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DYNAMIC OF THE MARITIME ACCIDENTS OF THE MAIN TYPES OF SHIPS FROM EU AND THEIR IMPLICATIONS. A LITERATURE REVIEW

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ABSTRACT

Maritime accidents and incidents are a major concern for the shipping industry, even though unified standards exist and solutions have been identified to improve maritime navigation and minimize accidents. This study aimed to carry out a statistical analysis of maritime accidents and incidents between 2014 and 2022, of ships belonging to EU Member States, highlighting the main shipping areas where maritime accidents occurred, the resulting consequences, the types of pollution, and the main factors leading to maritime accidents and incidents. The results showed that there were 23,814 accidents/incidents, of which 2.6% were very serious accidents, 28.5% were serious accidents, 53.9% were less serious accidents, and 15% were maritime incidents.

Keywords: maritime accidents, cargo ships, damage/loss of equipment, collisions, passenger ships, fishing ships

1. INTRODUCTION

To improve the safety of shipping, efforts have been made at the European level to reduce/eliminate shipping accidents by developing rules, regulations, and directives such as Regulation (EC) No 417/2002 and Regulation (EU) No 530/2012 for the introduction of safer oil tanker ships, Regulation (EC) No. 1406/2002 and Regulation (EU) No. 100/2013 by which the European Maritime Safety Agency (EMSA) provides EU Member States with scientific and technical support in the implementation of maritime transport safety rules, Regulation (EC) No. 391/2009 and Directive 2009/15/EC, which set various rules and standards for the inspection and control of ships, Directive 2002/59/EC requiring ships to have Automatic Identification Systems (AIS) and VDR systems for automatic voyage data recording, Directive 2009/18/EC regulating the investigation of accidents in the maritime transport sector and EMSA's support in the accident investigation process, etc [24÷30]. However, the frequency of accidents and incidents is still high, often leading to fatalities, injuries, damage, and even loss of vessels.

According to EMSA, a total of 604 deaths, 6781 injuries, 8545 damaged vessels, and 183 lost vessels were reported between 2014 and 2022. The main factors were 'Human action', 'System or equipment failure', 'Other vessel', 'Hazardous material', and 'Unknown'.

The study conducted in this paper, based on data collected from the literature ([3], [7], [8], [9], [10], [13], [15], [16], [17], [21], [22]) and from the EMSA database ([4], [5], [6]), proposes a framework for statistical analysis of maritime accidents and incidents, that occurred between 2014 and 2022, the ships belonging to EU Member States, the shipping areas where accidents occurred, their consequences, and the main factors leading to maritime accidents and incidents.

The paper is organized as follows: Section 2 - presents a brief literature review; Section 3 - presents the data collected and the research method; Section 4 - presents the study's findings and conclusions.

2. LITERATURE REVIEW

To identify the causes and consequences of maritime accidents and incidents, as well as how to reduce the share of serious and very serious accidents, several scientific papers have been developed ([3], [10], [14], [15], [17], [20], [21]), bringing the rather high frequency of maritime accidents to the forefront of the discussion. Thus, Youn et al, (2019) used an optical sensor system to observe the behavior of mariners in a simulated environment. The study showed the effectiveness of this model that accurately measured the specific activities in a real navigation environment, which can serve to prevent maritime accidents.

Zheng et al., (2020) present a new nonlinear algorithm for modeling the collision probability of ships, which combines the risk of different situations. The authors performed simulations in three collision situations covering head-on collision, crossing situation, and overtaking situation and concluded that the proposed method for quantitative risk assessment provides the possibility of risk assessment that varies with the ship's state.

Dominguez-Pery et al, (2021) conducted a literature review on human-caused maritime accidents. It was found that the main causes are due to socio-technical information systems, management, and human resources, individual errors, and the application of informational technologies. At the same time, the authors propose that these human errors should be addressed from the perspective of the possibility of anticipating actions, correct perception of information, and correct understanding of onboard systems, so that the safety of maritime transportation can be improved.

Maceiras et al., (2021) conducted a study with more than 163 ships involved in accidents in Spain and showed which of the ship's characteristic variables are related to different types of accidents. The authors determined that ship length is the most relevant variable from the perspective of differentiating maritime accidents.

Vinagre-Ríos et al., (2021) analyzed a sample of ships that suffered various collisions and found that this type of accident is more frequent and severe at night, suggesting that the results obtained in this research can be extrapolated to other types of maritime incidents.

Zhang et al., (2021) proposed a data analysis framework to estimate the collision probability and to assess ship damage after a collision event. The results were obtained for an RO-Pax ship operating in the Gulf of Finland in 2018-2019 and showed that the collision probability differs depending on the traffic characteristics and the method is useful when assessing the risk of flooding.

Xue et al., (2021) present a study analyzing the characteristics and causes of ship accidents from a statistical point of view, using a ten-year database, comparing data in terms of the types of ships involved in accidents, the severity of accidents, accident categories, causes of accidents, and the losses that occurred during accidents.

3. DATA AND METHOD

Data collection

The data used in this paper has been collected from existing reports and studies in the literature, as well as from the European Maritime-time Safety Agency (EMSA) website, which contains data reported by EU Member States (28 countries plus Iceland and Norway), for the period 2014-2022, on shipping accidents and incidents resulting in lost/damaged ships, fatalities or injuries, and environmental pollution.

The data reported by EU Member States is centralized annually in the EMCIP (European Marine Casualty Information Platform) database, the European platform for information on any maritime incident, which stores and analyses all information on maritime casualties/incidents [4]. The maritime accidents and incidents analyzed in this survey concern ships flying the flag of one of EU Member States and occurring in their internal waters or territorial seas.

Method

The research method consisted of an extensive review of the literature on maritime accidents, the main causes and factors, as well as the consequences of these accidents [1], [2], [8], [9], [11], [12], [14], [16], [18], [19], [20], [23], to which the EMSA reports from 2014-2022 were added. The paper also presents statistics in the form of graphs and tables on the total number of maritime accidents/incidents on different types of ships, the evolution of accidents according to their severity, the evolution of different types of ships/number of ships involved in maritime accidents, the evolution of maritime accidents/incidents by seatime by sailing areas, evolution of lost/damaged ships as a result of maritime casualties, evolution of environmental pollution types as a result of accidents and pollution incidents by the type of ship, percentage of main factors contributing significantly to maritime casualties by the type of ship.

The stages of the developed methodology are presented in Figure 1.

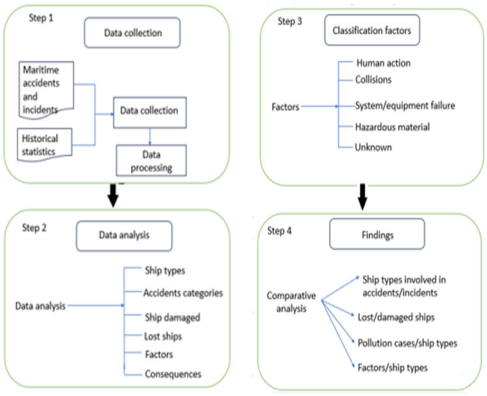

Fig. 1 The stages of the developed methodology

4. FINDINGS

1. Maritime accidents and incidents and their evolution between 2014 and 2022

Based on EMCIP figures, the total number of incidents during this period was 23,814, with an annual average of 2646 [4]. Of these incidents, 2.6% were very serious accidents (involving total loss of the ship/total loss of life/advanced environmental damage), 28.5% were serious accidents (which may consist of fire/explosion, hull rupture, collision with an obstacle or another ship, grounding of the ship, damage involving towing of the ship), 53.9% were less serious accidents, and 15% were marine incidents (which are related to ship operations and may affect the safety of the ship if timely action is not taken) (Figure 2 and Figure 3).

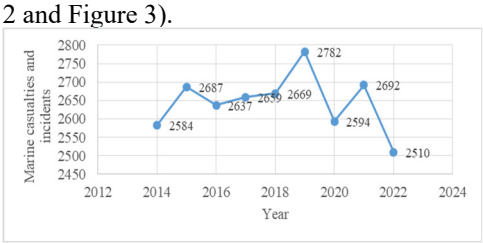

Fig. 2 Total number of maritime accidents/incidents between 2014 and 2022 for ships belonging to EU Member States (processing after [4])

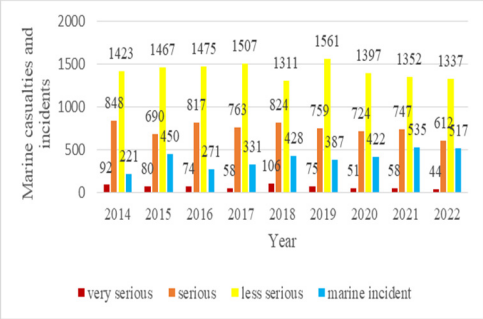

Fig. 3 Trend in the number of maritime accidents by severity for ships belonging to EU Member States between 2014 and 2022 (processing after [4])

Based on the information presented in Figure 3, the following can be noted:

In 2014, out of 2584 accidents, 3.56% were very serious marine accidents, 32.89% were serious marine accidents, 55% were less serious marine accidents, and 8.55% were marine incidents.

The year 2015 was characterized by 2687 accidents of which 1793 were cargo ships. Out of the total accidents, 3% were very serious marine accidents, 25.65% were serious marine accidents, 54.65% were less serious marine accidents, and 16.7% were marine incidents.

The main causes of these maritime accidents were loss of control, damage to ships or equipment, collision, contact, and fire/explosion [5].

Between 2016 and 2018, the total number of reported accidents was around 2650, and in terms of severity, they were categorized as follows: 3% very serious, 30% serious, and 55% less serious, while 12% were maritime incidents [4].

In the following year, the number of accidents increased by 113 from the previous year to 2782, of which 56% were less serious marine accidents, followed by serious marine accidents at 27.3%, then 14% were marine incidents, and only 2.7% were very serious accidents. After this peak in 2019, the number of marine accidents reported in the following year decreased to 2594, with the highest share being less serious marine accidents (53.85), followed by serious marine accidents (28%), with very serious accidents accounting for 1.96%.

In 2021 there was an increase in these accidents by 98 compared to 2020, and in 2022, due to low traffic in 2020, with a slight increase in 2021 due to the COVID pandemic, they fell to 2510, making this year a positive year. Thus, of the total number of ships involved in marine accidents, 53% were less serious accidents, 24% were serious accidents, and only 1.75% were very serious accidents, which is also the lowest percentage recorded for this type of accident, in the whole period analyzed [4], [5], [6]. This downward trend applies to cargo and fishing vessels.

2. Ships involved in maritime accidents and incidents between 2014 and2022

Ships involved in maritime accidents/incidents between 2014 and 2022 are categorized as follows: cargo ships, passenger ships, fishing vessels, service ships, and other types of ships.

Of all accidents during the analyzed period, 61.5% are attributed to cargo ships, 22.3% to passenger ships, and only 16.2% to service ships [4].

An overview of the evolution of the different types of ships involved in maritime accidents/incidents is presented in Figure 4.

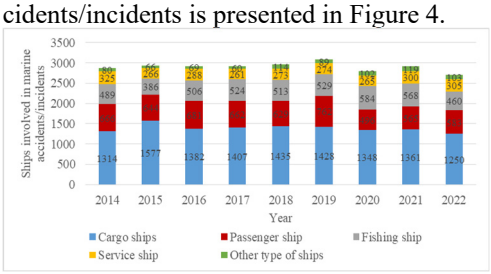

Figure 4 Evolution of the different types of ships involved in maritime accidents/incidents betweenin the period 2014 and 2022 (processing after [4])

Figure 4 shows that for the whole period under analysis, the highest share of vessels involved in maritime accidents/incidents are cargo ships, with a share between 45.7% and 53.65%, followed by passenger ships with a share between 17.74% and 24.72%, and in third place are fishing vessels with a share between 13%-21%.

The total number of ships involved in these shipping accidents reported during the period under review, including their averages, is shown in Table 1

Table 1 Total number of ships involved in maritime accidents and their averages, 2014-2022 [4]

Ship type	Total number of ships involved in maritime accidents	Average
Cargo ship	12502	1389
Passenger ship	5688	632
Fishing ship	4559	507
Service ship	2557	284
Other type of ship	802	89

Regarding cargo ships, the trend in the number of maritime accidents, by severity, for the period 2014-2022, is shown in Figure 5.

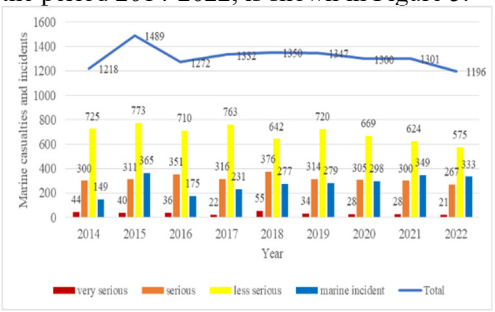

Fig. 5 Trends in the number of shipping accidents for cargo ships belonging to EU Member States, by seriousness, for the period 2014-2022 (processing after [4])

As shown in Figure 5, the number of maritime accidents for cargo ships peaked in 2015 and then decreased to 1196 accidents in 2022. Over the whole period 2014-2022, very serious accidents trended downwards, with a peak of 55 accidents in 2018; serious accidents decreased from a peak (376) in 2018 to 267 in 2022; less serious accidents accounted for the largest share, with a peak (773) in 2015 and another peak (763) in 2017, on a downward trend from 2020; maritime incidents recorded the highest values in 2015 (365) and 2021 (349).

3. Main shipping areas where maritime accidents occurred between 2014 and 2022

Regarding the locations where these accidents occurred, port areas (inland waters), the territorial sea, and the open sea are the most common. Between 2014 and 2022, 51.5% of maritime accidents occurred in inland waters, 24.3% in the territorial sea, and 20.8% in the open sea (Figure 6). The geographical area with the highest number of incidents, for cargo ships, was the Mediterranean Sea [4]. In terms of the percentage of these maritime accidents, by type of ship and sailing area, these are shown in Figure 7.

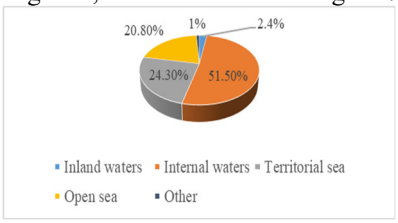

Fig. 6 Percentage of maritime accidents by navigation areas between 2014 and 2022 (after [4])

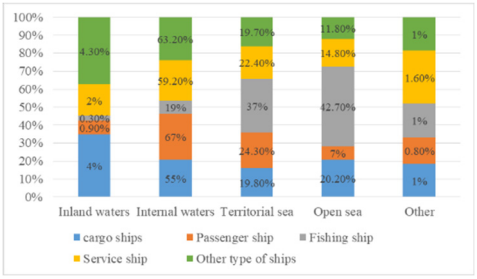

Fig. 7 Percentage of shipping accidents by type of ship and by navigation area between 2014 and 2022 (processing after [4])

Figure 7 shows that for cargo ships, 55% of maritime casualties occurred in internal waters, 20.2% of them occurred in the open sea, and 19.8% occurred in the territorial sea. For passenger vessels, 67% of accidents occurred in internal waters. And for fishing vessels, these accidents had the highest share (42.7%) in "open sea", followed by 37% in "territorial sea". Service vessels had 59.2% of accidents in internal waters.

4 Consequences of maritime accidents and incidents between 2014 and 2022

4.1 Consequences of the Human Factor

As a result of the occurrence of maritime accidents/incidents, between 2014 and 2022, there were a series of consequences, such as the deaths of crew members on the ship, their injuries, lost or damaged ships, and consequences on the environment.

The number of fatalities was 604, with an average for the period analyzed of 67 fatalities/year and a total of 6781 reported injuries, with an average of 753 injuries/year. In the same period, the number of injuries for onboard passengers was lower than for the crew [4].

Among the deaths caused as a result of maritime accidents, 32.2% were due to "Collisions" (which were reduced in the years 2015, 2018, 2022), 22.7% due to "Flooding/founding", and 18.2% resulted as a outcome of "Capsizing/listing"[4], [6].

The main causes of injuries were "Collisions", with a proportion of 24.2%, "Contacts" (21.6%), "Damage/loss of equipment" (14.6%), and "Fire/Explosion" (11.7%) [4], [6].

4.2 Consequences for Ships

Other consequences of accidents during this period were lost ships (Figure 8) and damaged ships (Figure 9).

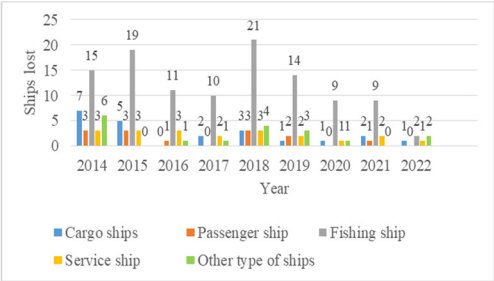

Fig. 8 Evolution of vessels lost between 2014 and 2022 (processing after [4])

As shown in Figure 8, 22 cargo vessels, 13 passenger vessels, 110 fishing vessels, 20 service vessels, and 18 other types of vessels were lost. Thus, the total number of vessels that were lost was 183 for all vessel types, with fishing vessels accounting for 60.1%, with a peak of these losses in 2018.

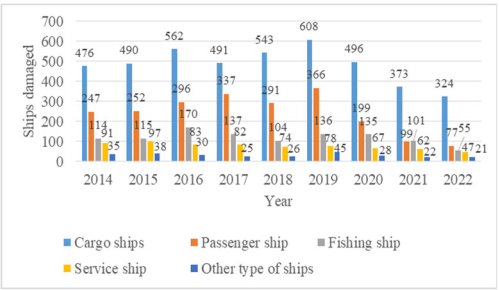

Fig. 9 Evolution of vessels that were damaged between 2014 and 2022 (processing after [4])

Figure 9 shows the evolution of damaged ships, which reached a peak in 2019 (1233 damaged ships), after which it followed an upward trend, reaching 524 damaged ships in 2022. Of the types of ships damaged during this period, 4363 were cargo ships, followed by passenger ships (2164), and fishing vessels (1067). The most damaged cargo and passenger ships were in 2019 (608 cargo ships and 366 passenger ships), and the most damaged fishing vessels (170) were in 2016.

4.3 Environmental consequences

In terms of the environment, the consequences of shipping accidents during this period led to 542 cases of pollution with fuel oil, cargo residues, lubricating or hydraulic oils (Figure 10).

Figure 10 shows the pollution cases, where, from 2014 to 2022, the number of pollution cases decreased significantly from 98 in 2014 to 38 in 2022. The minimum of pollution cases (37) was recorded in 2020 due to the COVID-19 pandemic. Pollution cases by ship type are presented in Table 2.

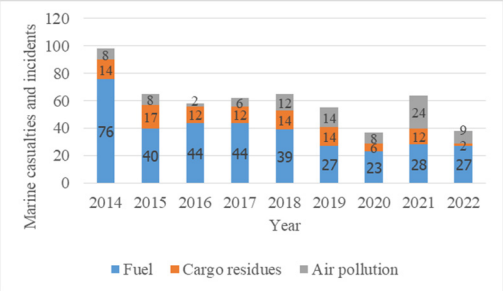

Fig. 10 Evolution of pollution types between 2014 and 2022 (processing after [4])

Table 2 Pollution cases by ship type [4]

Ship type	Number of pollution cases	%
Cargo ships	290	53.5
Passenger ships	71	13.1
Fishing ships	86	15.9
Service ships	82	15.1
Other types of ships	13	2.4
Total	542	100

5. Main contributing factors to maritime accidents/incidents between 2014 and 2022

The main factors (conditions) leading to maritime accidents are: 'Human action', 'System or equipment failure', 'Other vessel', 'Hazardous material', and 'Unknown' [4]. For the period 2014-2022, the percentage of factors leading to maritime accidents is presented in Figure 11.

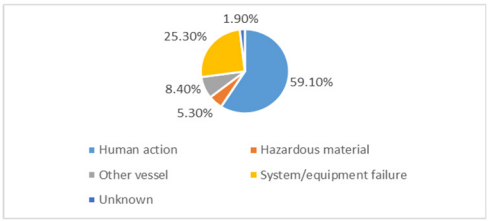

Fig 11 Percentage of factors leading to marine casualties between 2014 and 2022 (based on [4])

As shown in Figure 11, 'Human action' has the highest share (59.1%), followed by 'System or equipment failure' (25.3%).

The percentage of these factors contributing to maritime accidents between 2014 and 2022 for the different ship types is shown in Table 3.

Table 3 Percentage of the factors that contributed to marine casualties between 2014 and 2022, by ship type [4]

Factor	Ship type				
	Cargo ships	Passenger ships	Fishing ships	Service ships	Other types of ships
Human action	61.2	54.1	56.3	61.8	60
Hazardous material	6.3	5	4.2	3.8	2.9
Other vessel	9.8	6.9	6.3	6.9	11.4
System or equipment failure	21.4	33.5	28	26	25.7
Unknown	1.3	0.5	5.2	1.5	-
Total					

'Human action' is the most common factor in maritime accidents, followed by 'System or equipment failure', which is higher for passenger and fishing vessels.

5. CONCLUSIONS

European maritime transport is highly competitive, offering the possibility to economically transport goods and passengers through the seas, canals, and inland waterways of EU Member States.

Maritime accidents and incidents are quite frequent and they pose a permanent threat to human life, the ship, and especially

the marine environment. It is important to understand the history of maritime accidents and incidents to find solutions to prevent them in the future.

In the present paper, a statistical analysis of maritime accidents and incidents that occurred between 2014 and 2022 has been carried out, identifying the ships belonging to EU Member States involved in these accidents, the sailing areas where these accidents frequently occurred, their consequences, as well as the main factors that contribute to the occurrence of maritime accidents and incidents.

The most common ships involved in maritime accidents and incidents between 2014 and 2022, belonging to EU Member States, were cargo ships, passenger ships, fishing vessels, service vessels, and other type of ships.

The main major contributing factors or conditions to maritime accidents between 2014 and 2022 were 'Human action', 'System or equipment failure', 'Other vessel', 'Hazardous material', and 'Unknown', with the highest weight belonging to the 'Human action' factor.

In terms of the consequences of these maritime accidents and incidents between 2014 and 2022, involving ships belonging to EU Member States, they consisted of deaths (604), injuries (6781), damaged ships (8545), lost ships (183), and 542 cases of pollution with fuel oil, cargo residues, lubricating or hydraulic oils.

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