Received: 05.03.2019
Accepted: 17.01.2020
Published Online: 02.06.2020
DOI: 10.18613/deudfd.740152
Research Article

Dokuz Eylül University
Maritime Faculty Journal
Special Issue pp:1-26
ISSN:1309-4246
E-ISSN: 2458-9942

AN ANALYSIS OF MARINE ACCIDENTS IN THE STRAIT OF ÇANAKKALE

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ABSTRACT

The Strait of Çanakkale, is connecting the Black Sea with the Aegean Sea and Mediterranean by the Sea of Marmara is one the most important and risky straits in the world. Nearly 45.000 ships passed through Çanakkale in 2017. Çanakkale Strait contains high risks for marine accidents such as grounding and collision due to intense marine traffic. In the study, the marine accidents that occurred in the Strait of Çanakkale for 2001- 2015 have been analysed by using frequency distribution and Chi Square Test. The main findings of the study are as follows: The most accidents occurred between September and November; the most accidents occurred in the hours between 24:00–04:00; grounding/stranding was the most common accident type, respectively collision to occur in the Strait of Çanakkale;dry bulk ships were involved in the most accident, respectively cargo ships; the ships with a gross tonnage of less than 3,000 gross tonage and Turkish Flag vessels were those most involved in accident, human error is the maincause of accidents. As a result of the study suggestions for measures to be taken are given for the prevention of accidents and environment protection.

Keywords: *Marine accidents, safety of navigation, The Strait of Çanakkale, grounding, collision.*

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ÇANAKKALE BOĞAZI'NDA MEYDANA GELEN DENİZ KAZALARININ ANALİZİ

ÖZ

Çanakkale Boğazı; Karadeniz'i Marmara Denizi vasıtasıyla Ege Denizi ve Akdeniz ile birleştiren dünyanın en önemli ve riskli boğazlarından biridir. Çanakkale Boğazı'ndan 2017 yılında yaklaşık 45.000 gemi geçmiştir. Çanakkale Boğazı, yoğun trafik nedeniyle karaya oturması ve çatma gibi deniz kazaları açısından yüksek riske sahiptir. Bu çalışmada, 2001-2015 döneminde Çanakkale Boğazı'nda meydana gelen deniz kazaları frekans dağılım ve Ki-Kare Testi (Chi Square Test) kullanılarak analiz edilmiştir. Çalışmanın başlıca bulguları şunlardır; Çanakkale Boğazı'nda en fazla kaza Eylül ve Kasım ayları arasında olmakta, en fazla 24:00–04:00 saatleri arasında meydana gelmekte; en fazla kaza türü karaya oturma/kıyıya çarpma daha sonra çatma olup, en fazla kazaya kuru yük gemileri daha sonra genel yük gemileri karışmakta; en fazla kazaya 3000 gross tonajdan daha az tonajlı gemiler ile Türk Bayraklı gemiler karışmakta ve insan hatası başlıca kaza nedeni olmaktadır. Çalışmanın sonucunda, genel bir değerlendirme yapılarak kazaları önlenmsie ve çevrenin korunması ile ilgili alınacak tedbirlere ilişkin öneriler verilmiştir.

Anahtar Kelimeler: *Deniz kazaları, seyir emniyeti, Çanakkale Boğazı, karaya oturma, çatma.*

1. INTRODUCTION

Approximately 90% of global trade is transported by sea. Sea transport enables large quantities of cargo to be carried and is 3.5 times cheaper than railway transport, seven times cheaper when compared with road transport and 22 times cheaper than air transport (DPT, 2007).Asthe preferable mode for the transport of goods in large quantities,continuing growth is inevitable and despite the ever-increasing emphasis on safety standards, there will continue to be risk in marine transport (Nas, 2011: 10). The Turkish Straits, connecting the Black Sea and the Aegean, is one of the most congested and perilous waterway areas anywhere in the world. It also has geo-strategic and geo-political importance. The Montreux Convention of 1936 approved the current international status of the Turkish Straits (BASKENT-SAM, 2017). The Montreux Convention established freedom of passage and navigation with certain formalities for merchant vessels of any flag and with any kind of cargo, by day or night (Ece, 2005: 18; Akten, 2003: 241). According to Article 2 of the Montreux Convention "Pilotage and towage remain optional."

In 2017, 44,615 vessels passed through the Strait of Çanakkale, 9,478 of which were tankers.Çanakkale Strait contains high risks for marine accidentssuch as grounding and collision of the vessels due to the intense marine traffic in the strait and sharp turn in Nara Cape, where the ships run into a strong current.In recent years, local marine traffic, fishing vessels and yacht traffic in the Strait of Çanakkale have increased. As a result of this increase in marine traffic in a confined space, the risk of maritime accidents is also enhanced. Shipping accidents can result in human casualties, damage to property, oil pollution and environmental damage, as well as traffic disruption and financial loss(Akten, 2006: 272).It is not only the size of the commercial vessels passing through the Strait of Çanakkale that has increased; the tonnage of the cargo being carried has increased too. Furthermore, the chemical and hazardous materials in the cargo carried by the ships vary. According to Rule 13 of the Marine Traffic Regulations For The Turkish Straits (2017) the vessel transit speed from the Strait of İstanbul through the Strait of Çanakkale passage is 10 knots (denizmevzuat.udhb.gov.tr, 2017). The captains of ships passing through the Strait of İstanbul can navigate the strait with 12 course alterations; however, this number increases to 15 at the Strait of Çanakkale.The ships are bound alter course at least 12 times at the bends in the Strait of İstanbul and 15 times in the Strait of Çanakkale (Ilgar, 2011: 63-68).

The objective of this paper isto find frequency distributions of accidents by years, months and hours, types and reason, gross tonnage and flag of ships involved in accident; to analyse marine accidentsto reveal whether there is a relationship between type of flag involved in an accident and type of accident;between tonnage of the ships involved inan accident and type of accident;between type of accident and reason for the accident and between hours of accidents and type of ships occuring in the Strait of Çanakkale during the period 2001-2015. Finally, we propose some suggestions to provide navigational safety and environmental safety in the Strait of Çanakkale.

2. LITERATURE REVIEW

Kuleyin and Aytekin (2015) analysed marine accidentsthat occurred between 2004-2014 in the Strait of Çanakkale. They emphasised that the probability of a vessel running aground is greater when the vessel does not have a pilot onboard, that overage/old vessels have more breakdowns and that pilotage in the Turkish Straits should be encouraged, in order to decrease accident risk. Kuleyin and Aytekin (2015) stated that about %1,1 (2 cases) of 182 ship accidents/incidents resulting in death, injury or loss occurred on or involving the Turkish flagged ships between 2012 and 2014 registered in the database of Main Search and Rescue Coordination Center (MSRCC) of Turkey was grounding type of accident.

Ece (2012) analysed accidents that occurred in the Strait of İstanbul in the period from 1982 to 2010. This analysis found that collisions and groundings were the most common type of accident in the Strait of İstanbul and that most of the accidents were attributable to human error. Ece (2016) analysed the contribution of pilotage services to maritime safety in the Strait of İstanbul in the period from 1982 to 2014. The results indicate that 78.4% of ships involved in accidents did not have a pilot embarked in the Strait of İstanbul for the period 1982-2014, .using pilotage services reduces the number of accidents. and the primary reason for accidents was human error and that most of the ships involved in the accidents had not used the pilotage service.

Akten (2006) stated that the majority of accidents are attributable to human error. Özdemir and Güneroğlu (2015) used Hybrid Multiple Criteria Decision-Making(MCDM), combined with a Decision-Making Trial And Evaluation Laboratory (DEMATEL) and Analytical Network Process (ANP) methodology to investigate the human factors in maritime accidents and emphasised that scientific studies revealed that 75% to 96% of maritime causalities associated with professional maritime transportation are related to human error. Their study suggests extending the existing MCDM model by following a hybrid MCDM approach for investigating human-related maritime accidents.

Ilgar (2015) investigated the activity of vessels and determined the accident risk areas in the Strait of Çanakkale. This work concluded with the suggestions thatpilot embarkation and disembarkation points should be notified to vessels that will pass through the Strait of Çanakkale, and that precautions (escort/pilotage) should be taken when substandard vessels pass through the strait..In his study, Tatlısuoğlu (2008) investigated marine accidentsthat occurred in the Strait of Çanakkale and using a statistical analysis method, determined risk of loss of life, goods, ships, and situations causing environmental and marine pollution, together with their impacts. It was concluded that to prevent marine accidentsin the Strait of Çanakkale, there should be an increase in the number and appearance of navigational aids, pilotageshould be encouraged, there should be adequate training and certification for seafarers and care should be taken in all aspects of auditing.

In their study, Kılıç and Sanal (2015) investigated the accidents that resulted in vessels running aground that occurred in the Strait of Çanakkale between 2000 and 2011, using the Fault Tree Analysis method. It was discovered that the most encountered grounding accidents occurred as a result of human error with dry cargo vessels smaller than 15,000 gross registered tonnes, belonging to the Black Sea Memorandum of Understanding on Port State Control (Black Sea MOU). It was concluded that encouraging and increasing pilotage for vessels navigating this area was required. The casualty investigations shows that in most of the accidents, vessels lose their maneuverability in the course of taking a sharp turn with the current. Akten (2004) and Ilgar (2010) examined marine traffic data of the Strait of Çanakkale and investigated the categories of accident. This study revealed that more than 90% of the vessels passing through the Strait of Çanakkale are more than 150 m in length and that collision and grounding are the two types of accident most encountered. Tok et al. (2016) investigated the marine accidentsthat have occurred in the İstanbul Strait and concluded that education standards should be improved and pilotage should be encouraged. Başar (2010) investigated marine traffic and a risky area in the Turkish Straits. The result of the study indicates that the current systems and approximately 90° turning make ship maneuvering difficult at Nara Turning point. Large ships and speed increase would regularly make maneuvering difficult. Thus, Nara point can be considered as a risky area.

3. THE STRAIT OF ÇANAKKALE

3.1. Geographical Fatures of the Strait of Çanakkale

The length of the Strait of Çanakkale is about 30 miles when measured at the midline. The coasts are vertical and the depths are sufficient to navigate without any restriction. The maximum width of 3,200 metres is at the northern border, while at the southern border it is 3,600 metres. The narrowest part of the strait is between Kilitbahir Çanakkale, at 1,200 metres (Ilgar, 2011: 63-68).

3.2. Depths and Banks

The western shorelines of the Strait of Çanakkale, less than 2 km further up the coast, are bordered with rocks and shoals. At the end of the shoals, sea depths suddenly increase to 50-60 metres. Depths vary from 50-80 metres in all navigation channels. At the northern entrance of the Strait of Çanakkale the average depth of 70 metres increases to 85 metres until Nara Cape. The deepest point of the strait is 104 metres, which is also the narrowest part of Nara. In the bays on the eastern coast there are more shallows than on the western side of the Strait. The shoal in front of the Nara Cape is 1,200 metres across, showing depths of 10-12 metres. The width is 400 metres from north to south (Ilgar, 2011:63-68).

3.3.Current System of the Strait of Çanakkale

There is a level difference of about 20 cm between the northern edge of the Strait of Çanakkale and the Aegean coast. There are two current systems opposing each other, referred to as the upper and lower current. From the Marmara Sea to Aegean Sea the water flows above, while the water from the Aegean Sea to Marmara Sea flows below. The current speed is around 1.5-2 knotswhereas at Nara and Kilitbahir currents reach about 4 knots (Başar, 2010: 6-10; UKHO, 1990).

4. MARINE TRAFFIC IN THE STRAIT OF ÇANAKKALE

In 1936, the Montreux Conventiondetermined the international status of the Turkish Straits(BASKENT-SAM, 2017).The Montreux Convention established free passage and navigation with some formalities for merchant vessels of any flag and with any type of cargo, by day and by night. “Pilotage and towage” remained optional. Turkey enacted the Traffic Separation Schemes, accordance with Rule 10 of the Convention on the International Regulations for Preventing Collisions at Seato provide navigational safety and decrease the marine accidents (IMO, 2017). The Maritime Traffic Regulations have been enforced in 1994and revised in 1998.The Republic of Turkey established Turkish Straits Vessel Traffic Service (VTS) Systemwhich has been fully operational since 31 December 2003 (Akten, 2003: 241).In 2018 43.999 vessels passed through the Strait of Çanakkale, 9.247of which were tankers respectively. As shown in Table 1, the rates of pilots on board the vessels were 45% in 2018 (UAB, 2019).

Table 1: Marine Traffic in the Strait of Çanakkale

Years	Total Traffic	Total Tanker Traffic	Ratio of Pilot Employed on Board Ships (%)
2006	48,915	8,157	34
2007	49,913	9,271	34
2008	48,978	8,758	37
2009	49,453	9,567	38
2010	46,686	9,252	40
2011	45,379	8,818	42
2012	44,613	8,998	42
2013	43,889	9,299	43
2014	43,582	9,250	44
2015	43,230	9,524	44
2016	44,035	8,703	43
2017	44,615	9,478	45
2018	43.999	9.247	45

Source: Republic of Turkey Ministry of Transportation and Infrastructure (UAB), TurkishStraits Vessel Transiting Statistics 2006-2018.

5. ANALYSIS OF MARINE ACCIDENTS IN THE STRAIT OF ÇANAKKALE

The material and methods for the analysis of marine accidents in The Strait of Çanakkale is given as follows.

5.1. Data Collection

In this study, the available data has been gathered from the reported accidents statistics from the website of the Republic of TurkeyMinistry of Transportation MainSearch and Rescue Coordination Center (SRCC) and used to create a database of the marine accidentsthat occurred in the Strait of Çanakkale during the period from 2001 to 2015 (MSRCC, 2017).

The database of marine accidentsthat occurred in the Strait of Çanakkale contains 1,312 items of categorised data. These comprise the time and dates of the accidents, the type of the accident (including collisions, stranding/grounding, breakdown, fire/explosion, and furthertypes (contact, foundering, etc)). The data includes the type of ships involved, such as dry bulk ships, cargo ships (container, general cargo, container, Roll On-Roll Off(RO-RO) etc.) and passenger ships containing local traffic (ferryboat, local passenger shipsetc.), other ships and boats (service motorboat, tugboat, RO-RO, navy boats etc.) and the ships involved according to flag status (Turkish and foreign flag). In addition, the data includes the reason for the accidents, including those involving human error, bad weather conditions, currents and breakdown, or other causes. The classification scale has been used to define the category variables and to divide the data into sub groups.

5.2. Methods

The data used in all analysis was obtained from Republic of Turkey Ministry of Transport an Infrastructure Main Search and Rescue Coordination Center (MSRCC, 2017). Frequency Distribution is used to show a summarised grouping of the categorised data, which includes the year, month and hour of the accident, the type of accident, the type of ships involved in the accident, the ships involved in the accident according to flag status and the cause of the accident.

The Chi-Square (χ^2) Test is used to determine if there is a statistically significant relationship between the expected and observed accident data between the years 2001 and 2015. We used Statistical Package For The Social Sciences (SPSS) Version 15procedures to calculate Frequency Distributions, and the Chi Square (χ^2)Test.We tested the null hypothesis H_0that the multinominal probabilities p^1,….., $pk$are equal to a prespecified set of values $p_1=p_1^{(0)}$,$p_2= p_2^{(0)}$, …………, $p_k= p_k^{(0)}$, so that the null hypothesis has the form

$$H_0 : p_1= p_1^{(0)}, ; p_2= p_2^{(0)}, …………, p_k= p_k^{(0)}$$

The Chi Square (χ^2)formula is given as Equation (1) (Navidi, 2011:460):

$$\chi^2 = \sum_{i=1}^{k} \frac{(Observed\ value - Expected\ value)^2}{Expected\ value} = \sum_{i=1}^{k} \frac{(n_i - np_i)^2}{np_i} \qquad (1)$$

The Chi-Square Test can be safely used when all individual expected counts are one or more than one; no more than 20% of expected counts are less than five; the minimum expected count is one or more than one and the samples are simple random samples.The Asymptotic Significance (pvalue)determines the statistical significance of the relationship which is tested. All tests of significance,if $p < 0.05$, there is a statistically significant relationship between the two variables.The asymptotic significance level is determined at 5 % (Cochran, 1954: 417–451; Sheskin, 2004: 494-495).

6. RESULTS AND DISCUSSION

6.1. Frequency Distribution

This study investigated the frequency distribution of ships involved in the accidents. Between 2001 and 2015, 164 marine accidentsoccurred in the Strait of Çanakkale. As shown in Table 2, the most accidents occurred in 2008 (22%) and 2001 and 2007 (7.9%) respectively.The data used in Tables 1-14 was gatheredfrom Republic of Turkey Ministry of Transport and Infrastructure Main Search and Rescue Coordination Center (MSRCC) (MSRCC , 2017).

6.1.1. Frequency Distribution of Marine Accidents by Years

The most accidents occurred in 2008 (22%) and 2001 and 2007 (7.9%) respectivelyin the Strait of Çanakkale during the period 2001 and 2015as shown in Table 2.

Table 2: Frequency Distribution of Marine Accidentsby Years

Years of Accident	Frequency	Percentage (%)	Percentage of Cumulative (%)
2001	13	7.9	7.9
2002	8	4.9	12.8
2003	5	3.0	15.9
2004	11	6.7	22.6
2005	9	5.5	28.0
2006	12	7.3	35.4
2007	13	7.9	43.3
2008	36	22.0	65.2
2009	12	7.3	72.6
2010	12	7.3	79.9
2011	11	6.7	86.6
2012	5	3.0	89.6
2013	4	2.4	92.1
2014	9	5.5	97.6
2015	4	2.4	100.0
Total	164	100.0	

Source: Republic of Turkey Ministry of Transportation and Infrastructure (UAB), TurkishStraits Vessel Transiting Statistics 2006-2018.

6.1.2.Frequency Distribution of Marine Accidentsby Month of Accidents

The most accidents occurred between September and November (28.7%), respectively, between March and May (25.6%), between June and August (25.6%) and between December and February (19.5%), respectivelyin the Strait of Çanakkale during the period 2001 and 2015as shown in Table 3.

Table 3: Frequency Distribution of Marine Accidentsby Month of Accidents

Months of Accidents	Frequency	Percentage (%)	Percentage of Cumulative (%)
Unknown	1	0.6	0.6
December - February	32	19.5	20.1
March - May	42	25.6	45.7
June - August	42	25.6	71.3
September - November	47	28.7	100.0
Total	164	100.0	

Source: Republic of Turkey Ministry of Transportation and Infrastructure (UAB), TurkishStraits Vessel Transiting Statistics 2006-2018.

6.1.3.Frequency Distribution of Marine Accidentsby Hours of Accidents

In the Strait of Çanakkale, the most accidents occurred in the hours between 24:00 – 04:00 (54.3%), and in the hours between 16:00 – 20:00 (13.4%), the hours between 20:00 – 24:00 (11%), the hours between 12:00 – 16:00 (10.4%), the hours between 08:00 – 12:00 (5.5%) and the hours between 04:00 – 08:00 (4.9%), respectively, in the Strait of Çanakkaleas shown in Table 4.

Table 4: Frequency Distribution of Marine Accidentsby Hours of Accidents

Hours of Accidents	Frequency	Percentage (%)	Percentage of Cumulative (%)
Not Known	1	0.6	0.6
2400 - 0400	89	54.3	54.9
0400 - 0800	8	4.9	59.8
0800 - 1200	9	5.5	65.2
1200 - 1600	17	10.4	75.6
1600 - 2000	22	13.4	89.0
2000 - 2400	18	11.0	100.0
Total	164	100.0	

Source: Republic of Turkey Ministry of Transportation and Infrastructure (UAB) TurkishStraits Vessel Transiting Statistics 2006-2018.

6.1.4. Frequency Distribution of Marine Accidentsby Type of Accidents

Most of the ships were involved in grounding/stranding in the Strait of Çanakkale (37.2%) and respectively, collision (25.0%), breakdown (20.7%) and fire/explosion (7.3%), as shown in Table 5.

Table 5: Frequency Distribution of Marine Accidentsby Type of Accidents

Types of Accidents	Frequency	Percentage (%)	Percentage of Cumulative (%)
Collision	41	25.0	25.0
Grounding/Stranding	61	37.2	62.2
Breakdown	34	20.7	82.9
Fire/Explosion	12	7.3	90.2
Others	16	9.8	
Total	164	100.0	

Source: Republic of Turkey Ministry of Transportation and Infrastructure (UAB), TurkishStraits Vessel Transiting Statistics 2006-2018.

The main reason for a collision is human error. Groundings and strandings having occurred in the Strait of Çanakkale constitute 37.2% of all casualties with the major risk factors being poor navigation; faulty navigation instruments; bad weather conditions; engine breakdown and currents.

6.1.5. Frequency Distribution of Marine Accidentsby Type of Ships

Dry bulk ships were the most common type of ships involved in accidents (53.7%) and respectively, cargo ships (container, general cargo, container, RO-RO) (14.0%), tankers (11%) and local traffic (ferryboat, local passenger ships, etc) (6.7%) were involved in accidentsin the Strait of Çanakkale as shown in Table 6.

Table 6: Frequency Distribution of Marine Accidentsby Type of Ships

Types of Ships	Frequency	Percentage (%)	Percentage of Cumulative (%)
Unknown	8	4.9	4.9
Dry Bulk	88	53.7	58.5
Cargo Ships*	23	14.0	72.6
Tanker	18	11.0	83.5
Local Traffic**	11	6.7	90.2
Others***	16	9.8	100.0
Total	164	100.0	

*Container, General Cargo Container, Ro-Ro, ** Ferryboat, local passenger ships, etc.
*** Service motor, tugboat, Ro-Ro, navy boats, etc.

Source: Republic of Turkey Ministry of Transportation and Infrastructure (UAB) TurkishStraits Vessel Transiting Statistics 2006-2018.

6.1.6. Frequency Distribution of Ships Involved Accidents By Flags

A total of 40.9% of the ships involved the accidents were Turkish flag vessels and respectively, 20.1% of the ships involved the accidents were European flag vessels, 16.5% of the ships involved the accidents were with Asian&Africanflagin the Strait of Çanakkale during the period 2001 and 2015 as shown in Table 7.

Table 7: Frequency Distribution of Ships Involved in Accidents by Flags

Types of Ship Flags	Frequency	Percentage (%)	Percentage of Cumulative (%)
Unknown	1	0.6	0.6
Turkish Flag	67	40.9	41.5
European Flag	33	20.1	61.6
Russian&Turkic Rep. Flag	14	8.5	70.1
Asian&Africa Flag	27	16.5	86.6
America&Antique Flag	22	1.4	100.0
Total	164	100.0	

Source: Republic of Turkey Ministry of Transportation and Infrastructure (UAB), TurkishStraits Vessel Transiting Statistics 2006-2018.

6.1.7. Frequency Distribution of Marine Accidentsby Gross Tonnage

Most of the ships with less than 3,000 gross tonnage were involved in marine accidents (45.1%) and respectively, ships of between 3,001 and 10,000 gross tonnage (28.0%), ships of between 10,001 and 25,000 gross tonnage (12.2%) and ships of larger than 25,001 gross tonnage (6.7%) were involved in accidents, as shown in Table 8.

Table 8: Frequency Distribution of Marine Accidentsby Gross Tonnage

Types of Gross Tonnage	Frequency	Percentage (%)	Percentage of Cumulative (%)
Unknown	13	7.9	7.9
<3.000	74	45.1	53.0
3.001-10.000	46	28.0	81.1
10001-25.000	20	12.2	93.3
25.001 and over	11	6.7	100.0
Total	164	100.0	

Source: Republic of Turkey Ministry of Transportation (UAB), TurkishStraits Vessel Transiting Statistics 2006-2018.

6.1.8. Frequency Distribution of Marine Accidents By Reasons

Table 9displays that human error is the major cause of accidents at 31.1%and respectively, breakdown (18.3%) and bad weather conditions and currents (7.35%).

Table 9: Frequency Distribution of Ships by Reason of Accident

Types of Ship Flags	Frequency	Percentage (%)	Percentage of Cumulative (%)
Unknown	60	36,6	36.6
Human Error	51	31.1	67.7
Bad Weather Conditions And Currents	12	7.3	75.0
Breakdown	30	18.3	93.3
Others	11	6.7	100.0
Total	164	100.0	

Source: Republic of Turkey Ministry of Transportation and Infrastructure (UAB), TurkishStraits Vessel Transiting Statistics 2006-2018

6.2. Chi Square (χ^2)Test

The Chi square (χ2) Test analysis was used to determine if there is a statistically significant relationship between two nominal (categorised) accident variables in the marine accidentsthat occurred in the Strait of Çanakkale between 2001 and 2015.

6.2.1.Chi Square (χ^2)Test Between Type of Flag Involved in Accident and Type of Accident

All unknown parameters which involve type of flag involved in an accident and type of ship have been omitted from the analysis to safely use the Chi Square Test. Therefore, there are a total of 163 parameters instead of 164. The ships with Turkish flags were those most involved in collision (32.8%) and the ships with European flag (24.2%) respectively. The ships with Russian and TurkicRepublic flag were those most involved in grounding/stranding (71.4%) and the ships with Asian&Africaflags (51.9%) respectively as shown in Table 10.

Table 10: Cross-Tabulation Between Type of Flag and Type of Accident Involved in Accident

Type Of Ship Flag/ Type Of Ship	Count Expected Count % within flag of the ship	Collision	Grounding /Stranding	Break-down	Fire	Others	Total
Turkish Flag	Count	22	17	9	10	9	67
	Expected Count	16.9	25.1	1.6	4.9	6.6	67.0
	% within flag of the ship	32.8%	25.4%	13.4%	14.9 %	13.4%	100.0%
European Flag	Count	8	10	10	1	4	33
	Expected Count	8.3	1.,3	6.7	2.4	3.2	33.0
	% within flag of the ship	24.2%	30.3%	30.3%	3.0%	12.1%	100.0%
Russian&Turkic Rep. Flag	Count	0	10	3	0	1	14
	Expected Count	3.5	5.2	2.8	1.0	1.4	14.0
	% within flag of the ship	0.0%	71.4%	21.4%	0.0%	7.1%	100.0%
Asian&Africa Flag	Count	6	14	6	1	0	27
	Expected Count	6.8	10.1	5.5	2.0	2.7	27.0
	% within flag of the ship	22.2%	51.9%	22.2%	3.7%	0.0%	100.0%
Cont. Of America& Antique Flags	Count	5	10	5	0	2	22
	Expected Count	5.5	8.2	4.5	1.6	2.2	22.0
	% within flag of the ship	22.7%	45.5%	22.7%	0.0%	9.1%	100.0%
Total	Count	41	61	33	12	16	163
	Expected Count	41.0	61.0	33.0	1.0	16.0	163.0
	% within flag of the ship	25.2%	37.4%	20.2%	7.4%	9.8%	100.0%

The Pearson Chi-Square (χ^2)=30,839[a], P=0.014, Likelihood Ratio =317,824. P= 0.002.

a. 12 cells (48.0%) have expected count less than 5. The minimum expected count is 1.03~ 1.0. Cramer's V= 0.217, Approx. Sig.=0.014.

All unknown parameters that involve the flag of the ships have been omitted from the analysis to safely use the Chi Square Test. Therefore, total parameters are 155 instead of 164.We performed the Chi Square Test for 155 variables. The Chi Square results is shown in Table 11.

Table 11: Chi Square Test Between Ship Tonnage and Type of Ship Flag Involved in Accidents.

	Value	df	Asymp. Sig. (p value) (2-sided)
Pearson Chi-Square	30,839[a]	16	0.014
Likelihood Ratio	37,824	16	0.002
Linear-by-Linear Association	1,953	1	0.162
N of Valid Cases	163		

* Approx. Sign.
a. 12 cells (48,0.0 %) has an expected count less than 5. The minimumexpected count is 1,03~ 1,0.

We perform a statistical test of the null hypothesis H_0: There is not a statistical significance relationship between type of flag and type of accident involved in accident H_1:There is a relationship between type of flag and type of accident involved in accident. The test result indicated that since the P-value (0.003) is less than the significance level ($\alpha=0.05$), independence of observation, no more than 20% of the expected counts are less than 5 and all individual expected counts are 1 or greater as mentioned in Section 5.1.2. The relationship between two variables is statistically significant if asymptotic significance (2-sided) (p value) < 0.05. Table 11shows that more than 20% of expected counts are less than 5 (48%). Therefore, the Chi Square Test cannot be used to test correlated data.

6.2.2. Chi Square (χ^2) Test Between Tonnage of the Ships Involved and Type of Accident

The ships that have a gross tonnage of less than 3,000 were those most involved in accidents with a ratio of 45.1% followed by ships with a gross tonnage of between 3,001 and 10,000 (28%), respectively. The ships with a gross tonnage of less than 3,000 were those most involved in groundings or stranding with a ratio of 50.8% and collision (46.3%), respectively. The observed value of the ships that have a gross tonnage of less than 3,000, which were involved in groundings/stranding, is 31 and the expected value is 27.5. The ships with a gross tonnage of between 3,001 and 10,000 tonnes were most involved in breakdowns, (47.1 %) and collision (26.8 %) respectively. The ships with a gross tonnage of between 10,001 and 25,000 were those most involved in breakdown (14.7%) and collision (9.8 %), respectively. The ships with a gross tonnage of over 25,001 tonnes (6.7%) were involved in breakdown (11.8%) and collision (7.3%), respectively, as shown in Table 12.

Table 12: Cross-Tabulation Between Tonnage of The Ships Involved and Type of Accident

Gross Tonnage of the Ships/ Type of Accident	Count	Collision	Ground-ing/ Stranding	Break-down	Fire	Others	Total
Unknown	Count	4	5	1	0	3	13
	Expected Count	3.3	4.8	2.7	1.0	1.3	13.0
	% within type of the accident	9.8%	8.2%	2.9%	0.0%	18.8%	7.9%
<3,000	Count	19	31	8	9	7	74
	Expected Count	18.5	27.5	15.3	5.4	7.2	74.0
	% within type of the accident	46.3%	50.8%	23.5%	75.0%	43.8%	45.1%
3,001-10,000	Count	11	14	16	1	4	46
	Expected Count	11.5	17.1	9.5	3.4	4.5	46.0
	% within type of the accident	26.8%	23.0%	47.1%	8.3%	25.0%	28.0%
10,001-25,000	Count	4	8	5	1	2	20
	Expected Count	5.0	7.4	4.1	1.5	2.0	20.0
	% within type of the accident	9.8%	13.1%	14.7%	8.3%	12.5%	12.2%
25,001 and over	Count	3	3	4	1	0	11
	Expected Count	2.8	4.1	2.3	0.8	1.1	11.0
	% within type of the accident	7.3%	4.9%	11.8%	8.3%	0%	6.7%
Total	Count	41	61	34	12	16	164
	Expected Count	41.0	61.0	34.0	12.0	16.0	164.0
	% within type of the accident	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The Pearson Chi-Square χ^2=20.887[a,] P=0.183, Likelihood Ratio =22,654, P= 0.123.

a. 15 cells (60.0 %) have expected count less than 5. The minimum expected count is 0.80.

The ships with unknown gross tonnage (fire) and the ships with a gross tonnage of over 25,001 (others) have less than one ("0") expected counts. Of the expected counts, 60% are less than five and the minimum expected count is less than one (0.80), as shown in Table 11. Hence, we cannot safely use the Chi-Square Test. The parameters concerning unknown ship gross tonnage have been omitted from the analysis to safely use the Chi Square Test. Therefore, the total parameters are 151 instead of 164 in the new Table. 55% of the expected counts are less than five and the minimum expected count is less than one (0.87), so here too it has not been safe to use the Chi Square Test.

6.2.3. Chi Square (χ^2)Test Between Type of Accident and Reason for The Accident

Unknown parameters concerning the type of accident and reason for the accident have been omitted from the analysis in order to safely use the Chi Square Test. Therefore, the total parameters are 104 instead of 164. The most accidents involved in collision (74.2%)and grounding/stranding (63.2%)occurred due to human error as shown in Table 13.

Table 13: Cross-Tabulation Between Type of Accident and Reason of Accident

Type of Accident/ Reason of Accident	Count	Human Error	Bad weather conditions	Break-down	Others	Total
Collision	Count	23	8	0	0	31
	Expected Count	15.2	3.6	8.9	3.3	31.0
	% within type of accident	74.2%	25.8%	0.0%	0.0%	100.0%
Grounding / Stranding	Count	24	2	7	5	38
	Expected Count	18.6	4.4	11.0	4.0	38.0
	% within type of accident	63.2%	5.3%	18.4%	13.2%	100.0%
Break-down	Count	1	1	11	5	18
	Expected Count	8.8	2.1	5.2	1.9	18.0
	% within type of accident	5.6%	5.6%	61.1%	27.8%	100.0%
Fire	Count	0	0	5	0	5
	Expected Count	2.5	0.6	1.4	0.5	5.0
	% within type of accident	0.0%	0.0%	100.0 %	0.0%	100.0%
Others	Count	3	1	7	1	12
	Expected Count	5.9	1.4	3.5	1.3	12.0
	% within type of accident	25.0%	8.3%	58.3%	8.3%	100.0%
Total	Count	51	12	30	11	104
	Expected Count	51.0	12.0	30.0	11.0	104.0
	% within type of accident	49.0%	11.5%	28.8%	10.6%	100.0%

The Pearson Chi-Square χ^2=62,762[a],P= 0.000,Likelihood Ratio =74,311, P= 0.000.

a. 13 cells (65.0 %) have expected count less than 5. The minimum expected count is 0.53, ~0.5.

As shown in Table 13, more than 20% of expected counts are less than 5 (65%) Therefore, The Chi Square Test can not used to test correlated data.

6.2.4. Cross Tabulations Between Hours of Accidents and Type of Ships Involved in the Accidents

All types of ships were involved in accidents in the hours 24:00 – 04:00. Dry bulk ships which were involved in the most accidents were involved in the accidentsin the hours 24:00 – 04:00 (64.0%). Container, general cargo and Ro-Ro ships were involved in the accidents in the hours 24:00 – 04:00 (7.0%). Tankers and local traffic were involved in the accidents in the hours 24:00 – 04:00 (6.7%)as shown in Table 14.

Table 14: Cross-Tabulation Between Hours of Accidents and Type of Ships

Hours of Accident/ Type of Ship	Count	Dry Bulk	Container Gn.Cargo, Ro-Ro	Tanker	Local Traffic	Others	Total
2400 - 0400	Count	55	12	6	6	7	86
	Expected Count	48,3	12,8	10,0	6,1	8,9	86,0
	% within hour of the accident	64,0%	14,0%	7,0%	7,0%	8,1%	100,0%
0400 - 0800	Count	5	0	1	0	2	8
	Expected Count	4,5	1,2	0,9	0,6	,8	8,0
	% within hour of the accident	62,5%	0,0%	12,5%	0,0%	25,0%	100,0%
0800 - 1200	Count	3	0	0	1	3	7
	Expected Count	3,9	1,0	0,8	0,5	0,7	7,0
	% withinhour of the accident	42,9%	0,0%	0,0%	14,3%	42,9%	100,0%
1200 - 1600	Count	9	5	3	0	0	17
	Expected Count	9,5	2,5	2,0	1,2	1,8	17,0
	% within hour of the accident	52,9%	29,4%	17,6%	0,0%	0,0%	100,0%
1600 - 2000	Count	7	2	5	4	2	20
	Expected Count	11,2	3,0	2,3	1,4	2,1	20,0
	% withinhour of the accident	35,0%	10,0%	25,0%	20,0%	10,0%	100,0%

Table 14: Cross-Tabulation Between Hours of Accidents and Type of Ships (Cont.)

Hours of Accident/ Type of Ship	Count	Dry Bulk	Container Gn.Cargo, Ro-Ro	Tanker	Local Traffic	Others	Total
2000 - 2400	Count	8	4	3	0	2	17
	Expected Count	9,5	2,5	2,0	1,2	1,8	17,0
	% withinhour of the accident	47,1%	23,5%	17,6%	0,0%	11,8%	100,0%
Total	Count	87	23	18	11	16	155
	Expected Count	87,0	23,0	18,0	11,0	16,0	155,0
	% within hour of the accident	56,1%	14,8%	11,6%	7,1%	10,3%	100,0%

The Pearson Chi-Square χ^2=34,754,,762[a,] P= 0.021,Likelihood Ratio =36,156, P= 0.015

a. 22 cells (73,3 %) have expected count less than 5. The minimum expected count is 0.5.

As shown in Table 14, more than 20% of expected counts are less than 5 (73.3%). Therefore, The Chi Square Test can not used to test correlated data.

7. CONCLUSION

Marine accidents occured in the Strait of Çanakkale have become a serious threat from the point of human life, property, and environmental safety. The findings of this paper are as follows; the most accidents occurred in 2008 (22%) in the Strait of Çanakkale during the period 2001 and 2015. The most accidents occurred between September and November (28.7%), between March and May (25.6%) respectively. The most accidents occurred in the hours between 24:00 - 04:00 (54.3%), in the hours between 16:00 – 20:00 (13.4%) respectively. Grounding/stranding was the most common accident type to occur in the Strait of Çanakkale with a ratio of 37.2% and collision (25.0%) and breakdown (20.7%) respectively. Dry bulk ships were involved in the most accidents with a ratio of 53.7% and cargo ships (container, general cargo, container, Ro-Ro) (14.0%), tankers (11%) and local traffic (ferryboat, local passenger ships, etc) (6.7%) respectively were involved in accidents.A total of 40.9% of the ships involved the accidents were Turkish Flag vessels, 20.1% of the ships involved the accidents were European flag vessels, 16.5% of the ships involved the accidents were with Asian&African flag.

Most of the ships with less than 3,000 gross tonnage were involved in marine accidents (45.1%) and respectively the ships of between 3,001 and 10,000 gross tonnage (28.0%), the ships of between 10,001 and 25,000 gross tonnage (12.2%) were involved in marine accidents. Human error is the major cause of accidents (31.1%) and respectively breakdown (18.3%) and bad whether conditions and current (7.3%) in the Strait of Çanakkale in the period 2001-2015. The most accidents involved in collision (74.2%)and grounding/stranding (63.2%)occurred due to human error.

The results of analysis shows that there is no statistically significant relationship betweentype of flag involved in accident and type of accident; between tonnage of the ships involved the accident and type of accident;between type of accident and reason for the accident and between hours of accidents and type of ships.According to the Montreaux Convention, pilotage is not compulsory in the Turkish Straits (BASKENT-SAM, 2017). The result of a study shows that the ratio of ships without the engagement of a pilot and were involved in accidents in the Strait of İstanbul, was 78.4%.

Although the number of ships having pilotage services is increasing by year, this number is not enough. It is known that the number of larger ships having pilotage servicesis higher than that of small ships. Even so, most of the ships with less than 3,000 gross tonnage were involved in marine accidents, which raises the question of there needing to be a pilot on board these types of vessels. As a result of face-to-face meetings with VTMIS operators, it was ascertained that small-sized vessels are considered to be of low risk; however, in reality, vessels of these sizes have a high risk factor and must be carefully planned.

The increase in marine traffic in the Strait of Çanakkale is also increasing the risk of accidents occurring within the region. As both ships engaged in international trade and ships operating locally are navigating in the same region, maritime traffic has become intense and with this, the risk of accidents increases. In order to reduce this risk in the coming years, practical training courses for masters in the areas in which they are navigating should be increased and training standards should be upgraded.

According to article 15 of the Maritime Traffic Regulations for the Turkish Straits, "Vessels which are involved in an accident, having equipment/machinery failures or dropped anchor in an emergency, shall immediately notify the Vessel Traffic Services and request instructions. After the safety measures for the vessel and the environment are taken by the relevant port authority such vessel may resume passage with a pilot on board and in compliance with other necessary requirements of the Administration for its safe passage." In this respect the use of a pilot is compulsory following an accident. In order to reduce groundings and collision-type accidents, pilotage should be encouraged, especially from dusk until dawn hours, for dry bulk vessels, foreign flag vessels, and ships of less than 3,000 gross tonnage with a Turkish flag.

Finally, more than 90% of the vessels passing the Strait of Çanakkale are more than 150 m in length. This still means that small sized vessels pass through the Strait of Çanakkale. Although it is thought that vessels of more than 10,000 gross tonnage have a higher risk of accidents and severe consequences, it was found in this study that lower gross tonnage (small-sized) vessels are involved in more accidents than higher gross tonnage vessels.

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