition, the authors investigated the number of deficiencies found during the next PSC inspection and detected that their number was reduced by 63%.

Furthermore, Cariou, Mejia, and Wolff [13] examined the main contributing factors to ship detentions following PSC inspections. They found that the ship's age at the time of inspection (40%), recognized organization (RO) (31%) and place of the inspection (17%) are the most significant ones. Also, the authors showed that differences between detention rates by different authorities are not due to differences in inspection methods but to different characteristics of ships calling specific ports. Similar results were presented by Şanlıer [14], where the ship's age was the main factor causing the increase in detentions and the number of deficiencies. Other factors like ship type, the flag of registry, RO, and inspecting authority have additionally increased the possibility of detention and a larger number of deficiencies detected during inspections. Xiao et al. [15] corroborated the finding that the ship's age, along with ship type and Flag state performance, are important factors when considering the number of detentions and detected deficiencies. In addition, the authors found that ships older than six years are more likely to be substandard than newer ships. A study by Graziano et al. [16] showed that the probability of discovering deficiencies and detaining ships is higher if the number of inspectors boarding a specific ship is larger than one. In addition, the study confirmed that specific backgrounds of PSC inspectors increase the probability of finding specific types of deficiencies onboard ships (for example, inspectors who sailed as deck officers will more likely find deck or navigating bridge deficiencies compared to inspectors with other backgrounds).

Based on statistical analyses, Knapp and Frances [17] used econometric analyses to identify differences between multiple PSC regimes. Their proposal for adjusting the frequency of ship inspections according to the risk profile was adopted by the Paris MoU. It resulted in a change of approach in selecting ships for inspection and establishing the NIR in 2011 [17]. Xiao et al. [18] studied and compared the inspection efficiency of the PSC inspection regimes and confirmed that NIR is more stable than other inspection regimes. The review of the contemporary selection methods of ships eligible for PSC inspections used in various ports was discussed by Yan, Wang and Peng [19]. Based on study findings, the authors developed and validated a combined predicting model for ship risk estimation considering deficiencies and detentions. Another model for detecting

substandard ships was presented by Wang, Yan and Qu [20]. The authors developed Tree Augmented Naive Bayes (TAN) classifier to identify high-risk ships calling ports. According to the results, their developed classifier can discover 130% more deficiencies on average compared to the Ship Risk Profile selection scheme implemented in practice. In that way, their classifier could help allocate PSC resources better and more effectively detect substandard ships. Knapp and Franses [21] measured the effect of inspections on reducing accidents a year later. For this purpose, they used data from PSC inspections, data on victims, and data from industrial inspections. They performed binary logistic regression to determine the correlation between ship age, type, and flag variables. Their research showed that the type of ship, age, and tonnage significantly affect the severity of maritime accidents [21]. The benefit of ship inspection from an economic point of view was studied by Knapp, Bijwaard and Heij [22]. The authors found that the ship inspections are reducing the risk of maritime accidents, and the economic benefit of PSC inspections is estimated to range from 70.000 to 190.000 US dollars.

Over the years, research into PSCs' effectiveness and general operation has developed into a trendy academic research field. Various approaches were applied, either qualitative or quantitative, to a wide range of topics, which shows that PSC inspections are attracting more and more attention.

3. PORT STATE CONTROL INSPECTIONS / *Nadzor države luke*

PSC is an inspection of foreign ships in national ports to check whether the ship's condition and equipment follow international regulations' requirements and whether the ship is manned under these rules [6]. The primary goal of PSC inspections is to target and eliminate substandard ships from sailing. To answer that task, IMO adopted Resolution A.682(17) on regional ship control cooperation to promote regional agreements [23]. Harmonization of ship inspections by PSC control within a given region was to be achieved. This way, inspections in a specific region would focus on substandard ships where significant deficiencies were found and simultaneously avoid double inspections of ships where no deficiencies with conventions and rules were found. In such circumstances, the first Memorandum of Understanding on European port control was adopted and signed by the maritime authorities of 14 European countries in 1982, also called the Paris Memorandum (Paris MoU), which entered into force on July 1, 1982 [24]. Several other regional MoUs were established ten years after the Paris MoU's establishment. The IMO has encouraged the establishment of other memoranda to achieve compliance and enforcement of inspections by PSCs globally. For this reason, it adopted the first resolution, A.787(19), on PSC inspection procedures, which was adopted in November 1995 [25]. The currently valid resolution is A.1155(32), adopted on December 15, 2021 [26]. This resolution is intended to provide basic guidelines for the PSC inspection. Today, nine regional agreements on port inspection worldwide exist (Table 1) [6].

It is important to note that the US Coast Guard established and maintains the tenth PSC regime and that some countries are members of multiple MoUs, such as Australia, Canada, or Russia. The areas mentioned above cover almost the entire world. However, some countries are not members of any memorandum. Such countries implement their own PSC regimes, such as Taiwan, which since 2003 has been conducting its PSC inspections under international standards established by competent international organizations or a regional memorandum (Tokyo MoU) [27].

Initially, the member states that signed the memorandum undertook that the total number of inspections in a calendar year should be at least 25% of the average annual number of foreign ship arrivals, calculated based on the last three calendar years. From this point of view, the ship's quality or condition was not considered. As a result, a large number of unnecessary inspections were undertaken. On January 1, 2011, a New Inspection Regime (NIR) was introduced within the Paris Memorandum to improve the entire system of inspection supervision and selection of ships [28]. Introducing this way of selecting ships for inspection ensures that ships found to comply with prescribed standards are less burdened by inspections than ships where certain deficiencies were found. According to NIR, there are two types of inspections; periodical and additional [29]. However, considering the type of inspection itself, it can be initial, more detailed or expanded (applicable to Paris MoU only) [30]. In addition to these three types, there are Concentrated Inspection Campaigns (CIC), which focus on specific areas where inspectors have encountered high levels of deficiencies or are conducted in periods after a new convention requirement has entered into force. These inspections occur annually for three months (September - November) and are combined with regular inspections.

A periodical inspection of ships by any PSC inspector (Figure 1) usually includes verifying ship certificates and documents and checking the ship's condition, the ship's equipment, and the crew's competence.

Table 1 Nine regional agreements on port inspection supervision
Tablica 1. Devet regionalnih sporazuma o inspekcijskom nadzoru u lukama

Name	Year of establishment	Area of activity
Paris MoU	1982.	Europe and the North Atlantic Ocean
Acuerdo de Vina del Mar	1992.	South and Middle America
Tokyo MoU	1993.	Asia and the Pacific
Caribbean MoU	1996.	Caribbean
Mediterranean MoU	1997.	Mediterranean
Indian Ocean MoU	1998.	Indian Ocean
Abuja MoU	1999.	West and Central Africa
Black sea MoU	2000.	Black sea
Riyadh MoU	2004.	Persian Gulf

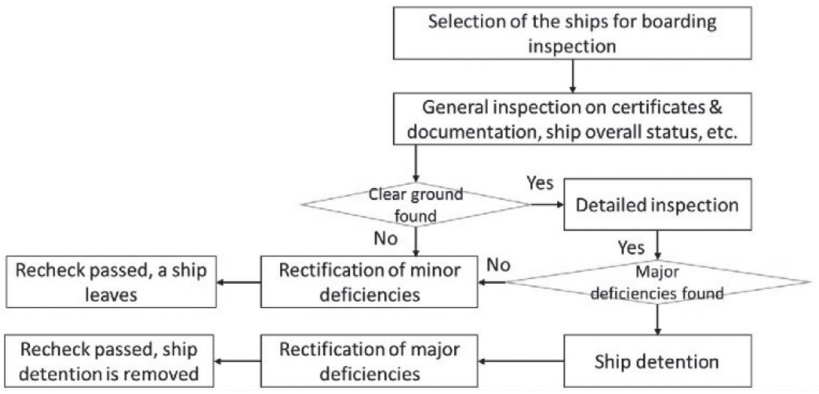

Figure 1 Port state control workflow
Slika 1. Tijek nadzora države luke

Source: [31]

It has to be noted that the list of Paris MoU deficiency codes consists of 497 defective items (deficiencies) that PSC inspectors can record during the inspection. In this paper, only the top ten deficiencies are analyzed according to ship type and flag.

4. METHODOLOGY / *Metodologija*

The data used in this paper can be found on the official website of the Paris MoU or in their officially published publications and are publicly available [32]. The data were statistically analyzed (descriptive statistical analysis based on the Paris MoU data on inspections over the period 2019-2021). The methodology workflow is presented in Figure 2.

The XLSTAT software tool was combined with the Excel software tool. The paper includes an analysis of the ten most frequent deficiencies found during inspections in the areas under the supervision of the Paris MoU. The most frequently found deficiencies were analyzed according to three primary parameters: the ship's type, flag, and the international convention or rule, that is, the sub-area to which a particular deficiency belongs.

5. RESULTS / *Rezultati*

According to the analyzed data, the Paris MoU region has an average of over 15,000 annual inspections. However, the yearly number of deficiencies detected (Table 2) shows that their number constantly decreases [8].

It is evident that despite the approximate number of total inspections, the irregularities found continuously decrease in this region. As can be seen from Table 2, the percentage of ship detentions due to deficiencies also tends to fall, which is undoubtedly a very positive trend. In the same way, but not in such a proportion, the deficiencies found concerning the total number of inspections tend to decrease. The decrease is also recorded in ships that have a ban on entry. For 2019, it amounted to 25 ships; for 2021, only 11 vessels received a ban on entry. However, the decrease may be due to the lower number of inspections due to the global coronavirus pandemic.

However, despite the good general impression of the overall indicators, and the downward trend regarding the deficiencies found on the ships [8], there is still much room for improvement. According to the results of the data analysis on the ten most significant deficiencies on vessels found in the region under the supervision of the Paris MOU (Figure 3), it is evident that implementation and utilization of International Safety Management (ISM) on ships is the most common cause of the found deficiencies. In addition, deficiencies related to fire doors on vessels are typical. It is important to emphasize that even three of the ten most common deficiencies on ships come from

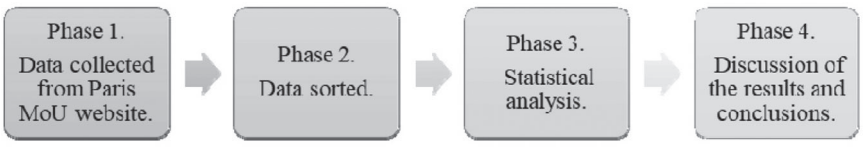

Figure 2 Methodology workflow
Slika 2. Metodologija

Table 2 Review of inspections and deficiencies detected and reported by Paris MoU.
Tablica 2. Pregled inspekcija i nedostataka prema Pariškom memorandumu

Year	2019	2020	2021
Number of inspections	17,916	13,168	15,387
Number of individual ships inspected	15,447	12,092	13,797
Number of deficiencies	39,821	28,372	36,113
Number of detainable deficiencies	3,015	2,182	3,274
Detentions in % of the total number of inspections	2.98	2.92	3.43
Number of refusals of access to ports	25	8	11

Source: Authors according to [8].

the safety of navigation sub-area. Furthermore, it is alarming that in all ten flags and nine out of ten types of vessels with the most found deficiencies, the first two places are occupied by deficiencies in the safety management and fire protection category.

In addition, it is important to emphasize the category of certificates and documents (ship's or crew members' certificates and documents), which is substantially represented in the total number of deficiencies detected. According to the data analysis, the most sensitive part of this category is seafarers' labour contracts, which rank third in the total share of found deficiencies.

It is interesting to compare the ten most frequent deficiencies found on ships with the sub-areas they belong to. The most prevalent type of deficiencies detected (Figure 4) is undeniably related to the ISM in the last three years. However, the situation significantly differs in the sub-areas where the ten most frequent deficiencies belong (Figure 5). For example, deficiencies related to ISM belong only to the ISM sub-area, while fire doors/openings in fire-resisting divisions belong to the fire safety sub-area, which is composed of 25 different types of deficiencies. Therefore, when comparing ISM with the fire safety sub-area, it is evident that fire safety has a significantly larger number of deficiencies detected (Figure 5).

Analyzing the categories found deficiencies belongs; it is clear that the most deficiencies were found in fire protection, while the category of ISM is only in sixth place. The sub-areas of the safety of navigation, labour conditions and certificate and documentation also have a significant share in the total number of deficiencies, which is a worrying fact. When the data from 2019 and 2021 are compared, it can be seen that all the most frequent deficiencies are in a downward trend, except in labour conditions - health protection. Table 3 shows the most represented types of ships and flags by the total number of deficiencies recorded from January 2019 to December 2021.

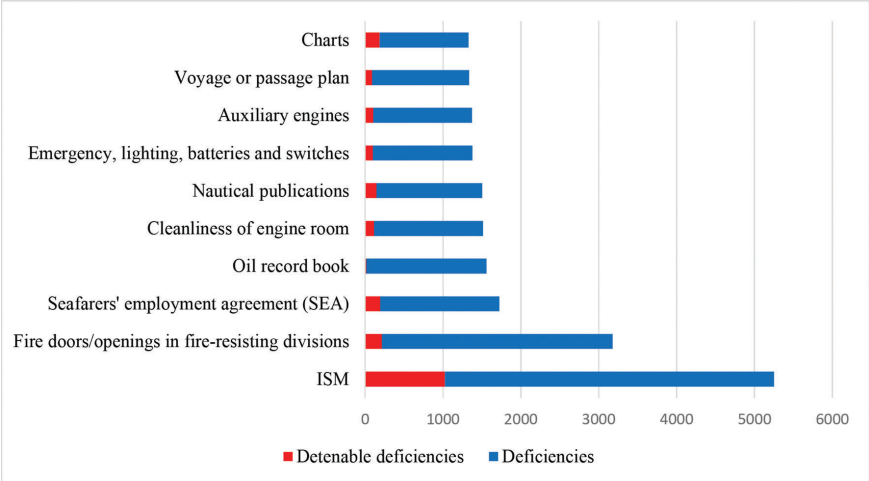

Figure 3 The ten most frequent deficiencies detected on ships in the period from January 2019 to December 2021.
Slika 3. Deset najčešćih nedostataka otkrivenih na brodovima u razdoblju od siječnja 2019. do prosinca 2021.

Source: Authors according to [32].

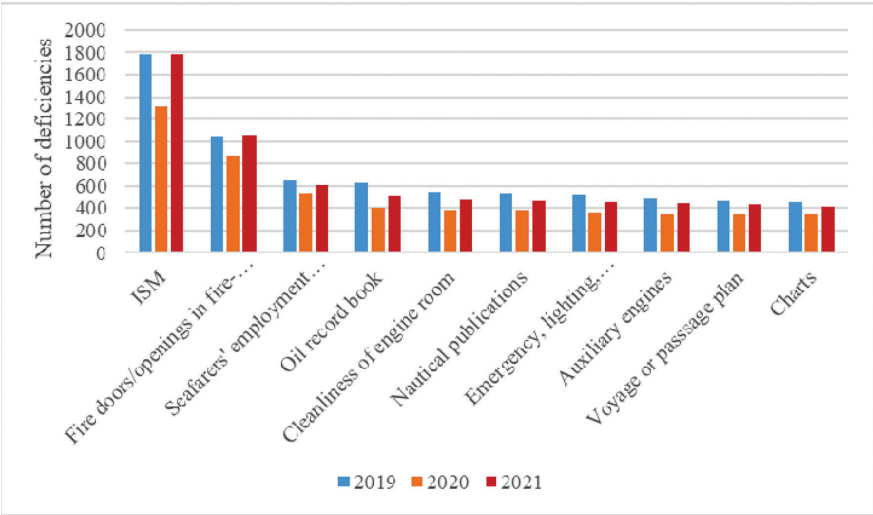

Figure 4 The ten most frequent deficiencies in the period 2019 – 2021.
Slika 4. Deset najčešćih nedostataka u razdoblju 2019. – 2021.

Source: Authors according to [32].

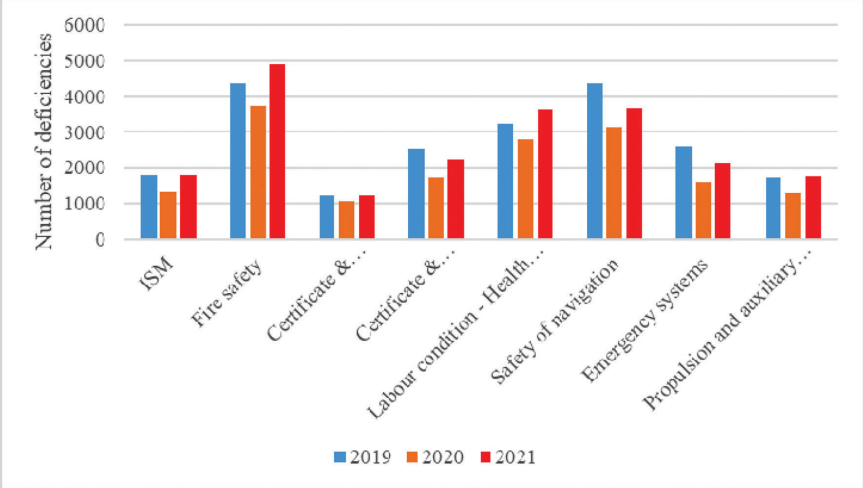

Figure 5 Sub-areas where the ten most frequent deficiencies belong to

Slika 5. Potpodručja kojima pripada deset najčešćih nedostataka

Source: Authors according to [32].

Table 3 Ship types and flags with the largest total number of deficiencies recorded in 2019 - 2021.

Tablica 3. Tipovi brodova i zastava s najvećim ukupnim brojem nedostataka zabilježenih u razdoblju 2019. - 2021.

Type of the ship	Total number of deficiencies	Number of top ten deficiencies	Flag	Total number of deficiencies	Number of top ten deficiencies
General cargo	41,795	7,689	Panama	16,788	3,026
Bulk carrier	24,754	4,064	Liberia	8,493	1,430
Container	8,129	1,395	Marshall Islands	7,728	1,273
Chemical tanker	4,845	759	Malta	6,662	1,167
Oil tanker	4,157	658	Antigua and Barbuda	4,300	837
Ro-Ro cargo	3,183	599	Cyprus	4,193	786
Ro-Ro passenger	2,922	606	Netherlands	3,734	723
Offshore supply	1,759	367	Hong Kong (China)	2,927	415
Livestock carrier	1,736	288	Norway	2,607	474
Tug	1,140	292	Russian Federation	2,561	574

Source: Authors according to [32].

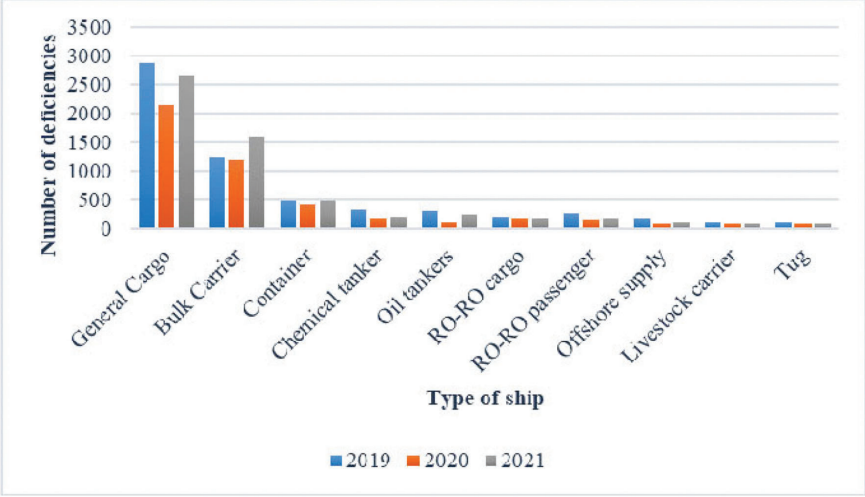

Figure 6 The most frequent deficiencies distribution according to the top ten ship types with the most deficiencies detected for the period 2019-2021.

Slika 6. Raspodjela najčešćih nedostataka prema prvih deset tipova brodova s najviše otkrivenih nedostataka za razdoblje 2019. – 2021.

Source: Authors according to [32].

The results showed that out of the ten most frequent deficiencies detected, the general cargo vessels have the most deficiencies detected in the analyzed period, followed by bulk carriers and container ships (Figure 6). Also, it is worth noting that the number of the most frequent deficiencies was significantly larger for 2021 than for 2019 only for bulk carriers.

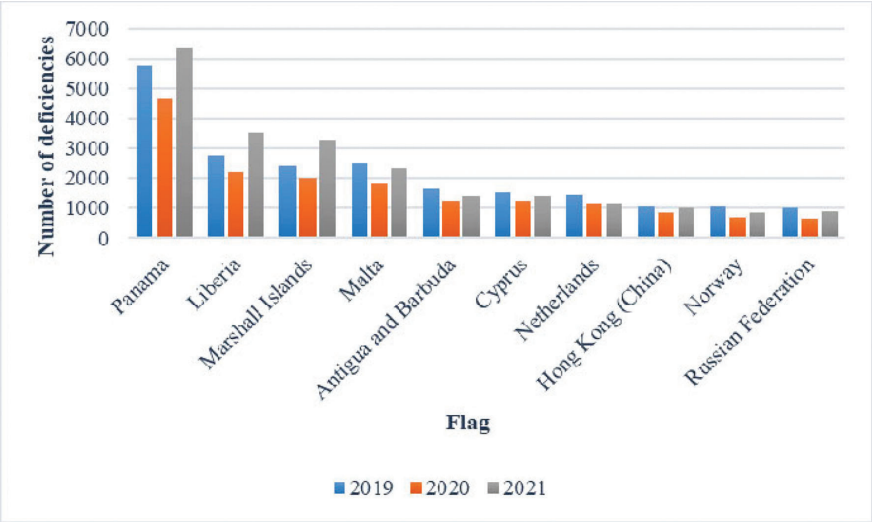

Figure 7 The most frequent deficiencies distribution according to the top ten flags with the most deficiencies detected for the period 2019-2021.

Slika 7. Raspodjela najčešćih nedostataka prema prvih deset zastava s najviše otkrivenih nedostataka za razdoblje 2019. – 2021.

Source: Authors according to [32].

Panama is the first when the most frequently found deficiencies are observed according to the flags, followed by Liberia and the Marshall Islands (Figure 7). Figure 7 shows that the number of the most frequent deficiencies was larger for 2021 than for 2019 for Panama, Liberia, and Marshall Islands registered vessels. For the Marshall Islands registered vessels, it was an increase of 36.5%, which is a significant figure.

When the most frequent ten deficiencies detected were attributed to the top ten types of ships, it was found that the ISM was the most represented type of deficiency for the bulk carriers, chemical tankers and container ships, with 30.9%, 30.6% and 30.3%, respectively, of the top ten deficiencies found (Figure 8). Fire doors/openings in fire-resistance divisions were the most represented deficiency for the ro-ro passenger ships, with 32.2% of the top ten deficiencies and offshore supply vessels (23.7%). Safety of navigation is a large concern for tugs since nautical publications, charts and voyage or passage plan made more than half (58.2%) of all deficiencies detected.

Hong Kong was the flag with the most ISM deficiencies detected (35.2%), followed by the Marshall Islands (31.3%), Panama (28.8%) and Liberia (28.7%) (Figure 9). Fire doors/openings in fire-resisting divisions were the most represented deficiency for Norway registered ships (23.8%), which also had a relatively large percentage of oil record book related deficiencies (18.8%).

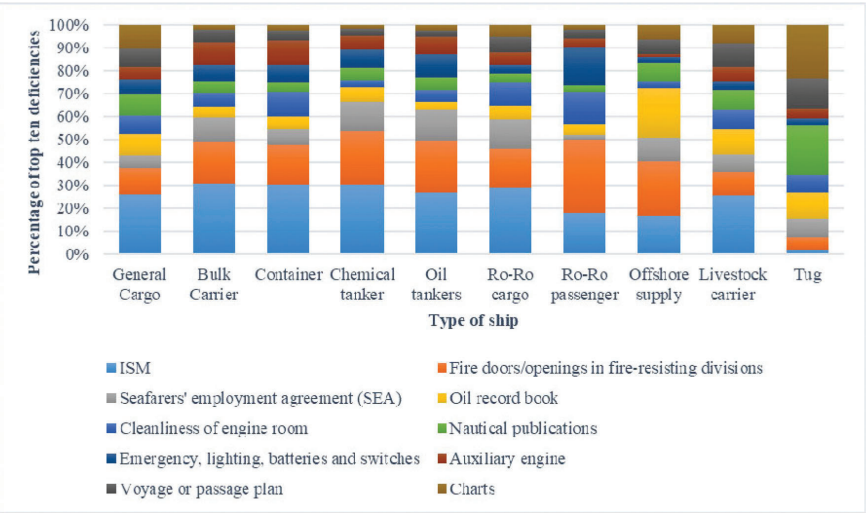

Figure 8 Percentage of top ten deficiencies according to top ten types of ships with the most deficiencies detected for the period 2019 - 2021.

Slika 8. Postotak prvih deset nedostataka prema prvih deset tipova brodova s najviše otkrivenih nedostataka za razdoblje 2019. – 2021.

Source: Authors according to [32].

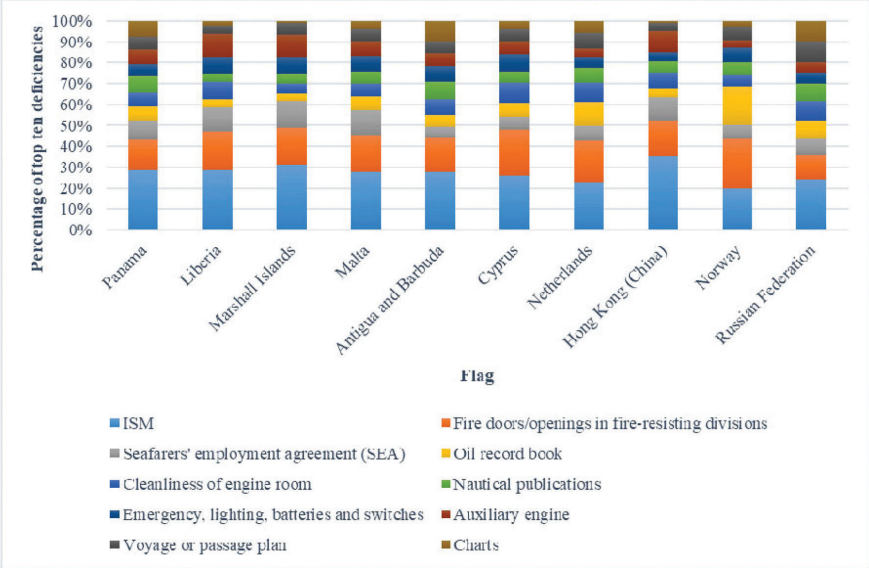

Figure 9 Percentage of top ten deficiencies according to top ten flags with the most deficiencies detected for the period 2019-2021.
Slika 9. Postotak prvih deset nedostataka prema prvih deset zastava s najviše otkrivenih nedostataka za razdoblje 2019. – 2021.

Source: Authors according to [32].

Table 4 Ten flags with the largest number of deficiencies detected.
Tablica 4. Deset zastava s najvećim brojem otkrivenih nedostataka

Flag	Number of ships inspected	Number of inspections	Detentions	Ten most frequent deficiencies	Total number of deficiencies	Percentage of the most frequent from the total deficiencies
Panama	3,017	5,491	310	3,026	16,788	18.0%
Marshall Islands	2,651	4,312	104	1,273	7,728	16.5%
Liberia	2,469	4,104	105	1,430	8,493	16.8%
Malta	1,979	3,883	100	1,167	6,662	17.5%
Netherlands	1,034	2,597	33	723	3,747	19.3%
Hong Kong	1,027	1,617	34	415	2,916	14.2%
Cyprus	815	1,998	42	786	4,193	18.7%
Norway	814	1,539	18	474	2,607	18.2%
Antigua and Barbuda	662	1,861	45	837	4,300	19.5%
Russian Federation	618	1,073	29	574	2,561	22.4%

Source: Authors according to available data from Paris MoU [32].

For a better comparison, the ten flags with the largest number of deficiencies from January 2019 to December 2021 are given in Table 4.

As presented in Table 4, Panama had the largest number of inspections and individual ships inspected. In addition, Panama registered ships had the highest ratio of detentions and inspections (5.6%). Russian Federation had the most significant ratio of top ten deficiencies and a total number of detected deficiencies (22.4%), followed by Antigua and Barbuda (19.5%) and the Netherlands (19.3%). It has to be emphasized that the ten flags with the largest number of recorded deficiencies were on the Paris MoU White List during the analyzed period. The absence of Black and Grey List flags in Table 4 could be related to the relatively small fleet size compared to White List flags.

6. DISCUSSION / *Rasprava*

The results show that in the last three years, most detected deficiencies belong to the International Safety Management, followed by the fire safety sub-area, regardless of the type of ship or the flag. It is indisputable that states with a larger fleet registered and more common types of ships have more deficiencies found during PSC inspections. This fact may lead one to think that the largest state flags are at a disadvantage compared to other small ones. However, the situation is much different. The calculation method according to which the success lists of state flags are determined puts the state flags with fewer registered ships at a disadvantage, thus classifying their ships as potentially high-risk, resulting in more frequent PSC inspections. As recommended during the PSC workshop held at the IMO (24 - 26 October 2017), one

of the possible solutions is moving away from the so-called list of successful flags (white, grey, and black) and accepting access to the individual risk profile of the ship [33]. This way, PSC regimes would target more individual ships with specific deficiencies in past inspections. In contrast, vessels that complied with international standards in past inspections would be less targeted for future PSC inspections [29]. The IMO is still considering developing and maintaining a coordinated list of ships with poor results and establishing a common platform that would enable a quick and efficient exchange of information between individual PSC regimes.

As the results of the statistical analysis show, the adequate implementation of ISM onboard ships presents a big problem for most shipowners and their ships. The ISM Code aims to ensure safety at sea, preventing human injuries and loss of life, and environmental damage (ISM). Furthermore, the Code requires that shipping companies develop and implement an onboard Safety Management System (SMS) for ships they operate to reduce the effect of human factors on maritime accidents [34]. However, the effect of human factors in maritime accidents is still large [35]. One of the reasons for this could be a seafarers' perception of the ISM and SMS. They perceive the ISM as an additional bureaucratic burden taking a significant amount of their time and, in return, taking their focus away from safe performance [36]. Also, as new technologies and equipment are being introduced on vessels, human-machine interaction is an important factor that needs to be constantly developed and improved. For example, when analyzing human factors in accident reports, Hasanspahić et al. [37] found that Organizational Climate and Software are the most significant contributory factors to maritime accidents. Organizational Climate includes culture and policies implemented onboard, and it is affected by various factors, such as seafarers' national culture, shipboard leadership, and seafarers' individual knowledge. The Software includes a shortage of prescribed procedures from the company, inadequate and obsolete checklists, manuals, instructions and others (in accordance with ISM Code Section 7) [37]. Therefore, top management should focus on these shortcomings of the ISM and act accordingly. Shipboard leadership should attend training to acquire adequate knowledge and develop skills in implementing a safety culture with all its elements onboard their ships. Also, there is a need to thoroughly check and revise all existing procedures and policies, including checklists, various permits to work and manuals to reduce the effect of Software on maritime accidents, but also on the number of deficiencies detected by PSC inspections. In addition, it has to be mentioned that the development of various checklists and work procedures should be done by maritime experts, who are well acquainted with the type of ship and the operations to which specific documents relate. As Baştuğ, Asyali and Battal [38] stated, shipboard procedures should be simplified in order to affect the seafarers' performance minimally. All crewmembers should be involved in SMS, provide ideas and solutions for onboard issues and problems, and communicate among themselves, especially on safety issues. In that way, a positive safety climate could be developed on ships, resulting in fewer deficiencies found and fewer accidents occurring.

Fire safety is also a significant concern since only in 2019, 40 cargo-related fires were reported on ships larger than 100 GT. Among those incidents, the most represented types of ships were container and ro-ro ships [39]. As analysis of the results showed, ro-ro passenger ships had the largest percentage of fire safety-related deficiencies, representing a serious risk for fire-related incidents. Additional familiarization and training in the usage of firefighting equipment and its maintenance, together with compliance with fire safety procedures aiming to increase fire-safety awareness, should be implemented onboard ships with the largest share of deficiencies found from sub-area of fire safety.

7. CONCLUSION / *Zaključak*

The inspection control system is continuously being improved. Today, it represents the backbone of the fight against exploitative ships that do not comply with conventions and regulations. The very establishment of the Paris Memorandum of Understanding significantly improved the control of ships in ports in that region. On the initiative of the IMO, other memoranda are established by region, so a global system of monitoring the state of ships in ports has been established. Memoranda are very effective means of maintaining safety and environmental standards on vessels. Although initially conceived as an aid to the flag state, the inspection control system has developed into an indispensable instrument in controlling ship standards.

The concentrated inspection campaigns regularly carried out by the PSC inspections are probably aimed at the most vulnerable areas to reduce deficiencies found. However, this research suggests that targeted inspections should focus on the ship's ISM and fire safety systems, especially on bulk carriers, chemical tankers and container ships for the ISM and fire safety for the ro-ro passenger ships.

One of the main concerns is that as many as three of the ten most frequent deficiencies come from the safety of navigation. Looking at the sub-areas of detected deficiencies, the safety of navigation is at the top, just behind fire safety. This fact represents a potential danger of unwanted events, such as groundings, with severe consequences. In addition, among the ten types of ships with the largest number of deficiencies detected, tugs have the biggest share of the safety of navigation related deficiencies. Therefore, there is a need to improve the safety of navigation system on these ships, possibly with additional training and better supervision from shore management, for example, in the form of more frequent navigation audits.

Despite the adopted regulations on labour conditions and health protection on ships, many deficiencies were found in this category. These deficiencies may stem from the fact that this category was monitored with more intensity, resulting in a higher number of deficiencies found since the Maritime Labour Convention entered into force in August 2013. Areas for which new rules and regulations have been enacted may be subject to more intensive inspections by PSC inspectors.

Also, continuous training of seafarers and more frequent checks by shipping companies would increase the expertise of the personnel on the ships. Raising the awareness of

the crewmembers about the importance of maintaining vessels under current requirements and regulations would help reduce the number of substandard ships. Shipping companies in the form of additional training could carry this out. In the achievement of these goals, the leadership of the vessel itself plays an important role. Regular safety and fire drills and training of the ship's crew for emergency and unplanned events should be maintained at a high level for continuous safety on boards and not only for satisfactory inspection results. Shipboard leadership should ensure that crewmembers on their ships are well trained, familiar with all safety and fire protection equipment, and know their duties in an emergency. Additional incentives for crew members in case of passing inspections without detected deficiencies during the duration of their contracts by shipping companies could also contribute to better maintenance, attention, and effort of the ship's personnel, which would result in a better standard of the vessel itself, and the reputation of the ship and the shipping company.

According to the current rules, State Flag inspections are carried out at an interval of one year. Introducing more frequent mandatory inspections by the Flag State could improve the vessels' standards and ensure compliance with conventions and regulations. Regarding all the deficiencies found during inspections, it is essential to note that the mere existence and adequate operational condition of the necessary equipment do not ensure the capability as required by the conventions and rules if the master and his crew are not familiar with the equipment and related procedures as required by STCW section A-I/4.4. Therefore, the primary responsibility in maintaining the ships according to the current standards lies primarily with the shipowner, who will send a responsible and conscientious crew on board that will have the obligation and responsibility to maintain the ship under all prescribed rules.

It should be noted that by further collecting recorded deficiencies and detention data, future research could examine the existence of relationships between the type of ships and flags with the deficiencies detected during PSC inspections.

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REFERENCES / *Literatura*

[1] International Maritime Organization (IMO) (1966). *Load Lines Convention 1966.* Consolidated 2005 Edition. ISBN: 9789280141948.

[2] International Maritime Organization (IMO) (1969). *Tonnage Measurement of Ships, 1969.* 1983 Edition. ISBN: 9789280110906.

[3] International Maritime Organization (IMO) (2004). *Ballast Water Management Convention and BWMS Code with guidelines for implementation.* 2018 Edition. ISBN: 9789280117028.

[4] International Maritime Organization (IMO) (2001). *Anti-Fouling Systems. International Convention on the Control of Harmful Anti-Fouling Systems on Ships.* 2005 Edition. ISBN: 9789280122916.

[5] Özçayir, O. (2004). *Port state control.* New York: Informa Law from Routledge. ISBN: 9781315089614.

[6] International Maritime Organization (IMO). *Port State Control.* Retrieved from: https://www.imo.org/en/OurWork/IIIS/Pages/Port%20State%20Control.aspx

[7] Baniela, S. I. & Rios, J. V. (2011). Maritime Safety Standards and the Seriousness of Shipping Accidents. *Journal of Navigation*, 64, pp. 495–520.

[8] Paris MoU (2021). 2020 Paris MoU Annual Report Dealing with the pandemic Retrieved from: https://www.parismou.org/sites/default/files/TBB_Jaarverslag%20Paris%20MoU%202020_totaal_HRlos.pdf

[9] Payoyo, P. B. (1994). Implementation of international conventions through port state: an assessment. *Marine Policy,* 18(5), 379-392. https://doi.org/10.1016/0308-597X(94)90034-5.

[10] Mejia, M. Q. (2005). Evaluating the ISM Code Using Port State Control Statistics. (Licentiate Thesis. Publication of Lund University, Department of Design Sciences, Division of Ergonomics and Aerosol Technology, Lund University, Sweden). Retrieved from: https://worldcat.org/search?q=n2:16509773.

[11] Hare, J. (1997). Port state control: strong medicine to cure a sick industry. *Georgia Journal of International and Comparative Law,* 26(3), 571–594.

[12] Cariou, P., Mejia, M. Q. & Wolff, F.-C. (2008). On the effectiveness of port state control inspections. *Transportation Research Part E*, 44, 491-503. https://doi.org/10.1016/j.tre.2006.11.005.

[13] Cariou, P., Mejia, M. Q. & Wolff, F.-C. (2009). Evidence on target factors used for port state control inspections. *Marine Policy,* 33, 847-859. https://doi.org/10.1016/j.marpol.2009.03.004.

[14] Şanlıer, Ş. (2020). Analysis of port state control inspection data: The Black Sea Region. *Marine Policy,* 112, 103757. https://doi.org/10.1016/j.marpol.2019.103757.

[15] Xiao, Y., Wang, G., Lin, K.-C., Qi, G. & Li, K. X. (2020) The effectiveness of the New Inspection Regime for Port State Control: Application of the Tokyo MoU. *Marine Policy,* 115, 103857. https://doi.org/10.1016/j.marpol.2020.103857.

[16] Graziano, A., Cariou, P., Wolff, F.-C., Mejia, M. Q. & Schröder-Hinrichs, J.-U. (2018). Port state control inspections in the European Union: Do inspector's number and background matter? *Marine Policy,* 88, 230-241. https://doi.org/10.1016/j.marpol.2017.11.031.

[17] Knapp, S. & Franses, P.H. (2007). Econometric analysis on the effect of port state control inspections on the probability of casualty: Can targeting of substandard ships for inspections be improved? *Marine Policy,* 31(4), 550-563. https://doi.org/10.1016/j.marpol.2006.11.004.

[18] Xiao, Y., Qi, G., Jin, M., Yuen, K.F., Chen, Z. & Li, K. X. (2021). Efficiency of Port State Control inspection regimes: A comparative study. *Transport Policy,* 106, 165–172. https://doi.org/10.1016/j.tranpol.2021.04.003.

[19] Yan, R., Wang, S. & Peng, C. (2022). Ship selection in port state control: status and perspectives. *Maritime Policy & Management*, 49(4), 600-615. https://doi.org/10.1080/03088839.2021.1889067.

[20] Wang, S., Yan, R. & Qu, X. (2019). Development of a non-parametric classifier: Effective identification, algorithm, and applications in port state control for maritime transportation. *Transportation Research Part B: Methodological,* 128, 129-157. https://doi.org/10.1016/j.trb.2019.07.017.

[21] Knapp, S. & Franses, P. H. (2008). Econometric analysis to differentiate effects of various ship safety inspections. *Marine Policy,* 32(4), 653-662. https://doi.org/10.1016/j.marpol.2007.11.006.

[22] Knapp, S., Bijwaard, G. & Heij, C. (2011). Estimated incident cost savings in shipping due to inspections. *Accident Analysis & Prevention,* 43(4), 1532-1539. https://doi.org/10.1016/j.aap.2011.03.005.

[23] International Maritime Organization (IMO) (1991). Resolution A.682(17). Regional Cooperation in the Control of Ships and Discharges. Retrieved from: https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/AssemblyDocuments/A.682(17).pdf

[24] Paris MoU. (2017). Annual report 2017. Retrieved from: https://www.parismou.org/sites/default/files/2017%20Annual%20ParisMoU_0.pdf

[25] International Maritime Organization (IMO). (1995). Resolution A.787(19). Procedures for Port State Control. Retrieved from: https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/AssemblyDocuments/A.787(19).pdf

[26] International Maritime Organization (IMO). (2022). Resolution A. 1155(32), Procedures for port state control, 2021. Retrieved from: https://wwwcdn.imo.org/localresources/en/OurWork/IIIS/Documents/A%2032-Res.1155%20-%20PROCEDURES%20FOR%20PORT%20STATE%20CONTROL,%202021%20(Secretariat).pdf

[27] Maritime and Port Bureau, MOTC (2017). Port state control 2016 annual report. Retrieved from: https://www.motcmpb.gov.tw/ServerFile/Get/1c0aca04-0600-4b99-90a6-d50ea226cd3a?DLCount=1

[28] European Maritime Safety Agency (EMSA) (2010). Media Fact Sheet 02/2010. A New Inspection Regime for Port State Control in all Paris MoU Countries. Retrieved from: https://www.westpandi.com/globalassets/news/101223-emsa-media-sheet-on-nir.pdf

[29] BIMCO. The new inspection regime of the Paris MoU. Retrieved from: https://www.lesiagroup.com/Resources/BIMCO%20NIR%20Guide.pdf.

[30] Paris MOU – Inspection type, Retrieved from: https://www.parismou.org/inspections-risk/library-faq/inspection-types

[31] Yuan, C.-C., Chung, W.-H., Cai, C. & Sung, S.-T. (2020). Application of Statistical Process Control on Port State Control. *Journal of Marine Science and Engineering,* 8(10):746. https://doi.org/10.3390/jmse8100746.

[32] Paris MoU (2022). Inspection Results Deficiencies. Retrieved from: https://www.parismou.org/inspection-search/inspection-results-deficiencies.

[33] International Maritime Organization (IMO) (2017). Port State control regimes move to boost collaboration, harmonization and information sharing. Retrieved from: https://www.imo.org/en/MediaCentre/PressBriefings/Pages/30-PSC-workshop.aspx.

[34] Mišković, D., Jelaska I. & Ivče, R. (2019). Attitudes of Experienced Seafarers as Predictor of ISM Code Implementation: A Croatian Example. *Promet – Traffic & Transportation,* 31(5), 569-579.

[35] Baker, C. & McCafferty, D. (2005). Accident database review of human element concerns: What do the results mean for classification? In Proceedings of the *International Conference Human Factors in Ship Design and Operation;* RINA: London, UK.

[36] Bhattacharya, S. (2012). The effectiveness of the ISM Code: A qualitative enquiry. *Marine Policy,* 36(2), 528-535.

[37] Hasanspahić, N., Vujičić, S., Frančić, V. & Čampara, L. (2021). The Role of the Human Factor in Marine Accidents. *Journal of Marine Science and Engineering,* 9(3):261.

[38] Baştuğ, S., Asyali, E. & Battal, T. (2021). Beyond the ISM code: a conceptual proposal for an integrated system within the Seven C's approach. *Maritime Policy & Management,* 48(3), 354-377.

[39] SWZ|Maritime. Ship fires not decreasing and still a major cause of total loss. Retreived from: https://swzmaritime.nl/news/2022/12/23/ship-fires-not-decreasing-and-still-a-major-cause-of-total-loss/