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A stduy of approaches to mitigate seafarer fatigue based on workload self-assessment by ship's crew

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A STUDY OF APPROACHES TO MITIGATE SEAFARER FATIGUE BASED ON WORKLOAD SELF-ASSESSMENT BY SHIP'S CREW

D2316

A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of Master of Science in Maritime Affairs

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Declaration

I certify that all the materials in this dissertation that are not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

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Abstract

Title of Dissertation: **A study of approaches to mitigate seafarer fatigue based on workload self-assessment by ship's crew**

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This paper introduces the causes and hazards of seafarer fatigue, and analyzes the difficulties and challenges in mitigating fatigue at sea from three perspectives: maritime supervision, company management and crew execution. The research is conducted by three complicated methods including a systematic literature review, a series of interviews and surveys with maritime experts, ship owners, onboard captain and crews. The questions in the interviews and surveys were designed and revised after consulting maritime experts, ship owners, onboard captains and crews on several occasions.

These contributions include new insights into crew workload self-assessment, which may lead to the establishment of a ship workload audit mechanism based on the company's safety management system, and development of policies to mitigate seafarer fatigue by supervising and managing manning (level) through better understanding of actual ship workload.

The Chapter 5 of this paper is devoted to short-term and long-term suggestions, including the establishment of quantitative statistical data on the content of ship management by shipping companies through the data of self-workload assessment by ship's crew, which can reflect the time and proportion of each task in the whole ship operation. At the same time, it can also reflect the influence of competent authority supervision and company management on crew workload. These data help to evaluate whether the ship personnel allocation meets the requirements of MLC, so as to mitigate seafarer fatigue in a quantitative way in terms of the working hours and manning level.

Key words: Fatigue, Maritime industry, Workload, Workload self-assessment.

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List of Abbreviations

AIS	Automatic Identification System
BIMCO	Baltic and International Maritime Council
COSCO	China Ocean Shipping Company
COVID-19	Corona Virus Disease 2019
FSC	Flag State Control
HRA	Human Reliability Analysis
HTW	Sub-committee on Human Factors, Training and Watchkeeping
ILO	International Labour Organization
IMO	International Maritime Organization
ISM	International Safety Management
LAN	Local Area Network
MLC	Maritime Labour Convention
MSC	Maritime Safety Committee
PSC	Port State Control
SMS	Safety Management System

1 Introduction

Most of the research on maritime accident analysis is now emphasizing human error, but some scholars hold a skeptical attitude. Research on unmanned ships in the maritime industry has made some progress, but so far it has not been able to completely replace human behavior. The transportation of ships still needs to be done by crew until there is a major technological change. Although we have been studying how to reduce human errors, we cannot deny the fact that there is a limit to what a human can do in a limited amount of time and in a given environment.

There is a positive correlation between fatigue and working hours & work stress. Many studies focus on how to relieve work stress, but there are few studies on the time required by the workload from management. The maritime industry cannot do without the participation of seafarers. For the sustainable development of the maritime industry, the suggestions and voices of seafarers who are most directly related to human factors should be adopted by the industry. However, there is currently no such mechanism to show how much work seafarers take on during the whole voyage through employee workload assessment, as most land-based enterprises do. Even the management of shipping companies expressed distrust of much of the work done by seafarers. The current regulations on crew fatigue are yet not enough. There is no mechanism between crew and shipping companies and regulators to bring the three parties together to deal with fatigue at sea.

1.1 Background

Fatigue remains one of the most critical of the various human factors' issues. Allianz (Allianz, 2020) states that crew fatigue, one of the major underlying causes of human error, contributes to around 75% to 96% of all marine incidents. Crew fatigue may lead to easy inattention, reduced alertness, reduced memory, incorrect work procedures, loss of control of activities, inability to stay awake, inability to use strength when lifting heavy objects, incorrect judgement, wrong judgement &

understanding, change in attitude, silence and reticence, frustration and easy anger, and at the same time it may reduce alertness, memory and the ability to make decisions, the marine fatigue is necessary to be alert as shown in Figure 1.

Figure 1 Stay alert to fatigue

Source: Safety4sea website. https://safety4sea.com/wp-content/uploads/2018/08/infographic-on-fatigue-maritime-nz-1-1140x738.png

The concerns of the International Maritime Organization remain high, as the Maritime Safety Committee (MSC) in the Subcommittee on Human Factors, Training and Watchkeeping (HTW) discussed extensively (2014-2018) to 2019, followed by the Fatigue Standard (MSC. 1 / Circ. 1598) is an exemplification. These principles are two quantitative international instruments for minimum rest time and maximum working time for seafarers. The Fatigue Guidelines (MSC. 1 / Circ. 1598) recommend that effectively addressing fatigue at sea requires a comprehensive and systematic approach that clarifies ship design and the roles and responsibilities of all stakeholders in mitigating and responding to fatigue. An effective fatigue management strategy begins with determining operational workload requirements and matching onboard manning levels and onshore support resources, combined with efficient management

of workload and hours of work & rest on board the ship (IMO, 2019).

1.2 Research aim and objectives

The aim of this study is to find a quantitative evaluation method for the regulatory authorities, shipping companies and crews to jointly deal with fatigue at sea within the same system. This study provides a simple and feasible method to collect and analyze data on crew members' work hours and self-assessed work intensity to provide data support for quantitatively addressing crew fatigue issue. The data is matched with the corresponding basic types of work onboard, which can help us better understand the correspondence between the labor resources and specific work on board. At present, work on board a ship can be divided into four categories: normal operation, paperwork, emergency work and rescue work according to the nature of the work to be done by the crew. The purpose of the classification here is mainly to distinguish between ship operation and paperwork, and the simplicity of the classification is also for the convenience of the crew to answer the questions in the questionnaires, so as not to cause confusion and tedium. The method of data collection in this study needs to give policy and institutional safeguards to crew members, fully respect their professional opinions, eliminate any possible negative effects due to feedback on the real situation, and encourage them to actively participate in the survey and contribute to their own vital interests and ship safety in long run.

The methodology provided in this study can provide a quantitative basis for companies to assess whether the manning of a particular ship can ensure the safe operation of the ship, and a quantitative judgement for flag states to monitor the safe manning of shipping companies.

Future research can combine the mutual assessment of company and ship for safety management, data of the same industry, and the assessment of company's safety management by competent authorities to form big data for comprehensive analysis, and develop a plan for reasonable allocation of resources and safety management.

1.3 Significance of the research

The workload of a ship is an important factor in determining the allocation of crew members. Currently, we only supervise the workload of crew members on the ship by recording the hours of working and resting by the MLC. However, many studies have shown that the recording of the working and resting hours on the ship cannot truly reflect the working time on the ship because of the falsification and modification of the records. It is difficult to supervise the crew's records to solve the fatigue problem completely, the work on board a ship is largely depended on the management of the shipping company, and the overtime work of the crew is mainly due to the inability of the ship's personnel to meet the workload required by the ship's operation.

At present, there is no supervision of the crew workload generated by the company's management. The crew is the specific performer of the ship's work, so quantifying the time required by each piece of work done by the crew is an important basis for quantifying the shipping company's ship management. The amount of work required by a single job can be evaluated more objectively through the crew's own understanding of that piece of work at sea, while the average amount of workload evaluated by the crew group for the same job can well reflect the skill level of the industry to complete a certain job. The crew can be rationally allocated according to the type of work and the required time of it, which can lower the fatigue level of the crew and ensure the effectiveness of the crew in the completion of safety and anti-pollution work.

2 Literature review

2.1 Definition of fatigue in shipping

Fatigue itself has safety implications as it may make seafarers less alert in their work which is inherently risky, it is believed to be a major contributory factor in maritime accidents (MAIB, 2004; Parker et al., 1997; Smith, 2007).

In labor hygiene science, fatigue generally refers to a phenomenon of decline in

work ability caused by overwork (physical or mental labour), embodied in being unresponsive, a reduction in flexibility and coordination, an increase in work error rate , accompanied by a subjective fatigue feeling, weakness, and etc. (Baidu Baike, n.d.).

Fatigue is defined by the International Maritime Organisation (IMO) as “a reduction in physical and/or mental capability as the result of physical, mental or emotional exertion which may impair nearly all physical abilities including: strength; speed; reaction time; coordination; decision making; or balance” (IMO, 2001).

A state of physical and/or mental impairment resulting from factors such as inadequate sleep, extended wakefulness, work/rest requirements out of sync with circadian rhythms and physical, mental or emotional exertion that can impair alertness and the ability to safely operate a ship or perform safety-related duties (IMO, 2019).

2.2 Cause of fatigue at sea

The causes of fatigue on ships are varied, complex and difficult to determine, and many factors exist in a comprehensive and interactive way. Generally recognized and documented factors can be divided into five categories (IMO Guideline on fatigue, 2019), seafarer-specific factors, management factors including shore-based and shipboard management and the functions of competent authorities, ship-specific factors, environmental factors and operational factors.

2.2.1 Seafarer-specific factors

Seafarer-specific factors are related to lifestyle, habits and personality traits. However, fatigue varies from person to person and is often determined by the specificity of the job. According to Guidelines on Fatigue MSC.1/Circ.1598, the detailed seafarer-specific factors may include the following items listed in Table 1.

Table 1 Seafarer-specific factors related to fatigue at sea

No.	Factors	Details
1	Sleep and rest	a. quantity, quality and continuity of sleep b. sleep disorders/disturbances c. recovery rest/breaks
2	Body clock/Circadian rhythms	
3	Psychological and emotional factors	a. fear b. monotony and boredom c. loneliness
4	Health and well-being	a. diet/nutrition/hydration b. exercise and fitness d. illness and onset of illness
5	Stress	a. skill, knowledge and training as it relates to the job b. personal issues of concern in personal life; and c. interpersonal relationships at work or at home;
6	Medication and substance use:	a. alcohol b. drugs (prescription and non-prescription); c. supplements; and d. caffeine and other stimulants;
7	Age	
8	Shift work and work schedules	
9	Workload (mental/physical)	
10	Jet lag	

Source: IMO MSC.1/Circ.1598 Guidelines on Fatigue

Seafaring is still very much a 24-hour society (Sigurd W. Hystad & Jarle Eid, 2016). It is hard to divide time between work and life. Seafarers' sleep quality and physical activity level should also be paid attention to (Oldenburg and Jensen, 2019a). A good sleep needs to have quality, quantity and continuity to be most effective. Lack of sleep and poor quality of sleep and rest can cause fatigue, which is considered as the silent risk factor for seafarers (Safety4sea, 2019). Kwon et al. (2020) listed nine elements impacting job satisfaction of bus drivers, such as driver categories, working

experience, work hours, income and work pressure. Regarding the maritime field, one of the key factors affecting seafarers' desire to remain at sea can be perceived as the extent to which they are satisfied with life at sea (BIMCO/ISF, 2015). Seafarers who are satisfied with their life onboard tend to be more positive and optimistic about completing their work on board. The psychological resources of optimism, hope, self-efficacy, and resiliency seem to equip seafarers with the necessary tools to handle the stress associated with working at sea, resulting in less fatigue and better sleep quality (Sigurd W. Hystad & Jarle Eid, 2016).

Unhealthy lifestyles of seafarers, such as smoking, alcohol abuse, unhealthy eating habits, lack of physical activity, and drug abuse, negatively affect seafarers' health and induce various health problems. (Gregorio et al., 2016; Hoeyer and Hansen, 2005; Laraqui et al., 2017b; Song et al., 2021). There has been particular emphasis in previous literature on seafarers' dependence on drugs, alcohol and tobacco (Fort et al., 2010; Laraqui et al., 2017a).

Good family relations enable people to develop good living and working habits, especially for seafarers. The attitude of seafarers' family could significantly affect their seafaring decision (Chin-Shan Lu et al., 2018). The study found that seafarers with more family support and passion are better at coping with stress and have higher job satisfaction (Lan Song et al., 2021). Therefore, the guarantee of regular contact with families with the assistance of the Internet, a mutual understanding and the maintenance of a good family relationship, and family supports can relieve seafarers' pressure (Xue Li, Yusheng Zhou & Kum Fai Yuen, 2022).

For seafarers, working and living with a team onboard ship, interpersonal relationship is highly valued (Lidong Fan et al., 2018), But on a multi-national crewed ship, it is inevitable for them to encounter cultural clashes or misunderstandings (Youngshin Kim, 2016). The language and culture barrier among multinational seafarers would stress them as well during international trips (Karl Forsell et al., 2017). In addition, ships traveling across oceans often face the problem of jet lag.

Time-zone can disturb sleep pattern and lead to fatigue (Mazloomy et al., 2019).

2.2.2 Management factors

The economic attributes of the maritime industry dictate the management model of the ship, and the temporary nature of the crew's work makes it difficult for seafarers to influence the company's decisions. Shipping companies offer permanent and long-term contracts to senior officers or those that possess specific skills while offer junior officers and ratings temporary contracts as a way to control cost (Xue Li et al., 2022). Seafarers may have to work extra and unable to take a vacation between periods to secure more job opportunities (Österman et al., 2020). Long work hours can disturb sleep patterns and quality and lead to chronic fatigue (Andrei et al., 2020; Bhattacharya & Tang, 2013; Oldenburg and Jensen, 2019b; Pauksztat, 2017). Furthermore, the requirement of faster turnout time and strict security checks all shorten seafarers' shore leave time which is critical for recovering from fatigue and loneliness (Xue Li et al., 2022). Stress and exhaustion caused by forced extension of contracts and prolonged stay on ship, fear of being infected, sense of being abandoned, unable to go shore to be repatriated or receive medical treatments all jeopardize seafarer well-being (Slišković Ana, 2020).

Furthermore, the traffic condition of the ship's route is also related to the pressure of the crew, especially when sailing through complex waters, the duty officer often has to maintain a high state of alertness, if the crew members who are thus affected can not be effectively relaxed for enough time, it will cause fatigue to them and thus affect the safe navigation of the ship. From the AIS information of ships in Figure 2, we can see that the traffic density along the coasts of Europe, the United States and China is very high, especially in the waters of the English Channel, the Strait of Gibraltar, the Panama Canal, the Suez Canal and the Strait of Malacca. The traffic density brings great navigation pressure to the seafarers. It is easy to cause both physical and mental fatigue for the crew on duty for a long time in this kind of sailing environments.

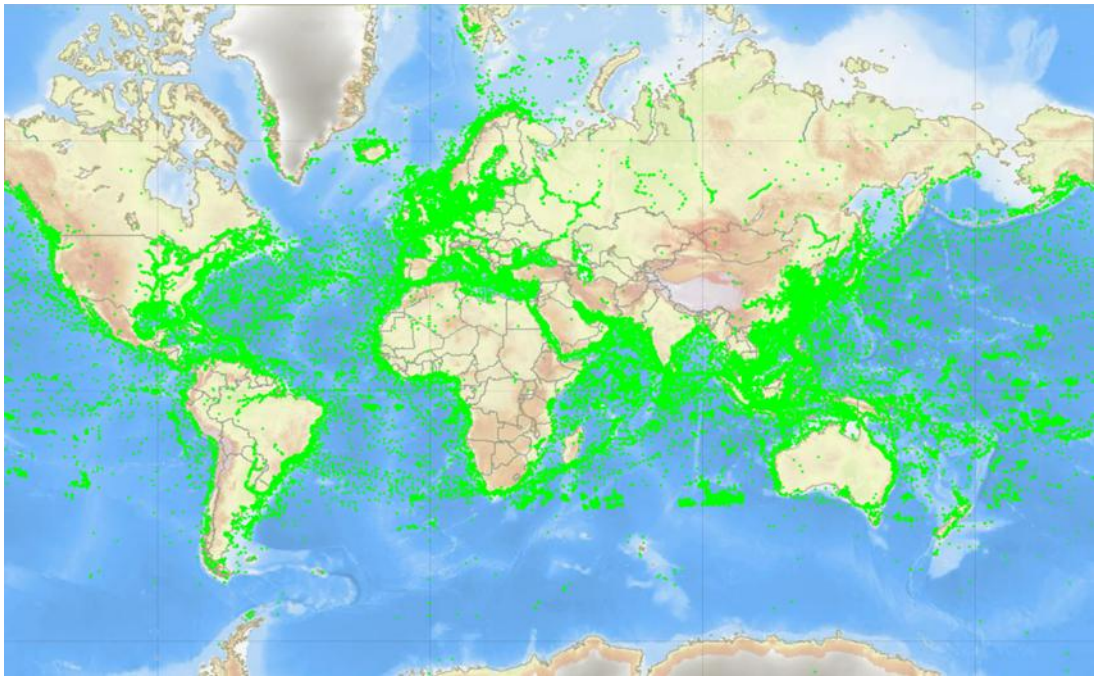

Figure 2 Shipxy AIS information on May 20, 2023 1517(GMT+8)

Source : Shipxy website： http://www.shipxy.com/(Shipxy, 2023)

2.2.3 Ship-specific factors

Except for a short stint in port, the crew spent almost all their time on board from the time they go on board to the end of their emplyment. Personnel on commercial vessels perform a large variety of duties around the clock, such as maintenance, navigation, and cargo handling, activities that often take place under time-pressure and hectic activity (Sigurd W. Hystad & Jarle Eid, 2016).

Despite the efforts the maritime industry has been making to improve structural stability and reliability through laws, regulations, training forums and technical means, the occurrence rate of maritime accidents still remains at a relatively stable level after a dramatic reduction in the past half of century (Fan et al., 2020; Liu et al., 2021; Shu et al., 2022; Wang et al., 2021). However, these laws, regulations, and forms of training require crew members to devote more time to ship operation, which to a large extent diluted the attention of the crew with the responsibility of safety and pollution prevention on the corresponding work, and also led to fatigue due to efforts for completion of extra work. In addition, the application of new technologies on ships

imposes higher requirements on the knowledge and skills of the crew. It discovers that the high demand for knowledge and skills and the heavy workload leads to the work stress of seafarers (Bao et al, 2021). The demanding working environments have negative influences on seafarers' health, which is critical for the achievement of sustainable development goals (Wang et al., 2021). Research has revealed that seafarers have higher mortality rate than other employees (Rinne et al., 2021).

Exposure to sunburn, noises, vibrations, chemicals, malnutrition, long-time tours, lack of medical assistance, and isolations can lead to various physical disease and mental illness (Xue Li, Yusheng Zhou & Kum Fai Yuen, 2022). Poor physical and mental health can weaken working efficiency, have long-term effects on seafarers' well-being and even lead to suicide (Sampson and Ellis, 2020). The confined space on the ship often brings bad feelings and stress to the crew. Hence, insufficient accommodation and tight compartment can increase seafarers' emotional stress (Yue et al., 2021; Zhang and Zhao, 2017).

2.2.4 Environmental factors

The environment at sea is different from that on land. The turbulence caused by strong winds and huge waves will make the crew tired and affect quality of rest. Seafarers face tougher and harsher environments, the working conditions of seafarers can be affected by natural environmental factors (Xue Li, Yusheng Zhou & Kum Fai Yuen, 2022). Also, seafarers tend to be overloaded with work due to the unpredicTable natural environment and inadequate resources, and this causes physical and psychological stress and fatigue (Robert, 2012). The motion of the vessel can lead to a disorder known as the sopite syndrome: a symptom complex that includes, among other things, drowsiness, lethargy, apathy, disinterest and disinclination to work, lack of participation in group activities, sleep disturbances, and mild depression (Graybiel A & Knepton J., 1976). Ship noise not only has adverse effects on the health of the crew, but also leads to fatigue damage of Marine equipment and shortens the service life of the ship (Chen Shi, 2013). In addition to the health effects on humans,

vibrations on ships may affect the durability of the mechanical structure of the ship (Anker Jensen & Jørgen Riis Jepsen, 2014). Exposure to sunburn, noises, vibrations, chemicals, malnutrition, long-time tours, lack of medical assistance, and isolations can lead to various physical disease and mental illness (Xue et al., 2022). Poor physical and mental health can weaken working efficiency, have long-term effects on seafarers' well-being and even lead to suicide (Sampson and Ellis, 2020).

2.2.5 Operational factors

Ships face various inspections, audits and visits from external parties. These activities are often accomplished through the time and effort of the crew in preparing various paperwork and answering various questions. External inspection from supply chains can put pressure on seafarers. (Xue et al., 2022). The short berthing time in port is often the best time to schedule activities such as replenishment, repairs and crew changes, and the hectic pace of the ship combined with these external stresses can cause physical and mental fatigue for the crew. The legality of audits, inspections and visits may overlook the safety hazards posed by the resulting fatigue on board.

2.3 Fatigue prevention in the maritime industry

2.3.1 The weak position of seafarers in employment relations

Although seafarers make an incredible contribution to the society, the public has yet to show more respect for them (Pengfei Zhang & Minghua Zhao, 2017). The feeling of being respected may engage seafarers and improve their self-evaluation and their sense of belonging (Yogendra, 2015). On the contrary, if seafarers feel being undervalued, their sense of participation in the work will be lowered (Bao et al, 2021). Although seafarers worked and lived on board and had a good knowledge and sensible opinions on the management of their ships and the inspections, their role was reduced to following orders and complying with procedures (Syamantak Bhattacharya & Lijun Tang, 2012), mechanical obedience and indifference to the outside environment obviously cannot meet the work requirements of the changing

environment of navigation.

2.3.2 Minimum manning and cost control

The crew manning requirements specified in the Minimum Safe Manning Certificate shall be qualified to ensure the safe navigation, berthing and operation of the ship and prevent and control environmental pollution caused by the ship. It is a basic condition for a ship to have adequate number of competent sailors to ensure its navigation safety. Vessel manning levels are critical to the safety of ship navigation safety (Hou Yuqiang, Wu Zaolin & Zheng Zhongyi, 2000). Insufficient staffing of ships will lead to fatigue of seafarer navigating, improper staffing or lack of senior crew members will seriously affect the strain capacity of ships, insufficient staffing of ships will cause serious safety hazards, leading to traffic accidents due to improper operation, and result in heavy losses of lives and property.

In addition to meeting the requirements of safe navigation, berthing and operation, and preventing and controlling environmental pollution, the crew members of modern ships have to complete all kinds of paperwork related to ship business, and even cargo loading and unloading operations at ports, especially since the outbreak of COVID-19, this workload has shown an increasing trend. However, the Minimum Safe Manning Certificate does not take into account these workloads as it does safety and pollution prevention issues. The minimum safe manning requirements approved by the maritime authorities are mandatory and the only way for shipping companies to comply with them (Yao Biao & Jin Haolong, 2012).

On the one hand, from the perspective of safety management, the company tries its best to make sure that crew fatigue does not cause accidents, which will bring huge reputation loss and economic loss to the company. On the other hand, due to the pressure of competition in the same industry, the company's operation and management office has to control costs, especially in the absence of fuel and freight pricing power, so they often pay more attention to the control of personnel costs than to crew fatigue.

2.3.3 Perfect management system and report

Shipping company management expect crews to achieve the safety goal of zero errors through all kinds of training and education, in other words they expect them to be craftsmen, but limit their discretion for fear of undermining the many advantages and improvements that come with bureaucratic systemization and standardization. Clearly there is a contradiction between the two, as the environment faced by ships is not a standardized one. The situation on board is that the company relies on the crew to perform specific operations as well as to complete various records under supervision. Without a true understanding of the crew's actual workloads, there is no way to know the effectiveness of regulations if all the regulations get only the results that the regulation itself want to. The farther the regulatory process is from the reality, the more difficult it is to assess the improvement of the regulations on safety, and more regulations will be likely to result in more work, which is even detrimental to safety if it exceeds the limits of the capabilities of the crew, as fatigue may affect the crew's ability to perform their duties effectively and safely. The validity of expert judgment in HRA should be highlighted. One way to justify the validity is to compare expert estimates with external data sources such as those from empirical studies (Peng Liu et al, 2020). However, in the maritime industry, due to the weak position of seafarers, it is very unlikely that they can become experts with the right to speak, so the validity verification almost does not include the contribution of seafarers.

Most of the time, the ship's checklist is not available for recording while the duty officer is conducting the operation, in fact they tend to record it only in their free time.. Worse still, in some cases they did so when such tasks were not even carried out. The important point here is that it diverted seafarers' energy and resources from doing things that could improve safety. Seafarers are compelled to work long hours and in conjunction with a poor shipboard environment, this results in a lack of good sleep and thus leads to progressive chronic fatigue (Syamantak Bhattacharya & Lijun Tang, 2012). The safety yield of further bureaucratization, however, is declining or

plateauing in many industries (Townsend, 2013). More rules do not create greater safety (Sidney W.A. Dekker, 2014), but increase workload. Fatigue, for reasons of safety, ironically, does not necessarily bring about improvement in safety levels.

2.3.4 Falsification of seafarers' work and rest hours records

Standard A2.3 of MLC stipulates that seafarers must not work more than 14 hours in any 24-hour period and 72 hours in any 7-day period as the maximum working time, and also stipulates that seafarers must not take less than 10 hours in any 24-hour period and 77 hours in any 7-day period as the minimum rest period. Rest periods may be divided into a maximum of two periods, one of which must be at least 6 hours, with no more than 14 hours between two connected rest periods. It also requires mustering, firefighting and lifeboat training as well as national laws, regulations and international documents should have minimal impact on rest time and training should be conducted in a manner that minimizes the impact on rest periods and does not cause fatigue (MLC, 2006). Except for holidays, most workers on shore know the common sense of an 8-hour workday. The departure between maritime and shore standards show that sectoral interests prevail over labour rights. More decisively, current standards detach labour rights from workers' human nature and attach them directly to sectoral interests (Raphael Baumler, 2020). In fact, the minimum rest time is a most unfavorable state, from the spirit of the Convention, such as below this minimum rest time requirements will infringe on the right to rest and lead to crew fatigue, but the actual situation is that the ship's senior crew's rest time in this provision often touches or even below this minimum requirement.

Crew employment pressures and the fear of losing jobs often make crews subservient to company interests, especially since many companies in China link the consequences of failure during third-party inspections to crew bonuses, driving crews to revise records or evens falsify records, when current regulations are not doing anything substantial in this regard. As a result, seafarers have chosen this low-risk but self-serving approach. Actually, fatigue, paperwork pressure and falsification are not

secret and have been widely reported and openly discussed in industry publications and conferences for a long time (Smith, 2007). Professor Raphael Baumler's study has shown evidence of violations of required rest hours and modification of shipboard logs by seafarers to conceal these violations (Raphael Baumler, 2021).

The modification or falsification of crew work and rest hour record is not for all ranks on the ship. If a crew member of a certain rank tends to modify or even falsify his work and rest hour record, it exactly reflects the under-manning of this rank.

3 Identify the gap of preventing fatigue in the maritime industry

3.1 Gap between administration and company

The purpose of supervision by maritime agencies is for the safety of ships and the prevention of environmental pollution, rather than for the operation management and profits of ships. The only implementation basis for ship staffing is the minimum staffing certificate, but the current minimum staffing certificate only determines the minimum staffing from the perspective of safety and pollution prevention responsibilities of the ship, and does not regulate the number of crew required for the normal operation of the ship. In addition, the inspection of the crew's work and rest time record has not played a substantive role in the current implementation. Port states, flag states and shipping companies seem to ignore violations (Raphael Baumler, 2021) as long as records are correct. From the perspective of shipping companies, the most important goal is that the ship will not be stranded as long as the crew members meet the requirements of the minimum crew certificate and the working rest time records on board meet the requirements of the Convention. It is difficult to develop consistency in supervision and management of ship fatigue when the priorities of objectives are different.

3.2 Gap between administration and seafarer

If crew members are able to complete the required work according to the time requirements of the Convention, it is believed that no one is willing to risk breaking

the law by falsifying, so it is difficult to achieve satisfactory results by just monitoring crew members to record their own working and resting time. Seafarer find more satisfaction in income than in safety and health concerns. If safety considerations were taken more seriously, arguably, seafarers' opinions and concerns would be attended to. After all, it is the seafarers who have the most intimate knowledge of their ships and have more reasons to safeguard themselves and their workplaces. The reality, however, is that seafarers are denied active participation in safety and health management and their concerns are not listened to (Syamantak Bhattacharya & Lijun Tang, 2012). Seafarer turnover and short-term employment makes it hard to form representative institutions and undermine the efficacy of regulations (Xue et al., 2022).

The structure of the modern shipping business develops additional issues that imperil the mental health of seafarers and MLC 2006 is insufficient to address issues even related to fundamental labour and human rights for seafarers such as the criminalization of their occupation. Thus, the current mechanism to check seafarers' working hours and hence their fatigue level is inadequate and the weakness in terms of checking their occupational health remains insurmountable (Syamantak Bhattacharya & Lijun Tang, 2012). Georgios Exarchopoulos's (Georgios Exarchopoulos et al, 2018) study reveals that the existing legislation is not adequate to provide solutions and promote strategies that satisfy the psychological needs of seafarers.

3.3 Gap between company and seafarer

When it becomes clear that the workload on board is greater than the workload of the personnel on board can undertake, the company will usually ask the captain to make more reasonable arrangements for the work of the crew. Otherwise, the captain will be considered incompetent. Even if the captain insists on asking for more hands, the manager feels no pressure to listen to him because the manager's pressure comes from cost control rather than the possibility of danger that the captain insists on. It is difficult to make a strong case for the possible consequences when constrained by

interest. Even if the possibility of hazards is present, it is often actively ignored by managers because there are no consequences for the time being, and such events often create distrust of the captain by managers. In the absence of quantifiable criteria, it is difficult for the captain to find a basis for demanding that the company increase staffing to meet the safety level of the ship's production, thus causing crew fatigue in certain positions and diluting crew's time investment in safety and pollution prevention.

3.4 Summary of Chapter 3

After the implementation of the MLC Convention, shipping companies focused most of their efforts and training on how to meet the MLC's records of working and resting hours on board, ignoring the spirit of the Convention itself, which is concerned about the health and welfare of the crew. Passing the port state and flag state inspection of the ship in port becames the core objective. Few management personnel of shipping companies are willing or unwilling to consider whether the staffing of ships can meet the work intensity required by the current ship operation, because the industry competition does not give the recognition of increasing crew expenses. Only when all ship staffing meets the minimum staffing certificate of the flag state can the seaworthiness be guaranteed, which in some cases becomes a reference standard for the shipping company to reduce personnel.

Although regulators are more focused on safety and shipping companies are more focused on profits, the core goal is to make a profit while fulfilling safety requirements. Some regulators and many of the managers of the shipping companies are promoted from the crew community and have a great deal of experience in being aware of the existence and hazards of fatigue at sea. At the present it is clear that shipping companies are clearly not plagued by fatigue problem that are prevalent in maritime industry. For specific company managers, they also need a clear manning basis in terms of how to deal with fatigue in practice. Experience can sometimes be used to analyze problems qualitatively, but not quantitatively. A platform needs to be

established within the existing fatigue regulatory framework to bring regulators, shipping companies and crews together to actively engage crews in fatigue response.

4 Maritime fatigue survey

4.1 Maritime fatigue survey and questionnaires design

This questionnaire aims to reveal the current status of seafarer fatigue in the maritime industry. The questionnaire survey on fatigue issue was mainly conducted among the staff of Chinese maritime agencies, the management personnel of shipping companies and the Chinese seafarers. To this end, we designed three different questionnaires to investigate maritime fatigue from three aspects: supervision, ship management and crew execution. The questionnaire is sent by the application WenJuanXing in Wechat and feedback is given anonymously to the first author. In order to reduce the comprehension bias caused by language and culture differences, the respondents received a Chinese-English questionnaire.

The questionnaires consisted of three sessions to cover all aspects of people involved in the maritime industry, the first part is setup for those people involved in competent authorities; the second part is aimed at the seafarers working onboard or those who have experienced working onboard; the last part is aimed at those people involved in managers of shipping companies. The questions should be as objective and direct as possible for ensuring reliability.

4.1.1 Questionnaires design for officers of China MSA

The Table 2 below shows question setting for officers who is working in China MSA, the fundamental intention is to attempt to cover all aspects within the maritime industry.

This questionnaire consists of 12 questions, where the experience of MLC enforcement and implementation are highlighted.

Table 2 Coping with fatigue at sea questionnaire for officers of China MSA

1	How many years have you worked in the maritime Bureau? ☐<1 ☐1 -3 ☐4 -10 ☐11 and above	To investigate how long maritime officials have been in China MSA.
2	Have you had any experience working on a merchant ship after the 2006 Maritime Labour Convention came into force? ☐ Yes ☐ No	This question will show whether maritime officials are aware of the reality of the implementation of MLC 2006 on board.
3	How many years have you worked at sea if you have experience on a merchant ship? (Please complete if applicable) ☐<1 ☐1 -3 ☐4 -10 ☐11 and above	This question will indicate the length of time maritime officers work at sea and the depth of their knowledge of maritime work
4	According to your work experience, how has the Maritime Safety Administration changed its supervision of shipping companies in recent years? ☐ Reinforce ☐ Reduce ☐ Basically unchanged ☐ Unclear	This question investigates the impact of regulation on the management of shipping companies
5	According to your work experience, what changes have been presented in the safety supervision of vessels under the jurisdiction of the Maritime Safety Administration in recent years?	This question investigates the impact of regulation on ship's workload.

	☐ Reinforce ☐ Reduce ☐ Basically unchanged ☐ Unclear	
6	Have you had any experience as a Flag State Control or Port State Control officer? ☐ Flag State Control officer ☐ Port State Control officer ☐ Both ☐ Neither	The question asks whether the respondent has a background as a flag state or port state inspector.
7	Apart from checking whether the minimum manning certificate is met and checking the ship's work and rest hours records, does the Bureau have any other specific measures to monitor the problem of fatigue caused by the under-manning of ships? ☐ yes ☐ no ☐ unclear	Existing measures to monitor fatigue at sea mainly include the verification of minimum manning certificates and the checking of on-board working and resting hours records. This investigation examines whether port and flag States have additional measures on this matter.
8	Based on your work experience, what difficulties do you think the current competent authorities have in supervising seafarer's fatigue? ☐ Checking minimum manning certificate cannot effectively solve the problem of crew fatigue ☐ The crew members modify or falsify the records of working and resting time ☐ No effective communication mechanism has been established between the competent authorities and the crew ☐ The crew working hours required for safety management by shipping companies are not quantified ☐ Others, please state.	To investigate the difficulties of seafarer's fatigue management from the perspective of supervision.

9	During your inspection of the ship, did any of the crew report to you personally that the ship's work and rest hours records were inconsistent with the actual situation? (If applicable) ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	The question focused on the frequency of communication between the crew and the competent authorities about ship's work and rest hours records.
10	During your inspection of the ship, did the crew ever report to you personally that the work intensity was too high due to the lack of personnel on board? (If applicable) ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	The question focuses on the frequency of communication between the crew and the competent authorities about manning level on board.
11	Have any crew members expressed to you a desire to improve crew fatigue through supervision? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	The question focuses on the frequency of communication between the crew and the competent authorities to address fatigue at sea.
12	Any suggestions related to coping with fatigue at sea ☐ Yes ☐ No （If yes, pls specify)_____	The aim of this question is to come up with some sensible proposals from a regulatory perspective.

4.1.2 Questionnaires design for seafarers

The following questions in Table 3 are used to characterize the maritime fatigue situation on board from the seafarers' point of view. This questionnaire is consisting of 22 questions, a survey was conducted on the perceptions of ship masters, senior crew and general crew about the intensity of work and fatigue on board. Due to the small number of women working on ships, the gender of the participants was not recorded in order to protect the anonymity of female seafarers.

Table 3 Coping with fatigue at sea questionnaire for seafarers

1	How old are you? ☐18-25 years ☐26-30 years ☐31-40 years ☐41-50 years ☐51 years and above	From the age of the seafarers
2	What is your marital status? ☐ Married ☐ Single ☐ Divorced	From the marital status of the seafarers
3	What type of ship do you work on in recent years? ☐ Container ☐ Bulk carrier ☐ Tanker ☐ General cargo ship ☐ LNG/LPG ☐ Ro-Ro ship/Pure Car Carrier ☐ Cruise ship	Type of ship on which the respondent has worked.

	☐ Others	
4	How many years have you worked on the ship? ☐<1 ☐1-5 ☐6-10 ☐10-15 ☐16 and above	From the service length of the seafarers, experience at sea largely determines the accuracy of the survey data.
5	What is your present rank? ☐Captain ☐Officer ☐Rating ☐Others	From the rank of the seafarers
6	How many years have you been in your present rank? ☐<1 ☐1 -3 ☐4 -10 ☐11 and above	From the service length of present rank of the seafarers
7	From your personal experience, how has the intensity of work on board changed in the last five years? ☐ Increase ☐ Decrease ☐ Basically unchanged	To investigate changes in the intensity of work on board during the last five years
8	Do the working hours in the existing record of working and resting time match your actual working hours on board? ☐ Completely ☐ Basically ☐ Sometimes ☐ Hardly	Many studies have shown that the records of working and resting time on board ships are falsified or modified. This issue aims to investigate the true extent of working and resting time records on board from the perspective of crew members

☐ None

9	If the record of working and resting time does not truly reflect your time spent on board, which or which of the following jobs stands out? ☐ Navigation ☐ Berthing/Unberthing ☐ Cargo handling operation ☐ Maintenance ☐ Training ☐ Port state and flag State inspection ☐ Anti-pollution inspection ☐ Bunkering or disposing of sludge ☐ Various paperwork ☐ Company safety inspection ☐ Message and mail exchanges ☐Other work is not included in the above options	Find out what specific types of work on the ship cause the falsification or modification of the ship's working and resting hours records from the crew's point of view.
10	Based on your work experience, which of the following tasks on board may causes you stress? (Multiple choice) ☐ Navigation ☐ Berthing/Unberthing ☐ Cargo handling operation ☐ Maintenance ☐ Training ☐ Port state and flag State inspection ☐ Anti-pollution inspection ☐ More replacement of crew unfamiliar with the ship ☐ Bunkering or disposing of sludge ☐ Various paperwork ☐ Official message mail exchanges ☐ Other work is not included in the above	There are many types of work on board from a managerial and operational point of view, and the stress felt by the crew to each type of work varies from individual to individual, but some common problems can be found through investigation. This question is used to investigate the types of work that cause stress to crew members

	options	
11	What factors do you think caused your fatigue intensity to increase during the three-year epidemic? (Multiple choice) ☐ Navigation ☐ Berthing/Unberthing ☐ Cargo handling operation ☐ Maintenance ☐ Training ☐ Port state and flag State inspection ☐ Anti-pollution inspection ☐ More replacement of crew unfamiliar with the ship ☐ Bunkering or disposing of sludge ☐ Various paperwork ☐ Official message mail exchanges ☐ Other work is not included in the above options	During epidemic there are some changes in crew workload because of the strict prevention and control of virus transmission on ships, and this question aims to identify the types of work that make crew fatigue increase.
12	What factors do you think made your fatigue intensity decrease during the three-year epidemic? (Multiple choice) ☐ Navigation ☐ Berthing/Unberthing ☐ Cargo handling operation ☐ Maintenance ☐ Training ☐ Port state and flag State inspection ☐ Anti-pollution inspection ☐ More replacement of crew unfamiliar with the ship ☐ Bunkering or disposing of sludge ☐ Various paperwork ☐ Official message mail exchanges	During an epidemic there are some changes in crew workload because of the strict prevention and control of virus transmission on ships, and this question aims to identify the types of work that make crew fatigue decrease.

	☐ Other work is not included in the above options	
13	Have you ever experienced a company-led reduction of permanent staffing on a ship in the last five years? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	As a result of cost control by shipping companies, some shipping companies reduce their operating costs by controlling the number of crew on board, which in turn increases the workload of the crew on board. The purpose of this question is to investigate the reduction of crew on board ships in the last five years.
14	Do you feel pressured to give priority to the more important tasks in the limited time available when the company assigns tasks that exceed the crew's workload? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	The question examines how often crew members compromise when they are under more than their workload
15	Do you give feedback to the company about the actual situation on board when the company has assigned tasks that exceed the crew's working intensity? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	This question investigates the willingness of crew members and the company to report when they exceed their work intensity on board.
16	Have you been requested by the company to make more reasonable arrangements for the crew working on the ship? (Applicable to captains and department heads) ☐ Always ☐ Often ☐ Sometimes	Investigate whether the crew has any request for additional staffing from the shipping company

	☐ Rarely ☐ Never	
17	Does the company take the initiative to communicate with you about whether the manning on board can meet the requirements of the work on board? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	From the perspective of crew, the shipping company's attention to the allocation of personnel on board is evaluated.
18	Have port state and flag State officials expressed doubts about the authenticity of the records of working and resting hours on board the ship that you have experienced? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	Investigate the extent to which port State and flag State officials care about the authenticity of on-board duty break records from the crew's perspective.
19	If applicable, do you inform port State and Flag State inspectors of changes to working and resting hours records due to current staffing conditions? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	This question investigates the willingness of crew members to communicate with port state and flag state prosecutors regarding the actual on-board working and resting hours records.
20	Has there ever been an increase in staffing on a ship where you have worked because the port state and flag State have raised the issue that the ship's working and resting hours records do not meet Maritime Labour Conventions? ☐ Always ☐ Often	Investigate whether the shipping company has increased the number of crew members due to the non-compliance of the ship's working and resting hours records from the crew's experience.

	☐ Sometimes ☐ Rarely ☐ Never	
21	Is there currently a method established in the management procedures of the shipping company where you work to assess whether the ship's staffing meets the ship's operational requirements? ☐ Yes ☐ No ☐ Unclear	The purpose of this question is to investigate whether shipping companies have established a mechanism to evaluate ship staffing.
22	What measures do you usually take to prevent crew fatigue on your good vessel? ☐ Adjust the time of duty in advance ☐ Take compensatory leave after working overtime ☐ Observe its working state and then determine the scheme ☐ Measures shall be taken according to specific circumstances ☐ No concrete plan (If any more, please state.)_____	Investigate existing measures taken on board to cope with fatigue at sea.

4.1.3 Coping with fatigue at sea questionnaire for shipping company managers

The following questions in Table 4 are a survey on the perception of maritime fatigue among shipping company personnel who manage ships. The questionnaire consists of 15 questions and all respondents are shipping company managers who are directly involved in ship operations, some of whom have experience working at sea.

Table 4 Coping with fatigue at sea questionnaire for shipping company managers

1	How many years have you worked for a shipping company? ☐<1 ☐1 -3 ☐4 -10 ☐11 and above	From the service length of the respondent, experience in shipping companies largely determines the accuracy of the survey data.
2	Which department do you work in company? ☐Commercial department ☐Operation department ☐Ship management department ☐Crew assignment department ☐HR department	From the managerial roles of the respondent
3	What kind of ships do your company specialize in? ☐ Container ☐ Bulk carrier ☐ Tanker ☐ General cargo ship ☐ LNG/LPG ☐ Ro-Ro ship/Pure Car Carrier ☐ Cruise ship ☐ Others	Investigate the types of ships managed by shipping companies
4	Do you think the manning of your fleet can meet the operational requirements on board?	

	☐ Completely ☐ Basically ☐ Difficultly ☐ Unsatisfyingly ☐ Unclear	Investigate from the shipping company's perspective their perception of whether the ship's manning meets the ship's operational requirements
5	Has the crew reported to the company that the work intensity is too high due to the lack of manning on board? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	Investigate whether shipping lines are able to publicly receive feedback from crew members that staffing does not meet the ship's operational requirements.
6	Have any crew members privately told you that they are working too hard because they are understaffed? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	Because of the vulnerability of crew members in the maritime industry, crew members are concerned that publicly reporting certain situations may be detrimental to them. This question investigates whether the management of shipping companies can receive feedback from private sources about that staffing does not meet the ship's operational requirements.
7	Has the ship management crew reflected to the company that the new crew has caused the ship management stress to a large extent? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	This question aims to investigate whether shipping companies receive feedback from management-level crew members of ships about the increased work stress on ships caused by new crew members.
8	Has there ever been a decrease in the permanent manning of ships in the shipping company where you work? ☐ Always	Investigate shipping companies' attrition in response to ship manning

	☐ Often ☐ Sometimes ☐ Rarely ☐ Never	
9	Did the shipping company you work for increase the manning of the ship in order to close the defect caused by the port state or flag state inspection because the ship's working and resting hours record does not meet the Maritime Labour Convention? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never ☐ Unclear	To investigate whether shipping companies have increased staffing in response to the failure of on-board working and resting hours records to comply with the Maritime Labour Convention.
10	Do you think there is crew fatigue in the main fleet of your company? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never ☐ Unclear	To investigate the perception of shipping company managers on the existence of crew fatigue in the fleet they managed.
11	In your ship management process, have you considered the ship's current staffing and current workload matching issues? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	To investigate the importance of shipping company management to the problem of ship staffing.
12	Does your company have a specific mean to evaluate whether the crew on board meets the job	

	requirements outlined in the company's safety management system? ☐ Yes ☐ No ☐ Unclear	To investigate whether shipping companies have appropriate management methods to evaluate the matching degree of ship manning and ship workload.
13	If there is a system in your company to evaluate the workload of ships, how is it implemented? ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never	To investigate the implementation of this measure by shipping lines that already use the method of assessing workload on board.
14	What is the cause if there is crew fatigue in the fleet you manage? ☐ Under-staffing ☐ Less skill of crew ☐ Harsh working environment ☐ Irregular route ☐ Insufficient shore-based support ☐ Over-management and monitoring	To investigate the cognition of shipping company managers on the causes of crew fatigue
15	What measures do you think would mitigate the crew fatigue in the main fleet of your company? ☐ Increase manning ☐ Improve seafarers' skills ☐ Improve the working environment of ships ☐ Slim down for safety management, reduce redundant regulation ☐ Assign staff according to workload (If any more, please state.)	To investigate the measures taken by shipping company managers to deal with crew fatigue.

4.2 Methodology and statistical data of questionnaires

4.2.1 Sample

The participants of this survey are people working in the maritime industry in

China. The interviewees include seafarers and shipping company managers from Chinese and other countries, such as Chinese-Polish Joint Stock Shipping Company, COSCO Shipping, China Merchants Group, Evergreen, Chun An Shipping etc. China maritime administration officials from different regions also took part in a questionnaire on how to cope with fatigue at sea.

The survey will use a stratified random sampling method with two stages of selection. In the first stage, three separate questionnaires will be set up according to the subjects' roles in the maritime industry. The questionnaires are distributed randomly through different WeChat application groups.

The second phase of the sample consists of selective face-to-face interviews using questionnaires corresponding to the respective roles. The survey respondents were selected in a representative manner. The range of interviews is broad, and officers of China MSA, managers of shipping company and seafarers are covered, even for a cadet who has just graduated from a maritime university.

All three questionnaires in this paper are subject to sampling error at the time of sampling. At the 95% confidence level, the sampling error rate for the entire questionnaire is plus or minus 2.5%. This means that all people in the sample were interviewed, which would yield a plus or minus 2.5% result for 95% of the sample.

4.2.2 Questionnaire and interviewing

The questionnaires used in the survey were prepared by myself together with other experts in the maritime industry. Comments were sought on three preliminary drafts of the questionnaires, and the content and length of the questionnaires were revised during the consultation process.

The survey was composed of an online survey, face-to-face interviews and online interviews. The interview was approximately 15 minutes in length on average, and the locations for the face-to-face interviews were chosen to be in conference rooms and quiet teahouses. The information obtained from the online survey was collected and sorted at all stages by Questionnaire Star to ensure accuracy and

reliability, and the information from the face-to-face interviews was recorded only as relevant to this survey and stored anonymously.

4.2.3 Data analysis

The survey data obtained by the above method covers three aspects: maritime regulation, shipping company management and crew, which can basically reflect the actual situation of China's maritime industry in dealing with maritime fatigue. By statistically weighting the collected information, these data can be used to analyze the current situation of the global maritime industry in coping with maritime fatigue.

4.2.4 Statistical data of questionnaires

The maritime fatigue survey consisted of three questionnaires reflecting the full responses of 135 people in the maritime industry, with the majority of respondents being 106 seafarers from different shipping companies and the other 29 people containing 18 shipping company managers and 11 officials from China MSA.

Answers that are generally accepted by maritime experts in the maritime industry and that have answers based on their rank that contradict their own rank will be considered invalid for the questionnaire. In analyzing all 135 questionnaires, 4 answers were classified as invalid. The final number of valid questionnaires was 131, and the effective response rate was about 97%. In Table 5 the number and percentage of valid answers for each group can be seen.

Table 5 Statistical data of questionnaires

	Total answer	Effective answer	Rate of effective answer
First questionnaire	11	11	100 %
Second questionnaire	18	17	94.1%
Third questionnaire	106	103	97.2%
Total	***135***	***131***	***97.0%***

Source: WenJuanXing.

A large percentage of seafarers were invited to participate in this survey, and from the standpoint of the seafarers themselves, they are the direct targets of maritime fatigue suffering. The survey data can reflect the current situation of coping with marine fatigue on board, and from them we can also understand the direct effect of shipping companies and maritime regulators' measures to cope with marine fatigue on board, so it is reasonable to set up a separate questionnaire for seafarers. From Figure 9 we can see that the surveyed crew members are mainly from Chinese coastal provinces, only 4 crew members are from inland provinces, 79 (76.7%) are married, 23 (22.3%) are single and 1 (1.0%) is divorced. Age was recorded in categories, and 16 (15.5%) reported to be 25 years or younger, 9 (8.7%) were aged 26-30 years, 47 (45.6%) were aged 31-40 years, 30 (29.1%) were aged 41-50 years, and 1 (1.0%) were 51 years or older.

Background checks on shipping company managers and officials of China MSA are conducted primarily on the basis of length of time in current employment. There is no direct link between age and the company's management policy and maritime regulation.

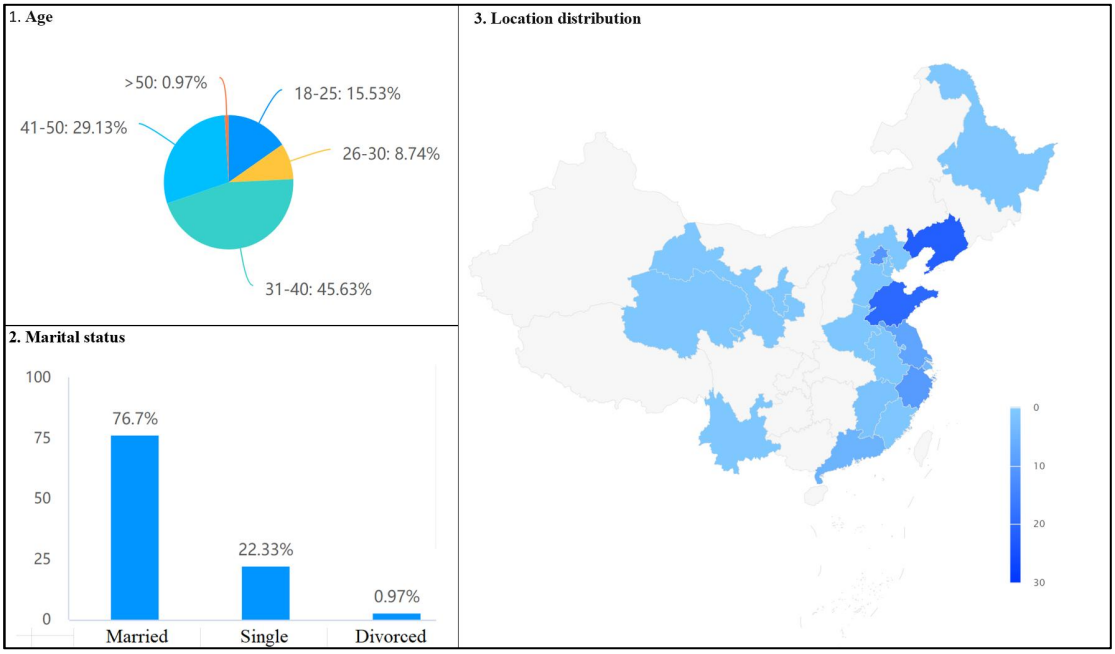

Figure 3 Basic information on 103 seafarers under investigation.

Source: WenJuanXing.

The limitations of this survey are mainly the limited time available and the limited participation of shipping company managers and maritime authority officials, which prevented me from ensuring the comprehensiveness and reliability of the regulatory and management responses to maritime fatigue. Moreover, the participation of crew members in this survey was concentrated on management-level crew members, whose participation was as high as 78.6% of the whole sample, and the participation of general crew members was lacking, especially for general seafarers working on ships.

4.3 Questionnaire findings

4.3.1 Officers of China MSA

A total of 11 officers of China MSA were surveyed, 7 of whom had PSC or FSC officer qualifications. As showed in Table 6, 4 of whom had been with the MSA for more than 1-3 years, 6 of whom had been with the Authority for 4-10 years, and 1 of whom had been with the authority for more than 10 years. 8 of the respondents had previous work experience at sea, 6 of which had worked on board merchant ships after the entry into force of the Maritime Labor Convention in 2006.

Table 6 Work background of the surveyed officers of China MSA

Years	China MSA	On merchant ship
None	0	3
<1	0	3
1-3	4	2
4-10	6	3
11 and more	1	0

Source: WenJuanXing.

The results of the survey on the changes in the regulation of shipping companies and ships by the competent authorities in recent years are shown in Figures 4 and 5.

72.7% of the respondents believe that the regulation of shipping companies has increased in recent years, while 27.3% believe that it has basically unchanged. The regulation of ships has increased for 82.8% of the respondents, while 18.2% of them think it has remained the same. From the above data, it is clear that no one thinks that regulation has weakened, and most of the respondents think that both shipping companies and ships have increased.

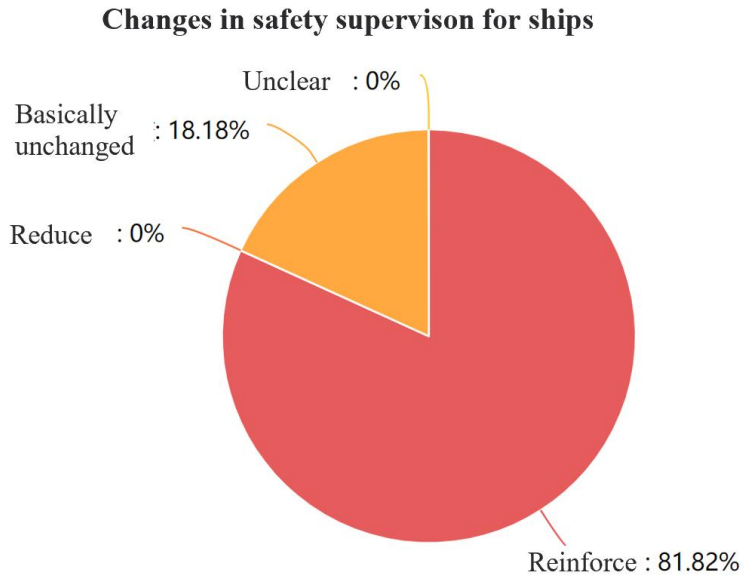

Figure 4 Changes in safety supervision for shipping company in recent years

Source: WenJuanXing

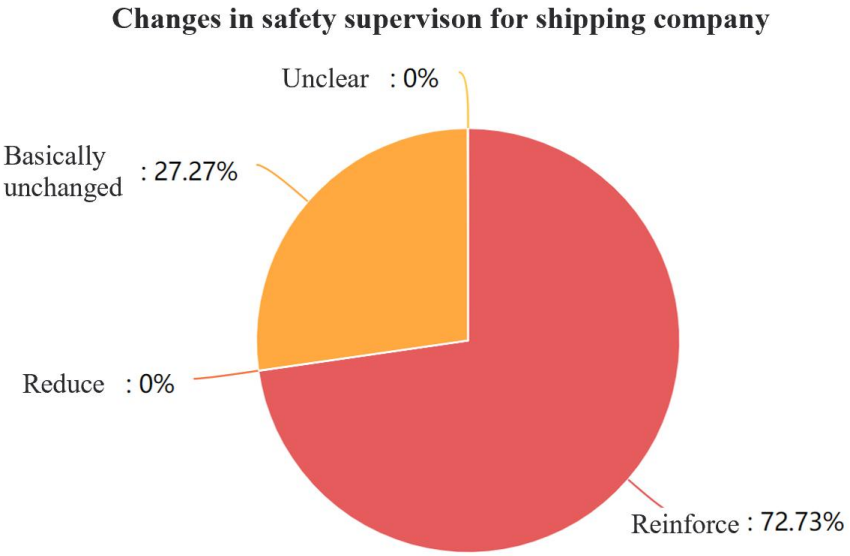

Figure 5 Changes in safety supervision for ships in recent years

Source: WenJuanXing

Generally speaking, almost all of the paperwork on board is done by the officers, and the captains interviewed also expressed concern about the difficulty of completing all the paperwork effectively by the officers on board. The results of Question 20 in the seafarer questionnaire are shown in Figure 15. 51.5% of the respondents thought that the regulation of the shipboard working and resting hours records never contributed to the increase in the number of crews, 24.3% thought that it rarely happened, 19.4% thought that it sometimes happened, while only 4.8% thought that the effect was better. The above results show that supervision has increased the workload of ship's officers to some extent without increasing the number of ship's officers assigned to them. In other words, the supervision that tries to deal with fatigue at sea does not get the desired result, while the supervision for other aspects promotes fatigue of some crew members.

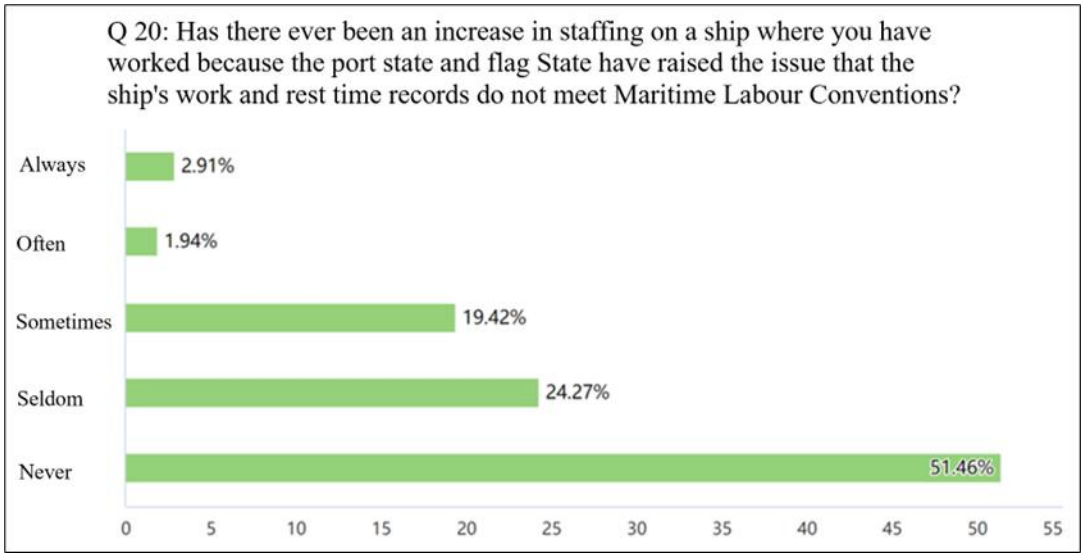

Figure 6 Survey data on the increase in manning under supervision

Source: WenJuanXing

In trying to understand the difficulties of the competent authorities in supervising crew fatigue from the surveyed maritime officials, Question 8 is designed with the help of maritime experts. The results of the survey in Table 7 show that all the

respondents agreed that verification of minimum manning certificates could not effectively solve the problem of crew fatigue, and that record modification or falsification hindered effective supervision. 72.7% of the respondents believed that there was no effective communication mechanism between the competent authorities and the crew, and 63.6% believed that the working hours required for ship safety management were not quantified which are the difficulties in effective supervision of crew fatigue.

Table 7 Statistics on the difficulties of crew fatigue supervision

Q8: Based on your work experience, what difficulties do you think the current competent authorities have in supervising crew fatigue?		
Options	Number	Percentage
A, Checking minimum manning certificate cannot effectively solve the problem of crew fatigue	11	100%
B, The crew members modify or falsify the records of working and resting time	11	100%
C, No effective communication mechanism has been established between the competent authorities and the crew	8	72.7%
D, The crew working hours required for safety management by shipping companies are not quantified	7	63.6%
E, Others, please state.	0	

Source: WenJuanXing.

The survey shows that the existing regulation framework for maritime fatigue lacks real quantitative data, the workload of the crew is not truly reflected by the work rest time records on board, and effective communication mechanisms between the crew and the regulatory authorities are lacking at present.

4.3.2 Seafarers

The questionnaire was completed by 106 crew members, of which 103 (Masters:35, Deck officers:29, Engineers:24, Ratings:15) were valid, 13 from container ships, 28 from bulk carriers, 40 from general cargo ships, 9 from tankers, 2

from passenger ships and 11 from other ship types, 92 of whom had been working on board for the last three years. 90 of them are engaged in international trade routes and 13 in domestic trade. Please see Figure 7 for the length of time they worked on the ship, only 1 (1.0%) person was less than 1 year, 26 (25.2%) were 1-5 years, 15 (14.6%) were 6-10 years, 31 (30.1%) were 11-15 years, and 30(29.1%) were more than 15 years. 73.8% of them have been working on board for more than 5 years, 25.2% for 1-5 years, and only 1 person has been working for less than 1 year, so they are very clear about everything that happens on board, and the survey data obtained is very credible.

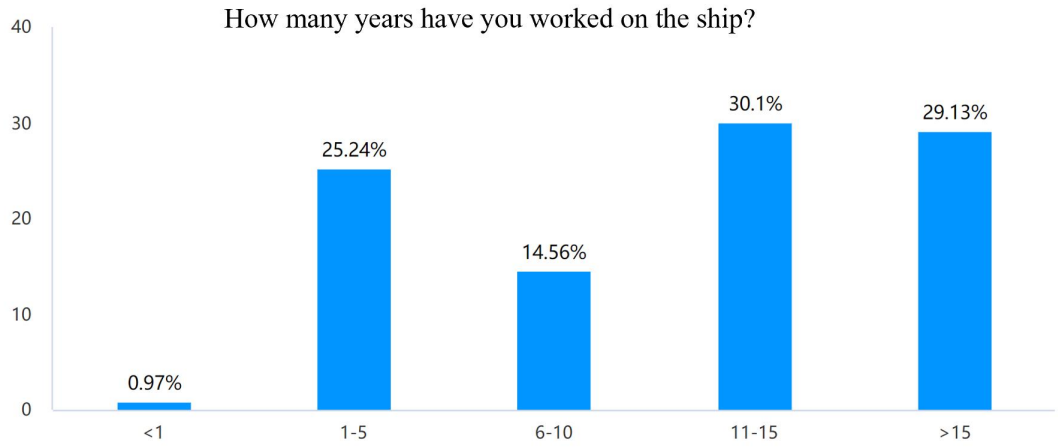

Figure 7 Length of time seafarers have worked on board

Source: WenJuanXing.

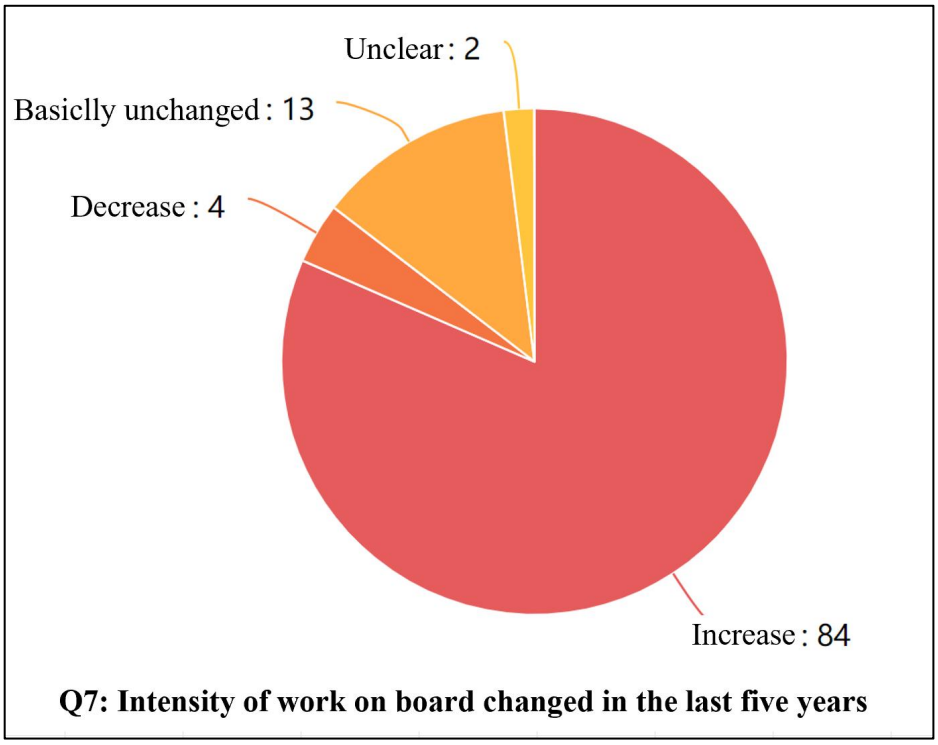

Figure 8 Changes in the intensity of ship work over the past 5 years

Source: WenJuanXing

The question 7 was a survey on the change in the intensity of ship work over the past 5 years, and as seen in Figure 8, 84 people answered "increased", while only 4 answered "decreased", and the remaining 15 said "basically unchanged". The remaining 15 people said "basically unchanged" or "unclear". Question 13 asked whether or not there had been a reduction in staffing on board in the past five years, and only 15 people said "never", while 88 people said there had been a reduction in staffing in the past five years, as shown in Figure 9. These two questions reflect the contradiction between the increase of ship workload and the decrease of crew in the past five years.

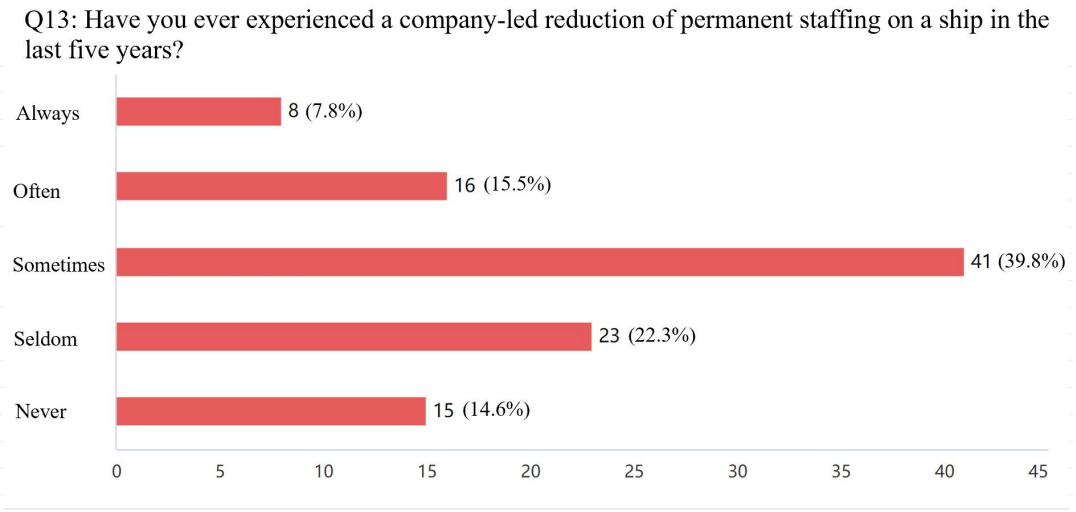

Figure 9 Reduction of seafarers on board in the past 5 years

Source: WenJuanXing

Respondents are asked to answer the extent to which the records of work breaks on board conformed to the actual ones, and as shown in Figure 8, and only 2.9% of them thought that they were fully compatible, while the remaining 97.1% thought that the records did not match to varying degrees, and even 7.8% thought that they did not match the actual ones at all. This is also a good proof that the records of working and resting hours on board the ship largely do not really reflect the real working and resting hours of the crew.

Matching question 8, question 9 investigated the discrepancies between the actual time spent and the records for those types of work on board the ship. The results are shown in Table 8, where the top five positions were taken by berthing and unberthing operations, cargo handling operation, port state and flag state inspections, various paperwork and company safety inspections. From the data, it can be seen that 77.7% of the respondents think that the discrepancy between the time spent on berthing and unberthing operations and the actual time spent on the records is the most serious. Looking at the top five, all the jobs are related to the period when the ship is in port, except for the various kinds of paperwork. Questionnaires and

interviews show that in order to maximize the profit, the ship's time in port today is compressed to the extreme, and the shortest possible time is required to complete various inspections, audits and visits, even repairs, refueling and supplies, in addition to meeting the ship's loading and unloading requirements. The ship's workload will explode in such a short period of time. It's no secret that crew members often work overtime in the port, but the records don't exactly show it.

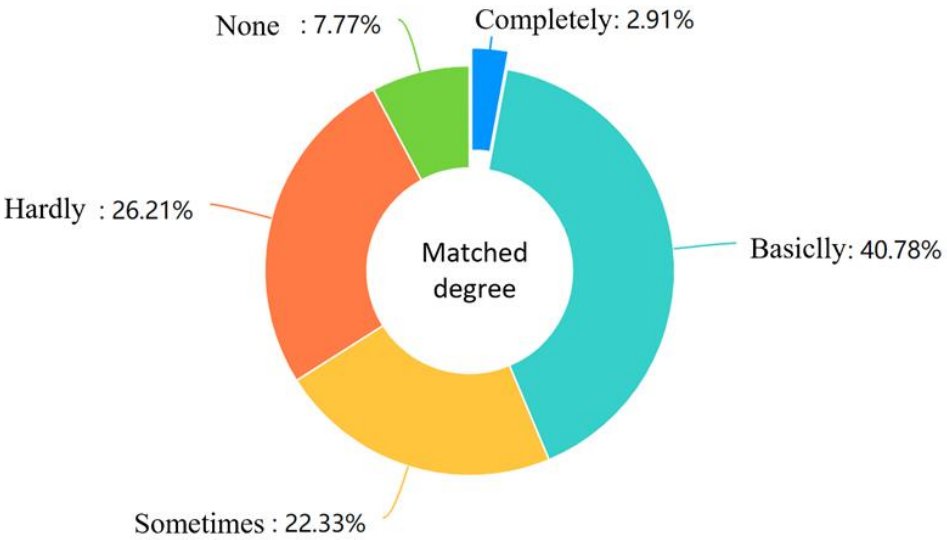

Figure 10 Degree of match of records of working and resting hours

Source: WenJuanXing

Table 8 Effective statistical results of question 9 for seafarers

Q9: If the record of working and resting time does not truly reflect your time spent on board, which or which of the following jobs stands out?		
Jobs type on board	Number	Proportion
1, Berthing/Unberthing	80	77.7%
2, Cargo handling operation	57	55.3%
3, Port state and flag State inspection	53	51.5%
4, Various paperwork	44	42.7%
5, Company Safety Inspection	40	38.8%
6, Bunkering or disposing of sludge	34	33.0%

7, Anti-pollution inspection	26	25.2%
8, Maintenance	23	22.3%
9, Official message mail exchanges	21	20.4%
10, Training	20	19.4%
11, Navigation	9	8.7%
12, Other work is not included in the above options	0	0%
Number of effective participants	103	

Source: WenJuanXing

Excessive work stress can cause both physical and mental fatigue for crew members. A survey of respondents is conducted on ship jobs that cause stress to crew members, and the results are shown in Figure 11. From the statistics, it is clear that port state and flag state inspections, replacement of crew members unfamiliar with the ship, company safety inspections, berthing and unberthing operation and anti-pollution inspections are more stressful for the crew than other scenarios.

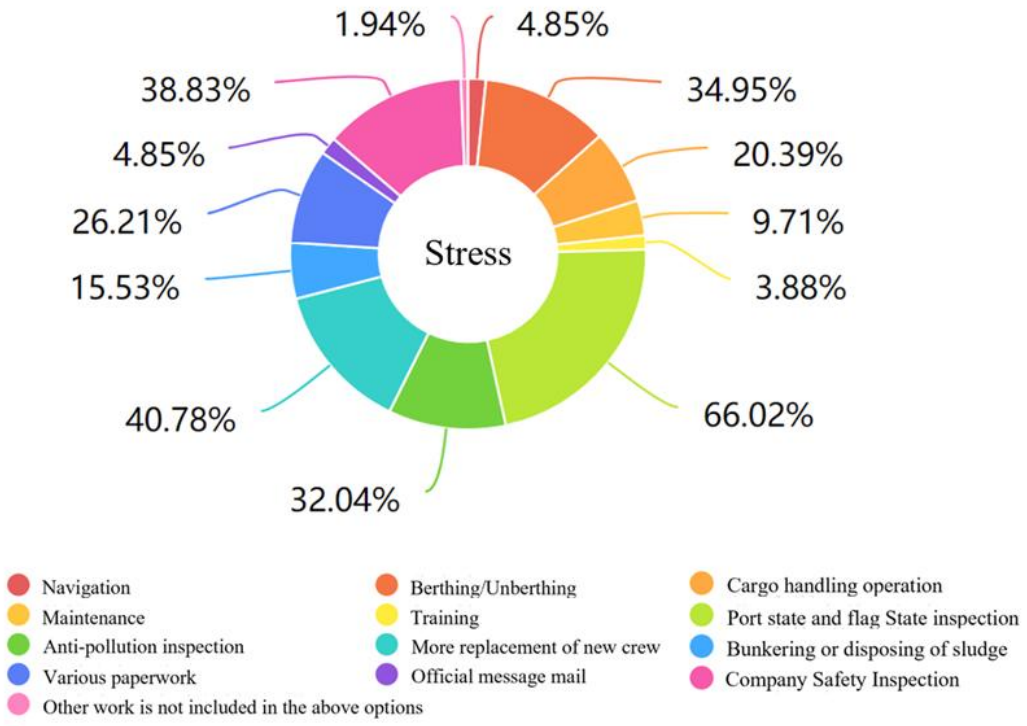

Figure 11 Ship work statistics that contribute to seafarer stress

Source: WenJuanXing

The high number of replacements of crew members who are not familiar with the ship increases the workload of the crew members who remain on board in the short term, since the new crew members need time to adapt to the ship's management and operations, and the ship is not out of operation to give the new and old crew members enough time to complete this adaptation, and there is no record of the time spent on the resulting workload. The high-risk nature of berthing and unberthing operations is stressful for the crew, and the short berthing time with various inspections makes it difficult to release crew stress during berthing. From the interviews with the interviewees, it is clear that today's crew, especially the management level, prefer to be at sea rather than enjoying their time in port, and that it is the management level crew who are under pressure from inspections rather than the general crew. In other words, much of the workload arising from the supervision and management of ships is more often taken up by the management crew, especially the various kinds of paperwork.

As a result, the current workload of the ship's crew at different ranks and the workload of each rank required for the operation of the ship do not match well, and quantitative regulatory measures such as the recording of working and resting hours on board do not fundamentally address the problem of crew fatigue.

4.3.3 Shipping company managers

The questionnaire survey of shipping company managers is targeted to find out how China shipping companies are responding to maritime fatigue. The majority of effective respondents were from the managers related to ship operations (total 17), commercial department (n=3), operation department (n=3), ship management department (n=4), crew assignment department (n=6) and others (n=1), as shown in the Table 9, and the percentage of managers directly related to ship operation was 94.1%. It can be seen from Figure 12 that 2 (11.8%) of the respondents have been working in

shipping companies for 1-3 years, while 5 (29.4%) and 10 (58.8%) have been working in shipping companies for 4-10 years and 11 years or more, respectively. They have considerable experience and are well qualified to represent the views of managers in various functions of shipping companies regarding the response to maritime fatigue.

Table 9 Respondent statistics from various departments of shipping companies

Q3: Which department do you work in company?		
Department	Number	Percentage
A, Commercial department	3	17.7%
B, Operation department	3	17.7%
C, Ship management department	4	23.5%
D, Crew assignment department	6	35.2%
E, HR department	0	0
F, Others	1	5.9%
Total	17	

Source: WenJuanXing

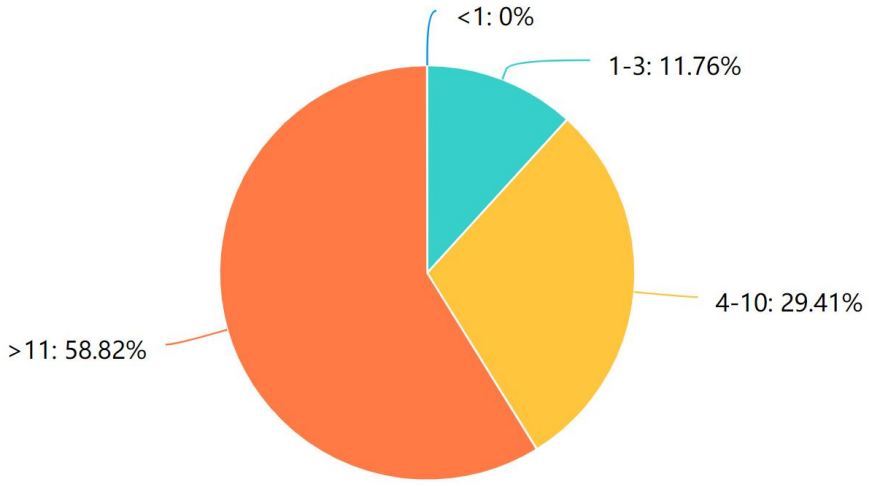

Figure 12 Years of working in shipping companies of respondents

Source: WenJuanXing

A survey was conducted for the company's management on whether the ship's manning meets the ship's operation, the results in Figure 13 show the divergences

between company managers on this issue. 6 respondents thought that the ship's crew could fully satisfy the normal operation of the ship, 7 thought that it was basically satisfied, and 4 thought that it was difficult to satisfy. 76.5% of the company's managers thought that the ship's crew could still satisfy the operational demand from the results.

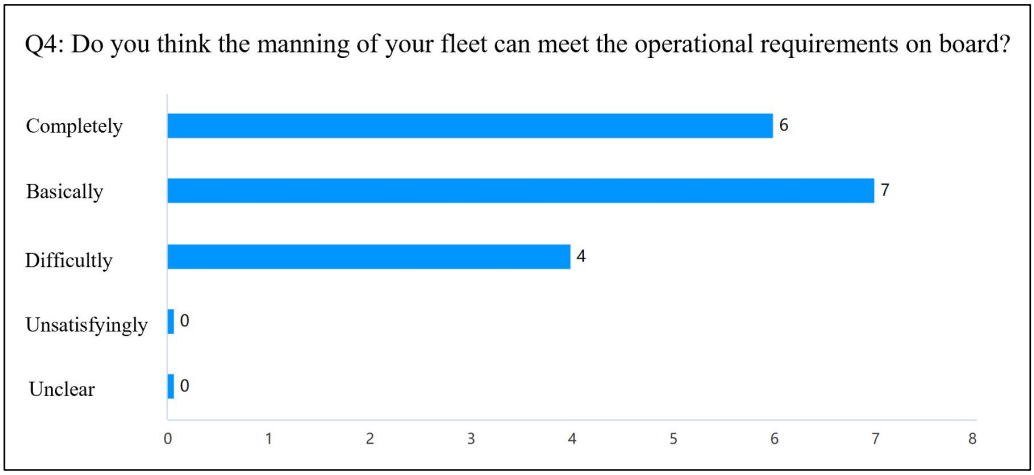

Figure 13 Satisfaction of company managers with ship manning

Source: WenJuanXing.

The results of the questionnaire survey on the causes of crew fatigue for the managers of shipping companies in the Table 10 showed that 70.6% of them considered over-management and supervision as the main cause of crew fatigue, followed by irregular routes, insufficient manning, harsh environment, insufficient crew skills and insufficient shore-based support. Two other respondents suggested that the type of vessel and more tasks during berthing also contributed to crew fatigue.

Table 10 Statistics on the causes of crew fatigue in the fleet

Q14: What is the cause if there is crew fatigue in the fleet you manage?		
Department	Number	Percentage
A, Under-staffing	8	47.1%
B, Less skill of crew	5	29.4%
C, Harsh working environment	4	23.5%

D, Irregular route	10	58.8%
E, Insufficient shore-based support	3	17.7%
F, Over-management and monitoring	12	70.6%
G, Others	2	11.8%

Source: WenJuanXing

The results of another survey on effective measures to cope with crew fatigue are shown in Table 11. The respondents showed a high degree of agreement on measures of manning according to the ship's workload, with 88.2% of the respondents expressing a favorable view on this issue. Another measure to slim down the company's management was also considered effective by 64.7% of the respondents. From this survey we can see that company managers are aware of the effects of excessive management and supervision on crew fatigue. Excessive workload caused by over-supervision and over-management, if not recognized and prevented, is likely to be the culprit of crew fatigue and thus safety accidents. However, what kind of management and supervision is considered excessive needs further study.

Table 11 Statistics on effective measures to relieve fatigue from managers

Q15: What measures do you think would mitigate the crew fatigue in the main fleet of your company?		
Department	Number	Percentage
A, Increasing manning	5	29.4%
B, Improving seafarers' skills	5	29.4%
C, Improving the working environment of ships	5	29.4%
D, Slimming down for company management	11	64.7%
E, Manning based on ship workload	15	88.2%
F, Others	0	0

Source: WenJuanXing.

In order to understand the effectiveness of communication between crew members and company managers in coping with fatigue, the frequency and manner of

communication between crew members and company managers regarding the problem of excessive work intensity due to insufficient manning on board was investigated from the managers' perspective. Communication ways in Questions 5 and 6 of the questionnaires for managers were set as in formal and in private, with five levels of frequency for each way including never, rarely, sometimes, often and always, which were assigned different integer values from 0 to 4 in the above order as communication index for comparison. The results of the survey in Figure 14 show that the sum value (n=36) of the private communication index is slightly higher than the sum value (n=27) of the formal communication between the 17 surveyed company managers and crew members, which revealed that crew members and company management tend to communicate more privately about manning issues. The same tendency was shown in the interviews with the crew members, especially that the willingness to communicate with the inspectors would be lower. Crew members are more worried about losing their jobs than about solving their own fatigue problems through effective communication, because there is an inequality of power and security in communicating about this issue. Bureaucratic regulation so far in the maritime industry has not created a safe environment for crew to communicate effectively, we don't hear real voices when we want to find out the root of the problem.

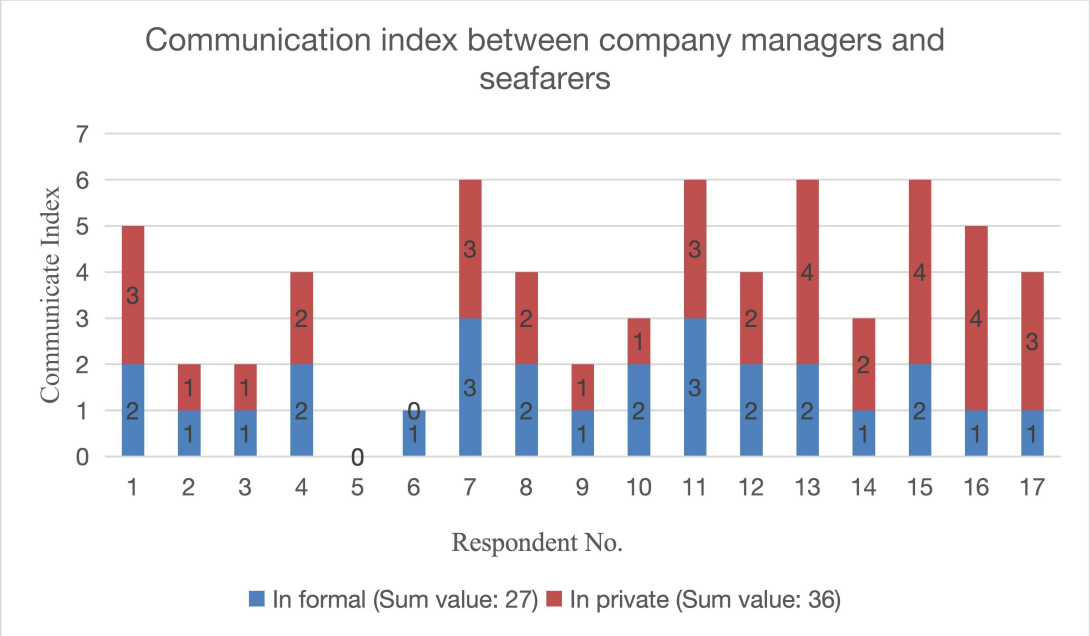

Figure 14 Communication index between company managers and seafarers

Source: WenJuanXing.

4.4 Summary of fatigue survey

The questionnaire surveys and interviews indicate that the current regulatory mechanism for marine fatigue does not fully address the current problem. There is no coherent purpose between regulators, shipping companies and crews to deal with fatigue, and effective communication between the three parties is lacking within a framework. There is no quantitative assessment of the impact of the company's safety management and regulatory system on the crew's workload, which breeds some managements and regulations that not only does not alleviate fatigue, but also overwhelms the crew with ship safety management responsibilities and dilutes the attention that would otherwise be devoted to other safety management aspects. Vessel manning is not managed according to the amount of workload undertaken by each grade on board. Crew members do not appear to contribute positively to the mitigation of fatigue at sea, even though they are victims of fatigue at sea.

4.4.1 Effectiveness of communication

Regulators, shipping companies and crews are all part of the maritime industry

and have their own roles to play in contributing to ship safety. But in other areas, it seems that because of their different interests, there are invisible barriers between them that prevent them from communicating effectively, especially in dealing with the problem of sea fatigue.

The crew members interviewed showed their distrust of the officers of MSA and the management of the shipping company, stating that telling the truth would not effectively solve the problem except for the inspector to issue a deficiency, but would instead lead to the crew being condemned or even losing their jobs. The managers of the shipping companies interviewed said that crew members sometimes report that the work on board is very intense, but the number of reports is very small, so they tend to consider it as an individual case, and usually solve the problem through private communication with the ship's management crew. The interviewed maritime officials said that we would hear various problems about fatigue on board in private, but when we actually carry out on-site inspections, few crew members would tell us the truth, perhaps because they were afraid of being fired, and it was difficult to find the real problems when we had to complete the inspections in a short time.-

4.4.2 The impact of regulation and management on fatigue

From the questionnaires and interviews with crew members, it can be seen that inspections from outside cause a lot of pressure on crew members and added a lot of workloads to management level crew members. Also shipping company managers in the survey think that over supervision is the main cause of crew fatigue, and from the company management point of view safety management needs to be slimmed down and optimized to really alleviate the crew fatigue phenomenon. Governing safety through a ‘bureaucratic infrastructure’ of planning, process, records, audits and administrative rationality all at a distance from the operation generates bureaucratic accountability requirements (Sidney W.A. Dekker, 2014). While emphasizing the positive impact of regulation and management on ship safety, its negative impact should not be ignored and disregarded.

4.4.3 Lack of quantitative evaluation methods

One of the topics that showed a high degree of consistency in the questionnaires and interviews with the three groups was that manning according to workload was considered to be an effective way to be able to reduce crew fatigue. The only quantitative regulation of ship manning in shipping companies is the minimum manning certificate, and there is a lack of quantitative assessment of the impact of ship workload generated by company safety management on crew with safety and pollution prevention duties in the minimum manning certificate. The quantitative regulation of the records of onboard working and resting time only regulates the legitimacy of the records, but does not contribute to the company's efforts to reduce crew fatigue through manning. Manning based on workload may be a good solution to the current dilemma, but we lack a quantitative methods of ship workload.

5 Managing and utilizing crew workload self-assessment data

In order to address the problem of fatigue at sea, a method based on crew workload self-assessment as mentioned at the beginning of this paper is introduced. The method is to quantify the time required for each job in the ship's operation by the crew member performing the job. The workload of each crew member is then accumulated and evaluated on a weekly, monthly or voyage cycle basis to determine whether the workload of the crew member exceeds the maximum working hours specified in the Maritime Labor Convention. Through this method, shipping companies are encouraged to optimize management and rationalize crew allocation based on this assessment of workload to achieve the goal of reducing fatigue at sea. It also allows regulators to have a quantitative indicator of the overall workload of ship operations and provides data support for dynamic supervision of ship manning.

In consideration of the above mentioned challenges and the inconclusive nature obtained by the survey, the authors will proposed in this chapter a set of short- and long-term approaches to address the maritime fatigue problem.

5.1 Short-term approaches

5.1.1 Data collection

The shipping company manages the ship's operations and the company safety management system covers the procedures and types of work of the crew on board. According to the work requirements specified in the safety management system for each duty crew member, we can list specific work items and periodicity in combination with the characteristics of the ship's service route, and fill in the data for each item according to the number of hours of work they have completed. Such data varies from person to person due to the different feedback of each individual to those factors of specific work.

Data collection for a single ship can be done using office computers in the ship's Local Area Network (LAN), and guidance and training is needed for each crew member of each rank to fill out the report during this period.

5.1.2 Establishing statistical models

With enough initial data on a single ship, a public platform is created for regulators, shipping companies and crew members based on web technology. The digital technology is used to analyze and model the data and then develop software that is user-friendly and can be used with porTable devices. Completing simple digital filing using cell phones does not cause much stress to the crew, but greatly facilitates further data collection.

A large number of statistics on the same job on the same type of vessel gives an idea of the average length of time spent on specific job in the maritime industry. A series of average hours form the basic unit of workload, and then a ship workload model can be built according to the specific company management model, ship type, route and other characteristics. The ship's workload model can be used to allocate staff according to the type of work and the number of hours, which is a reasonable use of human resources.

5.1.3 Recommendatory Standards

After a short trial run, we can evaluate the effectiveness of this method, especially the feedback from crew members should be paid more attention, only their active participation can ensure the authenticity of the data, no one knows more about their working hours and feelings than them.

When the feasibility of the methodology has been verified, the flag state may pilot a recommended standard as a transition based on a ship workload model in conjunction with a minimum manning certificate.

5.2 Long-term approaches

5.2.1 Mandatory standards

From a long-term perspective, for regulators to regulate according to the law, the recommended standards need to be further transformed into mandatory standards after they are generally accepted by the industry. However, at this point, the regulation is more based on data verification on a common platform of three parties, eliminating the possibility of crew falsification and modification of records. The audited safety management system of the company will not be easily changed, in addition, the average working hours of the industry can easily screen individual falsification on the one hand, and will not increase the psychological burden of individuals who fear retaliation from shipping companies for filling in the data on the other hand.

5.2.2 Establishment of a workload audit mechanism

The implementation of mandatory standards provides a basis for regulatory enforcement. In Chapter 5.1.1 it is discussed that the type of work for data collection comes from the company's safety management system and that the ship's manning level and company’s SMS are highly correlated. A bloated management system will inevitably result in internal consumption of human resources. The workload audit through the company's safety management system is an important step in digital safety management and has far-reaching implications for the company to improve and

optimize fleet management.

Establishing a workload audit system for the safety management system will not only give the company a better overview of its own operational status, but will also greatly circumvent the time costs associated with the massive amount of nuisance paperwork we encounter today. A cost control strategy does not allow for meaningless consumption, which runs counter to today's redundancy regarding safety strategies. One of the interviewees expressed concern about the overly bureaucratic way in which management is conducted today in the name of safety.

The digitization of workloads can effectively alleviate this ineffective management of companies, while also allowing regulators to see the impact that regulatory regimes have on shipping companies and ships.

5.2.3 Dynamic supervision under digital technology

Future innovation in technology will change the way collaboration works, but also will affect the way the maritime industry, drive performance improvements and create opportunities for maritime businesses to take better decisions (GOV UK, 2019). As a response to fatigue supervision can also make full use of the convenience brought by the new digital technology. Based on the ship's workload model and the data of the ship's crew grades and numbers overlaid with the data reported by the crew in real time, the match between the ship's crew and the ship's workload can be analyzed at any time, providing technical support for dynamic monitoring of the ship's crew and reducing fatigue at sea.

6 Summary and conclusion

This paper focuses on the current state of dealing with seafarer fatigue at three levels: maritime regulatory, shipping company, and shipboard. This paper attempts to find a quantitative method to assess the relationship between shipboard workload and ship manning in a new direction as a complementary method to the existing regulatory system.

The questionnaires were successful and maritime regulators, shipping company managers and crew members associated with maritime fatigue were covered and they provided a wealth of valuable information on coping with maritime fatigue. By analyzing these surveys, the author identified differences in motivation and implementation in response to maritime fatigue between the three groups.

The current minimum manning certificate and the working and resting hours records in the Maritime Labor Convention are not sufficient to cope with fatigue at sea. The minimum manning certificate, which is based solely on pollution prevention and safety duties, cannot deal with the diversity of work on board modern ships. The ship's working and resting hours records, while providing time statistics for the work included in the ship's official records, do not provide statistics for the non-recorded work that many crew members are required to perform within the regulatory framework of the shipping company, and therefore do not truly reflect the workload on board, while it is precisely this kind of record that becomes an obstacle for maritime regulators to develop regulations on fatigue at sea, because it is not compliant with procedures for PSC and FSC to carry out detailed inspections of ships without obvious evidences, but there is no guarantee of accuracy of the trivial records and work on board to achieve the reconciliation in a short time.

The paper looks into the future and proposes a method to quantify the workload on board for the company management system, by digitizing the shipping company management system by means of crew self-assessment, and then using big data analysis to derive the average workload required for a specific job in the industry as a recommended standard. By adding up the recommended workload data for each piece of work on board, the number of crew members required for each grade on board can be known, thus solving the problem of crew fatigue from the perspective of allocation of working hours.

A quantitative assessment of the workload of the management system of the shipping company ashore is probably the most effective way to assess the workload of

the crew from the root of the management system, and in terms of time, the assessment conducted ashore will allow the regulator to obtain more sufficient data to monitor the reasonableness of the ship's crew. However, the data obtained in the short term is not representative of the industry, considering the variation of different ship types and crews. Long-term data will also form many kinds of data with different conditions of ship designs, ship operation routes and navigation areas, and then processing the data according to different conditions can form workload cells, thus forming workload models for specific ships. The model not only provides a quantitative basis for the supervision of marine fatigue, but also provides reference data for the flexibility of personnel management of shipping companies, and finally improves the participation of crews in ship management and professional satisfaction through the involvement of crew self-assessment, which further will hopefully ensure the safe operation of ships.

While future vessels may reduce the number of crew on board, it is obvious that crew members will not be completely removed from the ships in short time (Tam & Jones, 2018). Even with a high level of automation on board, it is necessary to know exactly how much time is needed to complete each task on board that requires manual labor. If at some point of time in future unmanned ship technology matures to the point where no one is needed on board to perform the work, the same quantitative workload assessment methods for management systems apply to those who control and maneuver the ship ashore.

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Appendices 1 Coping with fatigue at sea questionnaire for officers of China MSA

Dear Participant,

Thank you for agreeing to participate in this research survey, which is carried out in connection with a Dissertation which will be written by the interviewer, in partial fulfilment of the requirements for the degree of Master of Science in in Maritime Safety Environmental Management delivered in Dalian, China, by World Maritime University in collaboration with Dalian Maritime University.

The topic of the Dissertation is "A research on fatigue resolution method led by crew workload self-assessment."

The information provided by you in this interview will be used for research purposes and the results will form part of a dissertation, which will later be published online in WMU's digital repository (maritime commons) subject to final approval of the University and made available to the public. Your personal information will not be published. You may withdraw from the research at any time, and your personal data will be immediately deleted.

Anonymised research data will be protected by strong password. All the data will be deleted as soon as the degree is awarded.

Your participation in the interview is highly appreciated.

亲爱的参与者,

感谢您同意参加本次调研，本次调研与面试官撰写的论文有关，部分满足了世界海事大学与大连海事大学合作在中国大连颁发的海上安全环境管理理学硕士学位的要求。。

本文的课题是"以船员工作负荷自评估为主导的疲劳解决方法研究"。

您在本次访谈中提供的信息将用于研究目的，其结果将构成论文的一部分，随后将在WMU的数字存储库(海事公地)中在线发布，并经大学最终批准并向公众开放。您的个人信息将不会被公布。您可以随时退出研究，您的个人资料将被立即删除。

匿名的研究数据将被存档在一个安全的USB驱动器。学位授予后，所有资料将立即删除。非常感谢您参加问卷调查。

Student's name …Liu Jun……
Specialization ……MSEM……
Email address ……liujun_dlmuhh@dlmu.edu.cn……
* * *

电子邮箱 E-mail:

1.您在海事局工作几年？How many years have you worked in the maritime Bureau?

□<1

□1 -3

□4 -10

□11 and above

2.在2006海事劳工公约生效后，您是否有过在商船上任职的经验？Have you had any experience working on a merchant ship after the 2006 Maritime Labour Convention came into force?

□是yes

□否 no

3.如果有商船任职的经验，您在海上工作了几年？（如适用请填写）How many years have you worked at sea if you have experience on a merchant ship? (Please complete if applicable)

□<1

□1 -3

□4 -10

□11 and above

4.依据您的工作经验，近些年海事局对于船公司的安全监管呈现什么样的变化？According to your work experience, how has the Maritime Safety Administration changed its supervision of shipping companies in recent years?

□加强 reinforce

□减弱 reduce

□基本不变 Basically unchanged

□不清楚 unclear

5.依据您的工作经验，近些年海事局对于辖区船舶的安全监管呈现什么样的变化？According to your work experience, what changes have been presented in the safety supervision of vessels under the jurisdiction of the Maritime Safety Administration in recent years?

□加强 reinforce

□减弱 reduce

□基本不变 Basically unchanged

□不清楚 unclear

6.您有过任职船旗国或港口国检察官的经历吗？Have you had any experience as a Flag State

Control or Port State Control officer?

□ 船旗国检察官Flag State Control officer

□ 港口国检察官Port State Control officer

□ 两者都任职过Both

□ 从未Neither

7.除了核查船舶配员是否满足最低配员证书和检查船舶工作休息时间记录，海事局有没有其它的具体措施去监管船舶配员不足造成疲劳的问题？Apart from checking whether the minimum manning certificate is met and checking the ship's working and resting hours record, does the Bureau have any other specific measures to monitor the problem of fatigue caused by the under-manning of ships?

□是yes

□否 no

□不清楚 unclear

8.依据您的工作经验，您认为当前主管机关对船员疲劳的监管难点有哪些？Based on your work experience, what difficulties do you think the current competent authorities have in supervising crew fatigue?

□核查最低配员证书无法有效解决船员疲劳问题Checking minimum manning certificate cannot effectively solve the problem of crew fatigue

□船员对工作休息时间记录修改或者造假The crew members modify or falsify the records of working and resting time

□主管机关和船员之间没有建立有效沟通机制No effective communication mechanism has been established between the competent authorities and the crew

□船公司安全管理所需的船员工作时间没有量化The crew working hours required for safety management by shipping companies are not quantified

□其它，请陈述。Others, please state.

9.在您检查船舶的过程中，有没有船员向您个人反映船上工作休息时间记录和实际情况不符？（如适用）

During your inspection of the ship, did any of the crew report to you personally that the ship's working and resting hours records were inconsistent with the actual situation? (if applicable)

□总是发生 Always

□经常发生 Often

□有时发生 Sometimes

□很少发生 Rarely

□从未发生 Never

10.在您检查船舶的过程中，有没有船员向您个人反映船上配员不足造成工作强度过大？（如适用）During your inspection of the ship, did the crew ever report to you personally that the work intensity was too high due to the lack of personnel on board? (if applicable)

□总是发生 Always

□经常发生 Often

□有时发生 Sometimes

□很少发生 Rarely

□从未发生 Never

11.有没有船员向您表达希望通过监管来改善船员疲劳的意愿？Have any crew members expressed to you a desire to improve crew fatigue through supervision?

□总是发生 Always

□经常发生 Often

□有时发生 Sometimes

□很少发生 Rarely

□从未发生 Never

12.任何和应对海上疲劳相关的建议Any suggestions related to coping with fatigue at sea

_____

Appendices 2 Coping with fatigue at sea questionnaire for Seafarers

Dear Participant,

Thank you for agreeing to participate in this research survey, which is carried out in connection with a Dissertation which will be written by the interviewer, in partial fulfilment of the requirements for the degree of Master of Science in in Maritime Safety Environmental Management delivered in Dalian, China, by World Maritime University in collaboration with Dalian Maritime University.

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亲爱的参与者,

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匿名的研究数据将被存档在一个安全的USB驱动器。学位授予后，所有资料将立即删除。非常感谢您参加问卷调查。

Student's name …Liu Jun……
Specialization ……MSEM……
Email address ……liujun_dlmuhh@dlmu.edu.cn……
* * *

一，个人信息 Personnel information

电子邮箱 E-mail:	

1.您的年纪？How old are you?

□18-25 years

□26-30 years

□31-40 years

□41-50 years

□51 years and above

2.您的婚姻状况？What is your marital status?

□已婚 Married

□未婚 Single

□离异 Divorced

二，工作信息 Job information

上一次在船信息 Information on last ship	
上次上船时间 Time on board	单击或点击此处输入日期。
上次工作船型 Ship type	选择一项。
上次在船船旗 Ship flag	选择一项。
上次服务航线 Routing served	选择一项。
上次在船甲板高级船员数量 Number of deck officers	选择一项。
上次在船轮机高级船员数量 Number of engine officers	选择一项。
上次在船甲板普通船员数量 Number of deck ratings	选择一项。
上次在船轮机普通船员数量 Number of engine ratings	选择一项。
上次在船事务部船员数量 Number of purser department	选择一项。

3.近些年您工作的主要船舶类型？What type of ship do you work on in recent years?

□集装箱船 container

□散货船 bulk carrier

□油船 tanker

□杂货船 general cargo ship

□天然气船/液化气船LNG/LPG

□滚装船 Ro-Ro ship/Pure Car Carrier

□客船Cruise ship

□其它类型 Others

4.您在船上工作几年？How many years have you worked on the ship?

□<1

□1-5

□6-10

□10-15

□16 and above

5.您的船上现任职务？What is your present rank?

□Captain

□Officer

□Rating

□Other

6.您担任现职务几年？How many years have you been in your present rank?

□<1

□1 -3

□4 -10

□11 and above

7.从您个人经验来看，最近五年船上的工作强度有什么样的变化趋势？From your personal experience, how has the intensity of work on board changed in the last five years?

□增加 increase

□减少 decrease

□基本不变 basically unchanged

8.船上现有的工作休息时间记录中的工作时间和您在船的实际工作时间是否相符？Do the working hours in the existing record of working and resting time match your actual working hours on board?

□Completely

□Basically

□Sometimes

□Hardly

□None

9.如果工作休息时间记录不能真实反映您的在船工作时间，下列哪些或者哪项工作是比较突

出的？If the record of working and resting time does not truly reflect your time spent on board, which or which of the following jobs stands out?

□航行 Navigation

□靠离泊Berthing/Unberthing

□装卸货作业Cargo handling operation

□维护保养Maintenance

□培训 Training

□港口国和船旗国检查Port state and flag State inspection

□防污染检查Anti-pollution inspection

□加装燃油或处理污油Bunkering or disposing of sludge

□各种文书工作Various paperwork

□信息邮件往来Message and mail exchanges

10.从您的工作经验来看，下列哪项船上的工作让您感到压力？（多选）Based on your work experience, which of the following tasks on board may causes you stress? (Multiple choice)

□航行 Navigation

□靠离泊Berthing/Unberthing

□装卸货作业Cargo handling operation

□维护保养Maintenance

□培训 Training

□港口国和船旗国检查Port state and flag State inspection

□防污染检查Anti-pollution inspection

□更换不熟悉本船的船员较多时More replacement of crew unfamiliar with the ship

□加装燃油或处理污油Bunkering or disposing of sludge

□各种文书工作Various paperwork

□正式信息邮件往来Official message mail exchanges

□上述选项不包含的其它工作 Other work is not included in the above options

11.你认为3年疫情期间，哪些因素导致你疲劳强度增加了？（多选）What factors do you think caused your fatigue intensity to increase during the three-year epidemic? (Multiple choice)

□航行 Navigation

□靠离泊Berthing/Unberthing

□装卸货作业Cargo handling operation

□维护保养Maintenance

□培训 Training

□港口国和船旗国检查Port state and flag State inspection

□防污染检查Anti-pollution inspection

□更换不熟悉本船的船员较多时More replacement of crew unfamiliar with the ship

□加装燃油或处理污油Bunkering or disposing of sludge

□各种文书工作Various paperwork

□正式信息邮件往来Official message mail exchanges

□上述选项不包含的其它工作 Other work is not included in the above options

12.你认为3年疫情期间，哪些因素导致你疲劳强度减低了？（多选）What factors do you think caused your fatigue intensity to decrease during the three-year epidemic? (Multiple choice)

□航行 Navigation

□靠离泊Berthing/Unberthing

□装卸货作业Cargo handling operation

□维护保养Maintenance

□培训 Training

□港口国和船旗国检查Port state and flag State inspection

□防污染检查Anti-pollution inspection

□更换不熟悉本船的船员较多时More replacement of crew unfamiliar with the ship

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□各种文书工作Various paperwork

□正式信息邮件往来Official message mail exchanges

□上述选项不包含的其它工作 Other work is not included in the above options

13.近五年在您工作的船舶上是否经历过由公司主导的减少船舶固定配员的情况？Have you ever experienced a company-led reduction of permanent staffing on a ship in the last five years?

□总是发生 Always

□经常发生 Often

□有时发生 Sometimes

□很少发生 Rarely

□从未发生 Never

14.当公司布置的任务超出船员工作强度的时候，您是否会迫于压力在有限的时间内优先完成一些更重要的任务？Do you feel pressured to give priority to the more important tasks in the limited time available when the company assigns tasks that exceed the crew's workload?

□总是 Always

□经常 Often

□有时 Sometimes

□很少 Rarely

□从未 Never

15.当公司布置的任务超出船员工作强度的时候，您是否会向公司反馈船上的实际情况？（适用于船长和部门长）Do you give feedback to the company about the actual situation on board when the company has assigned tasks that exceed the crew's working intensity?

□总是 Always

□经常 Often

□有时 Sometimes

□很少 Rarely

□从未 Never

16.您是否被公司要求对船上的人员工作进行更合理的安排？（适用于船长和部门长）Have you been requested by the company to make more reasonable arrangements for the crew working on the ship? (Applicable to captains and department heads)

□总是发生 Always

□经常发生 Often

□有时发生 Sometimes

□很少发生 Rarely

□从未发生 Never

17.公司就船上的配员能否满足船上的工作是否主动和您沟通过？Does the company take the initiative to communicate with you about whether the manning on board can meet the requirements of the work on board?

□总是 Always

□经常 Often

□有时 Sometimes

□很少 Rarely

□从未 Never

18.在您经历过的针对船上的工作和休息时间记录检查时港口国和船旗国官员对于记录的真实性有没有表示怀疑？Have port state and flag State officials expressed doubts about the authenticity of the records of working and resting hours on board the ship that you have experienced?

□总是 Always

□经常 Often

□有时 Sometimes

□很少 Rarely

□从未 Never

19.如适用，您是否在港口国和船旗国检查过程中就当前配员情况造成工作休息时间记录不得不修改一事向他们反映？If applicable, do you inform port State and Flag State inspectors of changes to working and resting hours records due to current staffing conditions?

□总是发生 Always

□经常发生 Often

□有时发生 Sometimes

□很少发生 Rarely

□从未发生 Never

20.在您工作过的船舶是否发生过因为港口国和船旗国提出船上工作和休息时间记录不满足劳工公约而增加配员的情况？Has there ever been an increase in staffing on a ship where you have worked because the port state and flag State have raised the issue that the ship's working and resting hours records do not meet Maritime Labour Conventions?

□总是发生 Always

□经常发生 Often

□有时发生 Sometimes

□很少发生 Rarely

□从未发生 Never

21.目前在您工作的船公司管理程序中有没有建立一种评估船上配员是否满足船上操作要求的方法？Is there currently a method established in the management procedures of the shipping company where you work to assess whether the ship's staffing meets the ship's operational requirements?

□是Yes

□否No

□不清楚 Unclear

22.贵轮通常采取什么措施，防止船员的工作疲劳.What measures do you usually take to prevent crew fatigue on your good vessel?

□预先调整值班时间Adjust the time of duty in advance

□加班后补休Take compensatory leave after working overtime

□观察其工作状态再确定方案Observe its working state and then determine the scheme

□根据具体情况采取措施Measures shall be taken according to specific circumstances

□没有具体方案No concrete plan

如有其它，请陈述。If any more, please state._____

Appendices 3 Coping with fatigue at sea questionnaire for shipping company

Dear Participant,

Thank you for agreeing to participate in this research survey, which is carried out in connection with a Dissertation which will be written by the interviewer, in partial fulfilment of the requirements for the degree of Master of Science in in Maritime Safety Environmental Management delivered in Dalian, China, by World Maritime University in collaboration with Dalian Maritime University.

The topic of the Dissertation is "A research on fatigue resolution method led by crew workload self-assessment."

The information provided by you in this interview will be used for research purposes and the results will form part of a dissertation, which will later be published online in WMU's digital repository (maritime commons) subject to final approval of the University and made available to the public. Your personal information will not be published. You may withdraw from the research at any time, and your personal data will be immediately deleted.

Anonymised research data will be protected by strong password. All the data will be deleted as soon as the degree is awarded.

Your participation in the interview is highly appreciated.

亲爱的参与者,

感谢您同意参加本次调研，本次调研与面试官撰写的论文有关，部分满足了世界海事大学与大连海事大学合作在中国大连颁发的海上安全环境管理理学硕士学位的要求。

本文的课题是"以船员工作负荷自评估为主导的疲劳解决方法研究"。

您在本次访谈中提供的信息将用于研究目的，其结果将构成论文的一部分，随后将在WMU的数字存储库(海事公地)中在线发布，并经大学最终批准并向公众开放。您的个人信息将不会被公布。您可以随时退出研究，您的个人资料将被立即删除。

匿名的研究数据将被存档在一个安全的USB驱动器。学位授予后，所有资料将立即删除。非常感谢您参加问卷调查。

Student's name …Liu Jun……
Specialization ……MSEM……
Email address ……liujun_dlmuhh@dlmu.edu.cn……
* * *

电子邮箱 E-mail:

1.您在航运公司工作几年？How many years have you worked for a shipping company?

□<1

□1 -3

□4 -10

□11 and above

2.您在航运公司什么部门任职？Which department do you work in company?

□Commercial department

□Operation department

□Ship management department

□Crew assignment department

□HR department

3.您公司主营的船舶类型？What kind of ships do your company specialize in?

□集装箱船 container

□散货船 bulk carrier

□油船 tanker

□杂货船 general cargo ship

□天然气船/液化气船LNG/LPG

□滚装船 Ro-Ro ship/Pure Car Carrier

□客船Cruise ship

□其它类型 Others

4.您认为贵公司经营的船队配员能够满足生产经营吗?
Do you think the manning of your fleet can meet the operational requirements on board?

□完全满足completely

□基本满足 basically

□很难满足 difficultly

□不能满足 unsatisfyingly

□不清楚 unclear

5.有没有船员向公司反映船上配员不足造成工作强度过大?
Has the crew reported to the company that the work intensity is too high due to the lack of manning on board?

□总是 Always

□经常 Often

□有时 Sometimes

□很少 Rarely

□从未 Never

6.有没有船员私下向你个人反映船上配员不足造成工作强度过大？Have any crew members privately told you that they are working too hard because they are understaffed?

□总是 Always

□经常 Often

□有时 Sometimes

□很少 Rarely

□从未 Never

7.有没有船舶管理级船员向岸基反映新船员在很大程度造成了船舶管理的压力？
Has the ship management crew reflected to the company that the new crew has caused the ship management stress to a large extent?

□总是 Always

□经常 Often

□有时 Sometimes

□很少 Rarely

□从未 Never

8.在您工作的航运公司船舶固定配员有没有发生过减少的现象？Has there ever been a decrease in the permanent manning of ships in the shipping company where you work?

□总是发生 Always happen

□经常发生 Often happen

□有时发生 Sometimes happen

□很少发生 Rarely happen

□从未发生 Never happen

9.在您工作的航运公司有没有为了关闭因为船舶的工作休息时间记录不满足劳工公约而被港口国或船旗国检查开出的缺陷去增加船舶配员？Did the shipping company you work for increase the manning of the ship in order to close the defect caused by the port state or flag state inspection because the ship's working and resting hours record does not meet the Maritime Labour Convention?

□总是发生 Always happen

□经常发生 Often happen

□有时发生 Sometimes happen

□很少发生 Rarely happen

□从未发生 Never happen

□不清楚 unclear

10.您认为贵公司的主流船型是否存在船员疲劳现象？Do you think there is crew fatigue in the main fleet of your company?

□总是 Always

□经常 Often

□有时 Sometimes

□很少 Rarely

□从未 Never

□不清楚 unclear

11.在您管理船舶的过程中，有没有考虑过船舶当前的配员和当前工作量的匹配问题？In your ship management process, have you considered the ship's current staffing and current workload matching issues?

□总是 Always

□经常 Often

□有时 Sometimes

□很少 Rarely

□从未 Never

12.在您的公司有没有具体的方法去评价船上的配员是否满足公司安全管理体系中所列明的工作要求？Does your company have a specific mean to evaluate whether the crew on board meets the job requirements outlined in the company's safety management system?

□是yes

□否 no

□不清楚 unclear

13.如果在您的公司有评价船舶工作量的制度，执行情况怎么样？If there is a system in your company to evaluate the workload of ships, how is it implemented?

□总是 Always

□经常 Often

□有时 Sometimes

□很少 Rarely

□从未 Never

14.您管理的船队中如果存在船员疲劳现象，它的原因是什么？What is the cause if there is crew fatigue in the fleet you manage?

□配员不足 under-staffing

□船员技能不足Less skill of crew

□恶劣工作环境Harsh working environment

□航线不固定Irregular route

□岸基支持不足 Insufficient shore-based support

□过度监管Over-management and monitoring

如有其它，请陈述。If any more, please state. _____

15.您认为哪些措施能够减缓贵公司主流船舶船员的疲劳现象？What measures do you think would mitigate the crew fatigue in the main fleet of your company?

□增加配员 increase manning

□提高船员技能Improve seafarers' skills

□改善船舶工作环境Improve the working environment of ships

□为安全管理瘦身，减少冗余监管Slim down for safety management，reduce redundant regulation

□根据工作量来配员Assign staff according to workload

如有其它，请陈述。If any more, please state._____