

## RISK-BASED EVALUATION OF DECISION-MAKING PROCESSES IN BRIDGE OPERATIONS OF SEAGOING VESSELS

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**Purpose:** This study aims to examine the operational risk factors that influence decision-making by watch officers on a ship's bridge. It focuses on human-related aspects such as stress, fatigue, routine behaviour, communication, and time pressure — elements that collectively shape the quality of decisions made in dynamic maritime environments.

**Design/methodology/approach:** The research was based on a structured questionnaire completed by deck officers. The survey collected opinions on working conditions, psychological strain, and the organisation of bridge duties. The responses were evaluated using an expert approach supported by fault tree analysis (FTA), which made it possible to design an initial model for assessing human reliability within the “human–ship” operational system.

**Findings:** The analysis revealed several recurring issues that reduce the reliability of officers on watch. The most significant include fatigue caused by irregular duty schedules, stress linked to safety responsibility, limited communication, and continuous time pressure. Long-term exposure to such conditions lowers focus and increases the risk of human error. The developed model helps to better understand how human factors interact and influence operational safety.

**Research limitations/implications:** The results are based on self-reported data, which may affect their general validity. Future studies should combine this approach with simulation-based testing or direct observation of bridge teams. Economic and organisational factors were not addressed.

**Practical implications:** The findings provide a basis for developing risk assessment and training tools centred on the human factor. The proposed reliability model may support bridge resource management and improve the overall safety culture on board.

**Social implications:** Improving working conditions and fatigue management can enhance both safety and crew well-being, contributing to sustainable maritime operations.

**Originality/value:** The paper combines human-factor analysis, reliability assessment, and operational risk evaluation in one framework, offering a practical contribution to understanding human performance in maritime navigation.

**Keywords:** Human Reliability Assessment(HRA), human factors, Rensis Likert scale, risk perception in navigation, workload assessment techniques.  
Category of the paper:

## 1. Introduction

Maritime transport continues to be the backbone of international trade, accounting for almost 80% of global cargo flows (UNCTAD, 2023). Although the shipping industry has adopted advanced technologies and increasingly sophisticated support systems, the number of maritime incidents remains a concern. Current research consistently highlights the human factor as a major cause of maritime accidents (Mu et al., 2024).

Operational decisions made by watch officers are shaped by a variety of internal and external factors, including stress levels, fatigue and environmental complexity (Jaram et al., 2021). While the International Safety Management (ISM) Code introduced by the International Maritime Organisation (IMO) was developed to strengthen the safety management framework, it has yet to fully address the challenges of human error (Bhattacharya, 2012).

Given the evolving threats in the maritime domain, it is crucial to examine the conditions that affect the decision-making ability of navigation officers. A better understanding of these conditions can lead to a more targeted approach to risk mitigation (Kizilay, 2023).

Assessing the competence of watchkeeping personnel should include an integrated view of human performance, including not only procedural knowledge, but also the relationship between the individual, the vessel and the surrounding operational environment (Fan, Yang, 2026). Methods such as Human Reliability Assessment (HRA) and Cognitive Task Analysis (CTA) offer valuable tools for analysing human-system interactions in dynamic navigation environments (Fan, Yang, 2024).

Against this backdrop, this thesis aims to explore the key variables that influence officer performance on the bridge, with a particular focus on how these factors shape navigation safety outcomes.

## 2. Review of existing research on factors affecting watch officer safety

The issue of performance of maritime watch officers and civil aviation pilots has consistently been of interest to the scientific community, and particular attention has been paid in recent years to the role of fatigue, stress and routine as factors affecting decision-making performance and operational safety. Although the maritime and aviation sectors differ in terms of the specifics of their work, both human functioning environments are united by intense

responsibility, prolonged concentration and often irregular working patterns. Contemporary scientific literature is increasingly clear that fatigue and occupational stress are among the main threats to operational safety in maritime transport. Officers of the watch are particularly vulnerable, carrying out their duties under conditions of sleep deprivation, multi-hour shifts and increasingly high administrative and technological demands (Rajapakse, Emad, 2024, Zhao et al., 2021).

Rajapakse and Emad (2023) indicate that the problem of fatigue is not just a result of poor working time organisation, but also a result of structural problems in the industry, such as lack of functional support and overload of duties (Rajapakse, Emad, 2024; Zhao et al., 2021). Similar observations appear in a study by Zhao et al. (2023), who analyse the effects of the COVID-19 pandemic on vessel crews, indicating an increase in symptoms of burnout, depression and sleep disorders (Zhao et al., 2023).

Bury et al. (2025) highlight how watch officers experience cognitive overload resulting from routine, pressure and conflict between technology and situational perception (Bury et al., 2025). This theme is deepened by Li et al. (2022), showing that fatigue recognition using AI methods can be an effective tool in error prevention (Li et al., 2022).

From a physiological and organisational perspective, studies by Yancheshmeh et al. (2020) and Mansyur et al. (2020) confirm that poor sleep quality and excessive working hours are the main factors that increase fatigue levels (Yancheshmeh et al., 2020; Mansyur et al., 2020). In contrast, Uğurlu et al. (2021) show that rotating navigation schedules in coastal shipping should be individually tailored to the officer's function (Uğurlu et al., 2021).

The impact of modern technology and automation on operator vigilance is analysed by Hannaford and Hassel (2021), suggesting that crew reduction does not lead to a reduction in workload and may even increase the risk of errors (Hannaford, Hassel, 2021). Stoliarov (2024) argues that modern systems on the bridge, such as integrated bridge management systems (IBS) or electronic navigational charts (ECDIS), in the absence of adequate training and integration with human perception, reduce performance (Stoliarov, 2024).

Fan et al. (2023) and Apostol-Mates and Barbu (2019) show that human errors are often rooted in cognitive and physical overload, and result in real accidents involving watch crew. The authors of (Fan et al., 2023) focus on the psychological aspects of safety and the use of behavioural assessment in risk analysis, while research (Apostol-Mates, Barbu, 2019) focuses mainly on empirical analyses of marine accidents resulting from fatigue and lack of concentration.

Equally relevant are Shan and Neis' (2020) observations of labour mobility and poor regulatory oversight in Canadian coastal shipping, leading to exacerbating problems of fatigue and burnout (Shan, Neis, 2020). Huang (2020), on the other hand, presents the results of an analysis of officer work intensity and how shifts are organised, highlighting the need for rationalisation. The study was qualitative and based on an analysis of observations and interviews with crew members, providing an in-depth understanding of practical organisational problems (Huang, 2020).

In civil aviation, the topic of fatigue has been developed for decades. Studies by Lee and Kim (2018) and Dawson et al. (2005) confirm that the primary preventative factor is adequate sleep time, not just technical procedures (Lee, Kim, 2018; Dawson, 2005). Drury et al. (2012) show a direct link between sleep deprivation and impaired mood and cognitive function (Drury, 2012). In contrast, Goode (2003) shows a correlation between pilot fatigue and aviation incidents (Goode, 2003).

Liao (2015) and Banks (2012) analyse cultural aspects and legal considerations related to fatigue management, showing differences between countries in the implementation of prevention strategies. Liao points out the contrast between Chinese and Western pilots' attitudes towards procedural adherence and risk perception, while Banks focuses on differences in fatigue legislation and the role of trade unions in shaping operational practices (Liao, 2015; Banks, 2012).

In summary, the literature review indicates that fatigue, stress and routine are key factors affecting the performance of both watch officers and pilots. It is not only the length of the shift or the number of hours of sleep that matters, but also the quality of recovery, psychological support and the structure of the tasks performed on the job. In light of the above research, it seems reasonable to implement personalised human risk management strategies that take into account the specifics of shift work and the pressure of responsibility in operational professions.

### **Structure of the watch officer's work**

The work of an officer of the watch on a seagoing vessel is multifaceted and requires consideration of both technical and psychosocial factors. A ship is simultaneously a place of work, residence and rest, which places seafarers in a situation of constant exposure to changing operational conditions and occupational stress. Therefore, the design of the ship's space should take into account the requirements of the natural, material-technical and psychosocial environment, in accordance with the applicable standards and regulations.

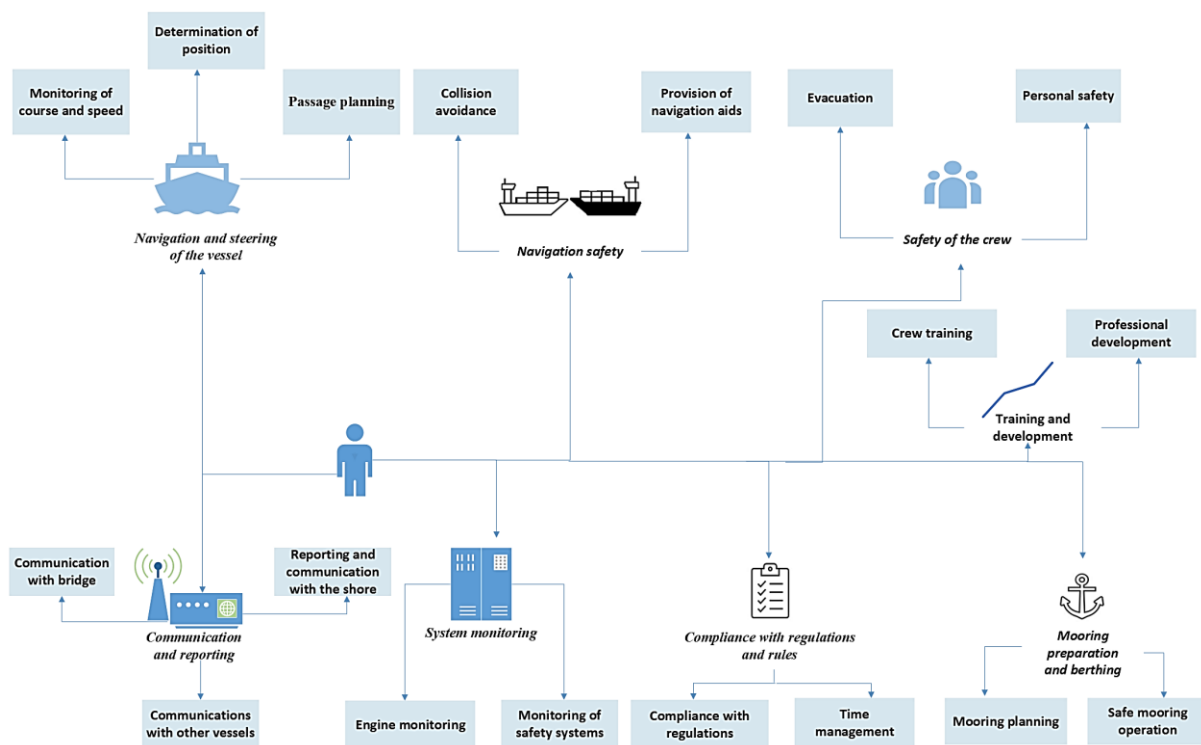
International regulations such as the STCW Convention (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers) and the MLC (Maritime Labour Convention) set standards for training, certification and working conditions for seafarers. Their main objective is to ensure safe navigation and decent working conditions for the crew. In addition, the International Safety Management Code (ISM Code) and the International Ship and Port Facility Security Code (ISPS Code) define procedures to minimise operational hazards and protect against incidents at sea.

The International Convention for the Safety of Life at Sea (SOLAS) and the SAR Convention (International Convention on Maritime Search and Rescue), which set out minimum safety standards and search and rescue procedures, are also crucial in the context of a watch officer's work. In addition, each country may also introduce its own national regulations governing working conditions at sea, which further complements existing international standards. Understanding and adhering to these regulations and adapting the

working environment on board to the needs of the crew are key to ensuring the efficiency and safety of the watch officer.

### Responsibilities of the officer of the watch

Serving as a watch officer requires not only a high degree of professional competence, but also the ability to make quick and accurate decisions in dynamically changing conditions. The officer of the watch must be prepared for emergencies and effectively manage the lower-level crew. His or her role is not just about following procedures - it is also about being able to anticipate risks and take preventive measures. The structure of his or her job is closely linked to ensuring the safety of the entire ship and crew (Figure 3).



**Figure 3.** Structure of the watch officer's work - own development.

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### Reliability of the officer of the watch and safety of maritime operations

The reliability of the officer of the watch is a key aspect of ensuring safe navigation. In the context of human-ship interaction, the term can be defined as the ability of a system to effectively perform its assigned tasks under specified operational conditions and within a set time (Bęczkowska, Grabarek, 2021). The human being, as a key element of this system, plays an important role in its functioning, and the influence of individual and environmental factors on its reliability has been the subject of numerous studies. In the literature, the concept of human reliability refers to a person's ability to maintain the required performance while performing

specific tasks (Hansen, Nazir, 2024). This means that a watch officer not only needs to have the right skills and qualifications, but also to be able to use them effectively, especially in dynamically changing navigational conditions.

Human factors, understood as the interaction between humans and the operational system, include perception, information processing and decision-making processes. In the context of maritime operations, it is human error that is identified as one of the main causes of incidents and accidents. Their analysis shows that both an individual's characteristics, such as resilience to stress or the ability to quickly assess risk, and environmental factors can significantly affect his or her performance and ability to make accurate decisions.

Navigational safety is shaped by the interplay of subjective (e.g. personality traits, level of experience) and situational (e.g. weather conditions, work organisation) factors. The situational awareness of the watch officer is a key element in the decision-making process and influences the effectiveness of the response to unexpected events. High levels of stress and increased operational risk can result in a reduced ability to perceive threats correctly, which in turn increases the likelihood of error. Understanding the impact of the human factor on watch officer reliability is essential to minimise the risk of errors and improve the safety of marine operations. Developing effective risk reduction strategies requires consideration of both individual predispositions and environmental factors that may affect human performance in navigation systems.

### **The human factor and reliability of the officer of the watch**

Human error is an inherent part of the watch officer's job and its impact on navigational safety is crucial (Adumene et al., 2022). Perception, interpretation of the situation and the amount of information influence decisions that can lead to incidents. Decisions are made under time pressure and based on experience. Officers who are more experienced act faster and more effectively, but conditions such as fatigue and stress can reduce the reliability of decisions (Kum et al., 2007). Risk perception decreases when the officer feels in control of the situation, but overconfidence or inexperience increases the likelihood of error. Not every mistake leads to an incident, but the consequences depend on environmental conditions and the ability to correct (Kum et al., 2007). Psycho-physical conditions such as fatigue, shift patterns, lack of rest and stress have a significant impact on work performance. Although rest regulations exist, the reality of work often deviates from the norm, increasing the risk of errors. Communication is crucial to navigational safety - problems in communication can lead to lack of cooperation and increased tension among the crew. All these elements affect the reliability of the watch officer and the safety of marine operations.

### 3. Methodological Framework for Questionnaire Design

The survey used the expert method, which is based on the selection of experts to take part in the study. Each participating respondent was consciously selected by the authors for their expertise and type of work

For the purpose of the article, a survey was conducted among watch officers from the deck department. Each person surveyed was an expert in his or her field - they had a university degree and were qualified to at least operational level. We expected them to be people with an interesting personality, a lot of knowledge, broad horizons, as well as thinking independently and, above all, able to justify their answers. We did not select random people for the survey, they were people who actually sail on the ship. This allowed us to eliminate the answers of those people who have no idea whatsoever about the answer by which would be inconsistent with the topic, while at the same time supporting those who have an unusual view of the safety situation. Experts gave their answers without contacting each other. The survey was conducted using the MS Forms platform.

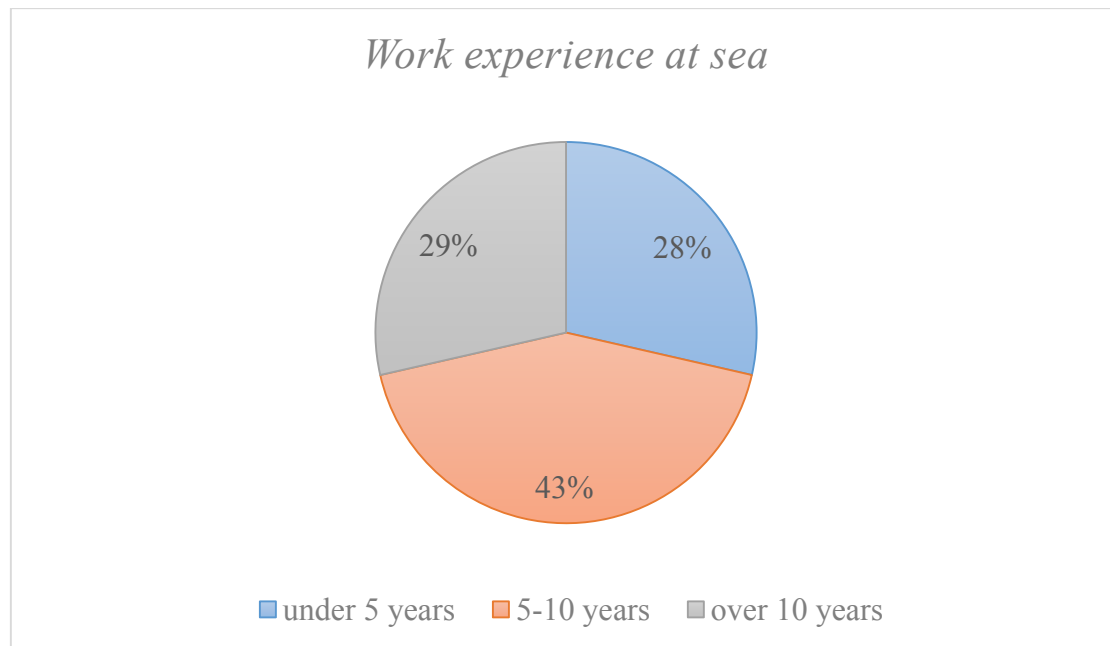
Through the questions asked, it was possible to define a common position on the management of safety on board and, most importantly, to identify the factors affecting officer reliability.

Conducted survey on mood among employees and their views on safety in the workplace.

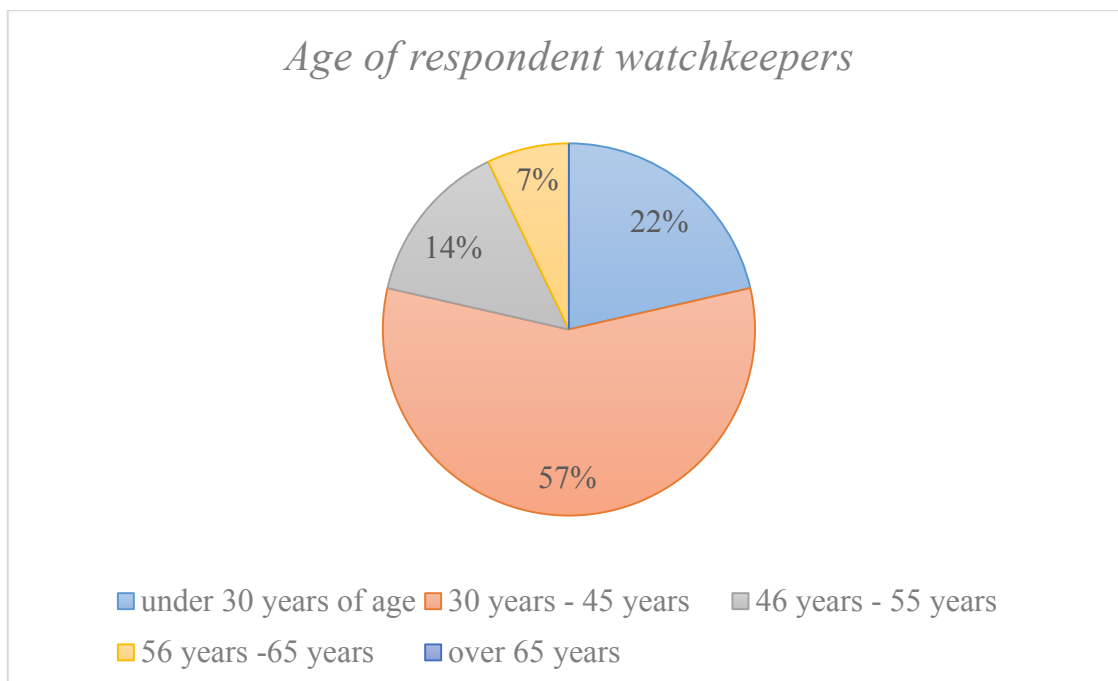
Purpose of the survey: The research undertaken was to identify human behaviour in assessing the reliability and safety of a watch officer in the performance of their duties.

The survey aims to collect information related to the hazards on board.

Survey sample: this survey was conducted on a group of 100 officers from the deck department. The subjects have a university degree and were sailing on a ship at the time of the survey. The survey takes into account the age, job position and length of service of the officers and the types of ships they sail on. The officers have a minimum of 5 years' work experience (Figure 5) and the age of the respondents is less than 65 years (Figure 6).



**Figure 5.** Distribution of work experience of respondents.



**Figure 6.** Age distribution of respondents.

The selection of respondents was a quota sample, which means that the selection of respondents usually takes into account characteristics such as age, gender, social and occupational status. This type of purposive sampling involves selecting people who, according to the researchers or expert assessment, are typical representatives of the target population. This means that the respondents meet predefined criteria of belonging, e.g. occupation, place of residence. An improvement on this method is quota selection, in which the distributions of the population characteristics of interest to the researchers are determined at the outset (Swiderska et al., 2023). The aim of the selection becomes to reproduce the same proportions

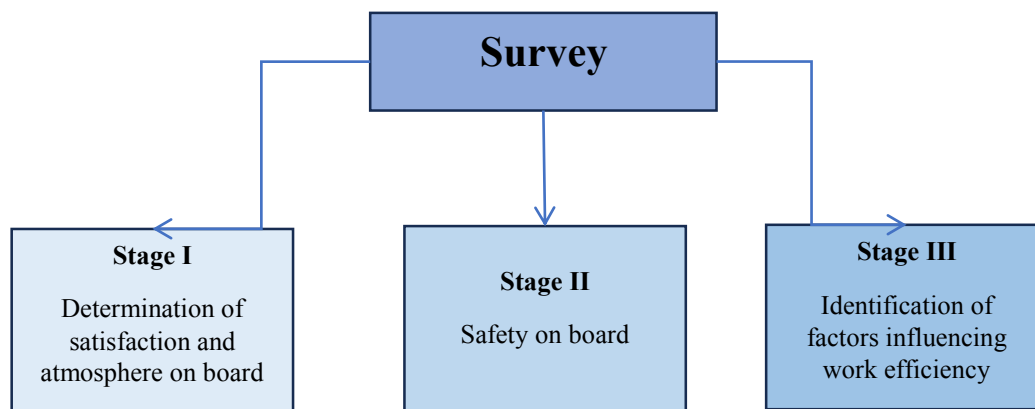
of these variables in the sample. In recent survey research, five-point scales are commonly used in different types of surveys and survey tools. They are used in both opinion surveys and employee satisfaction analysis.

### Structure of the survey: it consists of three stages (Figure 7)

Stage I - aims to determine the degree of satisfaction with the job and the atmosphere in the working environment.

Stage II - to obtain information on safety in the workplace.

Stage III - gathering information to identify factors affecting efficiency on board.



**Figure 7.** Structure of the survey.

Survey implementation form/methodology: The survey was conducted using the Microsoft service application, contained 71 questions and was completely anonymous.

Research technique used: the survey was given to the respondent to complete via a link that allowed access to the questions. The survey is a one-off, but will be evaluated for further research in the future.

The survey used the Rensis Likert scale, which is designed to measure attitudes towards specific problems or opinions on a particular topic. The Rensis Liert scale is one of the most popular methods in surveys of this type (5-point response scale). It can be used to obtain a response regarding the degree of acceptance of a phenomenon or opinion on a particular topic. It is also used in a large number of surveys to assess satisfaction (Interankiety, 2023).

Structure and options:

A five-stage scale:

- 1 - Strongly disagree.
- 2 - I rather disagree.
- 3 - I have no opinion.
- 4 - I rather agree.
- 5 - Strongly agree.

The authors wanted to use this method to determine the extent to which the respondent agreed with a statement.

Type of questions: closed questions (5-point scale) and open questions. Respondents were asked 71 questions. Questions 4 to 31 for a mood survey among employees - job satisfaction and atmosphere. Questions 32 to 52 on surveying perceptions of safety in the workplace. Questions 53 to 71 on the survey of identification of factors influencing work performance.

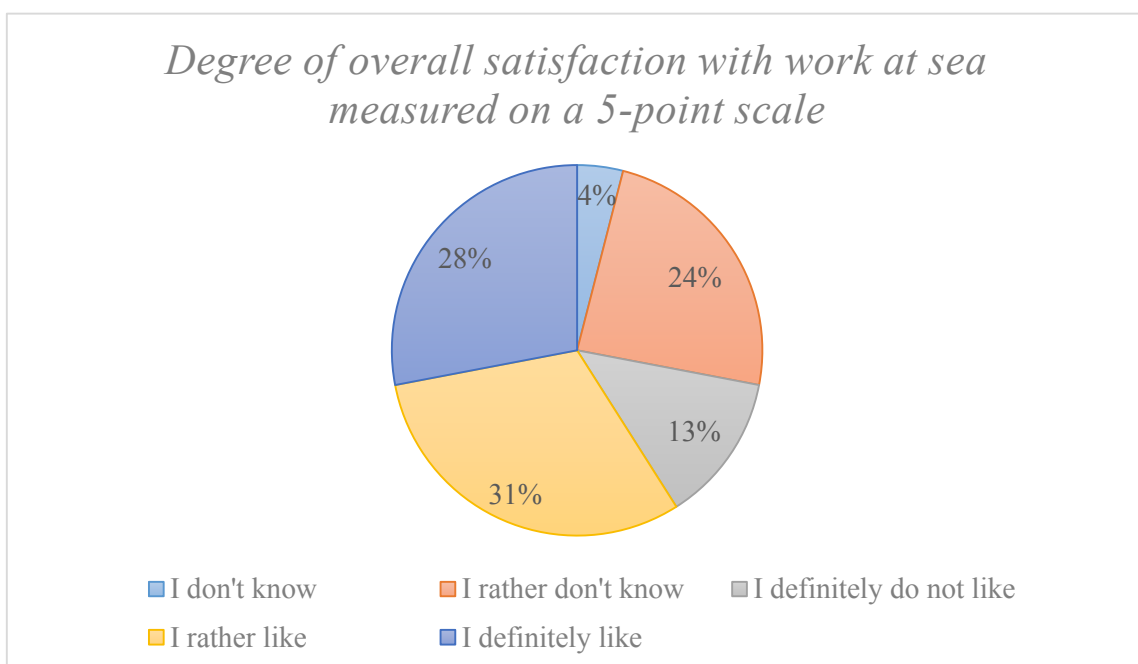
Time and place of implementation. There was unlimited time for responses. Each survey participant was able to answer the survey questions at their convenience. The estimated completion time was 16 minutes. The collection of completed surveys lasted from March 2023 to September 2023.

Exactly 100 surveys were collected during this period, each of which was completed correctly, although not every participant answered all the questions. There were 4 surveys where the respondent left a question unanswered.

#### 4. Quantitative Results of the Study

**Part I** of the survey determined the degree of satisfaction with the job and the atmosphere of the working environment on board. The survey at this stage provided information on loyalty to the employer and employee commitment, which helped to identify problems in the working environment. Responses to the satisfaction questions were measured on a 5-point Likert scale. Examples of questions and responses are shown in Figure 8 and Figure 10.

Figure 8 shows the percentage distribution of satisfaction with the maritime work, measured on a five-point scale.

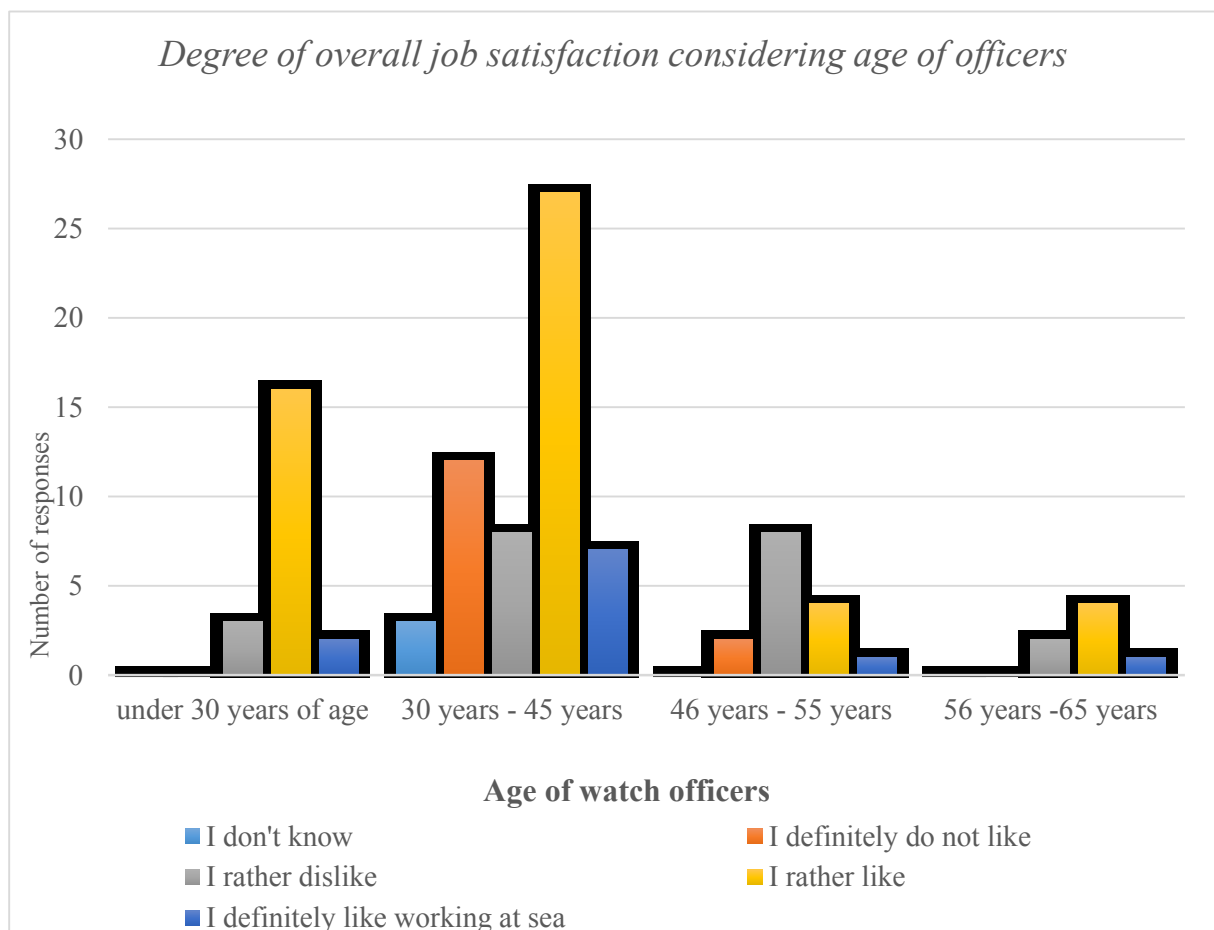


**Figure 8.** Degree of overall satisfaction with work at sea measured on a 5-point scale.

The sum of respondents who rather like (31%) and definitely like (28%) their job is 59%. This means that the majority of watch officers have a positive attitude towards their work at sea. In contrast, the sum of respondents who rather dislike (24%) and definitely dislike (13%) their work at sea is 37%. This indicates that there is a significant group of people with negative feelings. A small number of respondents (4%) are undecided about their satisfaction with their job, showing that the majority have an educated opinion.

Overall, Figure 8 shows that although the majority of watch officers are satisfied with their work at sea, there is a significant minority who have negative feelings. This may indicate a need for further analysis and possible action to improve working conditions and increase overall satisfaction.

Figure 9 shows the degree of overall job satisfaction among watch officers by different age groups.

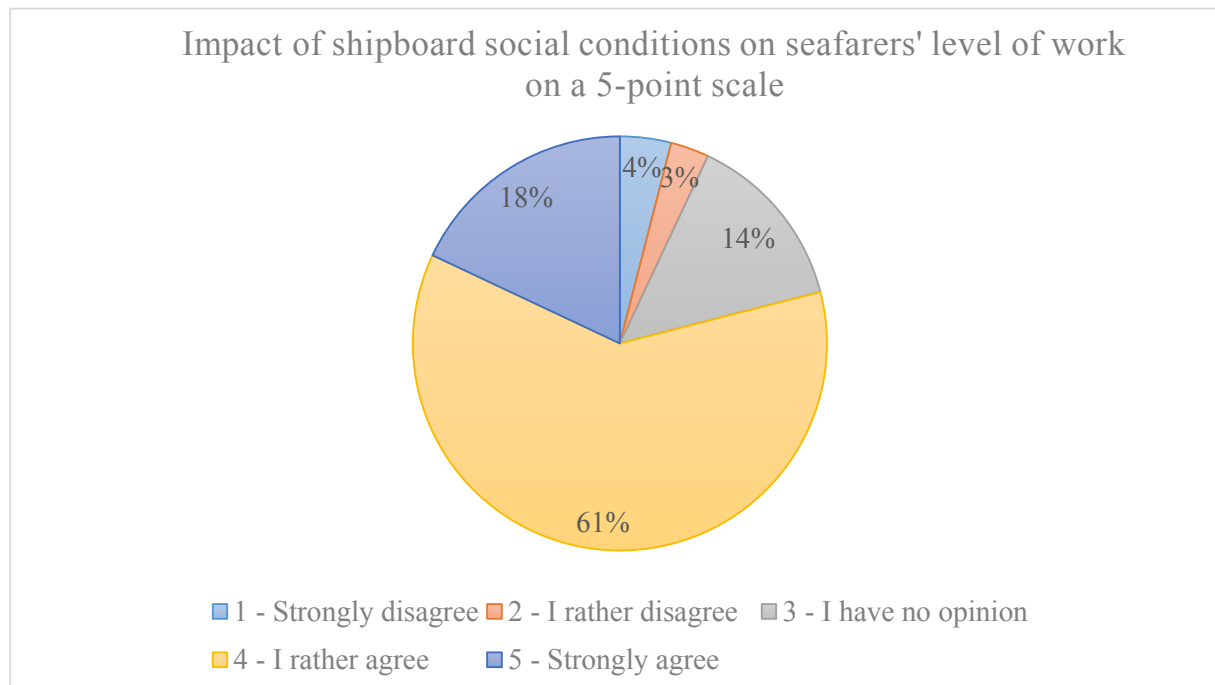


**Figure 9.** Degree of overall job satisfaction considering age of officers.

Overall, the majority of watch officers show a positive attitude towards their job, with the highest number of 'I rather like' responses in each age group. The highest degree of satisfaction can be seen in the 30-45 age group, where the predominant response is 'I rather like'. The under-30 and 56-65 age groups have a higher number of people unsure about their satisfaction ('Don't know'). Negative opinions are relatively rare in all age groups, but the highest percentage of dissatisfaction can be observed in the 30-45 age group. This graph

indicates a generally positive attitude of watch officers towards their work, with some differences depending on the age group.

Figure 10 shows how seafarers rate the impact of social conditions on board the ship on their level of work.

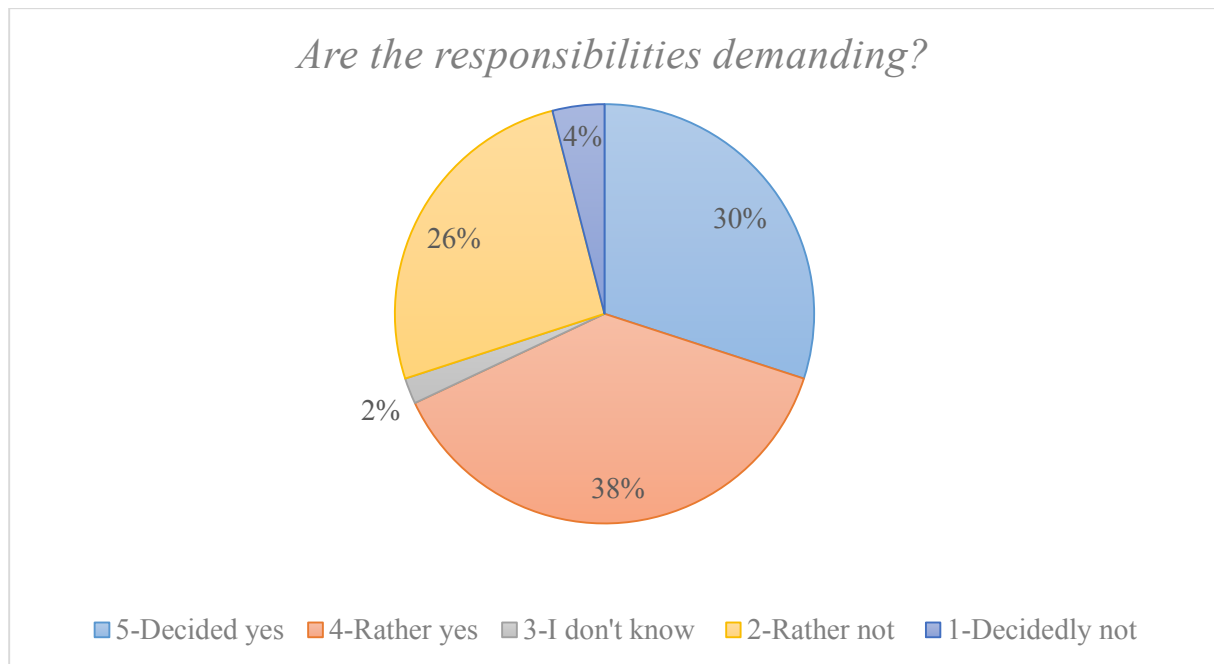


**Figure 10.** Impact of shipboard social conditions on seafarers' level of work on a 5-point scale.

Officers from the deck department by a large majority of 61% believe that the social conditions on board rather affect work efficiency.

The sum of respondents who tend to agree (61%) and strongly agree (18%) that the social conditions on board affect the level of work is 79%. This means that the vast majority of seafarers perceive a positive impact of social conditions on their work performance. A much smaller group (14% no opinion, 4% rather disagree, 4% strongly disagree) does not perceive or assess the impact of social conditions as unambiguously positive. The overall result shows that social conditions are a key factor affecting seafarers' job satisfaction and performance. It is therefore worth paying particular attention to improving these conditions in order to increase the overall level of crew satisfaction and efficiency on board ships. In conclusion, shipboard social conditions are an important element affecting seafarers' work levels, suggesting that improving them can bring tangible benefits in terms of crew satisfaction and productivity.

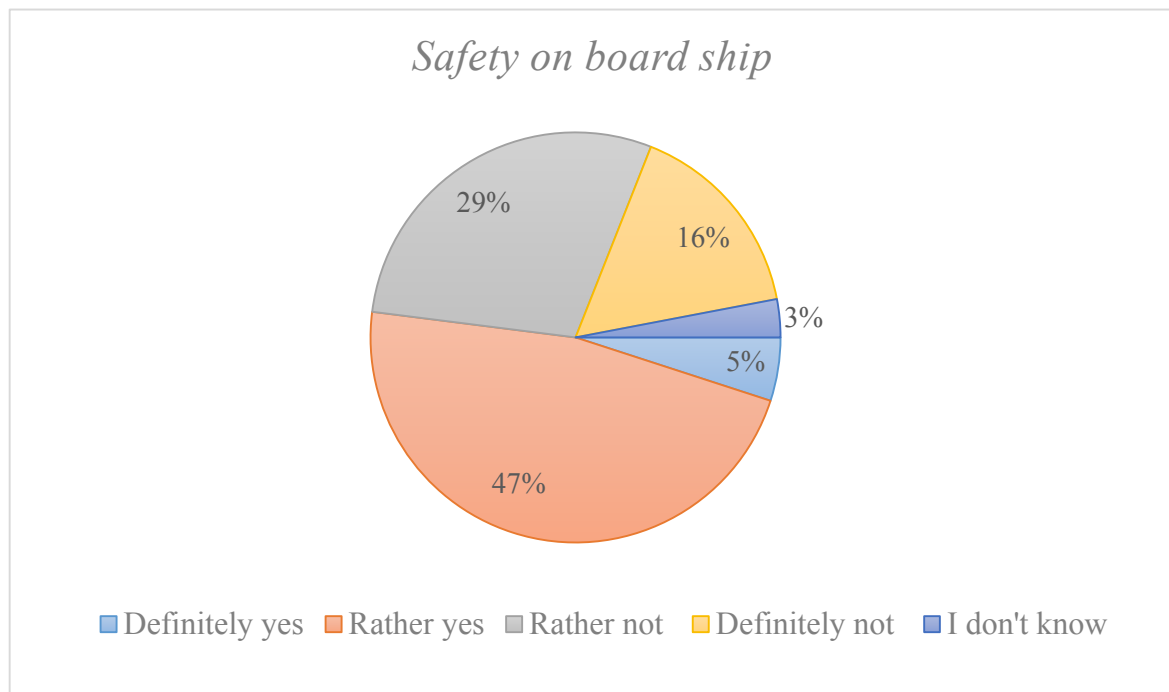
Officers were also asked on a scale of 1 to 5 whether their responsibilities were demanding. Figure 11 shows the results.



**Figure 11.** Responsibilities versus requirement on a 5-point scale.

According to the question asked, rather yes (38%) and definitely yes (30%) the responsibilities of their job are demanding.

**Part II** of the survey was aimed at obtaining information on safety in the workplace. At this stage, respondents were given the opportunity to comment on safety on the ship. One such question was; is the ship as a workplace safe. The results are shown in Figure 12.

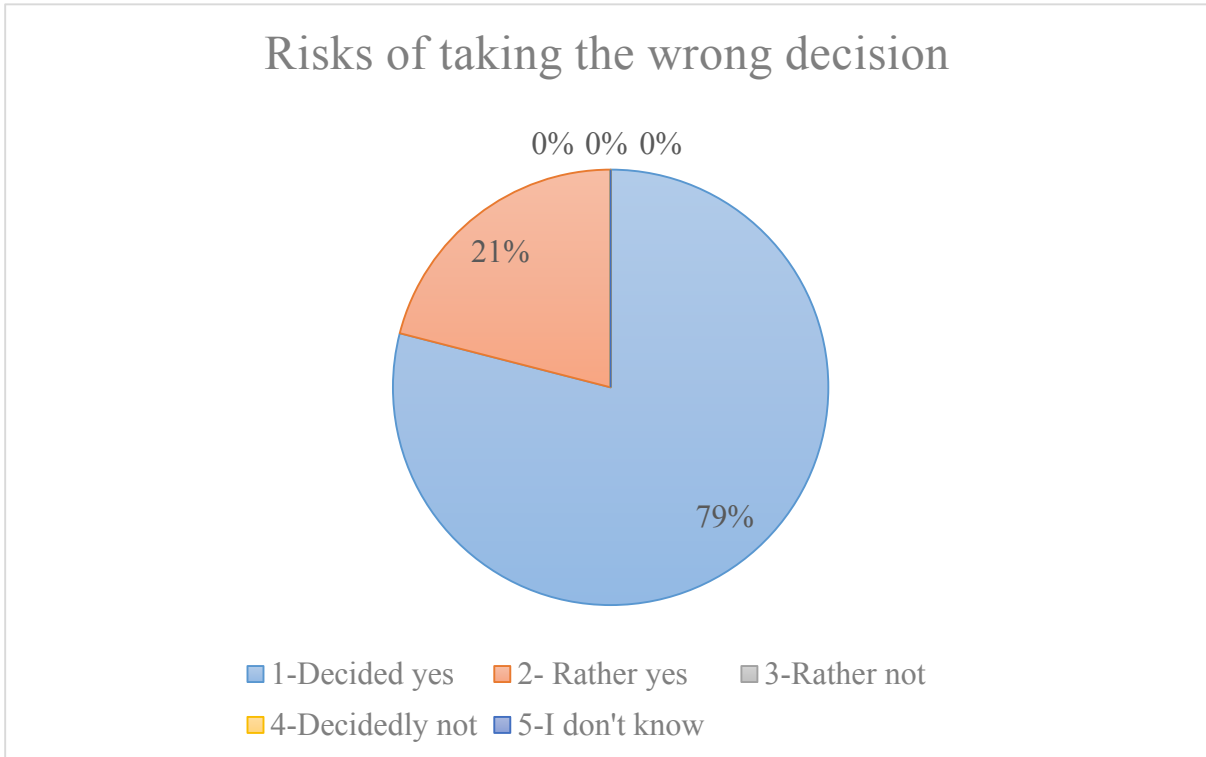


**Figure 12.** Safety on board.

The majority of respondents answered, 47%, that the ship was a rather safe place to work.

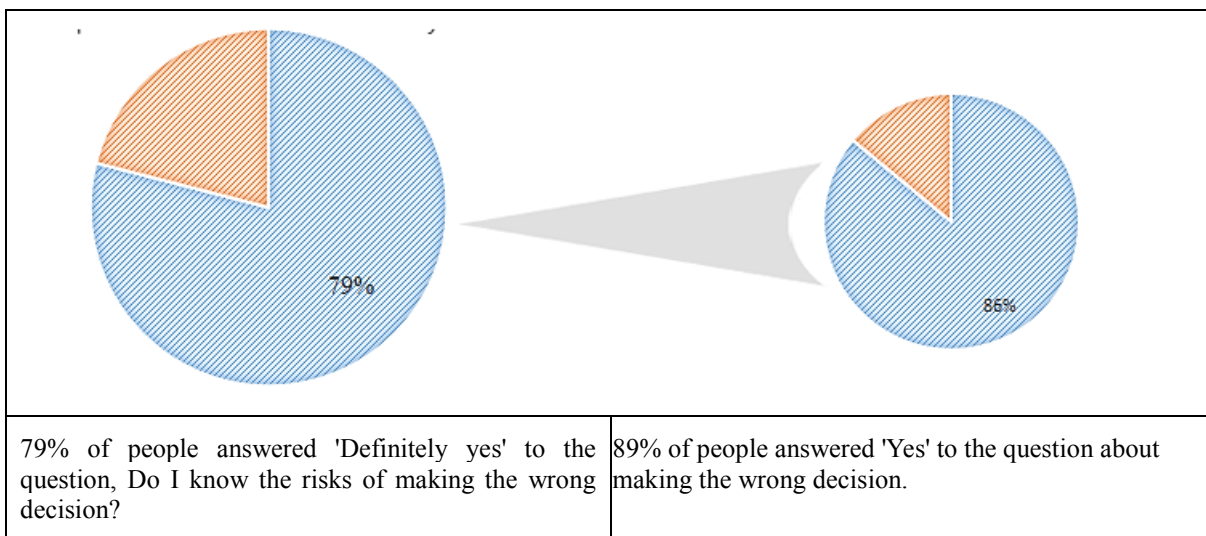
The next questions in Phase II of the questionnaire survey concerned the identification of risks arising from officer misconduct.

Figure 13 shows respondents awareness of the risks that can result from an officer making a wrong decision.



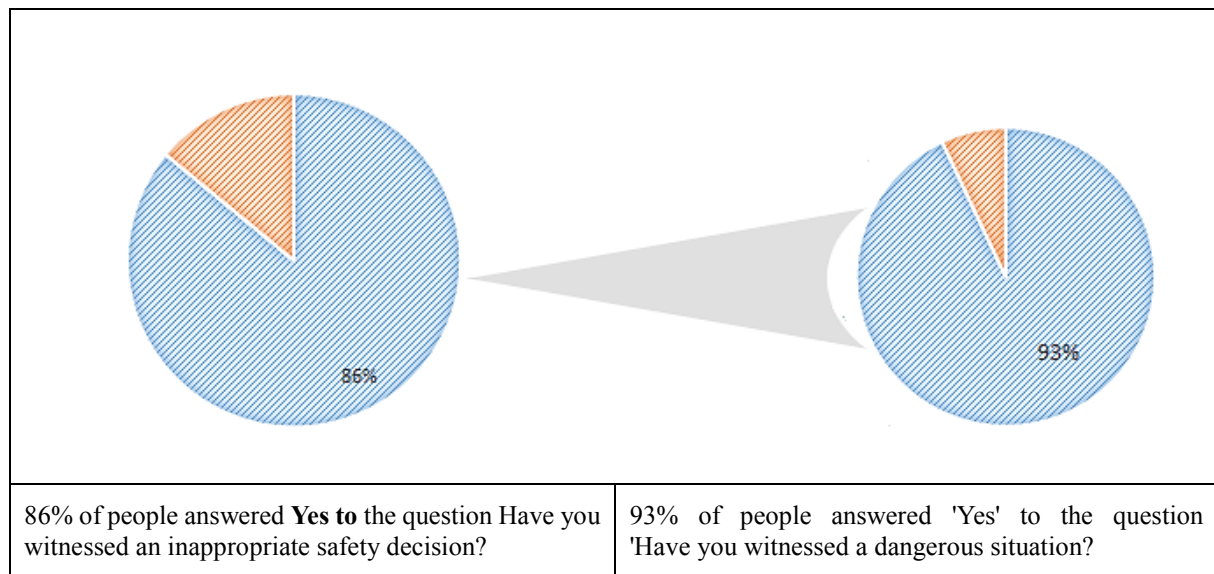
**Figure 13.** Awareness of risk when an officer makes a wrong decision.

For this question, as many as 79% answered **'Definitely yes'**, and also the majority answered **'Yes'** to questions about making the wrong decision. This shows that the majority of officers (100% of respondents) are aware of the risks of making the wrong decision. (Figure 14).



**Figure 14.** Awareness of risks of wrong decisions in the context of safety at work.

86% of those who witnessed a bad decision also mostly answered 'Yes' to the question 'Did you witness a dangerous situation?' (Figure 15).



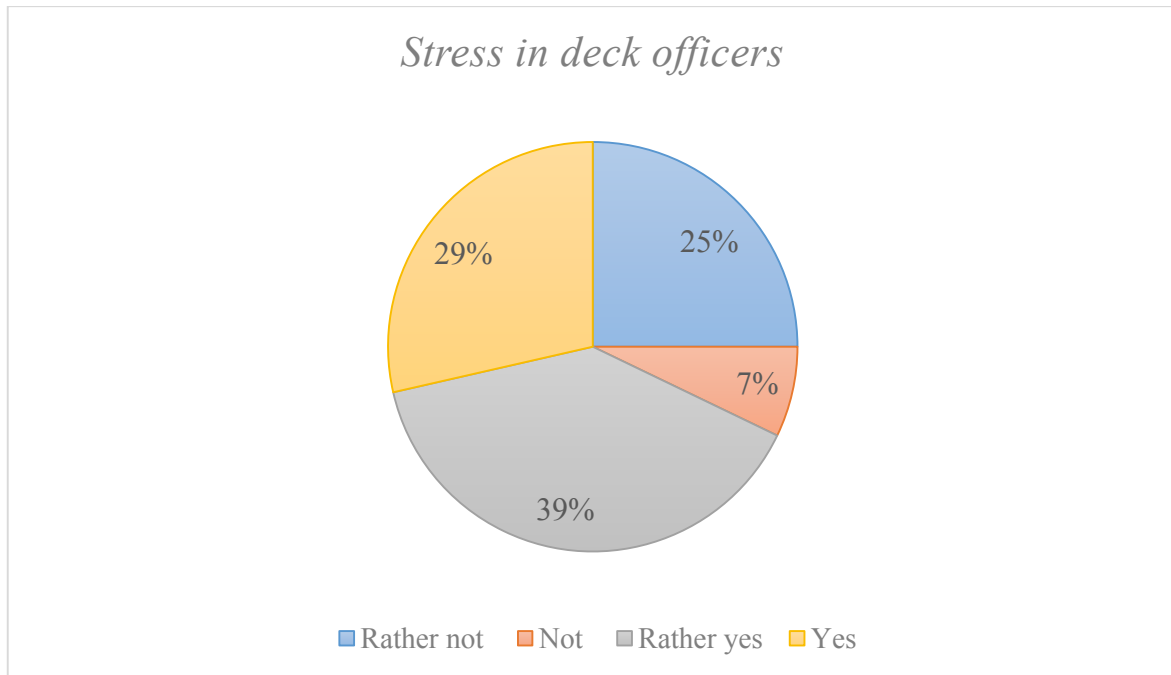
**Figure 15.** Awareness of poor safety decisions and the occurrence of dangerous situations at work.

**Part III** aims to gather information to identify the factors affecting the efficiency of the ship's work.

Many factors affect productivity and job satisfaction. One of them is stress. In most of our work duties, we are unable to avoid stressful situations that cause us problems, i.e. carrying out new tasks, interacting with colleagues, etc.

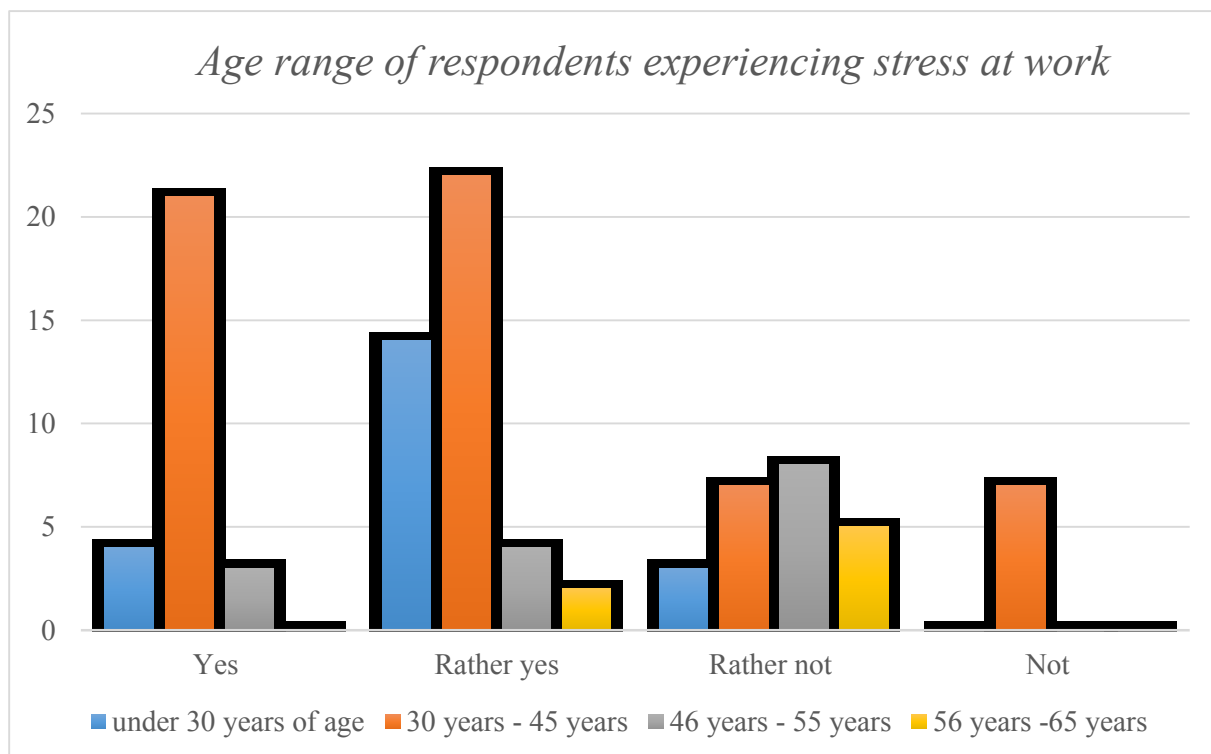
The following are the most interesting responses of officers in the boarding department to questions on stress.

One of the relevant questions is; do officers feel stressed about their job. To this question, the majority answered in the affirmative (considering the answer YES and RATHER YES). Figure 16 details the responses of the respondents.



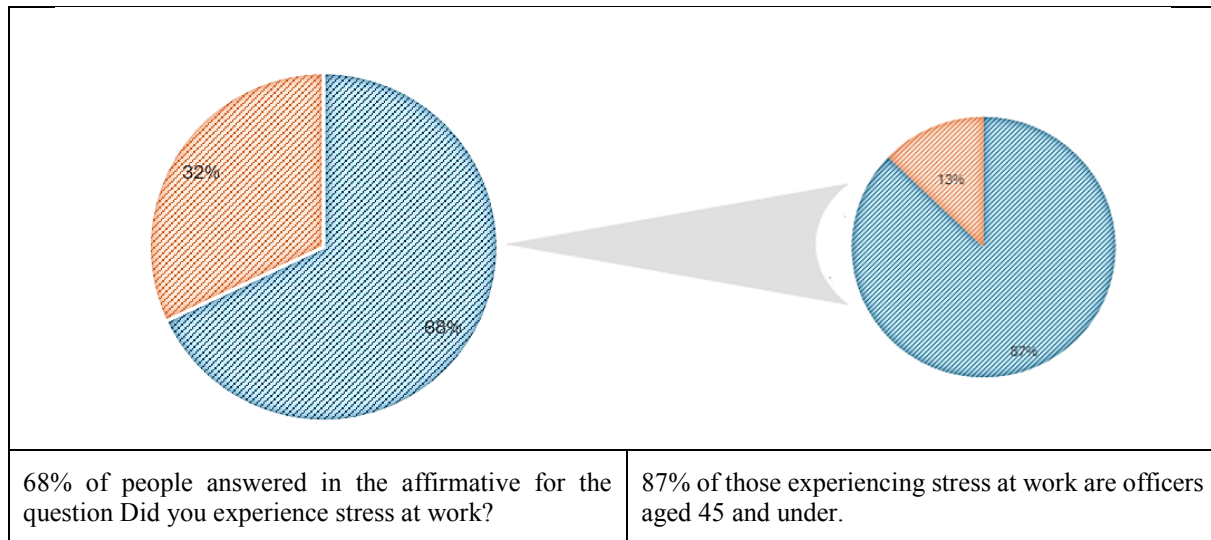
**Figure 16.** Perception of stress among officers of the deck department.

Figure 17 shows the effect of age on the perception of stress.



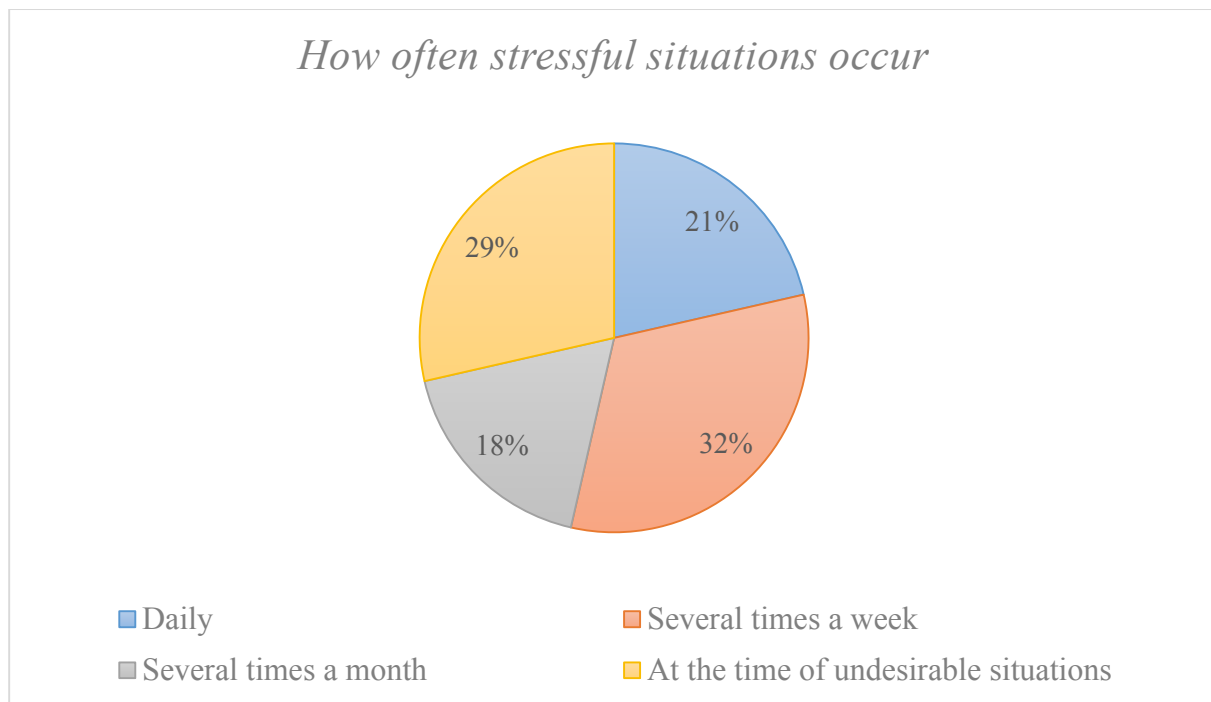
**Figure 17.** Age range of respondents experiencing stress at work.

It is noteworthy that 68% of the officers surveyed experiencing stress at work are aged 45 or under. Officers aged 46-65 are less likely to feel stress at work (Figure 18). This is likely to be due to a lack of experience in higher, more responsible positions.



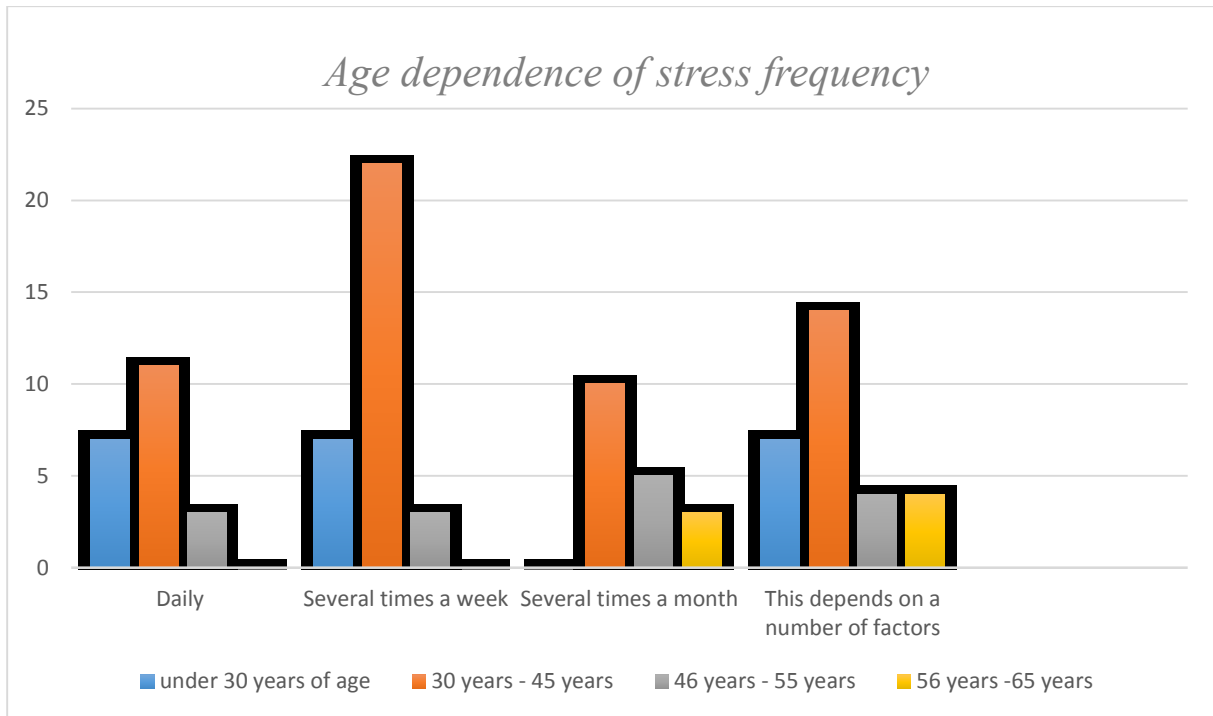
**Figure 18.** Percentage of people experiencing stress at work by age group and position.

Those who responded affirmatively to feeling stress also indicated how often it occurs during work. From Figure 12, it can be seen that as many as 32% of respondents feel stress several times a week and 21% daily. It is also worth noting the officers (29%) who marked a response in which they make the feeling of stress dependent on many other factors, i.e. undesirable situations during work. These types of factors will be explored later in the survey.



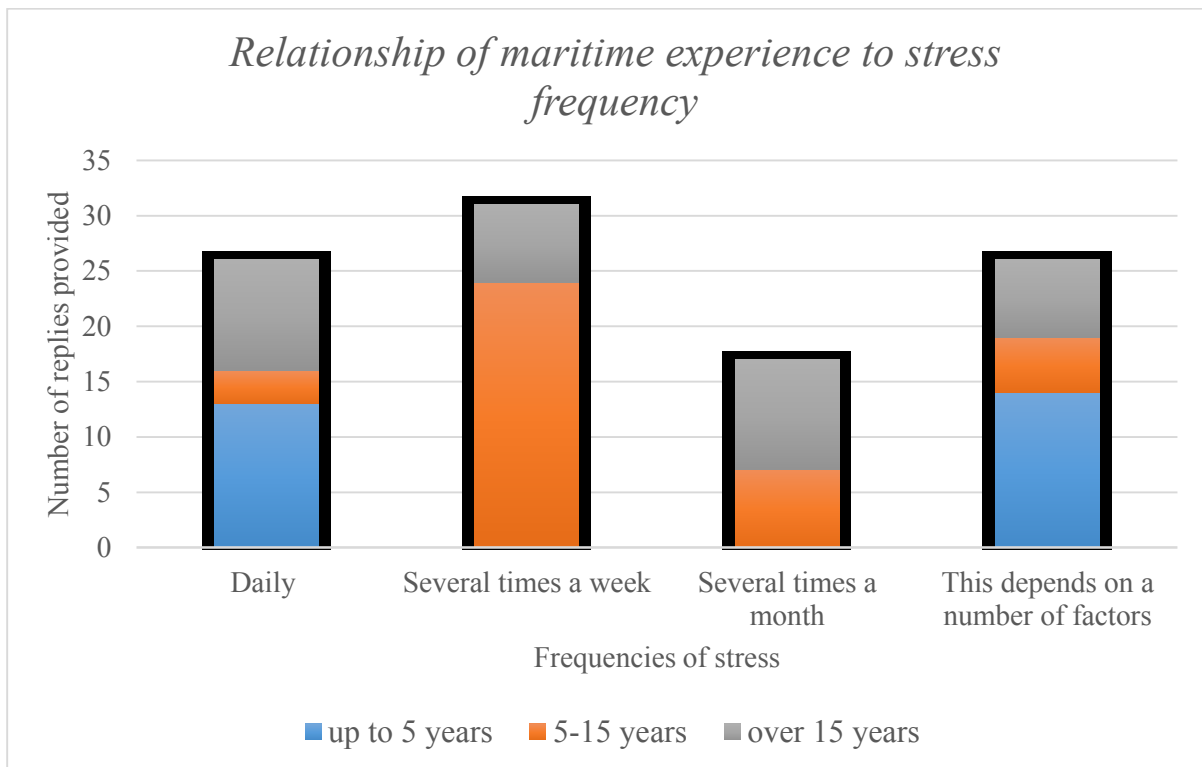
**Figure 19.** Prevalence of stress in the work of a deck officer.

Figure 20 shows how the frequency of perceived stress at work varies with the age of watch officers. The trend analysis shows that stress may be more or less common in certain age ranges.



**Figure 20.** Relationship between age and frequency of stress.

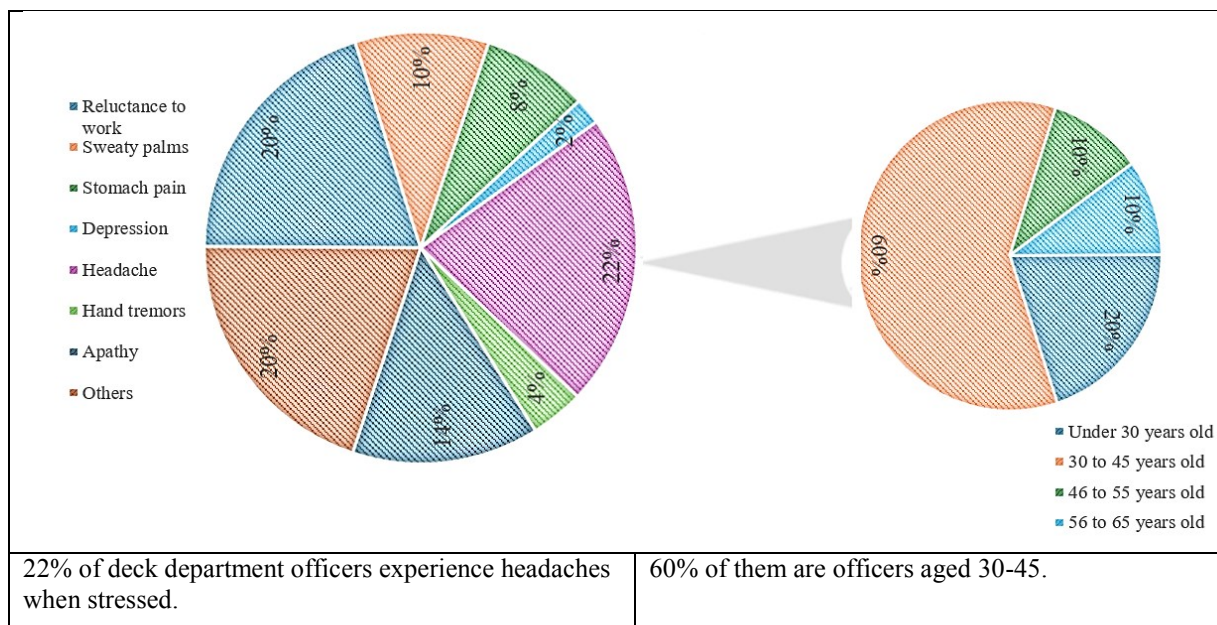
Figure 20 above shows that middle-aged officers (30-46 years) are more likely to experience stress than younger-aged employees (under 30 years). The age group above 46 years has the lowest frequency of stress. This is related to the fact that promotions are most common in this age range (30-46).



**Figure 21.** Shows how the frequency of stress at sea varies according to seafarers' years of work experience.

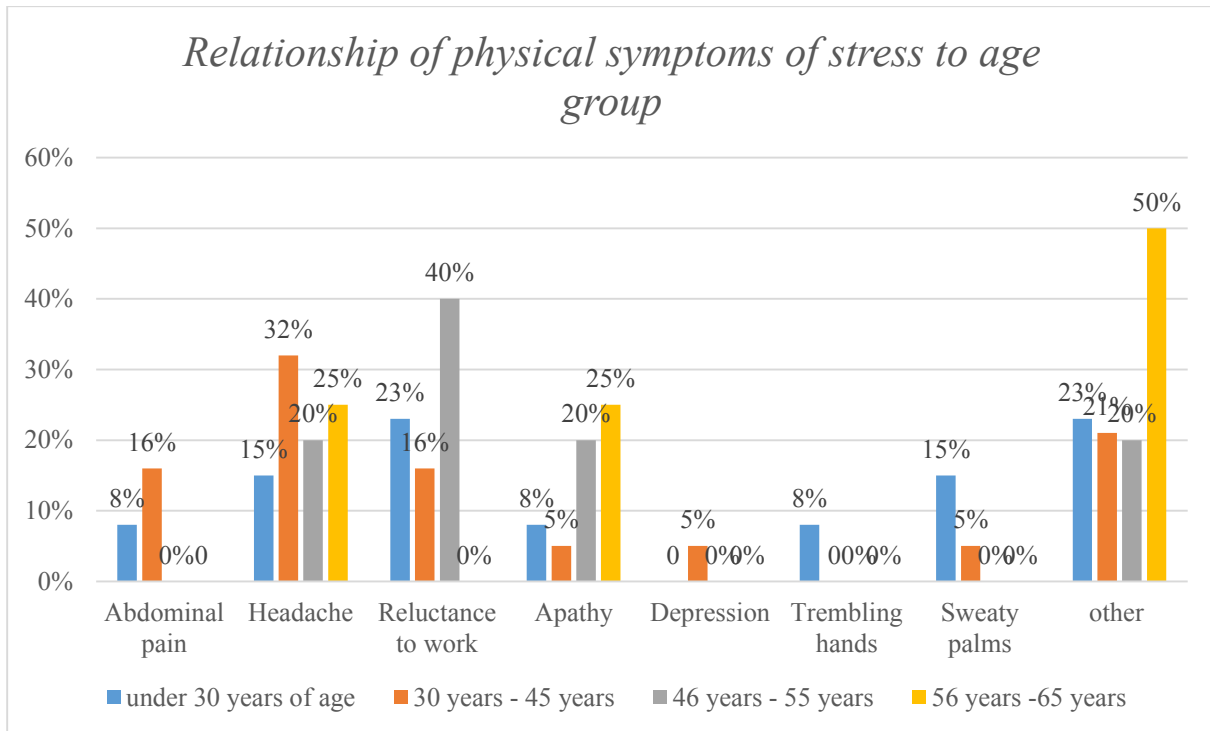
The trend analysis shows how stress levels change with increasing experience at sea. The graph shows that those with less experience (0-5 years) report a higher frequency of stress than the most experienced officers (group of more than 15 years). It is worth noting that the last group with the longest experience, may be more established professionally, which translates into less stress. Officers with experience of 5-15 years may be more likely to experience stress due to career advancement, which comes with greater responsibility for the safety of the vessel and crew. **Figure 21** suggests that experience at sea is a key factor in stress levels. Employers can learn from this about the need for more intensive support and training for newly promoted officers.

Figure 22 shows the various symptoms that most often accompany stress. Respondents indicated the most common symptoms that accompany them when stressed. Officers indicated that the most common symptoms that accompany them when they are stressed are a headache (22%) and an aversion to work (20%).



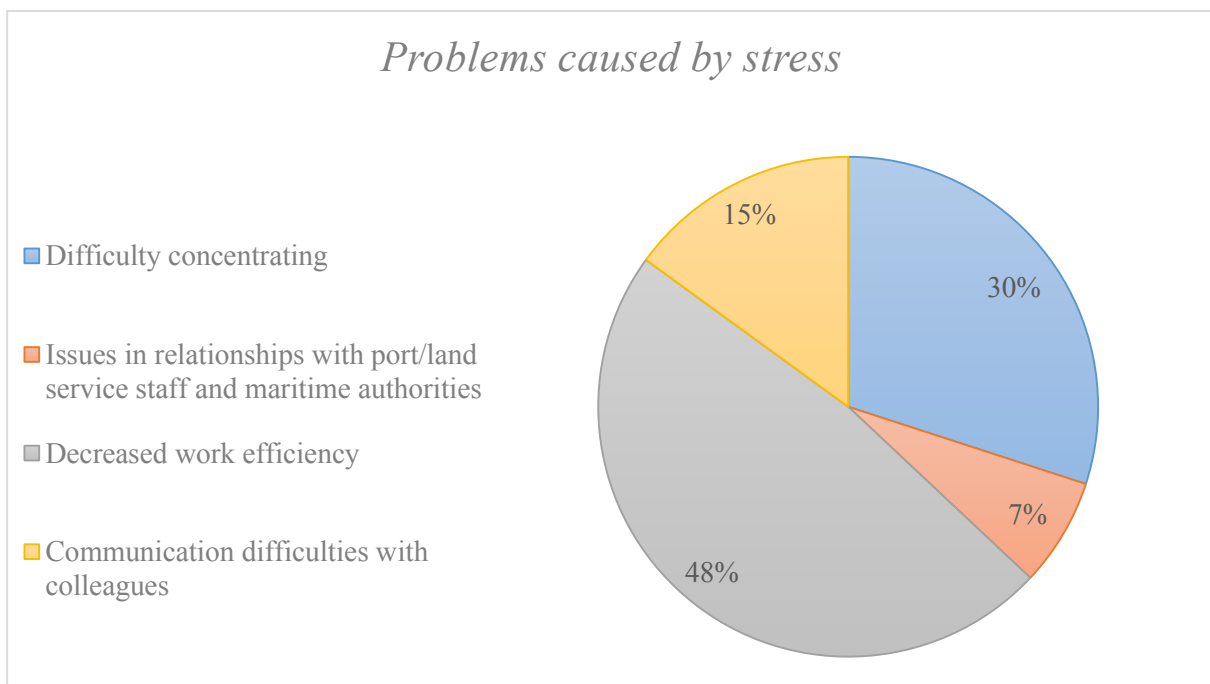
**Figure 22.** Physical symptoms of stress in officers of the department.

It is noteworthy (Figure 23) that officers in the 46-55 age bracket feel aversion to work as a result of stress (40%), while officers aged 56-65 complain of other stress-related symptoms.



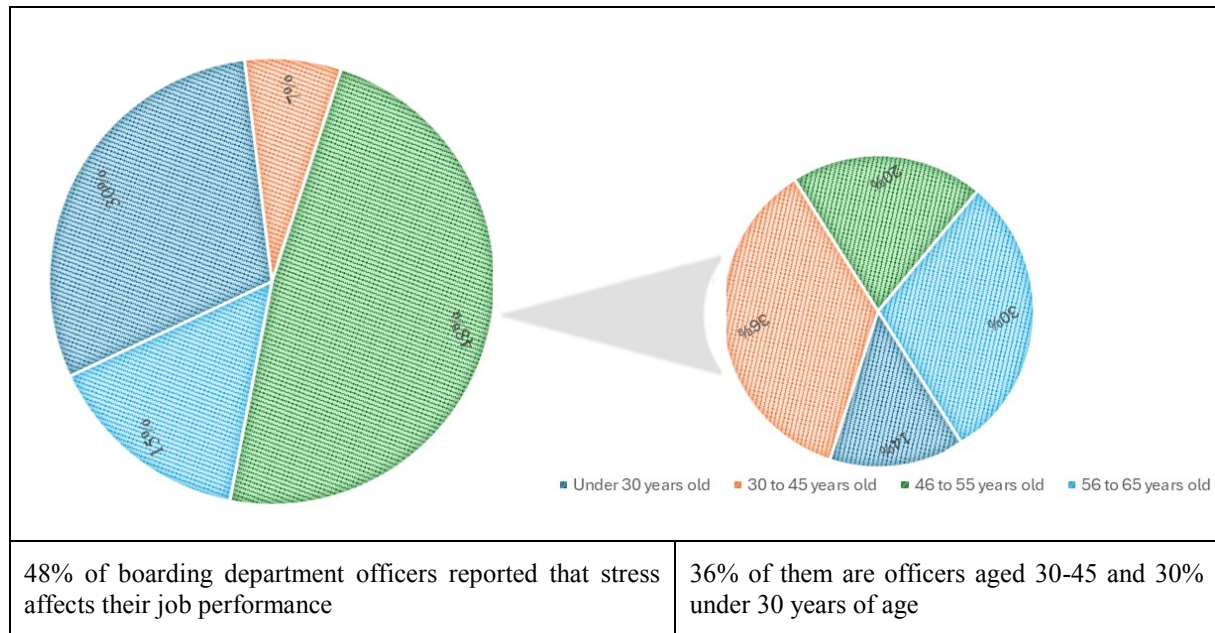
**Figure 23.** Relationship of physical symptoms of stress to age group.

It is interesting to note that as many as 48% of respondents confirm that stress motivates them to work effectively and 30% have problems focusing their thoughts (Figure 24).



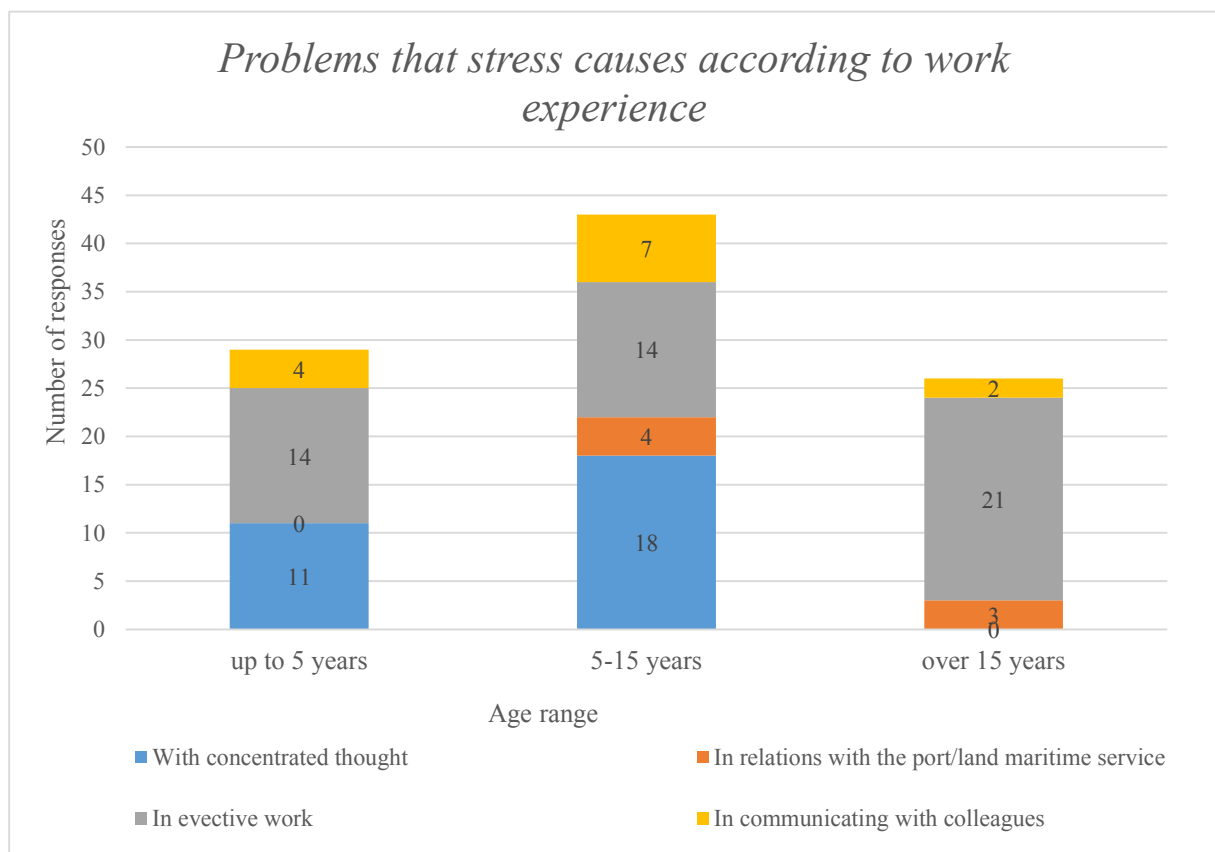
**Figure 24.** Problems caused by stress.

The group of respondents where stress is most likely to affect job performance are officers aged up to 45 years. This may be due to a lack of experience acquired with age, so that the onset of stress combined with inexperience results in lower efficiency at work (Figure 25).



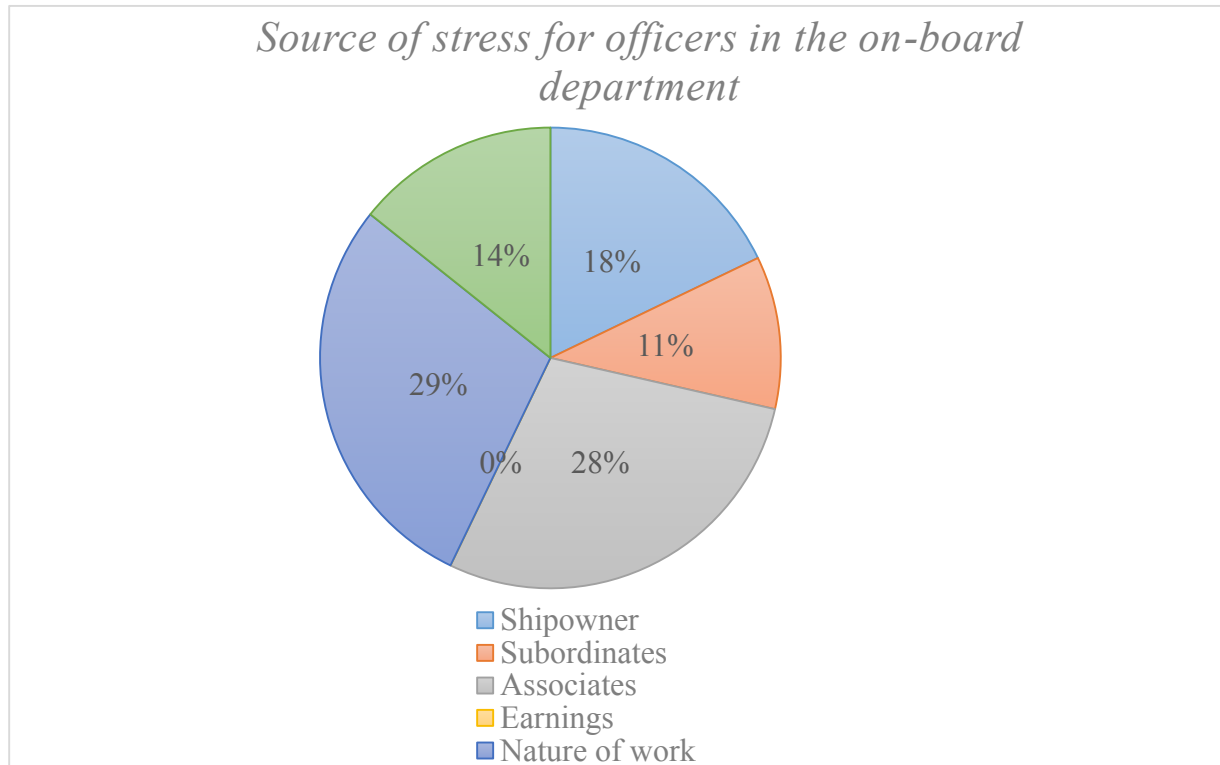
**Figure 25.** Impact of stressors on different age groups.

The main symptom appearing in all groups is a reduction in work efficiency. In the group with experience of up to 5 years and over 15 years, this is the most frequently mentioned item. In the group of 5-15 years, a slight advantage was given to the answer 'with concentration of thought', but the advantage is small enough that we can safely assume that stress, according to the officers surveyed, is most likely to translate into work efficiency.



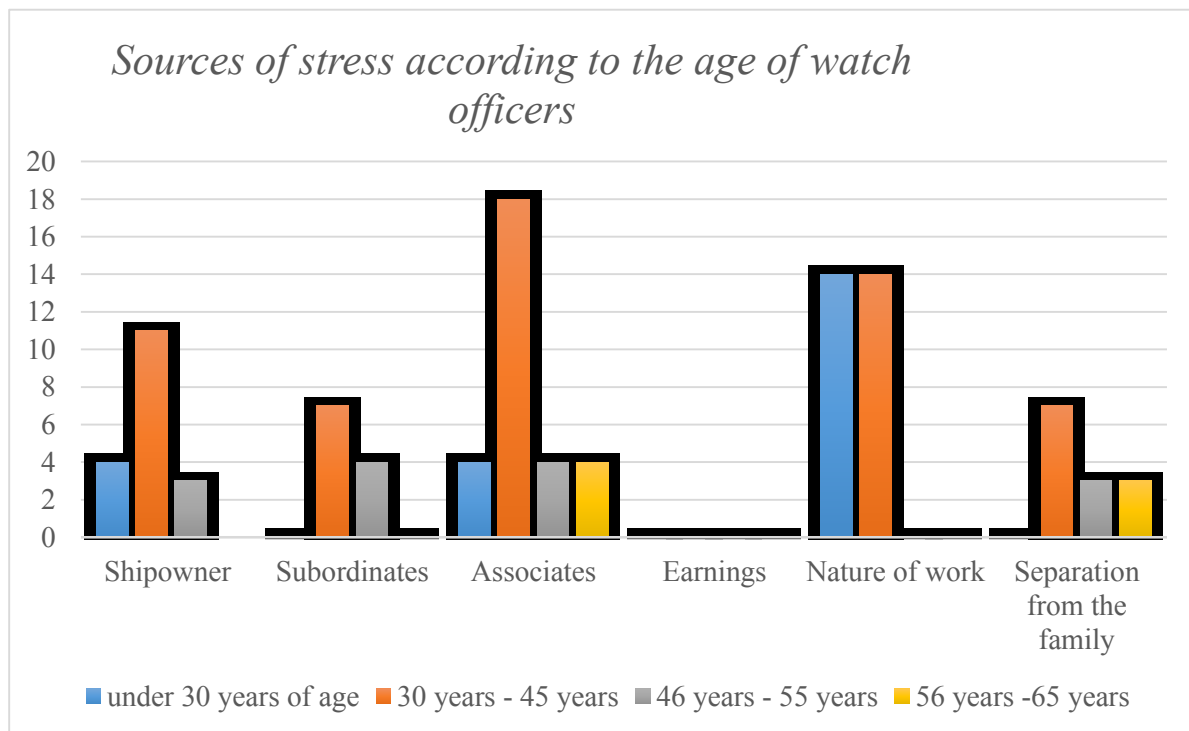
**Figure 26.** Problems that stress causes according to work experience.

The nature of the job was most frequently cited by the officers surveyed as a source of stress, with 29% and colleagues 28% (Figure 27).



**Figure 27.** Source of stress for officers in the deck department.

Figure 28 below shows the sources of stress according to the ages of the officers.

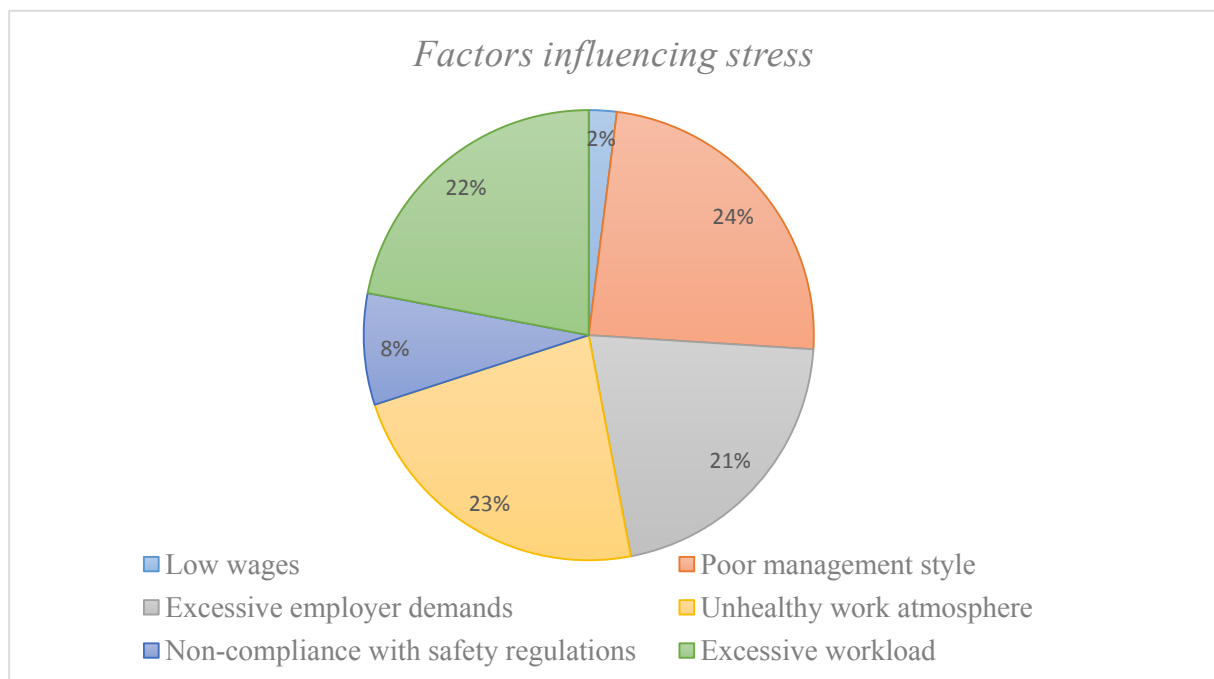


**Figure 28.** Sources of stress according to the age of watch officers.

In the under-30 age group, the main reason for stress is the nature of the job (63.6%). Officers aged 30-45 decisively indicate that the main reasons for stress are co-workers (31.6%) and the nature of the job (24.6%). In the 46-55 age bracket, stress is evenly distributed between the shipowner, subordinates, colleagues and separation from family. For the over 56s, the main reasons for stress are subordinates (57.1%) and separation from family (42.9%).

Analysis of the results shows that the nature of the job is a significant stressor for younger officers (under 30 and 30-45 years old). Co-workers are the main source of stress for officers aged 30-45. Shipowners cause stress mainly in the 30-45 age group. Subordinates and separation from family are the main causes of stress for older officers (56-65 years).

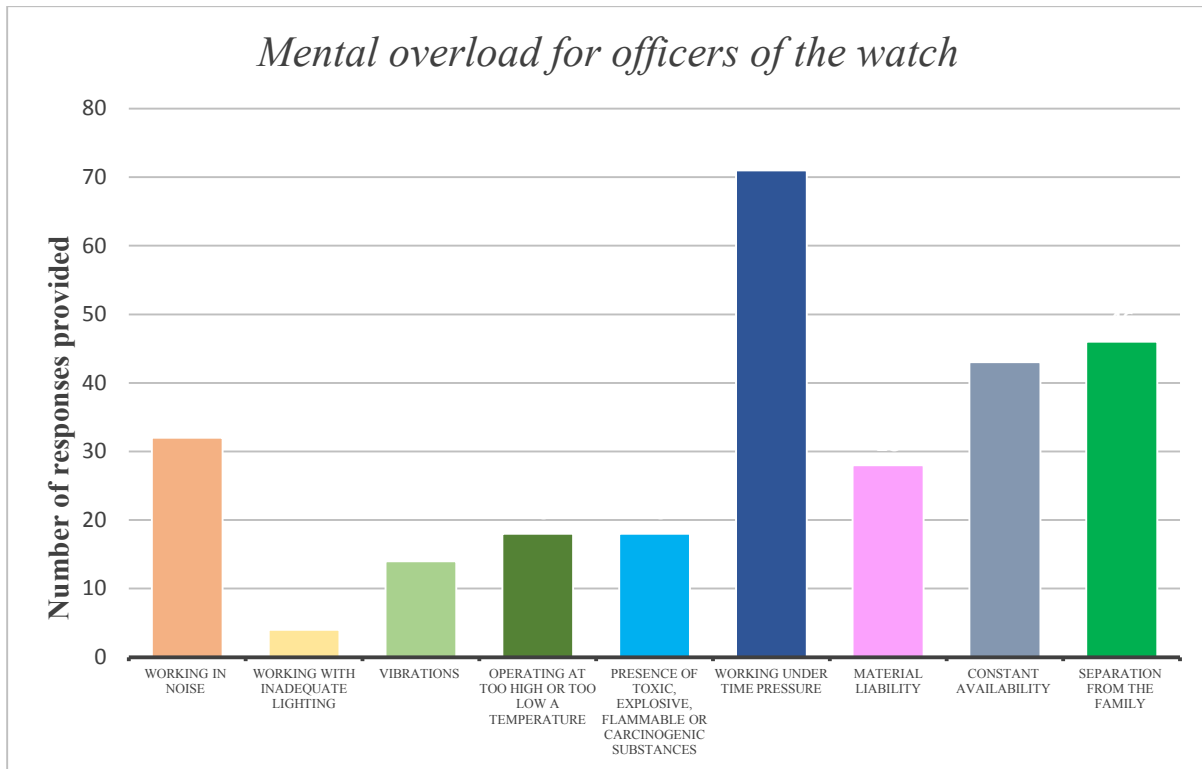
Additional factors contributing to stress are illustrated in Figure 29.



**Figure 29.** Factors contributing to stress.

The most commonly cited factors were poor management style 24%, an unhealthy working atmosphere 23% and overwork 22%.

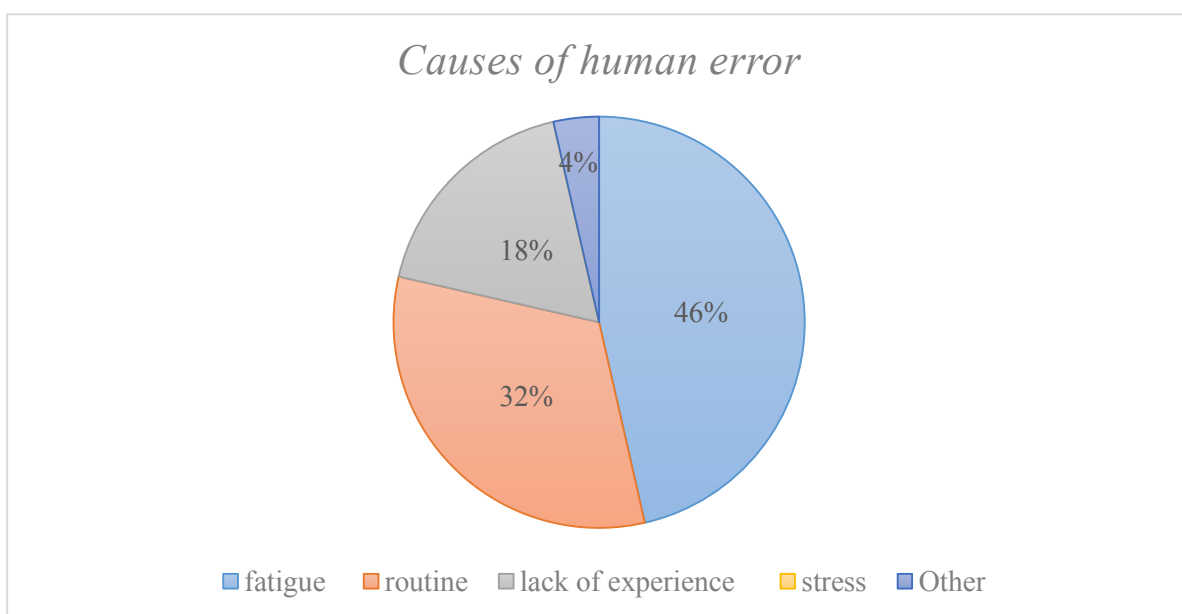
Figure 30 below shows the results of the responses to the question on the causes of mental strain on the watch officer. The respondent was asked to choose three visits that cause him/her mental strain.



**Figure 30.** Mental overload of watch officers.

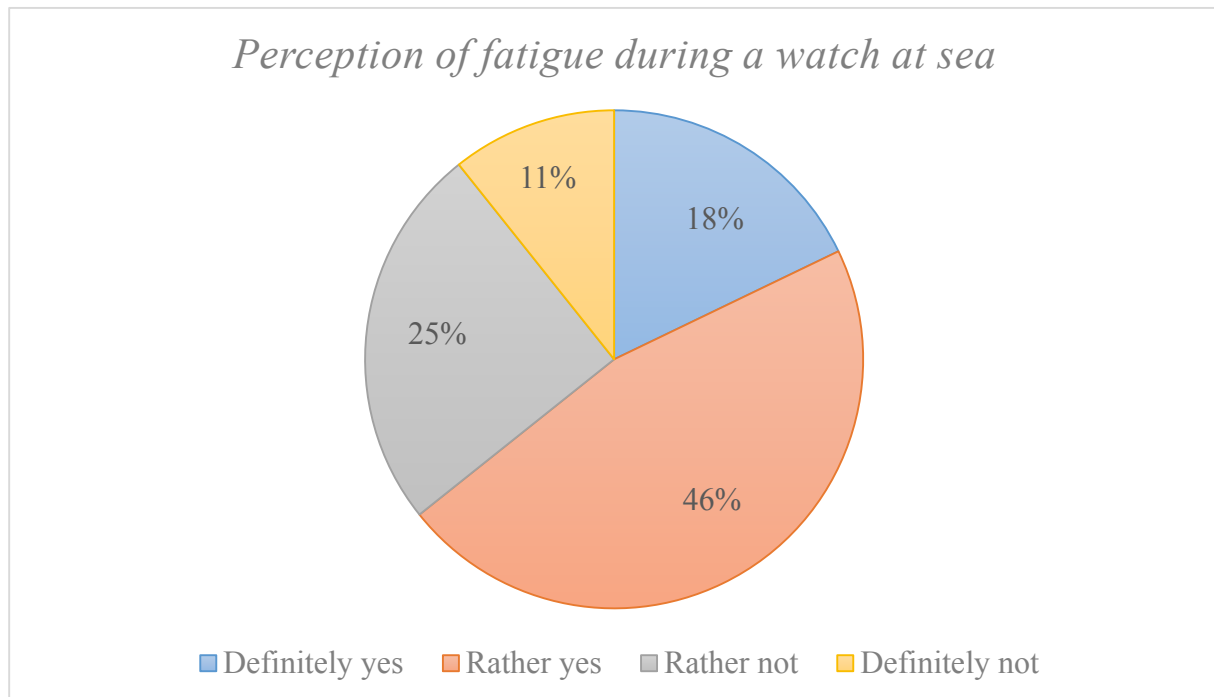
Out of 100 respondents, as many as 71 said that their mental health was most affected by working under pressure, followed by 46 indicating separation from loved ones and for 43 it was the constant availability. These three responses were most frequently answered by respondents in the 30 to 45 age group with a minimum of five years' experience.

At this stage of the study, respondents also answered questions on human error. When asked about the most common cause of human error, the majority of officers, 46%, indicated that it was fatigue, followed by routine at 32% and inexperience at 14% (Figure 31).



**Figure 31.** Most frequently cited causes of human error according.

Figure 32 shows the responses of respondents regarding the perception of fatigue during a watch at sea.

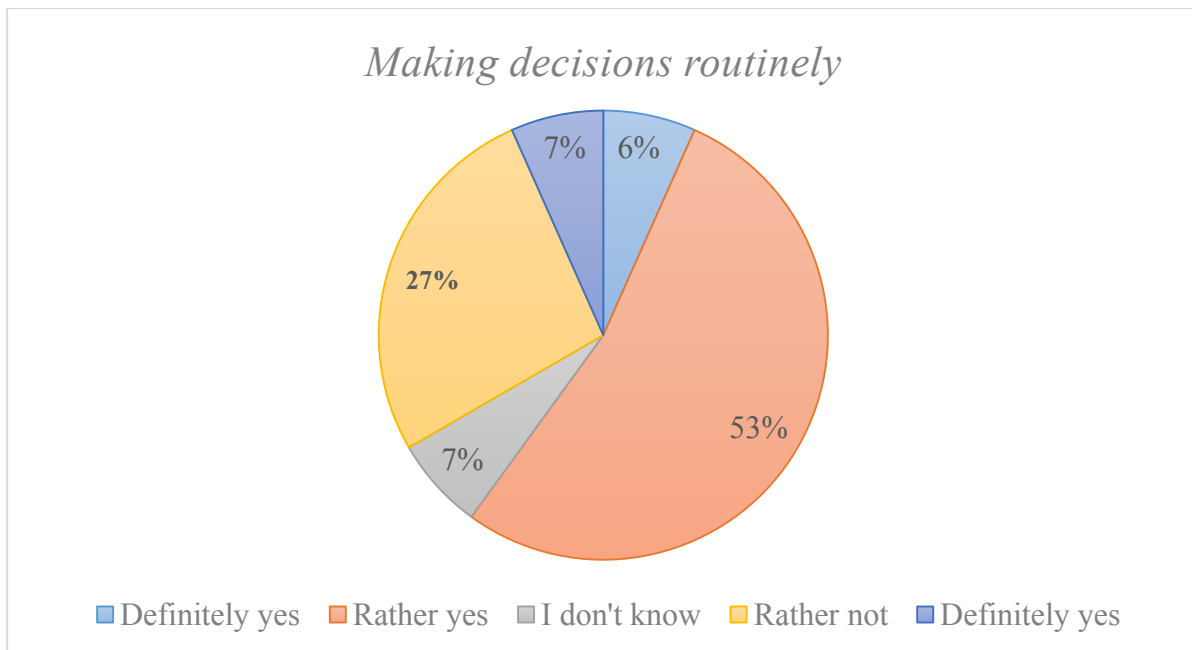


**Figure 32.** Perception of fatigue by respondents during a watch at sea.

The largest proportion of respondents definitely feel fatigue when on watch at sea (46%). This is almost half of all respondents. Another group of respondents, accounting for a quarter (18%), also feel fatigue, although not as intensely as the first group. A significant proportion of respondents (less than a fifth) are unlikely to feel fatigue during the watch. The smallest group of respondents definitely does not feel fatigue.

It is worrying that the majority (71%) of respondents feel fatigue when on watch at sea (sum of 'definitely yes' and 'rather yes' responses). A minority (29%) of respondents do not feel fatigue (sum of 'definitely not' and 'rather not' responses). These results suggest that fatigue is a significant problem for the majority of watch officers, which can affect their performance and safety while working at sea.

Figure 33 shows the respondents' answers to the question on making safety decisions routinely.



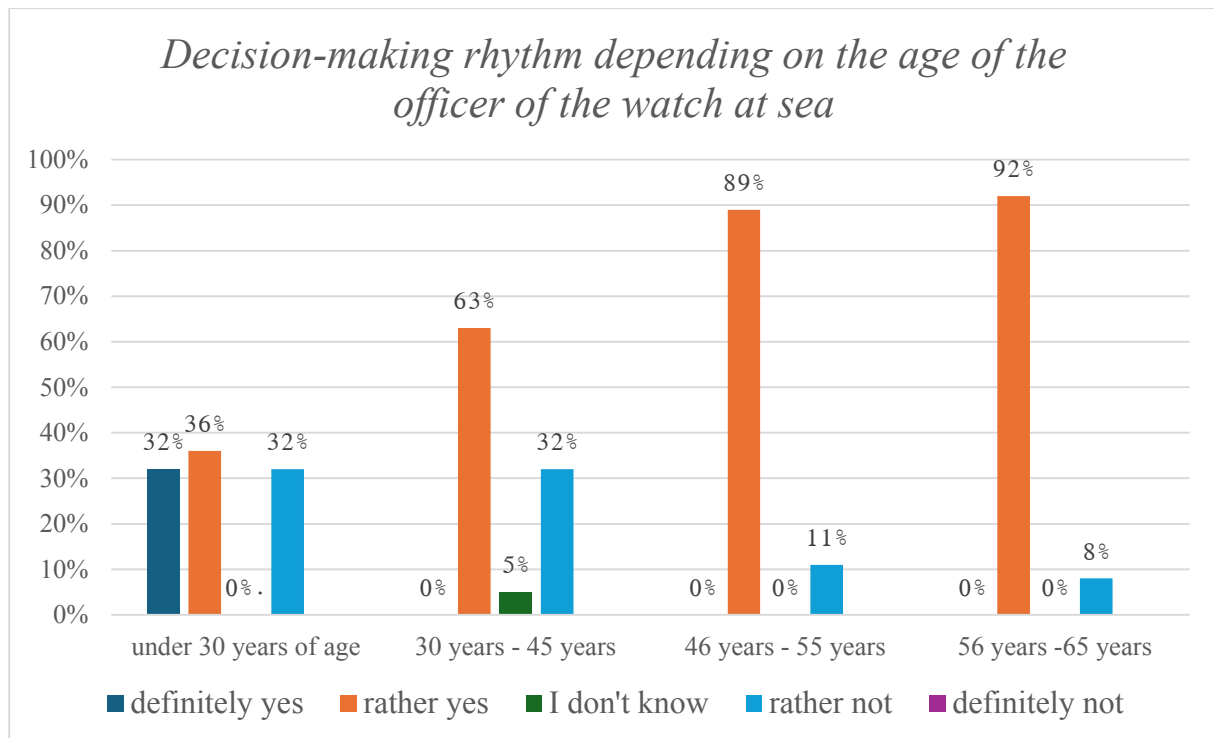
**Figure 33.** Taking safety decisions on board as a matter of routine.

Experts 53% admitted that **Rather Yes** happened to make a decision routinely.



**Figure 34.** Percentage of deck department officers making rescue decisions during a watch, by age group 30-45 years.

Figure 35 shows the results of the questionnaire on routine decision-making according to the age of the respondents. The question asked about the situation in which the respondent has led to an undesirable situation leading to danger. The responses are divided into five categories: "definitely yes", "rather yes" "no" and "don't know", "rather not" and "definitely not", and the results are presented in four age groups: under 30, 30-45, 46-55 and 56-65.



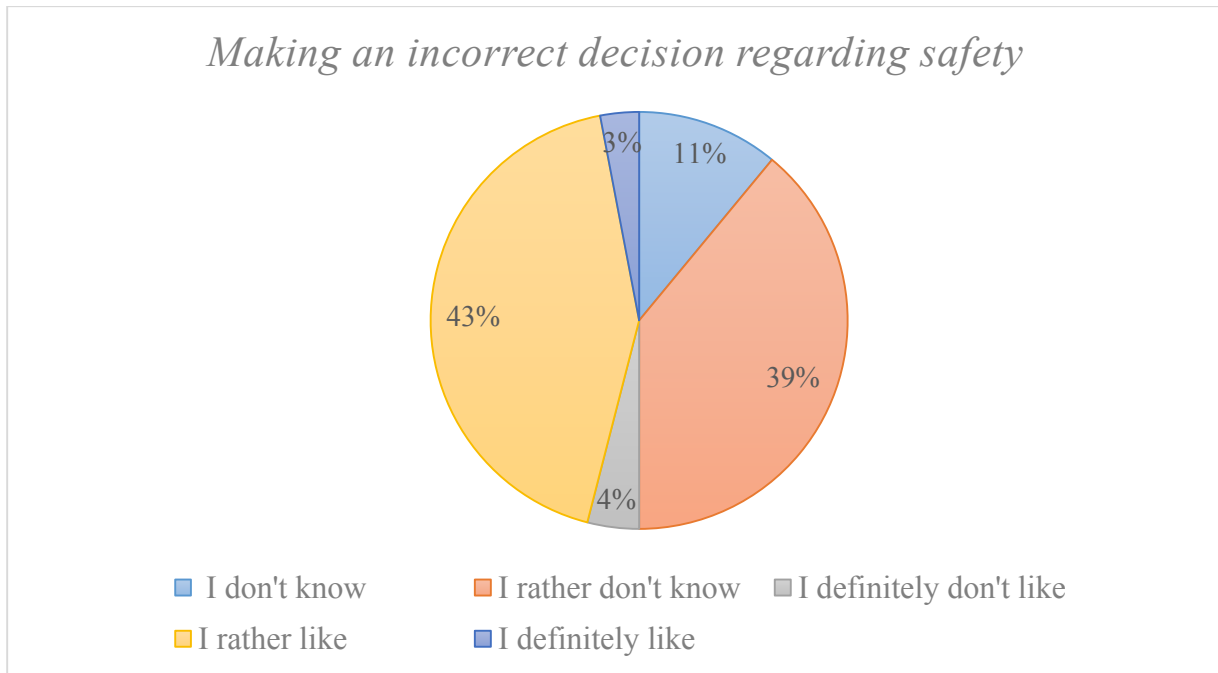
**Figure 35.** Rescue decision-making in relation to the age of the officer of the watch at sea.

In the under-30 age group, responses are mixed. The majority of respondents tend to make decisions routinely (68% summing 'definitely yes' and 'rather yes'), however 32% tend not to make such decisions. The 30-45 age range is dominated by 'rather yes' responses (63%), suggesting that the majority of middle-aged respondents tend to make decisions routinely. A small proportion (5%) are unsure and 32% tend not to make decisions routinely. For respondents aged 46 and over, a large majority say they tend to make decisions routinely (above 89%), suggesting a strong belief in routine decision-making.

It can be concluded that younger officers (under 30 years old) have a mixed attitude towards making decisions routinely, with the majority tending to make decisions routinely. Officers aged 30-45 are mostly more likely to make decisions routinely, with a small percentage of those unsure and a similar percentage of those unlikely to make decisions routinely. The older age groups (46-55 and 56-65) clearly indicate rather routine decision-making, with no uncertainties or refusals.

Such results may suggest that as officers get older, they become more confident in their decision-making, which may be due to their experience and stability in their professional role.

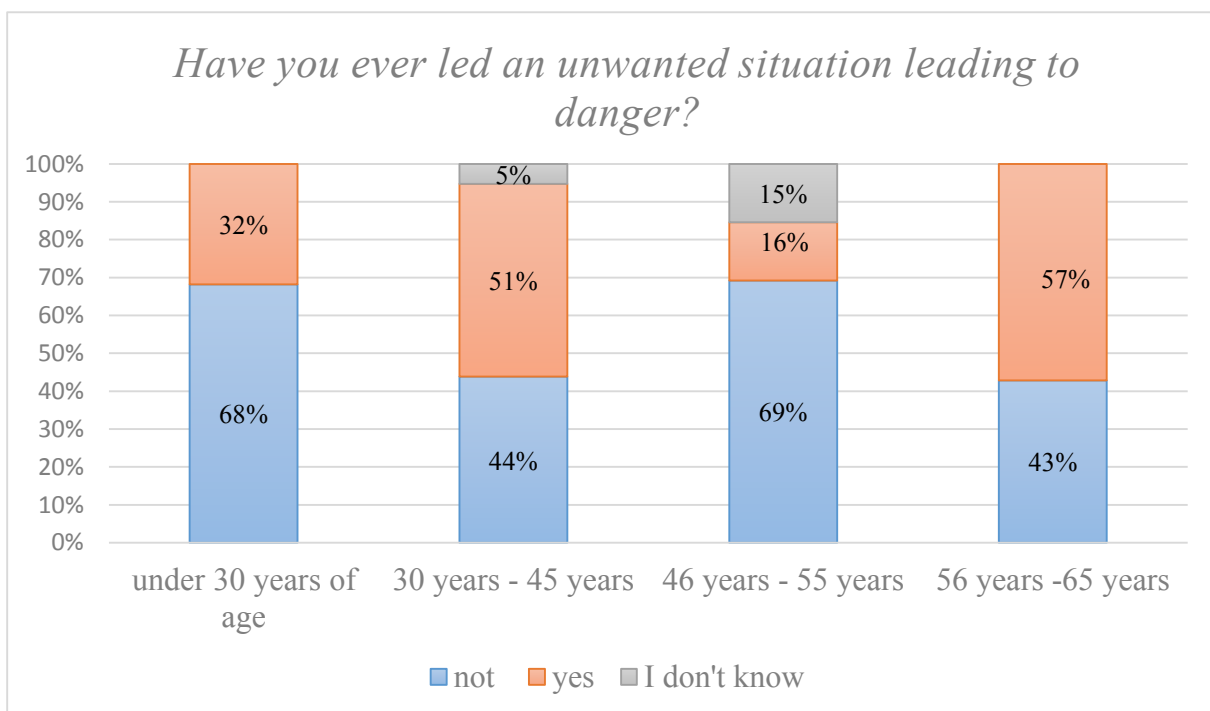
The next Figure 36 shows how many percentages of officers surveyed made the wrong safety decision.



**Figure 36.** Taking the wrong decision regarding navigational safety.

There are marginally more affirmative answers than negative ones, a difference of only 3%, and it is interesting to note that as many as 11% do not know whether they made the wrong security decision.

The bar chart below (Figure 37) shows the results of the survey on the decision that led to the undesirable situation according to the age of the respondents. The results are presented in percentages for four age groups: under 30, 30-45, 46-55, and 56-65. Responses are divided into three categories: 'yes', 'no' and 'don't know'.



**Figure 37.** Incidence of Situations Leading to Danger.

The majority of respondents (around 70%) under the age of 30 have not led to an unwanted situation, but around 30% have such experience. In the 30-45 age group, we see a higher number of "yes" answers (51%), which means that almost half of the respondents in this age group have had experience of unwanted situations leading to danger, while 44% answered "no" and 5% that they "do not know". Respondents the 46-55 age group 69% had not led to an unwanted situation, but 16% answered 'yes' and a further 15% 'don't know'. The results in the 56-65 year old group are similar to the 30-45 year old group, with 56% answering 'yes' and 43% answering 'no'.

Analysing the graph above, it can be seen that younger people are less likely to bring about undesirable situations (around 70% of 'no' answers). Middle-aged people have a higher percentage of "yes" answers (about 51%), which may suggest more professional experience and therefore a higher risk of making mistakes. The 46-55 age group shows more uncertainty (15% of 'don't know' responses), which may suggest difficulties in evaluating their experience or changes in professional responsibility. Older people are more likely to bring about undesirable situations, as is the group in the 30-45 age range, which may be due to greater confidence and routine decision-making.

It is worth noting that the highest uncertainty in responses is found in the 46-55 age group. The highest proportion of those who have had experience of adverse situations is in the 30-45 age group. The younger and older age groups (under 30 and 46-55) have similar distributions of responses, with a predominance of 'no' responses.

With the results obtained, it is possible to analyse the relationship between routine decision-making and the occurrence of adverse situations leading to danger. To do this, we use data on the responses of respondents in different age groups (**Table 1 and Table 2**).

**Table 1.**

*Data on decision-making routinely*

Age	Definitely yes	Rather yes	I don't know	Rather not	Definitely not
Under 30 years	32%	36%	0%	32%	0%
30-45 years	0%	63%	5%	32%	0%
46-55 years	0%	100%	0%	0%	0%
56-65 years	0%	100%	0%	0%	0%

**Table 2.**

*Data on adverse situations leading to danger*

Age	Yes	Not	I don't know
Under 30 years	32%	68%	0%
30-45 years	51%	44%	5%
46-55 years	16%	69%	15%
56-65 years	57%	43%	0%

The majority of junior officers (68%) make decisions routinely (summing up 'definitely yes' and 'rather yes'). At the same time, about 70% of them have not had adverse situations. It seems that younger officers who make decisions routinely are more cautious, leading to fewer undesirable situations. They seem to have a more nuanced approach to making decisions

routinely and their percentage of undesirable situations is relatively low. Younger people (under 30 years) are often recently trained and have fresh theoretical and practical knowledge that is in line with the latest standards and procedures. This can lead to a more cautious and procedurally compliant approach. Younger officers may also be less likely to take a routine approach (32% are unlikely to make decisions routinely), which may mean that they analyse each decision in more detail and carefully, rather than relying on established patterns. Those under 30 may be more motivated and committed to their work, seeking to avoid mistakes in order to build their reputation and advance their careers.

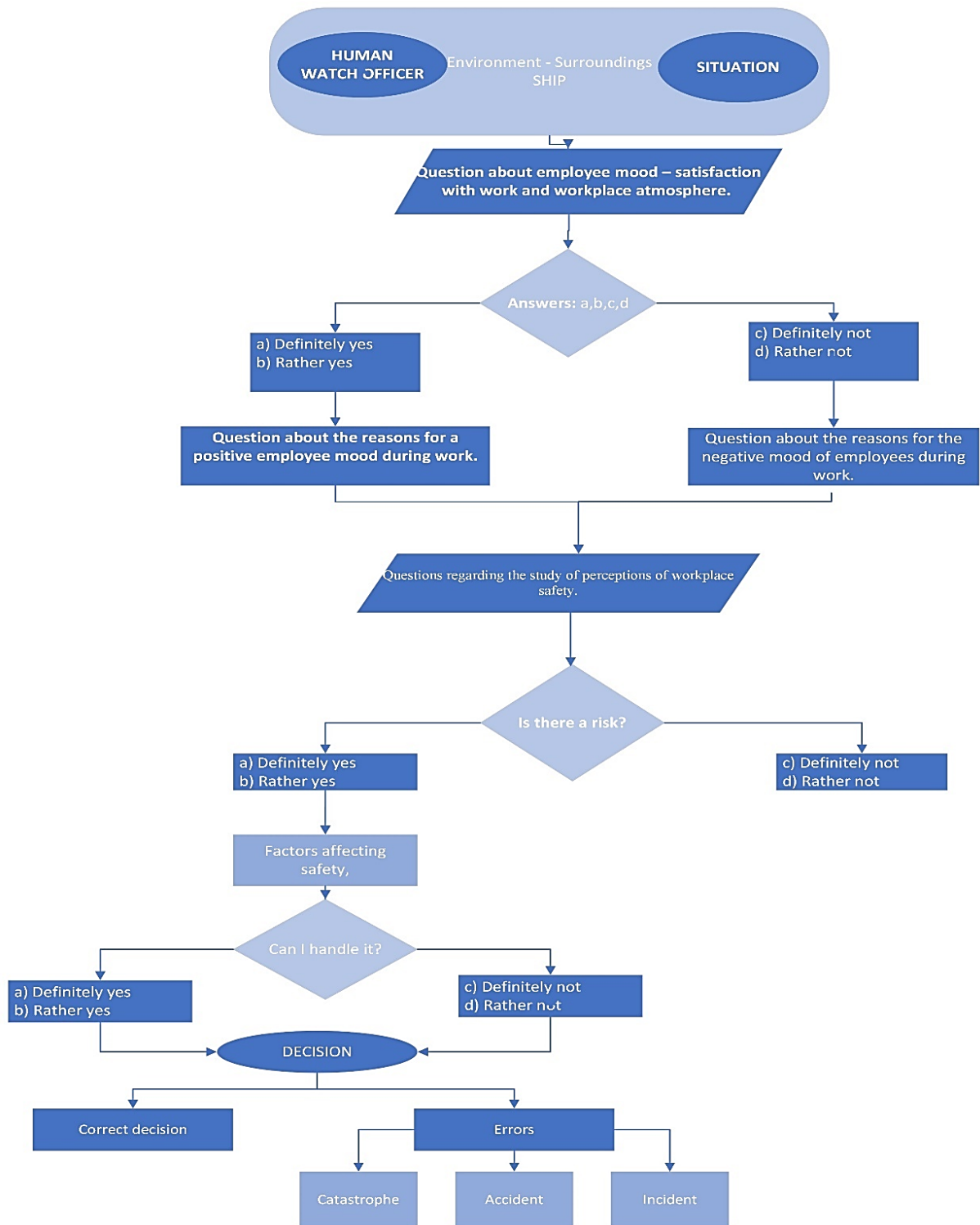
In the 30-45 age group, although most people make decisions routinely (63%), a high proportion (51%) admit to adverse situations. This may suggest that in this age group, routine decisions alone are not sufficient to avoid risky situations, which may be related to work experience or task specificity. People aged 30-45 often have enough experience to make decisions routinely (63%), but may encounter more complex and challenging situations that cannot always be solved routinely. This age group may tend to be routine (rather yes: 63%), but at the same time they have to adapt to new challenges and situations, which can lead to more undesirable situations (51%). This is often linked to career advancement; during this time, a large number of officers gain new qualifications (e.g. change of job at management level).

Officers in the 46-55 age range, make decisions routinely, with only 16% admitting to adverse situations. It appears that routine decision-making can be effective in reducing risk in this age group. Professional experience and a stable position in one's job will have a big impact.

In the 56-65 year-old group, the high incidence of adverse situations (57% of respondents) may be related to a greater awareness of risk or professional fatigue.

## **5. Concept for a method to assess watchkeeping officer reliability**

With the help of the analysis carried out, it is possible to develop the concept of a method to assess the reliability of the officer of the watch. The authors, after careful analysis of the questionnaire, developed a model that makes it possible to identify factors influencing officer reliability as well as shipboard safety management. A diagram of the model is shown in Figure 38.



**Figure 38.** Reliability assessment model for a watch officer from the deck department.

The Officer of the Watch reliability assessment model provides a comprehensive tool to identify and assess the factors affecting officer quality and safety levels on the vessel. The model consists of individual factors, environmental factors, safety management system and systemic risk factors.

Individual factors relate to an officer's personal characteristics, such as experience, knowledge and psycho-physical abilities, which influence decision-making. Environmental factors include working conditions, such as weather, noise or equipment, which can increase the risk of errors. Safety management focuses on work organisation and crew cooperation, minimising human error. Systemic risk factors and the human-system relationship emphasise the importance of the effectiveness of supporting technologies, such as radar and ECDIS, and their intuitive use. The purpose of the model is to identify risk factors affecting watch officer reliability and to develop corrective actions in the areas of training, vessel equipment and operational procedures. The model also serves to improve safety management on the vessel by reducing human errors and minimising the risk of accidents, leading to an increased overall level of maritime safety.

The diagram shows the interrelationships between the factors mentioned, allowing a better understanding of the impact of the different elements on the end result, i.e. the reliability of the watch officer and the level of safety on the vessel.

## 6. Discussion

A survey of officers of the watch at sea provided valuable data on factors affecting their reliability in the course of their duties. With the information obtained, it was possible to create a reliability assessment model that takes into account key aspects of working in a dynamic and demanding maritime environment.

However, it is worth critically assessing the limitations of the study. The survey method used, based on the officers' self-assessment, although useful for learning about their experiences and opinions, carries the risk of subjectivity and bias in the responses. Participants may have unconsciously underestimated or overestimated the frequency of stress, fatigue or routine decisions.

The sample of 100 deck officers is a limited and homogeneous group, which makes it difficult to generalise the results to other ship departments, ship types or cultural contexts. The results should therefore be treated as indicative.

The lack of direct observation and simulation studies limits the ability to capture the real context of decision-making on the bridge. In future studies, it would be worthwhile to combine survey methods with observation, simulation experiments or physiological measurements to obtain a more complete picture of human reliability in the maritime environment.

Organisational and economic factors, such as safety culture or management style, which may influence stress and fatigue levels, were also not taken into account. Despite these limitations, the study provides valuable empirical data on the relationships between

psychological factors and the work environment and serves as a starting point for further modelling research on human reliability in the maritime environment.

Despite these limitations, the study provides valuable empirical data on the relationships between psychological factors and the work environment and provides a starting point for further modelling research on human reliability in shipping.

The study allowed the identification of key areas of risk, such as the impact of fatigue, the complexity of operations or team communication, which can lead to undesirable situations. The use of an empirical data-driven approach has enabled a better understanding of the relationship between human factors and the reliability of watch officers' operations. The results of the survey provide a basis for further analysis and potential interventions to improve navigational safety. The reliability assessment model can be applied to both training and operational practices, helping to minimise the risk of errors and improve performance at key moments.

## **7. Results**

The main objective of the study was to assess officer reliability and identify factors contributing to human error. In order to carry out a comprehensive analysis, it was necessary to use an expert method. The study identified the sources of hazards arising from human activity as part of the man-ship system and the analysis of human error in the reliability and safety of this system. It also enabled the development of a model method for assessing the reliability of the officer of the watch.

The results of the study provide new insights into the relationship between age, professional experience and decision-making by watch officers. The analysis showed that younger officers are more likely to be cautious and risk-aware, while those with more professional experience are more likely to make routine decisions, which can lead to reduced vigilance and an increased likelihood of error. A clear impact of stress and fatigue on the quality of decisions was also identified, especially in groups with less experience and a higher level of responsibility.

The results confirm previous findings on the impact of psychophysical factors on human reliability, but at the same time expand our knowledge of the structure of the relationship between age, experience and risk perception in the maritime environment. They also show that psychological factors (such as stress and time pressure) are just as important as technical or organisational factors.

Productivity and job satisfaction are affected by many factors. One of them is certainly stress. In most professions, we are unable to avoid stressful situations, such as carrying out new tasks and interacting with colleagues etc.

The classification of the causes of stress can vary, mainly depending on the individual, the situation and the context. Nevertheless, there are some factors that were frequently mentioned by the interviewees as the main causes of stress. Table 2 shows the hierarchy of the most frequently mentioned causes of stress by the surveyed watch officers.

**Table 3.**

*Classification of the most frequently cited causes of stress in the position of officer from the deck department*

Work environment	<ul style="list-style-type: none"> <li>• Unregulated working hours.</li> <li>• Time pressure and pressure from the client/charterer-at the expense of safety and comfort.</li> <li>• Lack of sleep, non-compliance with occupational hygiene rules related to working time.</li> <li>• Lots of things to do in a short space of time.</li> <li>• Rush.</li> <li>• Fear associated with loss of health and, as a result, of work.</li> <li>• Unloading, loading operations.</li> <li>• Manoeuvres.</li> </ul>
Weather conditions	<ul style="list-style-type: none"> <li>• Weather conditions.</li> <li>• Sudden change in weather conditions.</li> <li>• Bad weather for manoeuvring.</li> </ul>
Relationship with the supervisor	<ul style="list-style-type: none"> <li>• Superior (Chief, Captain).</li> <li>• Difficult relationship with the supervisor.</li> <li>• Pressure from the shipowner.</li> <li>• Pressure from the office.</li> <li>• Ship inspections and unannounced inspections.</li> <li>• Bullying.</li> </ul>
Technology	<ul style="list-style-type: none"> <li>• Equipment unreliability on board.</li> <li>• Emergency situations e.g.: blackout or General Alarm.</li> <li>• Unforeseen hazardous situations related to equipment failure.</li> <li>• Ship collision situation.</li> </ul>
Associates	<ul style="list-style-type: none"> <li>• Other crew members- training and crew morale.</li> <li>• Lack of crew competence.</li> <li>• Crew conflicts.</li> </ul>
Communication	<ul style="list-style-type: none"> <li>• Communication between crew, shipowner or port staff.</li> </ul>
Human relations	<ul style="list-style-type: none"> <li>• Conflicts and relationship difficulties with other crew members.</li> <li>• Interpersonal difficulties.</li> <li>• Meeting the exorbitant expectations of others.</li> <li>• Responsibility for the safety of the vessel and crew.</li> </ul>
Family and relationships	<ul style="list-style-type: none"> <li>• Limited contact with family.</li> <li>• Separation from family.</li> <li>• Problems in family or partner relationships.</li> <li>• Life changes - e.g. loss of a loved one.</li> <li>• Conflicts with children or other family members.</li> </ul>
Other	<ul style="list-style-type: none"> <li>• Unjustified controls in third world countries based on extortion and bribes, etc.</li> </ul>

It is worth noting that these factors are not completely independent of each other, and many of them can interact, reinforce each other or lead to complex interactions. As a consequence, strategies for coping with stress often require a holistic approach that takes into account different aspects of an individual's life.

Workplace stress is a mental and emotional state that results from the tension and pressure associated with the demands and expectations set in the workplace. Analysing the responses of the officers interviewed, it can be said that the source of stress is:

- Heavy workload due to excessive responsibilities.
- Performing duties under time pressure, constant rush.
- Irregular working hours and lack of rest.
- Poor communication between colleagues and supervisor.
- Conflicts within the crew and lack of support or assistance from superiors.
- Changes for which workers are not prepared- changing weather conditions and breakdowns of technical equipment.
- Tasks beyond capacity.
- Too much responsibility.
- Hazardous physical conditions in the working environment.
- Unannounced inspections, etc.

The impact of stress at work can be negative for both employees and the employer. When stress is experienced regularly, it leads to fatigue, regular headaches and other physical complaints. Stress can also lead to reluctance to perform one's duties, indifference or mood swings. When analysing the responses of all age groups of officers, the most frequently cited causes of stress and mental strain are pressure and unregulated working hours. Mental strain is also worth mentioning for officers, who point out the non-compliance with occupational hygiene rules regarding lack of sleep and unregulated working hours. The most severe symptoms accompanying stress, according to the respondents, are headache and unwillingness to work (Figure 15).

The routine associated with working at sea can be considered a mistake for several reasons. Many unforeseen situations occur in maritime conditions, such as changing weather conditions, technical failures of equipment or emergencies. If a person performs his or her tasks automatically and is unable to adapt to changing conditions, this can lead to human error. Working at sea is physically and mentally demanding. If a seafarer gets stuck in a routine without rest, it can lead to fatigue, reduced productivity and potentially mistakes. Above all, routine has an impact on safety. Such routines can cause the crew to miss certain hazards or fail to take appropriate precautions. Habitual performance of tasks can result in a lack of attention to important details, which can in turn increase the risk of accidents. Performing work in monotonous conditions can result in a loss of interest and commitment to the task. This can have a negative impact on motivation and increase the risk of errors and inaccuracies.

To avoid the above problems, it is important that the crew is flexible, adequately trained in safety, undergoes regular reviews of operating procedures and is aware of the need to adapt to changing conditions. It is also good practice, to make changes to work schedules and procedures from time to time, which can help to keep the crew alert and engaged.

## **Fatigue**

Crew fatigue on board a vessel, can be the result of various factors related to the characteristics of work at sea. Some of the main factors that contribute to fatigue are outlined below:

- **Shift work and lack of contact with family**

Crew on ships work in shifts that involve long working hours, sometimes without breaks. Long flights between ports, frequent lack of coverage and therefore no constant access to family and social life can lead to mental and physical fatigue.

- **Adverse conditions**

Working at sea sometimes involves extreme weather conditions (storms, high waves or strong winds). Such conditions can lead to increased physical and mental stress.

- **Monotony and routine**

Performing routine tasks for long periods of time without much change can lead to boredom and fatigue. Monotony in daily duties can affect crew morale and conflict.

- **Limited opportunities for rest**

Due to the need to maintain the safety of the vessel, the crew may have limited opportunities for rest, including during rapid loading/unloading, frequent port entries and exits, sailing in bad weather conditions. This encourages a lack of regular breaks and short sleep, which can affect the overall fatigue of crew members.

- **Security stress**

Each member of the ship's crew is responsible for maintaining safety at sea. The stress of being responsible for the safety of themselves and others, especially in the event of an emergency, can lead to increased fatigue.

To counteract fatigue, it is important to put in place appropriate fatigue management procedures, provide adequate rest conditions, and regularly train staff on how to manage stress and maintain a healthy lifestyle during the voyage. Providing adequate breaks and opportunities for crew to relax can help maintain their physical and mental fitness.

## **Communication**

Miscommunication is a common cause of incidents and accidents at sea, and plays a key role in ensuring safety on ships. Any misunderstanding, miscommunication or error can lead to significant consequences. The major causes of communication errors at sea include:

- **Inadequate communication**

Lack of clear and correct communication between crew members, as well as between vessels, can lead to numerous misunderstandings. Improper communication of, for example, one's intentions, course, speed, or other important variables can lead to collisions or other incidents.

- **Language barriers**

Many seafarers come from different countries, which can lead to language misunderstandings (variety of dialect). Understanding messages in this case can be difficult, especially in stressful situations. This can lead to errors of interpretation and potential problems.

- **Lack of uniform procedures**

Each ship and each maritime campaign may follow slightly different communication procedures. A lack of uniform understanding and adherence to these procedures can lead to mistakes being made.

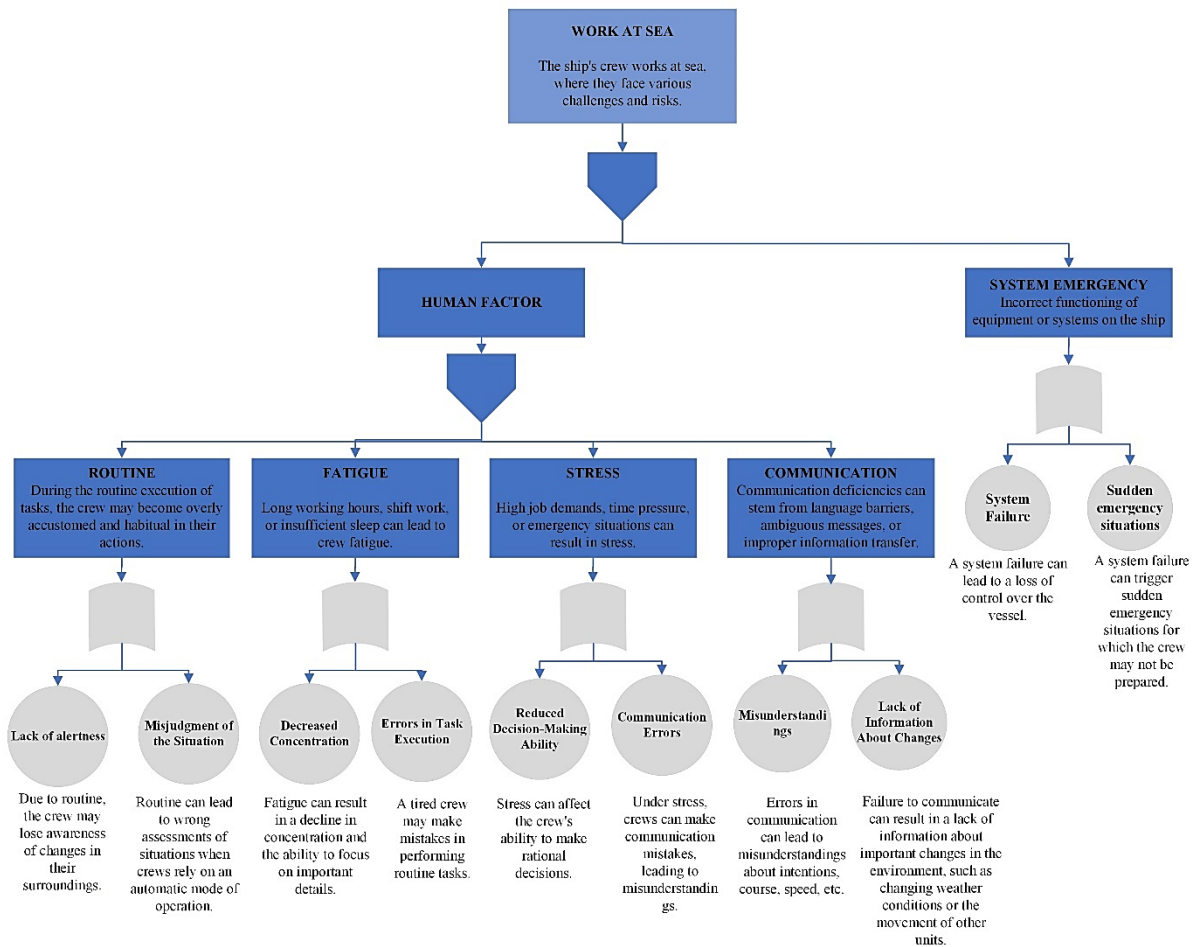
- **Too many messages**

Excessive information (e.g. in situations where multiple vessels are communicating simultaneously), can lead to confusion and cause important messages to be overlooked.

In order to mitigate communication errors on board, it is important to ensure that the crew is adequately trained in communication, that procedures are standardised, and that the focus is on clear and understandable messages. Situational awareness of potential difficulties due to language barriers is also important. Systematic situational exercises and training can be helpful here to help improve the effectiveness of communication at sea.

It is also worth noting that the survey also took into account the age and experience of the officers. From this it was possible to show that young workers with little seniority responded that they sometimes make mistakes regarding safety on board. They also often feel stressed if unforeseen situations occur. Some of them also feel that they still lack experience. In contrast, the longest-serving employees admit that they sometimes make decisions routinely. They feel confident in their jobs.

Based on an analysis of the factors influencing shipboard safety in a watch officer's job, it is possible to develop a fault tree that can help to understand how different factors, i.e. routine, stress, communication, fatigue and system failure, can lead to errors at sea (Figure 39).



**Figure 39.** Damage tree.

The tree above illustrates how different types of factors can interconnect and lead to mistakes being made at sea. This type of tool allows for risk analysis in further studies, helping to identify areas that may require additional attention, training or improvements to procedures.

To summarise the study carried out; errors are caused by several factors resulting from taking the wrong action. This article looks at factors related to human nature: stress, fatigue, routine and inexperience. The survey and its analysis will enable further research into maritime safety. In future, the results will be used to carry out further research on this topic using a simulation method. This research will be based on a model for assessing the reliability of a watchkeeping officer from the deck department.

## 8. Conclusions

The study expands existing knowledge about human reliability in maritime operations by empirically demonstrating how fatigue, stress and routine affect decision-making on the navigation bridge.

The results show that younger officers are more cautious and risk-aware, while those with more experience are more likely to make routine decisions, which may increase the likelihood of error. From a theoretical point of view, the study contributes to the development of risk-based reliability assessment models in maritime navigation.

In practical terms, the results obtained can form the basis for improving Bridge Resource Management (BRM) training programmes, developing fatigue prevention strategies and improving communication procedures on the bridge.

In the future, it is recommended to conduct research verifying the model in simulated conditions and cross-sector comparisons – for example, with aviation or the offshore industry – in order to deepen the understanding of factors affecting human reliability in the maritime environment.

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