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Analysis of the Impact of Daylight on Grounding and Collision Accidents

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ABSTRACT

It is crucial to conduct accident investigations in order to identify the root causes and prevent further accidents in the future. Investigations have revealed that the number of accidents occurring at night is greater than during the day, and that they have a more significant impact. The difference in the number of accidents and their causes between day and night is a critical issue that requires attention. This study examined the distinct differences in accident times between the Straits of Canakkale and Istanbul. These straits have considerable maritime traffic both day and night, which increases the potential for accidents. The aim of this study is to analyze the accident times in the Istanbul and Canakkale Straits in terms of ship watches. Between 2001 and 2016, 451 grounding and collision accidents occurred in the straits. The accident data were analyzed using SPSS and the chi-square test. The analysis of the data shows a meaningful and significant difference in the number of accidents between night watches and day watches, with night watches having more accidents. The tests showed that this difference was statistically significant.

1 Introduction and literature review

Many accident studies have been carried out to increase safety in shipping. Examining past accidents for safe navigation and determining the effective factors and possible relationships in these accidents is very important in terms of preventing possible future accidents. Observations show that night watches typically have a higher number of accidents and more serious consequences than day watches.

Grounding is one of the most common accident types among ship accidents [1]. Furthermore, collision is one of the types of accidents that can be fatal [2]. Due to their adverse effects, ship collisions pose a danger to the maritime sector and the economy. In [3], [4] authors stated that the human error margin in collision accidents is 74%. It is evident that human error has a serious role in the accidents that occur. It has been determined that human error is associated with fatigue, and fatigue is associated with excessive demand and irregular working hours in grounding accidents [5]. In [6] authors stated that there may be a linear relationship between the fatigue of the crew on board and their tendency to make mistakes. As seen in previous studies, ship crews play a critical role in ensuring the ship's safe navigation.

The safety of the navigation is directly related to the navigational competence of each crew member in the bridge team [7]. The navigational competence expressed here consists not only of technical skills, but also of non-technical skills. The ship operator must ensure that the ship's captain and officers, who are in the decision-making position in the bridge team, have such competences [8]. On the other hand, it is necessary to prevent the accidents that may arise from fatigue, especially by arranging the rest and working hours of the ship's captains and officers who must have these competences. In terms of the crew's working performance,

Table 1 Watch system on board.

Ship Watches (h)	Watches Names	Light	Officer of the Watches
0000-0400	Middle	Night Watches	2nd officer
0400-0800	Morning	Night Watches	Chief officer
0800-1200	Forenoon	Day Watches	3rd officer
1200-1600	Afternoon	Day Watches	2nd officer
1600-2000	Dog	Day Watches	Chief officer
2000-2400	First	Night Watches	3rd officer

it is stated that the unusual working hours of the ship's captain and officers cause fatigue, circadian rhythm and sleep disturbance [9].

Considering the watch work system on the ship, the question of this study is whether there is a meaningful and statistically significant difference between the accidents that occur during the night and day watches. Since collision and grounding accidents are accidents in which the human factor comes to the fore, they were chosen in this study.

The ship's watch system determines the daily working hours of officers. This watch system also regulates rest hours. Despite the existence of a variety of watchkeeping systems in non-commercial ships, navigation bridge watchkeeping is usually performed in six watches of four continuous hours on merchant vessels worldwide [10]. The ship's watch system is as follows: the 2nd officer is on duty in the hours of 0000-0400 and 1200-1600, the chief officer in the hours of 0400-0800 and 1600-2000, and the 3rd officer in the hours of 0800-1200 and 2000-2400, as shown in Table 1.

Looking at past studies, it is seen that the relationship between night and day watches and circadian rhythm has been examined. There are also studies focusing on how the circadian rhythm and working at night affect the performance of individuals. As is known, the circadian time system modulates human physiology and behavior according to the 24-hour daylight-dark cycle [11]. All healthy people automatically exhibit the common behavior of sleeping at night and waking up in the morning. When a person starts a new day, the body prepares itself for new tasks by increasing heart rhythm, blood pressure, and body temperature; at the end of the day, all these parameters decrease. This daily cycle is related to the circadian rhythm [12]. It is seen that the number of existing studies on circadian rhythm and shift workers is increasing day by day. Shift work is becoming more and more common due to advances in technology and 24-duty days, which require individuals to work the hours they would normally sleep [13]. The endogenous circadian clock organizes sleep and wakefulness on a daily basis [13]. While circadian rhythm can be interpreted as an individual's internal clock, it has been observed that certain external factors may also have an effect on circadian rhythm. In [14] authors investigated ways of providing circadian adaptation to night shifts. As a result of their research and experiments, they suggested that shift workers' having a consistent sleep schedule, not changing these hours, and sleeping in complete darkness, while being exposed to bright light while working at night, is an effective way of circadian adaptation to night shifts [14]. In [15] authors conducted another study that agrees with the results of the studies by the authors in [14]. In the study, subjects initially adhered to a regular sleep schedule for three weeks, resting from 2300 to 0700 hours. Subsequently, they transitioned to a night shift, maintaining the same hours. It was observed that peak sleepiness, typically occurring in the early morning and midnight, was postponed to the daytime sleep period, resulting in enhanced nighttime alertness and reduced fatigue during the day [15].

The daily working hours, which are known as "shift work" in the working environments on land, are called "watch work" on the ships. It has been determined that the relationships between the watch work system on ships and the circadian rhythm have similarities with the results of the study on land. While some of these studies were carried out on military ships, some of them were related to commercial ships. The study carried out by [16] on a naval ship concluded that exposure to bright light during the night shift resulted in an increase in alertness and performance compared to dim light. Similar results have been found in the land-based studies in [14], [15]. In [17] authors examined the circadian adaptation status of both crew who work in daylight and watchkeepers on commercial ships. The second step of their study, watchkeepers, is divided into fixed and rotating watchkeepers. They found that the sleep efficiency of fixed watchkeepers and crew who work in daylight is higher than that of rotating watchkeepers. Also, they suggested that the most likely reason for this may be that the crew's internal clock does not adapt quickly to sudden changes in work schedules [17].

Unlike the others, Leeuwen et al. [18] used simulation to examine sleep, insomnia, and neurobehavioral performance during the watch in the 4 h on/8 h off watch work system. They observed that sleepiness peaked during the night and "morning watch" (0400-0800), which is the time period when accidents often occur. On the other hand, Folkard et al. [19] concluded that the risk level increased significantly in the "middle watch" (0000-0400). In general, the conclusion reached in both studies is that the night watch period has the highest risk level in terms of ship accidents.

There are studies on the effect of the watch work system on the ship and the circadian rhythm on the psychological functions of the crew. In [9] authors conducted a study examining the effects of circadian rhythm and sleep on the psychological functions of seafarers working on merchant vessels. They mentioned that ship safety is closely related to the performance of the bridge watchkeeper, and experiments were carried out on 114 ship personnel while on board [9]. In order to measure the effect of circadian rhythm and sleep quality on the psychological functions of the watchkeeper, they followed the heart rate, body temperatures, and amount of adrenaline noradrenaline in the urine of the personnel, and the crew was requested to complete a mental test. As a result of their experiments, they deduced that the watchkeepers did not provide full phase adaptation of the circadian rhythm to the watch work hours. Using these tools and experimental data, they investigated the effects of time zone crossings on crew sleep and circadian rhythm [20]. During the examined period, it was observed that the average amount of sleep of crew who work in daylight on ships sailing eastward was 1 hour less than those on ships sailing westward, and their sleep quality was also lower; it has been observed that the main sleep of the watchkeeper on ships going east is also less than those going towards¸ the west. Using the instrument and experimental data from the main study, they stated that interrupted sleep due to the 4 h on/8 h off schedule system is one of the most important factors preventing psychological adaptation to the watch system, and they claimed that this problem can be overcome with a system that provides an undivided sleep pattern for every day [21]. These findings are also similar to the findings of the authors of [14], [15]. It is seen in these studies that uninterrupted quality sleep has an important place in the performance efficiency of the crew. In [22], investigating the relationship between fatigue and maritime accidents, it was suggested that poor quality sleep and circadian rhythm may be among the causes of fatigue. In [23] authors conducted an analysis of the potential risks associated with poor sleep quality, long working hours, and fatigue for deck officers on oil tankers operating in coastal areas. In [24], the analysis of Incident at Sea Reports revealed that sleeping or sleepiness was the cause of the accident in 39% of cases. In [10] authors investigated the effect of circadian rhythm on collision accidents. They argued that there is a relationship between the circadian rhythm peaking at night and the probability of ship accidents. Collision accident analyses [25], [26], [27], [28], [29] revealed that collision accidents occur more frequently at night and that collision accidents that occur at night have more serious consequences than those that occur during the day.

A review of the literature on the relationship between circadian rhythm and watch work reveals that there is a potential impact of circadian rhythm on the performance of the crew. Nevertheless, it is thought that there is no satisfactory explanation for the role of circadian rhythm in accidents in the existing literature. A limited number of studies have examined the potential relationship between circadian rhythm and maritime accidents. It is not feasible to attribute solely to circadian rhythm the occurrence of maritime accidents. Conversely, it is considered inappropriate to disregard the potential influence of circadian rhythms based on the observation that the incidence of accidents appears to increase during night watches.

The following is a description of the structure of this study: In the initial section, the introduction, the existing literature was examined, the motivation behind this study was explained, and the frequency and chi-square test used for analysis were explained in the methodology section, which constitutes the second part. The findings resulting from the analysis of the accident data discussed, which constitutes the third part of the study, are presented in the findings section. In the conclusion section, the results of the study, its limitations, and suggestions for future studies are shared.

2 Methodology

The purpose of this study is to determine whether there is a meaningful and statistically significant difference between day and night watches in grounding and collision accidents in the Istanbul and Canakkale Straits (Fig.1). The hypothesis of the study is as follows: there is a meaningful and significant difference between accidents that occur during night and day watches.

The Turkish Straits, comprising the Istanbul Strait, the Çanakkale Strait, and the Marmara Sea, have constituted a vital maritime route for centuries, largely due to their strategic location. Figure 1 illustrates the locations of the Turkish straits, with letter A denoting the Canakkale Strait, B the Marmara Sea and C the Istanbul Strait. As the sole maritime link between the Black Sea and the Mediterranean, the Turkish Straits constitute a vital transit route for commercial and maritime traffic. The Black Sea is situated between Southeastern Europe and Asia Minor, and is landlocked; it is connected to the world's oceans via the Turkish Straits. The Straits thus constitute a highly significant gateway for maritime trade and maritime activities, serving not only countries in the region but also those beyond. With a total length of 164 miles, the Turkish Straits represent one of the longest natural and narrow waterways in the world used for maritime transportation. Of this total value, 17 nautical miles is the Istanbul Strait, 110 nautical miles is the Marmara Sea waterway, and 37 nautical miles is the Canakkale Strait. This is due to a combination of their geographical location, physical structure, and unique characteristics [30]. In 2022, 35146 ships passed through the Istanbul Strait, while the total number of ships passing through the Canakkale Strait was 42340 [31].

In order to analyze the mentioned accidents, data on 1244 accidents that occurred in the Istanbul and Canakkale Straits between 2001 and 2016 was obtained from the Republic of Turkey's Ministry of Transport, Maritime Affairs, and Communications Main Search and Rescue Coordination Center. Only grounding and collision accident types were focused and other accidents that took place in the straits between 2001 and 2016 were discarded. In this study, the data of the collision of any ship with merchant vessels and the grounding of the merchant vessels were used. The data regarding accidents between fishing vessels, yachts, and sailing vessels, and each of them individually, is excluded from the scope. In the data used, each collision accident involved two or more ships, but this data was considered as a single collision case in the analysis. As a result, after the data were extracted, the remaining 451 grounding and collision accidents were analyzed.

According to the Republic of Turkey Ministry of Transport data, the number of vessels passing through the Istanbul and Canakkale Straits between the years 2006 and 2021 is given in Figure 2. As seen in Figure 2, since 2016, the number of vessels passing through the Canakkale Strait has exceeded the number of vessels passing through the Istanbul Strait (Republic of Turkey Ministry of Transport).

Within the scope of this study, the bridge teams of the ships involved in the accident in the straits include the ship's captain, officer/s, crew, and maritime pilots. It has been discovered that there is a link between the bridge crew and the events that lead to risky acts that result in accidents, and the presence of a pilot, captain, or lookout on the bridge makes a difference [32]. On the other hand, it was determined that some of the ships involved in the accident did not have a pilot. This could be attributed to the fact that, in accordance with the Montreux Convention, there is no obligation for vessels undertaking a nonstop passage to have a pilot on board [33]. Besides, some suspicious data was found in the collected data about whether the pilotage services were received by the ships or not. For this reason, it was not taken into account whether the ships received pilotage service or not received during the analyses. In this study, unlike the other researches [9], [20], [21], [34], [35], the accident data that occurred during the passage of the İstanbul and Canakkale Straits, a process in which a bridge team was on duty, were examined. For this reason, accidents occurring in the Marmara Sea are excluded from the scope.

Accident data was analyzed with the frequency and nonparametric chi-square tests using the SPSS statistical program. The Chi-square statistic is a non-parametric tool utilized to examine group differences when the dependent variable is measured at a nominal level. The Chi-square test, similar to other non-parametric statistics, demonstrates robustness concerning data distribution [36]. Statisticians often use the chi-square test of goodness of fit to determine whether a sample originates from a population with a particular distribution. To do this test, one first establishes a null hypothesis asserting that the sample originates from a population with a known distribution [37]. The null hypothesis states the absence

Figure 1 Turkish Straits.

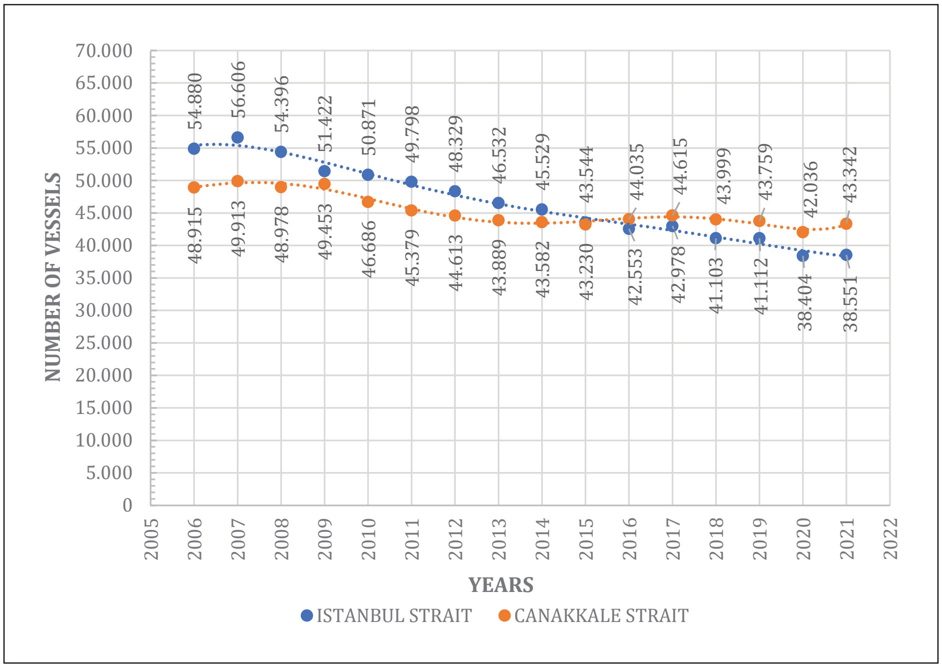

Figure 2 Distribution of the number of vessels passing through the Istanbul and Canakkale straits by years.

of an association, whereas the alternative hypothesis asserts the existence of an association [38]. Then the test statistic is calculated using the following formula [39]:

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \tag{1}$$

In this context, the term "*n*" refers to the number of cells in the table. The resulting test statistic is then compared against a critical value derived from the chi-square distribution, with (r – 1) (c – 1) degrees of freedom.

The Nonparametric Chi-Square test is based on whether the difference between observed frequencies and expected frequencies is statistically significant. Type of accident (collision and grounding), location of the accident (İstanbul and Çanakkale Straits), watches, time period (day and night) are used as nominal data in this study. The null hypothesis of the study states that there is no significant difference between accidents occurring during night and day watches. The alternative hypothesis of the study suggests that there exists a significant difference between accidents occurring during night and day watches. In order to test the hypothesis, the Chi-Square test was performed.

3 Results

The data of the 451 grounding and collision accidents that occurred in the Istanbul and Canakkale

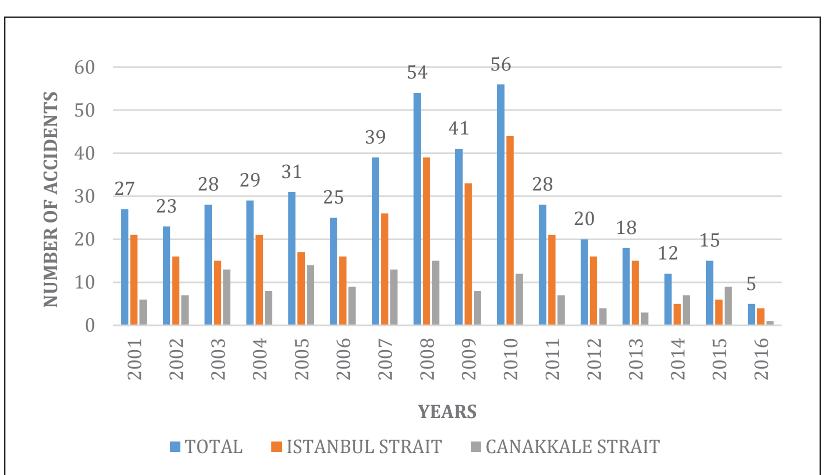

Figure 3 Distribution of collision and grounding accidents by years.

straits between 2001 and 2016 was examined in this article, which was obtained from the Republic of Turkey Ministry of Transport, Maritime Affairs, and Communications Main Search and Rescue Coordination Center. When we look at the distribution of accidents by years, as seen in Figure 3, the highest accident rate occurred between 2008 and 2010.

While 315 (69,8 %) of accidents took place on the Istanbul, 136 (30,2 %) of them occurred on the Canakkale. Out of a total of 451 accidents, 223 (49,4 %) are grounding accidents and 228 (50,6 %) are collision accidents. While 193 (84,6 %) of the 228 collision accidents occurred in the Istanbul Strait and 35 (15,4 %) in the Canakkale Strait, 122 (54,7 %) of the 223 grounding accidents occurred in the Istanbul Strait and 101(45,3 %) in the Canakkale Strait (Table 2). It has been observed that most of the collision accidents took place in the Istanbul Strait.

Table 2 Number of accidents in Canakkale and Istanbul straits.

TOTAL	İstanbul Str.	Çanakkale Str.
Accident 451	**Accident** 315 (69,8 %)	**Accident** 136 (30,2 %)
Grounding 223	**Grounding** 122 (54,7 %)	**Grounding** 101 (45,3 %)
Collison 228	**Collison** 193 (84,6 %)	**Collison** 35 (15,4 %)

There are six watches in total on board ship, in the following order: 0000-0400, 0400-0800, 0800-1200, 1200-1600, 1600-2000, and 2000-2400. Midwatch 0000-0400, morning watch 0400-0800, and first watch 2000-2400 watches are considered as night watches in this study. The accidents examined took place in Turkey and, considering Turkey's time zone, the sunset takes place at 20:49 at the latest. As a result, the 2000–2400 watch has been accepted as the night watch for Turkey. The remaining 0800–1200, 1200–1600, and 1600–2000 watches are considered day watches.

In order to test whether daylight affects the behavior of the bridge team, the distribution of 451 grounding and collision accident data according to the accident time and watches was examined. The distribution of accidents according to watches is given in Figure 2. As can be seen in Figure 4, the night watches 2000–2400 and 0000–0400 are the watches with the highest number of accidents, while the number of accidents occurring in the day watches is lower than in the night watches.

Figures 5 and 6 show the distribution of collision and grounding accidents in the Canakkale and Istanbul Straits based on watches. Figure 4 shows that the number of grounding accidents in the Canakkale Strait is higher in the 0800-1200 watch than in the other watches, but the total number of accidents in the night watches is still higher than in the day watches. Figure 5 shows that during all night watches, the number of grounding and collision accidents in the Istanbul Strait is significantly higher.

As illustrated in the figures, the watch with the highest number of accidents in the Istanbul Strait is 2000-2400, while in the Canakkale Strait it is 0000-0400. However, the watch with the lowest number of accidents in both is 1200-1600. It is evident that collision accidents occur with greater frequency than grounding accidents in all watches in the Istanbul Strait. This may be attributed to the geographical structure of the Istanbul Strait, the narrowing of the strait at certain points, and the presence of two-way traffic.

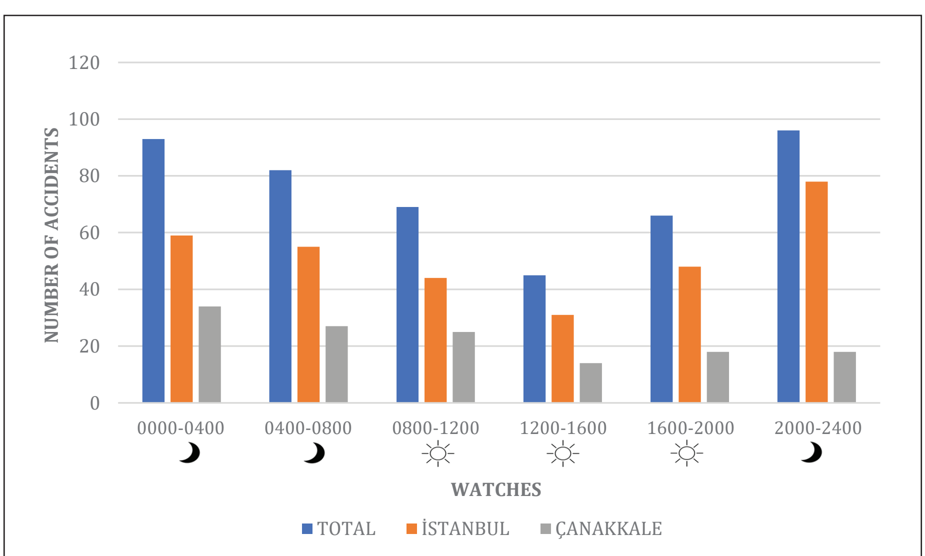

Figure 4 Histogram of the number of accidents distribution in the watches.

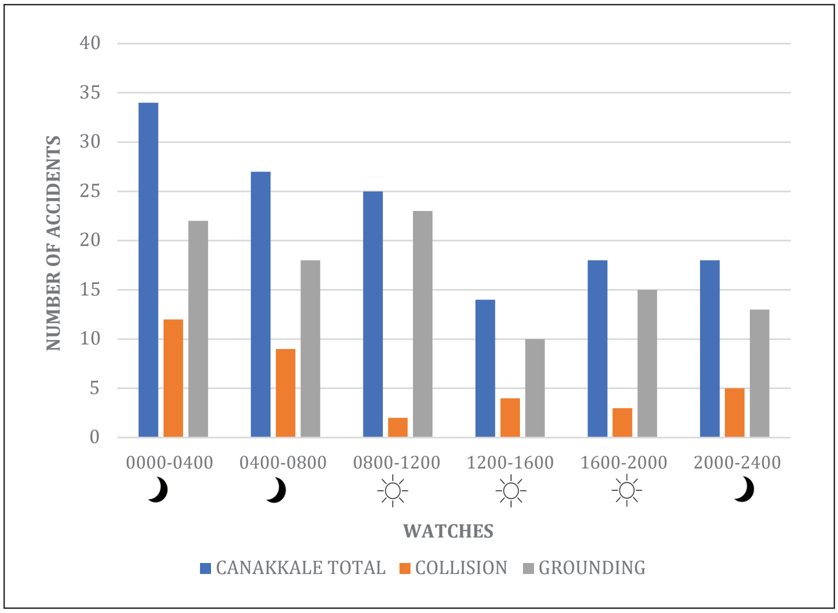

Figure 5 Distribution of collision and grounding accidents in the Canakkale strait according to the watches.

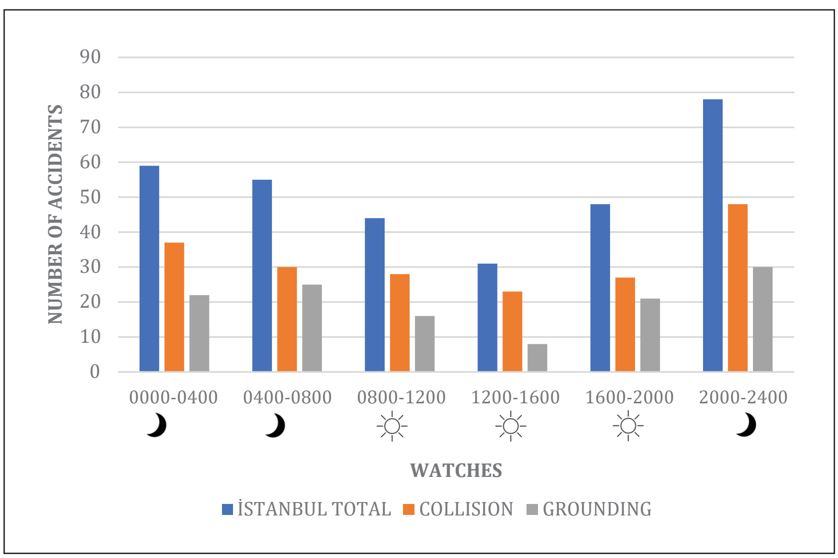

Figure 6 Distribution of collision and grounding accidents in the Istanbul strait according to the watches.

When all watches are analysed over expected and observed numerical values, the number of accidents observed in night watches is higher than expected; it is seen that the number of accidents (collision and grounding) observed in day watches is less than expected, as shown in Table 3. A Chi-Square test was performed to determine whether the differences in the number of accidents considered night and day watches were statistically significant. As demonstrated in Equation 2, the chi-square test indicated that the calculated difference was statistically significant. From this point of view, the statistically significant difference between the number of accidents (collision and grounding) occurring during the night and day watches can be concluded to support our hypothesis. Night and day watches can be concluded to support our hypothesis.

$$\chi^2\ (5) = 24{,}357a,\ p < 0{,}000 \qquad (2)$$

Table 3 Expected – Observed values of accidents in Canakkale and Istanbul straits considering the watches.

	OBSERVED	EXPECTED	RESIDUAL	Day/Night
0000-0400 watch (Middle)	93	75,2	17,8	☽
0400-0800 watch (Morning)	82	75,2	6,8	☽
0800-1200 watch (Forenoon)	69	75,2	-6,2	☼
1200-1600 watch (Afternoon)	45	75,2	-30,2	☼
1600-2000 watch (Dog)	66	75,2	-9,2	☼
2000-2400 watch (First)	96	75,2	20,8	☽
TOTAL	451			

In order to investigate whether daylight had an effect on the accidents, 136 collision and grounding accidents that took place only in the Canakkale Strait were analyzed. The expected and observed values of the number of accidents (collision and grounding) considering the watches were compared. As a result of this analysis, the number of accidents observed during night watches was higher than expected. Also, it was observed that the number of accidents observed during day watches was less than expected, as shown in Table 4. The Chi-Square test was performed again to investigate whether the difference was statistically significant, and the result was found to be significant as demonstrated in Equation 3.

$$\chi^2 (5) = 11{,}971a, p < 0{,}035 \quad (3)$$

The grounding (101) and the collision (35) accidents in the Canakkale Strait were examined separately, and it was investigated whether there was a significant relationship between accident types and the watches. It was observed that the number of collision accidents during night watches was higher than expected. In the chi-square analysis, it was determined that there was a significant relationship between the number of collision accidents and watches (Equation 4). No significant relationship was found between the number of grounding accidents in the Canakkale Strait and watches.

$$\chi^2 (5) = 12{,}829a, p < 0{,}025 \quad (4)$$

In order to investigate whether daylight had an effect on the accidents, 315 collision and grounding accidents that took place only in the Istanbul Strait were analyzed. It is found that, the number of accidents observed during night watches was higher than expected; it was also observed that the number of accidents observed during day watches was less than expected, as shown in Table 5. The Chi-Square test was performed to investigate whether the difference was statistically significant. The result was found to be significant (Equation 5).

$$\chi^2 (5) = 28{,}876a, p < 0{,}000 \quad (5)$$

The grounding (193) and the collision (122) accidents in the Istanbul Strait were examined separately, and it was investigated whether there was a significant relationship between accident types and the watches. It was observed that the numbers of both collision and grounding accidents during night watches were higher than expected. In the chi-square analysis, it was determined that there was a significant relationship between

Table 4 Expected-Observed values of the number of accidents in the Canakkale strait considering the watches.

	OBSERVED	EXPECTED	RESIDUAL	Day/Night
0000-0400 watch (Middle)	34	22,7	11,3	☽
0400-0800 watch (Morning)	27	22,7	4,3	☽
0800-1200 watch (Forenoon)	25	22,7	2,3	☼
1200-1600 watch (Afternoon)	14	22,7	-8,7	☼
1600-2000 watch (Dog)	18	22,7	-4,7	☼
2000-2400 watch (First)	18	22,7	-4,7	☽
TOTAL	136			

Table 5 Expected-Observed values of the number of accidents in the Istanbul strait considering the watches.

	OBSERVED	EXPECTED	RESIDUAL	Day/Night
0000-0400 watch (Middle)	59	52,5	6,5	☽
0400-0800 watch (Morning)	55	52,5	2,5	☽
0800-1200 watch (Forenoon)	44	52,5	-8,5	☼
1200-1600 watch (Afternoon)	31	52,5	-21,5	☼
1600-2000 watch (Dog)	48	52,5	-4,5	☼
2000-2400 watch (First)	78	52,5	25,5	☽
TOTAL	315			

the number of accidents and watches according to the types of grounding (Equation 6) and collision (Equation 7) accidents.

$$\chi^2\ (5) = 14{,}23a,\ p < 0{,}014 \tag{6}$$

$$\chi^2\ (5) = 12{,}648a,\ p < 0{,}027 \tag{7}$$

4 Discussion and Conclusion

To investigate whether there is a significant difference between day and night watches in grounding and collision accidents, 451 grounding and collision accidents that took place between 2001 and 2016 in the Istanbul and Canakkale straits, were analyzed in this study. As a result of the analysis carried out, it was found that the accidents occurring during the nighttime were significantly higher than those occurring during the daytime, and this difference was statistically significant. From this point of view, it is seen that daylight may have an effect on grounding and collision accidents. The results supporting the hypothesis that there is a significant difference between the accidents occurring at night and day watches were obtained from the analyses carried out. From this point of view, it can be said that this result supports the previous studies suggesting that there is a relationship between circadian rhythm and watches. It is not possible to express only the circadian effect as the cause of maritime accidents. On the other hand, it is thought that it would not be appropriate to ignore the circadian effect with the proof that the number of accidents increases during the night watch.

In this study, we believe that we have contributed towards increasing the safety of the ship by emphasizing the significant difference between the accidents that occur during the night and day watches. In addition, considering the effect of the night watches in the accidents, it is seen that there are measures that can be applied to prevent accidents that occur on vessels. While in other studies [10], [17], [40] the effect of night watch on accidents was examined in terms of watchkeeping officers, in this study, the accidents in the straits, where the bridge team is manned at the highest level, were examined. This study makes an original contribution to the existing literature by investigating the effect of daylight on accidents in busy waterways, with a particular focus on the Istanbul and Canakkale straits. Furthermore, the research was carried out by considering the role of the bridge team, which represents a novel approach to the topic.

During the resting period of the bridge team members, measures such as ensuring that members sleep in the dark and uninterrupted as much as possible, and that they can go to night watches in a rested manner can be taken. Ensuring that the cabins are suited for complete dark sleep is crucial for this. The MLC regulations must be correctly implemented on board ships to ensure that personnel have the opportunity to rest uninterrupted. In addition, according to the Turkish Straits Maritime Traffic Regulation, allowing tankers larger than 200 meters, other vessels larger than 250 meters, and towed vessels to pass through the straits only during the daytime period can be considered as one of the measures taken [41]. This measure is understood to be a correct measure taken to reduce the impact value of accidents that occur more frequently at night.

According to the Montreux Convention, there is no obligation to take a pilot for “vessels engaged in non-stopover passage” through the Turkish Straits [33]. Only 54% of the ships engaged in non-stopover passage get a pilot [42]. However, imposing a pilotage requirement on ships transiting through the straits at night could be an effective measure to reduce the risk of accidents during night watches.

Unfortunately, the accident data used in this study lacked the essential information to allow us to include the severity level of the incidents in the analysis. In addition, the number of reach accidents examined in this study is limited to 451. These can be considered limitations of the study.

In future studies, more detailed and more accident data can be studied, in which the severity level of the accidents can be added to the analysis. In this study, grounding and collision accidents were investigated. Other accident types may be included in the analysis in future studies. Further detailed studies and analyses may be carried out in the future regarding the measures to be taken regarding the effects of the Circadian rhythm on night watch accidents.

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