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Investigation of Maritime Accidents with Exploratory Data Analysis in the Strait of Çanakkale (Dardanelles)

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***Abstract*—**The Strait of Çanakkale (Dardanelles), together with the Strait of Istanbul and the Sea of Marmara, form the Turkish Straits System. In other words, the Strait of Çanakkale is the southern gate of the system that connects the Black Sea countries with the other countries of the world. Due to the heavy maritime traffic, it is important to scientifically examine the accident characteristics in the region. In particular, the results indicated by the descriptive statistics are of critical importance in order to strengthen the safety of navigation. At this point, exploratory data analysis offers strategic outputs in terms of defining the problem and knowing the strengths and weaknesses against possible accident risk. The study aims to determine the accident characteristics in the Strait of Çanakkale with temporal and spatial analysis of historical data, using Exploratory Data Analysis (EDA) as the research method. The study's results will reveal the general characteristics of maritime accidents in the region and form the infrastructure for future studies. Therefore, the text provides a clear description of the research goals and methodology, and the study's contributions are well-defined.

***Keywords*—**Maritime Accidents, EDA, Strait of Çanakkale, navigational safety.

I. Introduction

THE Strait of Çanakkale is a natural waterway between the Marmara Sea and the Aegean Sea. Its length is 37 nautical miles [1]. The narrowest part of the Strait is measured as 1,200 meters between Kilitbahir and Çanakkale. On the other hand, the widest area was recorded as 8,275 m between the shores of İntepe and Domuz Stream. The average depth in the Strait is 60 m. The deepest point is 106 meters between Kilitbahir and Çanakkale [2], [3]. The shallowest point was recorded as 2.0 meters on Çardak Bank. Due to geomorphological conditions, a ship passing through the Strait is faced with at least 10 course changes. Two of these course changes are sharp and very wide angles. These are 70° and 50° turns for Nara and Kilitbahir, respectively [1].

Maritime traffic in the Strait of Çanakkale is operated within the scope of the Turkish Straits Maritime Traffic Regulation, under the control of Ship Traffic Services and within the Traffic Separation Scheme, taking into account the IMO's resolutions A.857(20) and A.827(19) [4]. The Strait hosts an intense international maritime traffic. In 2022, 42.340 ships passed through the region [5].

The text contributes to the solution of identifying the characteristics of maritime accidents in the Strait of Çanakkale, which is crucial for developing accident prevention measures. It also provides a framework for future studies to investigate the topic further.

The topic is scientifically and methodologically significant since maritime accidents in busy waterways can have significant economic, environmental, and social impacts. Analyzing the accident characteristics through EDA can provide valuable insights into how to improve safety measures and reduce the likelihood of accidents in the future.

In essence, EDA is an analysis technique that describes data statistically and helps to see the big picture by visualizing the descriptive statistics obtained with various graphs. The main plots commonly used in EDA are line, bar, boxplots, and pie charts. Frequency table, histogram and scatterplots are also frequently used tools in EDA [6]-[8]. The question or issue is clearly stated in the text. The study aims to investigate maritime accidents that occurred in the Strait of Çanakkale between 2001 and 2015, focusing on ship type and accident type. The use of EDA as a research method is appropriate for the research question addressed. EDA is a powerful exploratory tool that can help identify patterns, trends, and relationships in complex datasets, making it an appropriate method for analyzing maritime accident data.

II. Study Area

Marine traffic in the Strait of Çanakkale is tracked by radar, Automatic Identification System, closed circuit television cameras, ENC, VHF devices such as RT, DSC and DF. Furthermore, Vessel Traffic Services (VTS) provides services that are critical for navigational safety to ships passing through the Strait of Çanakkale. These are information, navigational assistance and traffic organization services [4]. Maritime traffic operating on the Strait of Çanakkale is monitored by VTS within three VTS sectors. These are the Gelibolu, Nara and Kumkale sectors, from north to south, respectively. These sector areas are given in Fig. 1.

III. Materials and Method

This study aimed to contribute literature via determining the characteristics of the region in terms of navigational safety. For this purpose, maritime accidents in the Strait of Çanakkale have

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been investigated by EDA. It is a process about discovering data. This process starts with getting to know the data and looking for answers to our questions about the data. With EDA, it is possible to generate various graphs from the data, transform it, model it and visualize descriptive statistics [9]. At the end of this process, it becomes clear which questions we can seek answers to with the data set. The selection of appropriate methods and techniques for our research becomes easier. EDA contributes to the literature by creating the infrastructure for many scientific studies to be done in the same field.

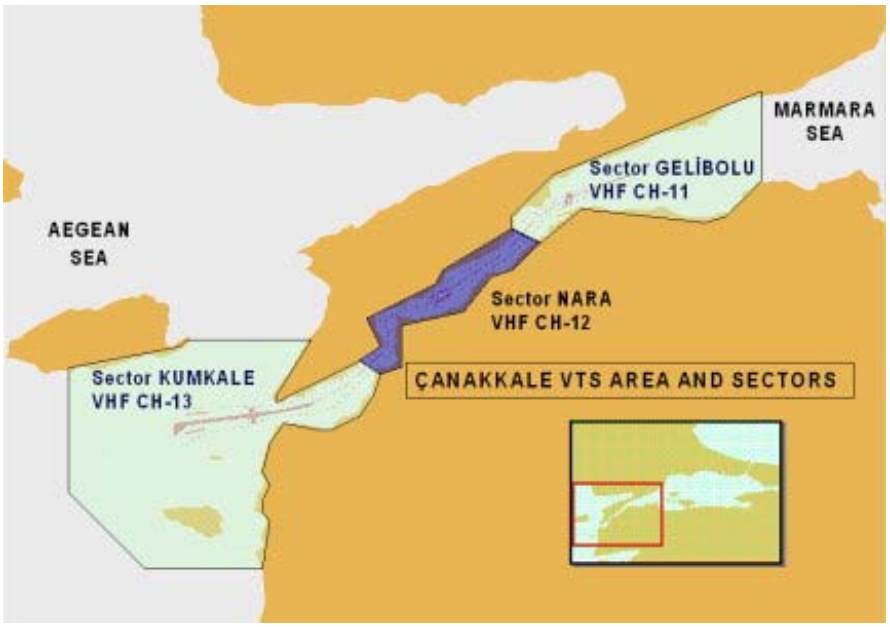

Fig. 1 Sector borders of Çanakkale VTS [4]

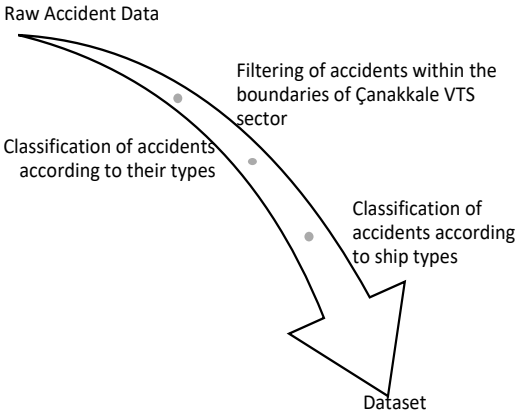

Fig. 2 Dataset Creation Process

In this study, maritime accidents that occurred in the Strait of Çanakkale between 2001 and 2015 were examined with EDA in terms of accident type, ship type and accident area. Pie charts, boxplots and bar graphs are produced at macro scale from the analysis results. The time-dependent changes of all three variables are examined at the micro level and visualized with the help of time series.

The data used within the scope of the study have taken from the Republic of Turkey Ministry of Transport and Infrastructure Main Search and Rescue Coordination Center. The data set is obtained by filtering the accidents occurring within the boundaries of Çanakkale VTS sector areas among all accident records. In this context, 211 accidents that took place between 2001 and 2015 were reached. The dataset creation process is given in Fig. 2.

IV. Result and Discussions

The distribution of maritime accidents in the Strait of Çanakkale between 2001 and 2015 according to ship types is given in Fig. 3. According to the results of the pie chart, the distribution of the accidents according to the ship types are General Cargo, Tanker, Bulk Carrier, Ferryboat and Container, respectively.

Distribution of accidents by types is given in Fig. 4.

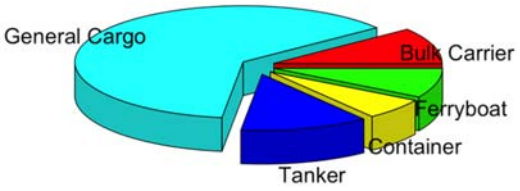

Fig. 3 Pie chart distribution of Maritime Accidents by Ship Types

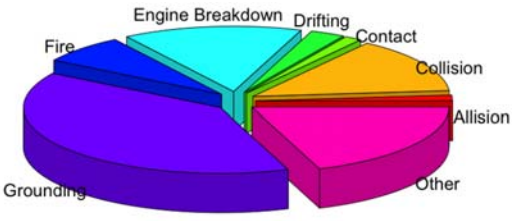

Fig. 4 Pie chart distribution of Maritime Accidents by Types

According to Fig. 4, the main accident types in the region are respectively; Grounding, Other, Engine Breakdown, Collision, Fire, Drifting, Contact, Allision.

The distribution of accidents by sectoral regions is as in Figs. 5 and 6. According to the results obtained, the spatial distribution of the accidents is Sector Nara, Sector Gelibolu and Sector Kumkale, respectively, according to the sector areas.

Bar plots of the time-dependent change of accidents according to sectoral areas are presented in Fig. 6. When the bar plots of the distribution of accidents by years are examined, 2008 stands out and it has seen that the accidents have concentrated in the Sector Nara. Results show that 2008 has been the only year in which the number of accidents exceeded 15 in all three sectors.

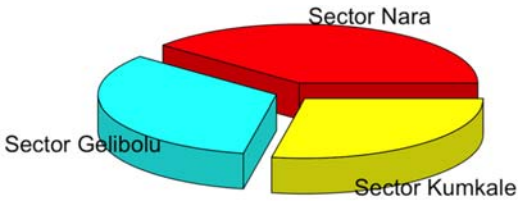

Fig. 5 Pie chart distribution of Maritime Accidents by Sectoral Area

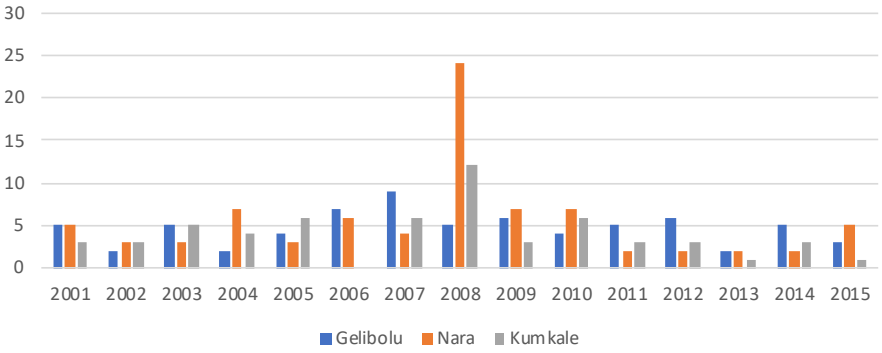

Fig. 6 Bar plots of the time-dependent change of accidents according to sectoral areas

The boxplot regarding the spatial distribution of the accidents is given in Fig. 7.

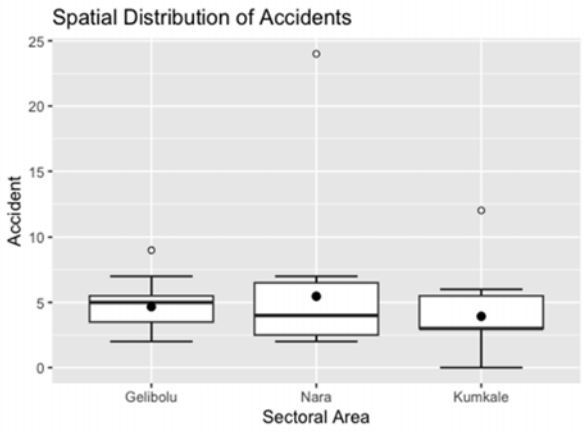

Fig. 7 Boxplots of spatial distribution of the accidents

The 15-year accident average is 4.6, 5.4 and 3.9 for the Gelibolu, Nara and Kumkale sector areas, respectively. Possible outliers have observed in all regions. While the mean value has below the median value in Sector Gallipoli, the opposite situation has observed in Nara and Kumkale.

The results obtained showed that the accidents that occurred in the Strait of Çanakkale during the 15-year period have concentrated within the boundaries of Sector Nara. Furthermore, most common type of accident is grounding. Lastly, ship type with the highest accident rate is General Cargo.

After the spatial analysis, the accident data were analyzed temporally. In this context, 15 years of accident data were firstly analyzed on a macro scale on an annual and monthly basis. The results obtained have revealed the general profile of the accidents in the region. The findings are given in Figs. 8 and 9.

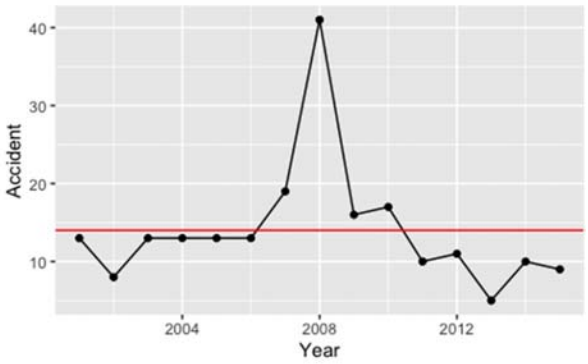

Fig. 8 Annual change of accidents

When the change of the accidents over the years is examined, the 15-year average of accidents has been obtained as 14. The number of accidents reached its peak with 41 accidents in 2008. The number of accidents in 2007, 2008, 2009 and 2010 is above the 15-year average.

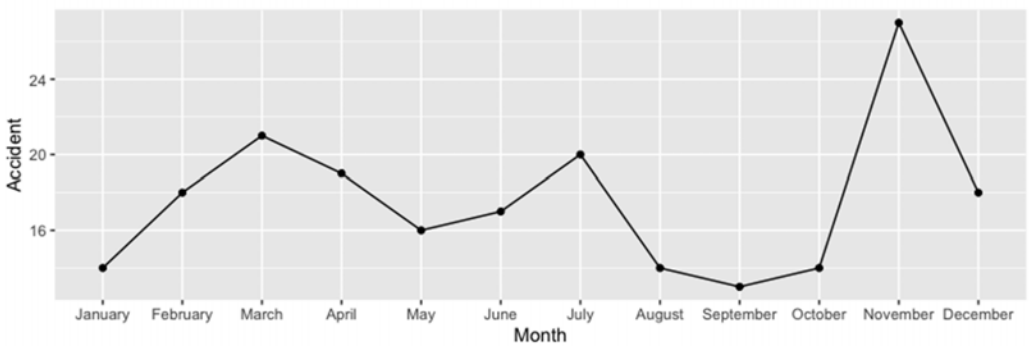

Fig. 9 Monthly change of accidents

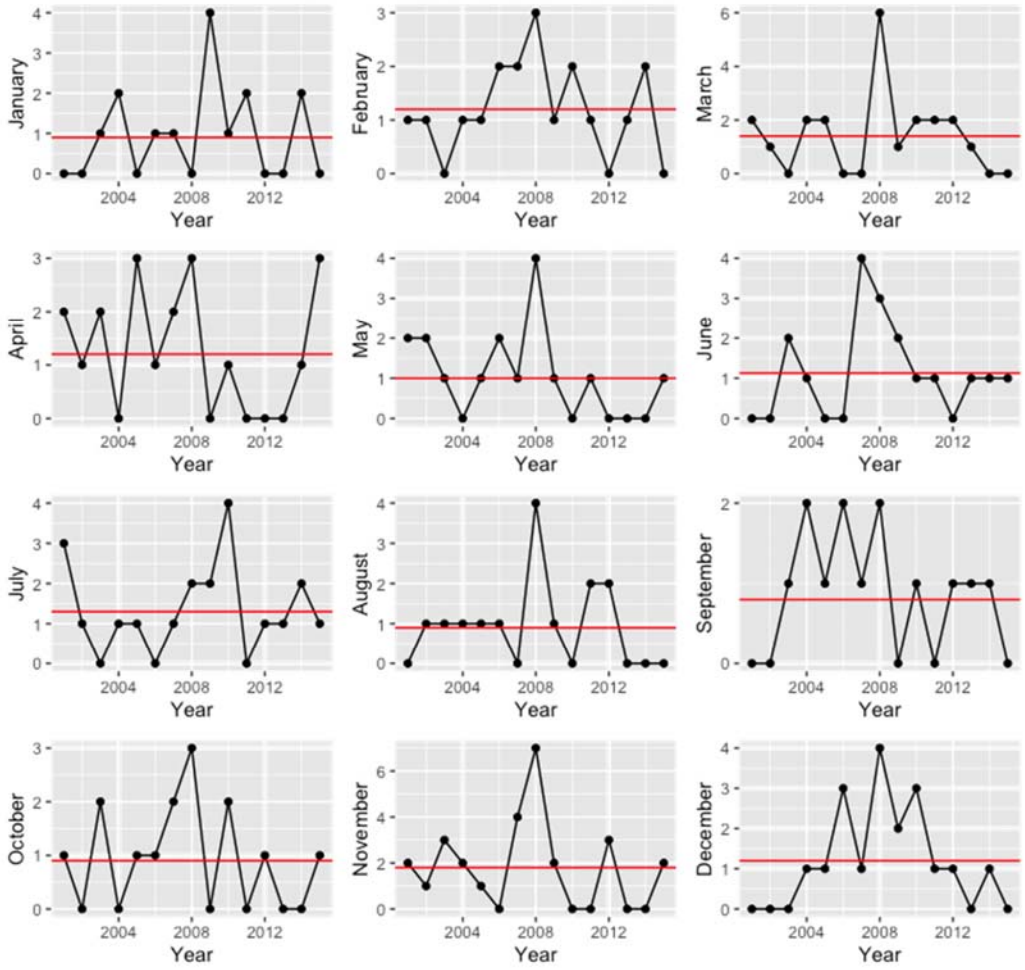

Fig. 10 Monthly change of accident micro perspective

The distribution of the total number of accidents for 15 years by months showed that the highest number of accidents in the region occurred in November.

When the temporal changes of the accidents depending on the months are examined on a micro scale, the results in Fig. 10 have been obtained.

In terms of the number of accidents, a 15-year profile was followed for each month. It has been observed that the accident average for all months varies between 1 and 2. It has been observed that the maximum number of accidents on a monthly basis is at most 6. The results obtained are given in Fig. 11 when the time-dependent change of accidents is examined in terms of accident types.

While the upper limit for the annual number of accidents is 4 in Collision and Fire, this number is recorded above 10 in Grounding and Engine Breakdown. The accident averages exhibited different behavior for each accident type. While the annual number of accidents in Contact type accidents varied between 0 and 1, the number of accidents for Drifting and Allision have changed between 0 and 2. The bar plot of the

time-dependent change of accident types is given in Fig. 12.

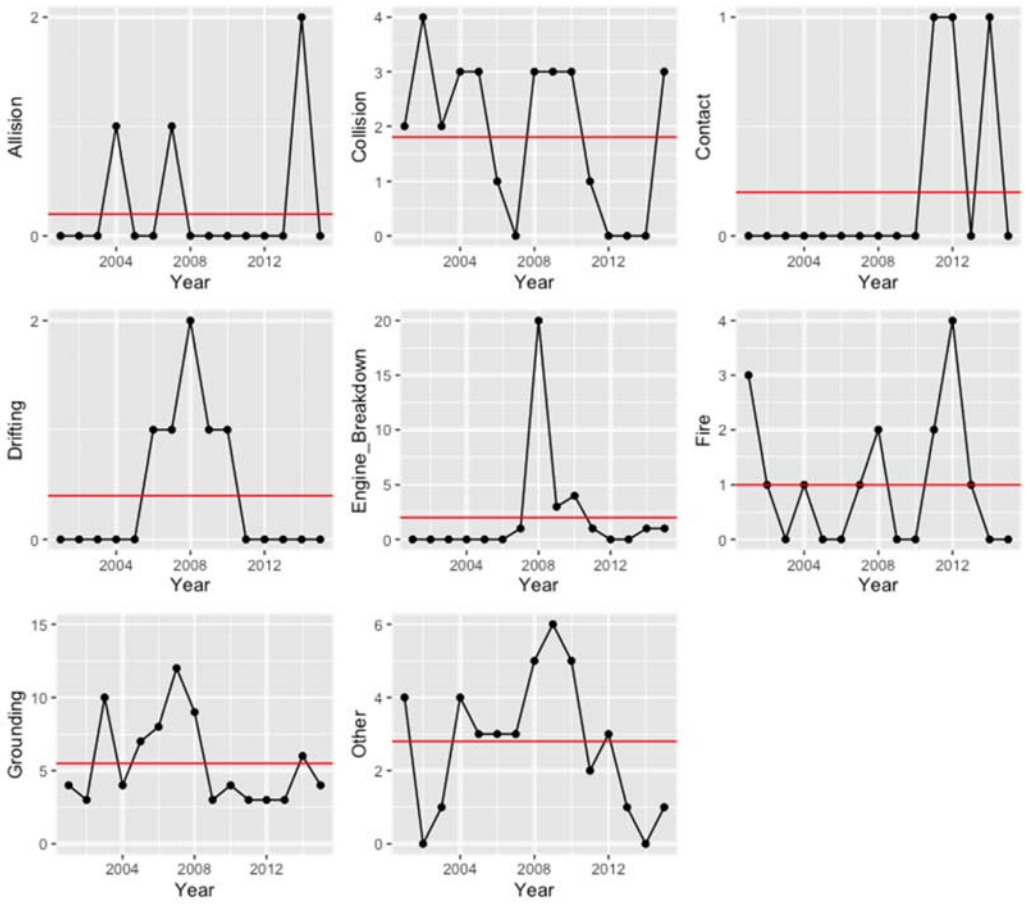

Fig. 11 Annual change of accident type

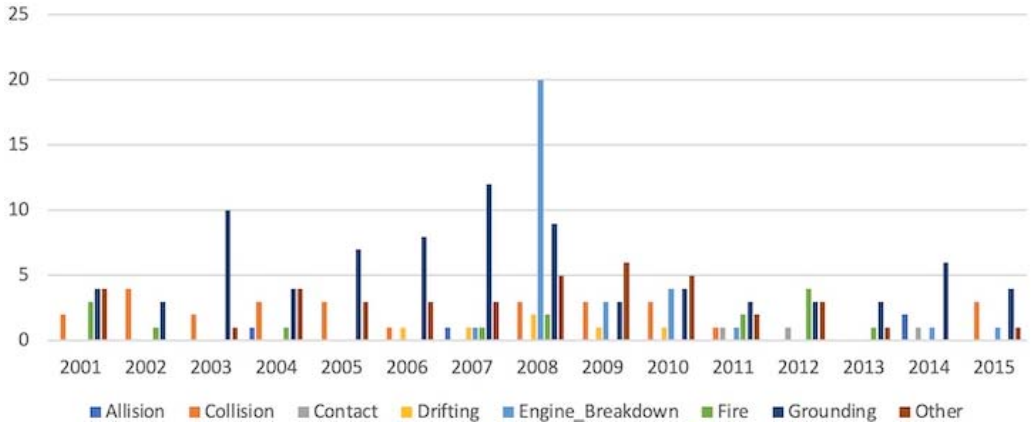

Fig. 12 Bar plots of time-dependent change of accident types

When the time-dependent change of accident types in the 15-year period is examined, it is striking that the major accident type in the region is grounding. In 2008, Engine Breakdown type accidents constituted the highest value in 15 years.

When the time-dependent change of accidents has been examined in terms of ship types, the results obtained are given in Fig. 13.

When the 15-year accident average is analyzed on a ship basis, it has been observed that the average varies between 1 and 2 for ships other than General Cargo. On the other hand, the average of 15-year accidents is around 10 in General Cargo type ships. The bar graph of the time-dependent variation of ship types is given in Fig. 14.

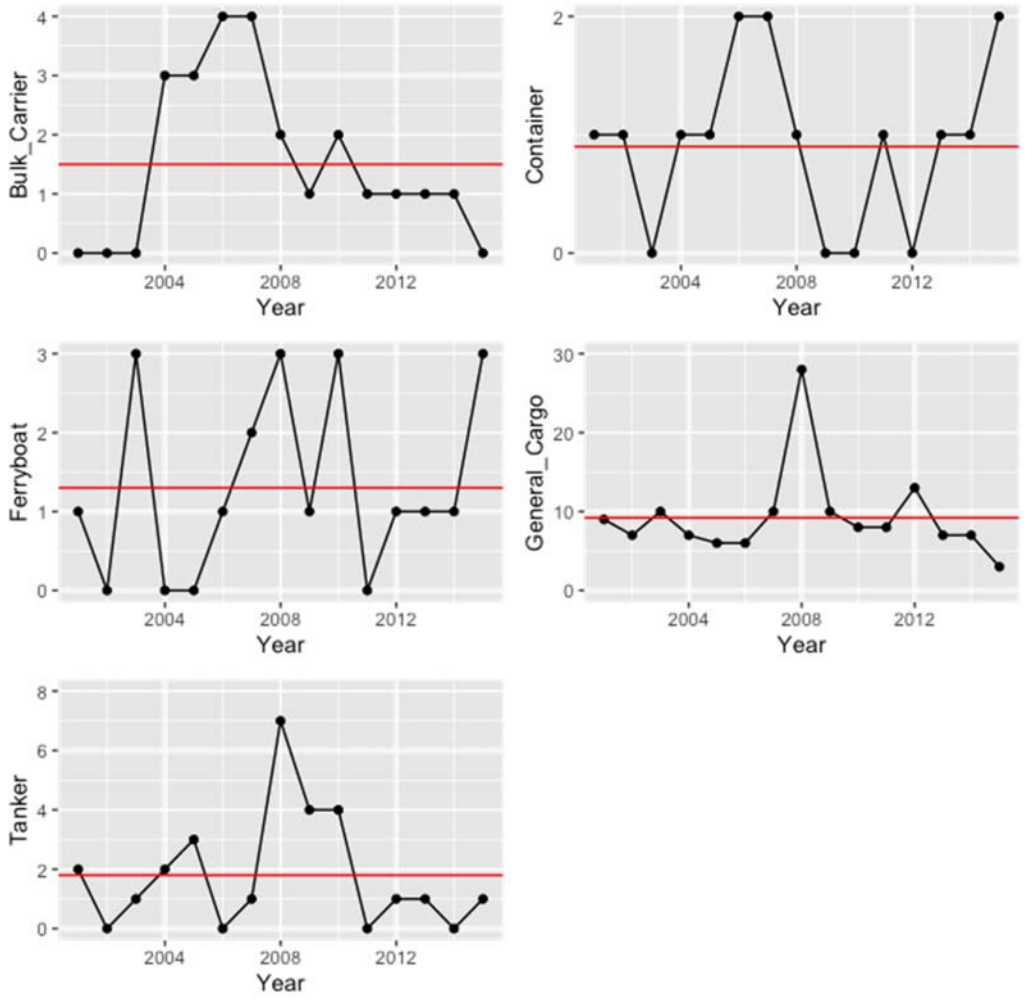

Fig. 13 Annual change of ship type

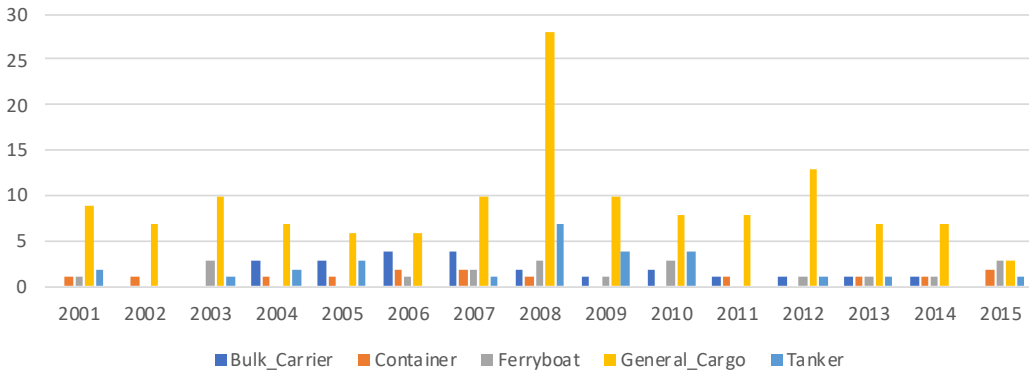

Fig. 14 Bar plots on the annual change of maritime accidents according to ship types

When the accidents are examined in terms of ship types, it is seen that General Cargo type ships are in the first place every year. 2008 is the year in which the number of accidents reached its maximum value in a 15-year period.

V. Conclusion

The outputs obtained as a result of the EDA focusing on maritime accidents in the Strait of Çanakkale during the 15-year period is as follows:

- When the maritime accidents are analyzed in terms of ship types, it has been observed that the highest number of accidents belonged to the general cargo type ships.
- When maritime accidents are examined in terms of accident types, it is seen that the most frequently observed accident type is grounding with a noticeable difference.
- When maritime accidents are analyzed from a spatial

perspective, it has been observed that the accidents are concentrated within the boundaries of Sector Nara.

- When maritime accidents are examined temporally, the average of 15-year accidents is 14.
- Time series graphics drew attention to 2008. The maximum number of accidents in a year for 15 years is below 20, while 41 accidents took place in the Strait in 2008.
- When the monthly distribution at the macro level is analyzed, the time series graphs indicate that November stands out. When the monthly change is considered at the micro level, it has been observed that the number of accidents generally varies between 1 and 2.

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