Determination of Risk Levels in the Southern Aegean Region in Terms of Ship Accidents Using Geographic Information System (GIS)

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Abstract

The aim of this study is to determine the risk levels of the marine areas in the Southern part of Aegean Region related to ship accidents using Geographic Information Systems (GIS). In this context the spatial analysis was performed using multiple spatial data provided by Turkish Main Search and Rescue Coordination Center (TMSRCC). A total of 130 ship accidents involving 9 different ship types were included to carry out risk assessment process. The location distribution of ship accidents was analyzed with MapInfo 8.0 software, and then risky areas and risk levels were identified in accordance with the accident frequencies. It is concluded that the accidents frequently occur in yachts and listing/capsizing are the most frequent accidents. As a result, Bodrum and Fethiye have been identified as very high risk (VHR) zones depending on the number of ship accidents.

Key words: Gis, Aegean region, ship accidents, spatial analysis.

1. Introduction

In the last 50 years, the density of sea traffic in the Aegean Sea has increased significantly. This increase in ship traffic also increases the likelihood of sea accidents, which may have long term environmental and socio-economic impacts. The most risky area in terms of sea accidents in the Mediterranean region is the Aegean Sea. The diversity marine environment in the Aegean Sea varies from the other regions which may have catastrophic consequences in case of an accident. It is therefore vital to reduce the likelihood of accidents in the area [1,2].

GIS has an extremely important infrastructure in terms of making, analyzing and interpreting the spatial analysis of ship accidents. This system has become a frequently used method in recent years especially in terms of identifying the points where accidents are likely to occur and risk assessment. Furthermore, in terms of being a living system with the possibility of updating the data, the decision makers are also easy to take an instant reaction [3].

2. Literature Review

Geographical Information System (GIS) is an information system that stores, interprets and uses geographic information in the simplest terms [4, 5, 6]. GIS includes location information of the data in addition to the attribute information of the different objects as a difference from Information System (IS) [7]. Data collection for the GIS is defined as the compilation and digitization of graphic and non-graphical information required for a GIS [8]. GIS provide an applicable information system in every field where geographic data exists. This method frequently used in the analysis of population density, intelligent map production, appropriate site selection, pollution modeling, three-dimensional terrain modeling, health management and transportation planning [9]. The most important stage of GIS is the accumulation and processing of data. The most important part of this phase is to accurately express the statistical data of the field to be studied [10]. In this study, initially, provided statistical data was identified and

classified. Then, the data set was created using encoded ship coordinates. A data set was established using the descriptive data of accident reports (accidents reasons, accident type, coordinates, date, and time or zone name) and ship information (gross tonnage, name, and flag) related to ship accidents [11].

3. Materials and Method

In this study, it was aimed to determine risk levels of areas in Southern Aegean Region in terms of ship accidents using a spatial analysis. Within this scope, MapInfo 8.0 software based on Geographical Information System was used in order to be able to perform analysis. The "Point Density" analysis which uses two different methods (simple and kernel density) was used to perform the spatial analysis in the study.

Both methods use a circular region or scan region for density calculation [6]. This method is used to identify and monitor the point distribution of data in an area. This method makes it possible to analyze the number of spot accidents in a given cell or pixel [12]. So that with the conduction of the method the risk levels of each 10 km polygons are determined by density analysis method and risky regions are defined.

3.1. Study Site

Aegean Sea region plays an important role in fishing and tourism activities in global industry. The region is hosting habitats with a very rich biological diversity. Due to the increase in ship traffic in the region, the likelihood of ship accidents is also increasing. Passing the narrow strait of more than 1,600 islands scattered all over the Aegean is quite risky for ships [13]. Due to the geographical suitability of this region, it is hosting quite a lot of tourism facilities such as marinas as shown in Fig. 1.

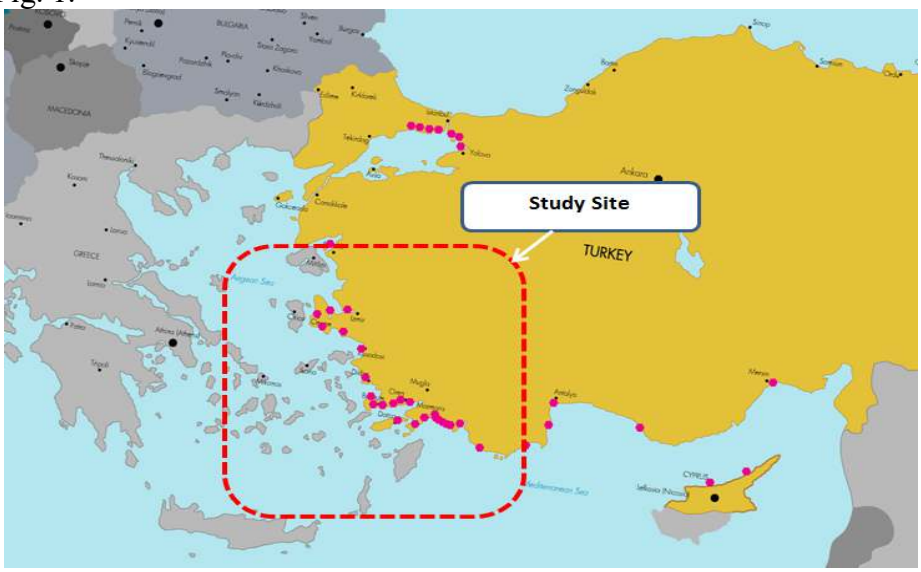

Figure 1. Marina distributions in Turkey

As can be seen from the figure that marinas are mostly concentrated in the southern Aegean region. In recent years the region has become quite popular tourism destination in the world with

natural and historical features. Therefore, the region is also a traffic-intensive region where different types of vessels frequently sail. Ship traffic density of study site is shown in Fig. 2.

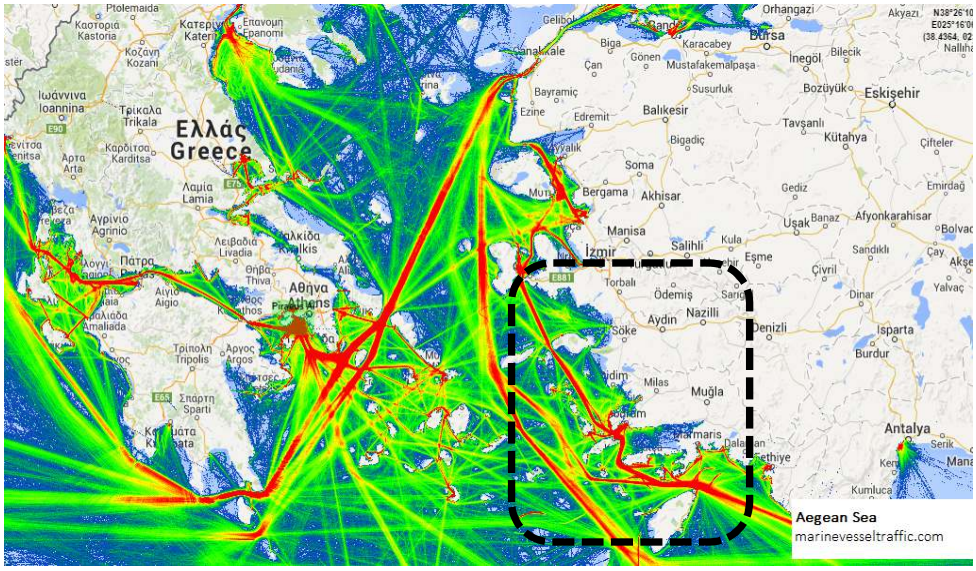

Figure 2. Aegean sea shipping traffic density map (2017)

Note. The color coding represents traffic density in each area. The numbers refer to quantity of distinct vessels on a daily basis and count their positions per square km. The colors stand for: blue—less than 30; green—30 to 70; yellow—71 to 140; red—more than 140.

There is an increase in maritime traffic density, which may pose risks to the community as a result of vessel collisions, fires and other accidents. Such incidents may result in spills and discharges that might spread, affecting marine life and environment. The region is not only a voyage area for commercial vessels, but also for sightseeing boats in tourist activities and passenger ships for island transportation. In this context, almost 75-80% of the yacht fleet consists of traditional wooden or classical boats that have been in the Aegean and Mediterranean waters for hundreds of years.

3.2. Findings

In this study, ship accidents occurred in the southern Aegean region was taken into consideration. In this context, it has been observed that a total of 130 ship accidents covering 9 different emergency situations that resulted in collision, grounding, drifting, capsizing, flooding, machinery failure, contact, medical evacuation, and fire occurred in the area. The detailed descriptive accidents information which covers data between 2001 and 2016 were obtained from TMSRCC database. The details of each accident were entered into the software of Map Info Version 8.0. in the following format.

Table 1. Ship accidents details format

Date	Time	Region	Latitude	Longitude	Ship Name	Gross Tonnage	Flag	Accident Cause	Accident Type
20.10.2014	08:30	Fethiye	36.65	29.1	Delphin	8.63	Turkey	Flooding	Capsizing

The data obtained is entered into Microsoft Excel software and subsequently converted into a format that can be used in MapInfo 8.0. software. The descriptive information on accident statistics is shown on the following table.

Table 2. Descriptive information of accidents

SHIP TYPE		FLAG			
Fishing Vessel	14 (10.7%)	Germany	7 (5.4%)	Malta	1 (0.8%)
Bulk Carrier	2 (1.5%)	United States	4 (3.1%)	Norway	1 (0.8%)
Fiber Boat	1 (0.8%)	Bahamas Island	1 (0.8%)	Panama	2 (1.5%)
Recreational Craft	8 (6.2%)	Cayman Island	1 (0.8%)	Sierra Leone	2 (1.5%)
Pleasure Craft	1 (0.8%)	Denmark	1 (0.8%)	ST. Vincent	3 (2.3%)
Chemical Tanker	1 (0.8%)	France	2 (1.5%)	Togo	1 (0.8%)
General Cargo	7 (5.4%)	Georgia	2 (1.5%)	Turkey	88 (68%)
Oil Tanker	1 (0.8%)	Holland	1 (0.8%)	Greece	3 (2.3%)
Powerboat	15 (11.5%)	England	8 (6.2%)		
Yacht	74 (57%)	Italy	1 (0.8%)		
Cruise Ship	6 (4.6%)	Comoros Island	1 (0.8%)		

As seen in Table 2, most of the ships involved in the accident are yachts 57% (74), powerboat 11.5% (15) and fishing vessel 10.7% (14). It is seen that a large majority of the vessels 68% (88) involved in the accidents are Turkish flagged. The accident types are shown in Fig. 3.

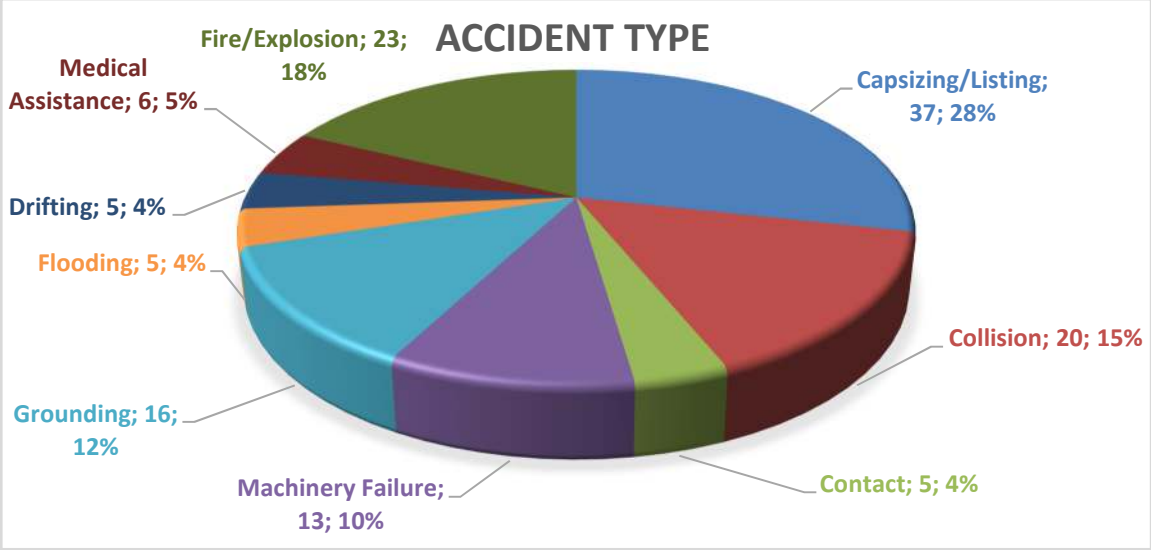

Figure 3. Accident types

As can be seen from the figure that the type of accidents most frequently experienced in the region is capsizing/listing with the rate of 28.5%. This type of accident is followed by collision with the rate of 15% and fire with the rate of 18%. The distribution of accidents' types with regarding to ship types is shown in Table 3.

Table 3. Accidents' types distributions by ship types

	Capsizing/ Listing	Collision	Contact	Machinery Failure	Grounding	Flooding	Drift	Medical Assistance	Fire/ Explosion
Fishing Vessel	5	3	2	1	2			1	
Bulk Carrier						1	1		
Fiber Boat	1								
Recreational Craft	7								1
Pleasure Craft		1							
Chemical Tanker								1	
General Cargo					5			2	
Oil Tanker					1				
Powerboat	4	7	1		1		1		1
Yacht	17	9	2	11	6	4	3	2	20
Cruise Ship	3			1	1				1
Total	37	20	5	13	16	5	5	6	23

The most frequent emergency situation on fishing vessels is capsizing, while yachts have a fire and explosion. The most important and necessary step in this study is the creation of a database and the questioning of data. By putting a certain datum (reference system) of the geographical element on the ground and collecting the data containing the position (coordinate) information in the projection setup, it is ready to be used in MapInfo software in Microsoft Excel. The positional analysis of ship accidents was carried out by "Point Density Analysis" method in MapInfo software. Figure 4 shows the regional distribution of the accidents obtained from the database.

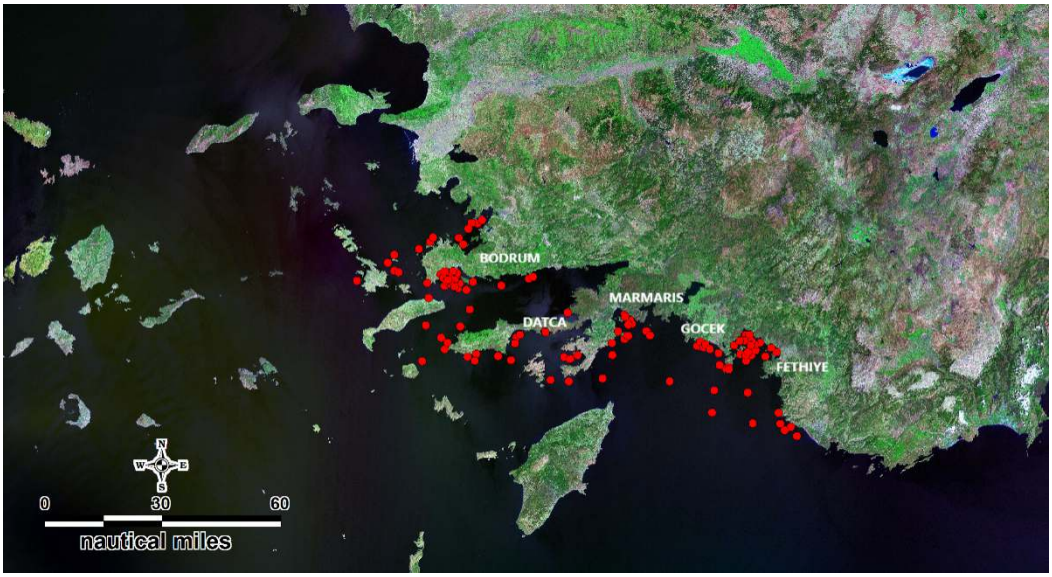

Figure 4. Geographical distributions of ship accidents

Figure 4 shows that the ship accidents are mostly located near the shore and in the inner areas of the port. It is seen that ship accidents are concentrated especially around Bodrum and Fethiye.

Figure 5 and figure 6 show the geographical distribution of ship accidents according to ship types and accident types.

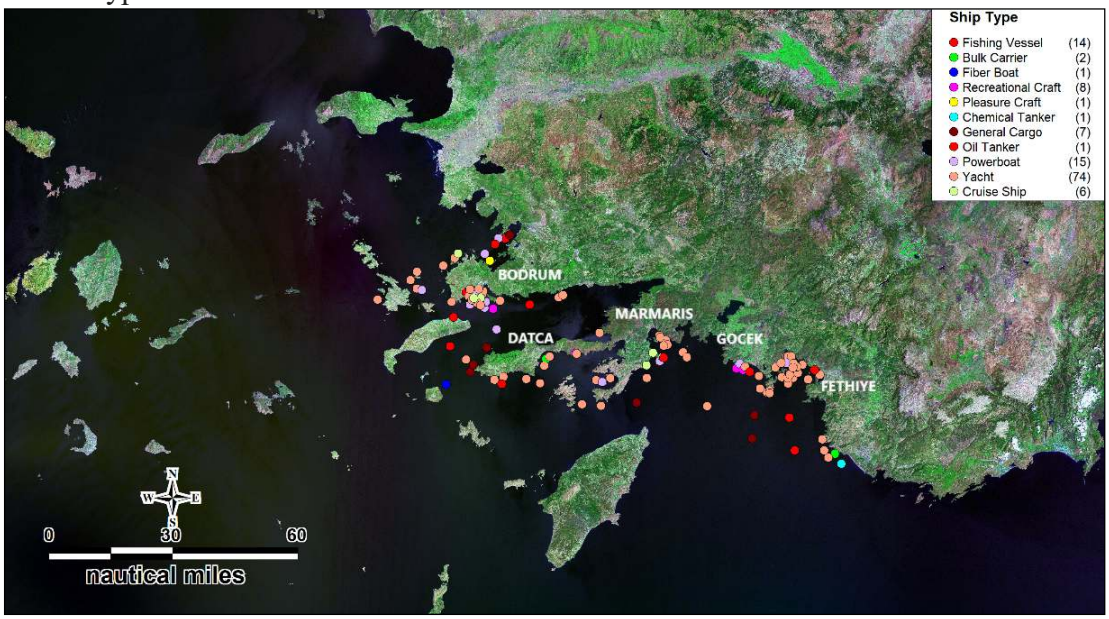

Figure 5. Geographical distribution of ship accidents according to ship types

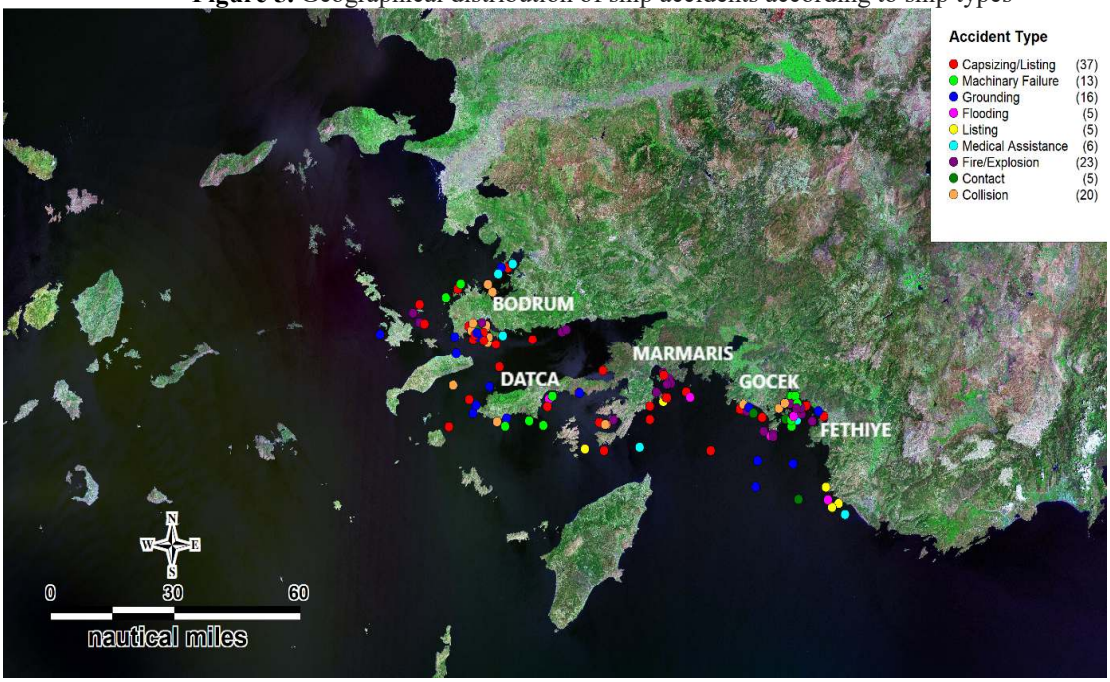

Figure 6. Geographical distribution of ship accidents according to accident types

As seen in Figure 6, it is observed that collisions due to intensive port operations are frequently experienced especially in areas close to the land and inside the port. In coastal areas, capsizing and listing accidents are also frequently observed.

After performing the spatial analysis of the ship accidents using GIS, the risk levels were determined by dividing the South Aegean region into 10 km polygon areas. These risk levels

include very high risk, high risk, medium risk and low risk marine areas. In order to classify the risk levels of marine areas, the scale used by [12,14] have taken as a reference. According to this classification, marine areas are classified as low risk (Low Risk 0<x<3), medium risk (Medium Risk 3<x<6), and high risk (High Risk 6< x<15) [14]. The distribution of the risky areas for the accidents investigated in the study is shown in Figure 7.

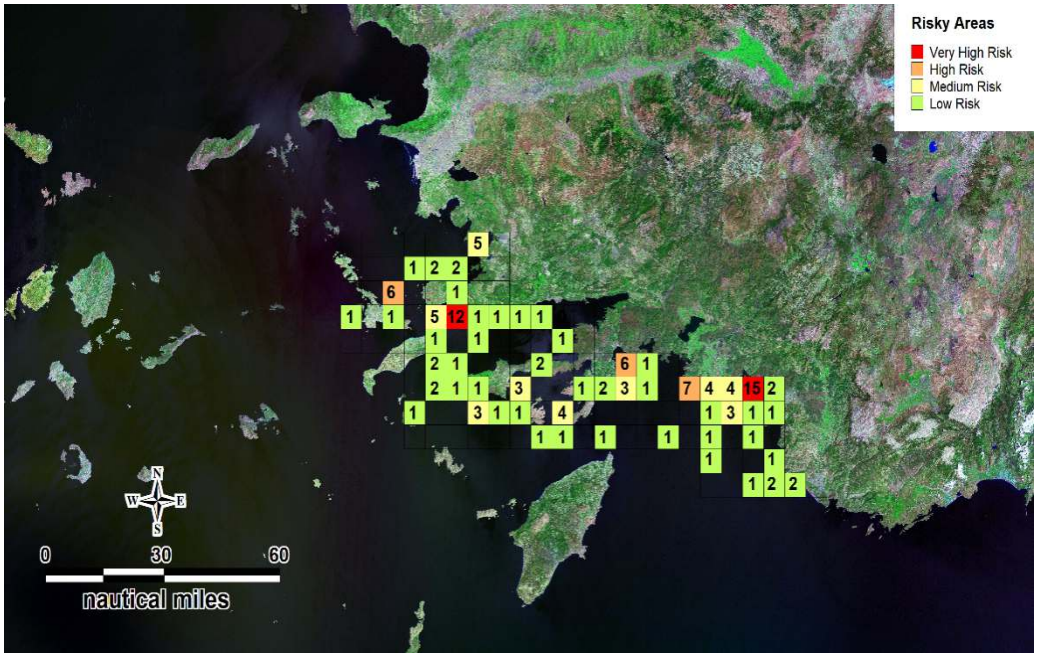

Figure 7. Risk levels of areas

It is seen in the figure that the region covering Bodrum Marina and Göcek marina found as VHR (Very High Risk) zone while the region including Marmaris Setur Marina, Dalyan and Bodrum Turgutreis region is HR (High Risk) zone. The port of Güllük, located in the northern part of Bodrum peninsula, is one of the most important industrial areas where large tonnage of bulk cargo is handled. This area identified as the MR (Medium Risk) region where groundings and capsizing accidents frequently occur. Dalaman, Icmeler region of Marmaris and Selimiye seas are identified as MR (Medium Risk) areas. Other areas in the study area carry the LR characteristics.

In summary, due to the increase in marine tourism potential, yacht traffic has increased and accordingly there has been a visible increase in accidents that have occurred in yachts. The southern Aegean regions with their yacht berthing capacity also increase the likelihood of ship accidents due to intensive yacht and leisure boat traffic.

Conclusions

In this research, ship accidents in the South Aegean Region were examined and their spatial analyzes were carried out with MapInfo 8.0 software supported by Geographic Information Systems. In this context, only the data of accidents occurred in the years of 2001 and 2016 are obtained from TMSRCC database. Future studies for Turkey's importance for marine tourism digger coastline can be done by taking cover general risk mapping and spatial analysis.

One of the most important conclusions of the study was that ship accidents were frequently experienced in Bodrum and Fethiye regions classified as high risk areas. In these areas with intensive yacht traffic, the establishment of emergency response stations and the recruitment of qualified personnel are needed to minimize bad effects of accidents. It is revealed that the boat crews navigating in the region should be inspected more frequently in terms of taking safety precautions.

One of the other important consequences of the investigation is the incident of listing and capsizing are frequently happening to the boats particularly small-tonnage fishing boats and yachts. It is recommended to take extra precautions to restrict the voyage of these boats especially in bad weather conditions.

Regional risk assessments can be made by experts within ports or yacht harbors to reduce risk levels. It may be possible to reduce the risk levels by establishing an effective communication network between the yacht captains or other marine craft captains and by using the necessary navigational monitoring systems. Therefore, it is one of the targets for further studies to ensure that priority activities do not affect marine tourism and that the risk levels of the region are minimized.

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